From Museum Specimen Database to Ecological Statement

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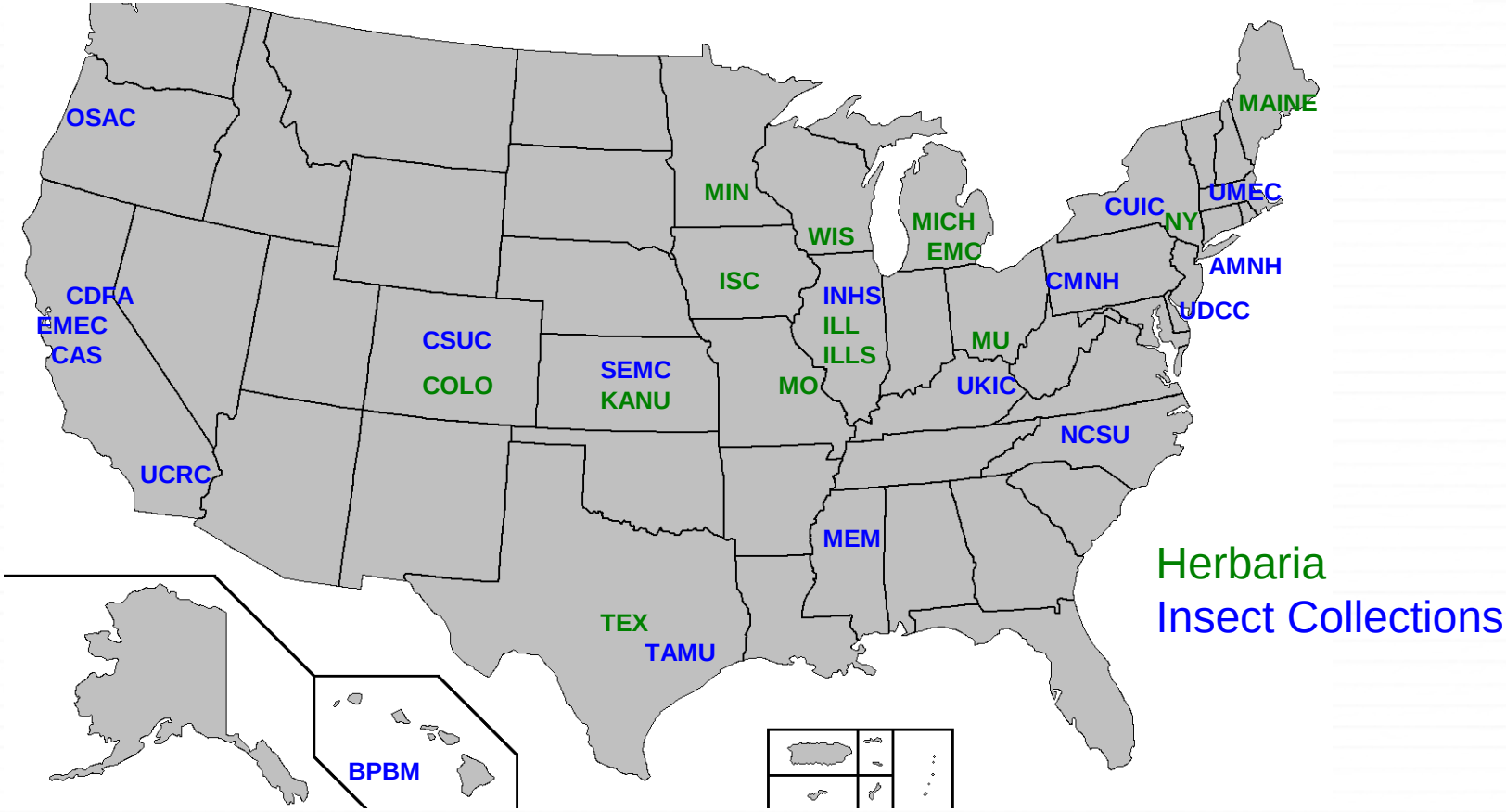
SPNHC – Cardiff - 2014

Tri-trophic Digitization
Thematic Collections Network

PI: Randall "Toby" Schuh (AMNH)

32 institutions: 18 insect collections, 14 herbaria

NYBG is lead on botanical digitization, AMNH on entomological



Goals

- Plants
  - Image and database 1.26M specimens from 20 families of vascular plants
  - Unify these with 3.5M specimens from 3 data providers
  - Mobilize total of 6.06M specimens
- Bugs
  - Database 1.16M specimens from 92 families of Hemiptera
  - Unify these with .38M specimens from 3 data providers
  - Image selected specimens
- Parasitoids
  - Database 45K specimens from 5 families of Hymenoptera
- Integrate trophic levels (7.65M records) in Discover Life

Progress on Goals
Start of Year 4

- Botany: (currently at NY)
  - 1,003 M images (79% of expected)
  - data capture and georeferencing varies from skeletal to complete
- Insects + Parasitoids:
  - 825K records completed (73.3% of expected)

Happening Just Last Week

- Utilization of Collection Data Workshop
  - UC-Riverside, June 17-18, 2014
  - data-mining and species distribution modeling
  - use Tri-trophic Database as platform
  - targeted to systematists and ecologists

From Museum Specimen Database to Ecological Statement:

Data Quality Inspection

From Museum Specimen Database to Ecological Statement:

Data Quality Inspection

Climate change has an effect on the timing of bug emergence

- Download Hemiptera ("true bug") records associated with "*Quercus*" (oak trees) from AEC database (N = 27,656)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Acanaloniidae							5		1				6
Achilidae					1	2	3	13	2	3		1	25
Aetalionidae				1		1		1					3
Aleyrodidae	25	31	40	43	7	7	8	15	9	15	4	7	211
Aphididae	23	14	74	93	252	176	140	91	170	228	80	16	1357
Aphrophoridae					1					2			3
Berytidae					3					4			7
Caliscelidae					1								1
Cicadellidae	1	1	2	1	1	24	23	26	27	14		1	121
Cicadidae					5	49	60	3	1				118
Cixiidae					4	2	2						8
Coccidae		8	7	15	19	4			4				57
Coreidae					1		1				1		3
Delphacidae						2							2
Derbidae				3	1		4	6	1				15
Diaspididae	23	18	20	32	33	31	35	12	14	25	20	26	289
Dictyopharidae								2					2
Eriococcidae		1	4		2	2	1		2	1	1		14
Flatidae			1	1	1	1	11		1				16
Fulgoridae								1					1
Geocoridae								1					1
Issidae			1	1		2	31	22					57
Kermesidae	1	2	1	17	27	15	19	33	12	5	7	8	147
Membracidae	2	40	789	2722	4560	2662	951	205	141	147	19	6	12244
Miridae		7	488	2273	5352	2938	757	545	35	4		1	12400
Pentatomidae		1		4	2	3	14	3	5	12		2	46
Phylloxeridae					6				6	1	13		26
Pseudococcidae				4	3		7	2		1			17
Reduviidae						2		1			1	1	5
Rhopalidae									1				1
Tingidae				22	51	11	23	47	11				165
Grand Total	75	123	1427	5232	10333	5934	2095	1029	443	462	146	69	27368

Membracidae (Treehoppers)

Membracidae (Treehoppers)

Gregarious, plant feeders, strong host plant associations

From Museum Specimen Database to Ecological Statement:

Data Quality Inspection

Climate change has an effect on the timing of bug "emergence"

- Download all Membracidae ("treehopper") records associated with "*Quercus*" (oak trees) from AEC database (N = 12,245)
  - Deleted records where "single entry" or locality unknown (n=25)
  - Deleted records where at least month date not apparent (n=1)
  - Records where year unknown (n=66) used for month data only

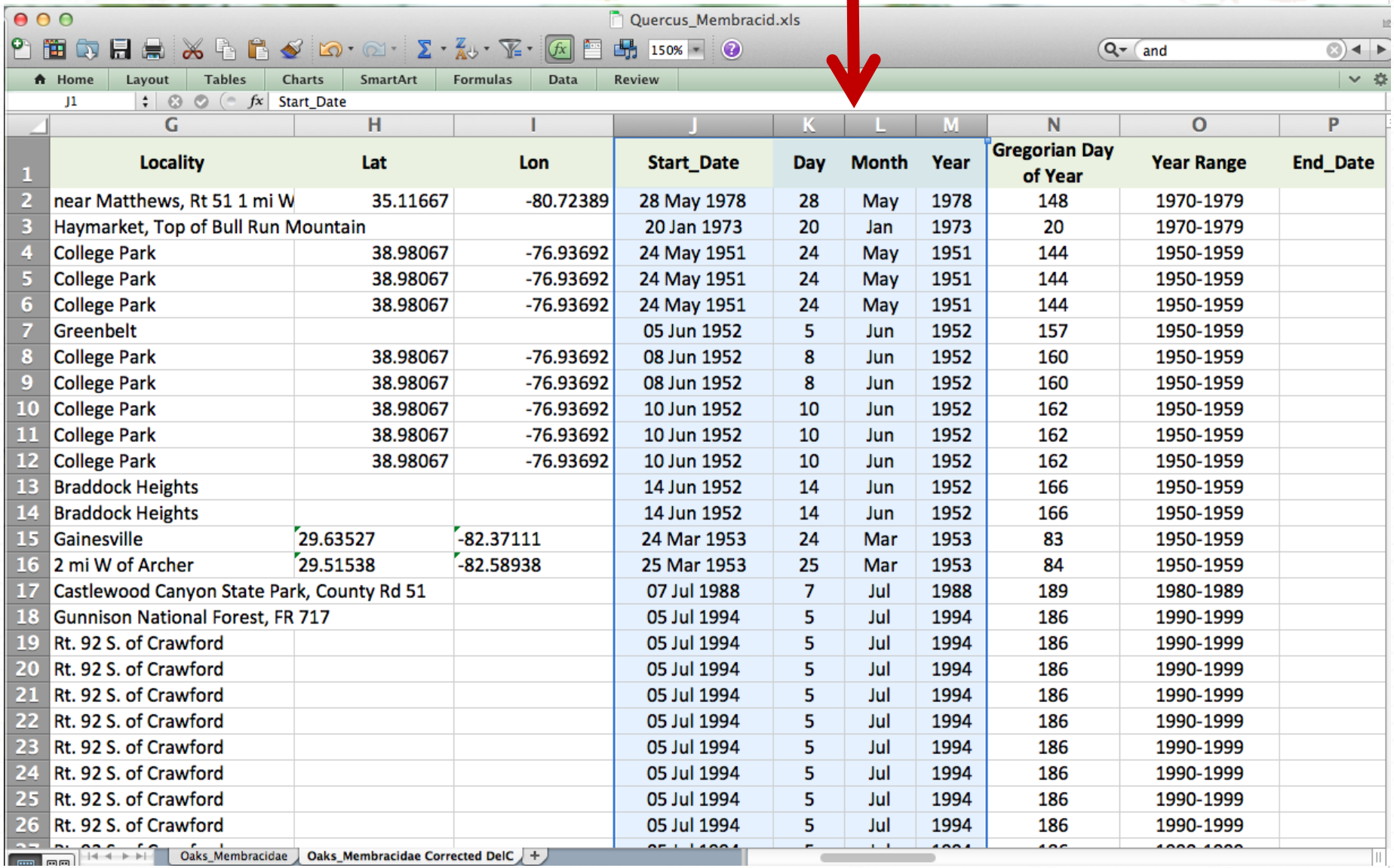
From Museum Specimen Database to Ecological Statement:

Data Quality Inspection

Climate change has an effect on the timing of bug "emergence"

- Download all Membracidae ("treehopper") records associated with "*Quercus*" (oak trees) from AEC database (N = 12,153)
  - Deleted records where "single entry" or locality unknown (n=25)
  - Deleted records where at least month date not apparent (n=1)
  - Records where year unknown (n=66) used for month data only

Parse Day, Month, Year



	G	H	I	J	K	L	M	N	O	P
1	Locality	Lat	Lon	Start_Date	Day	Month	Year	Gregorian Day of Year	Year Range	End_Date
2	near Matthews, Rt 51 1 mi W	35.11667	-80.72389	28 May 1978	28	May	1978	148	1970-1979	
3	Haymarket, Top of Bull Run Mountain			20 Jan 1973	20	Jan	1973	20	1970-1979	
4	College Park	38.98067	-76.93692	24 May 1951	24	May	1951	144	1950-1959	
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13	Braddock Heights			14 Jun 1952	14	Jun	1952	166	1950-1959	
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16	2 mi W of Archer	29.51538	-82.58938	25 Mar 1953	25	Mar	1953	84	1950-1959	
17	Castlewood Canyon State Park, County Rd 51			07 Jul 1988	7	Jul	1988	189	1980-1989	
18	Gunnison National Forest, FR 717			05 Jul 1994	5	Jul	1994	186	1990-1999	
19	Rt. 92 S. of Crawford			05 Jul 1994	5	Jul	1994	186	1990-1999	
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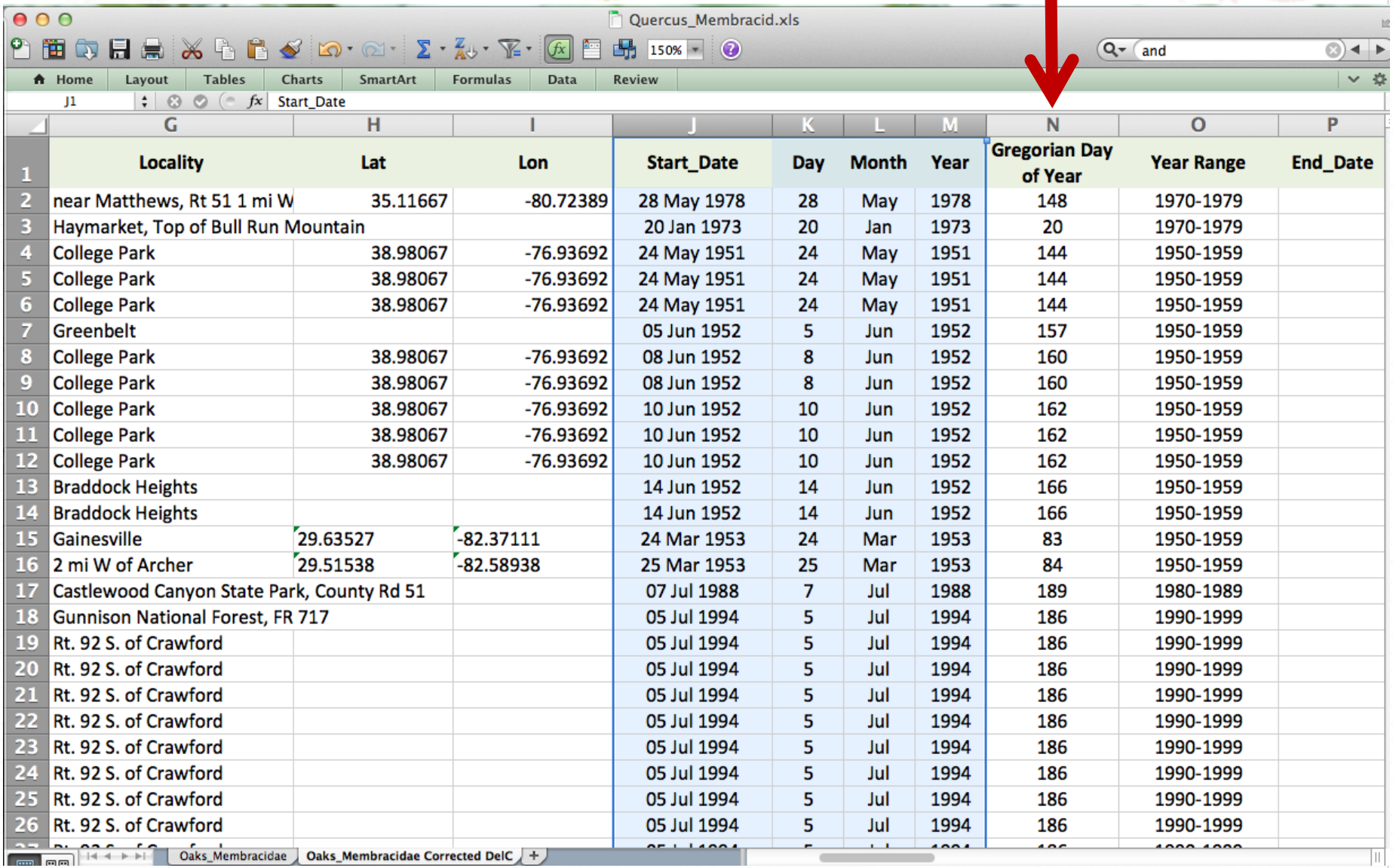
Oaks_Membracidae | Oaks_Membracidae Corrected DelC

Calculate Day of Year

= A1-Date(Year(A1),1,0)



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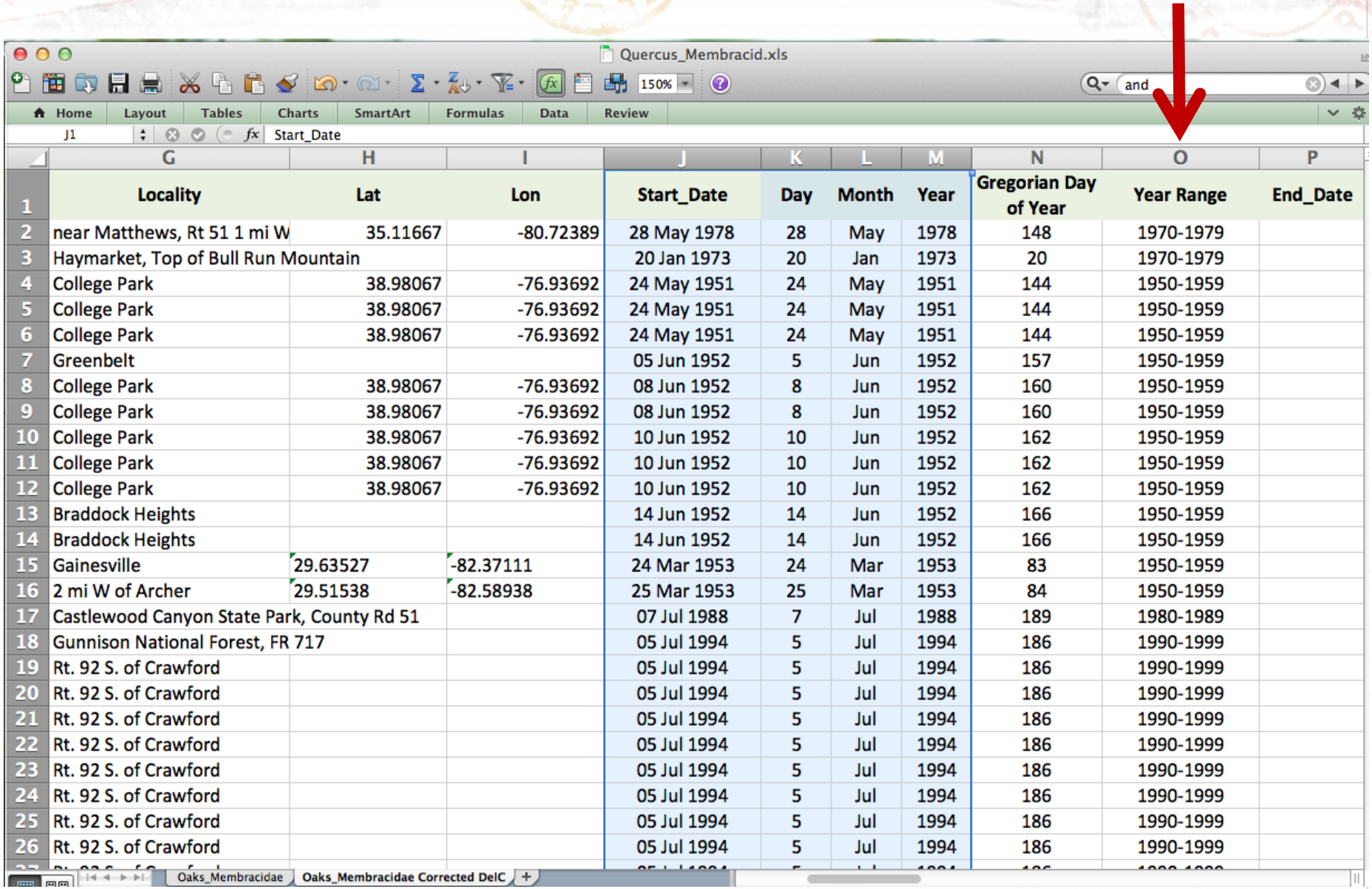
Oaks_Membracidae | Oaks_Membracidae Corrected DelC

Bin Year



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Oaks_Membracidae | Oaks_Membracidae Corrected DelC

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Climate change has an effect on the timing of bug "emergence"

- Download all Membracidae ("treehopper") records associated with "*Quercus*" (oak trees) (N = 12,153)

- *Check for errors in taxon, locality, collector names*

castanea
<snip>
cenis
cerris
cersis
cf. acutifolia
<snip>
engelmanni
engelmannii
englemanni
<snip>
inopina
john
john-tuckeri
kelloggii
kellogii
laeta
laeve
laevis
laurifolia
levis
lobata
lyrata
macrocarpa
macrocarpus
magnoliaefolia
margaretta
margaritacea
marilandica
marylandica
<snip>
michauxii
muehlenbergii
muhlenbergii

Use Pivot (or any) Table to find Errors

- Returns single instances of each taxon/locality/collector name etc.

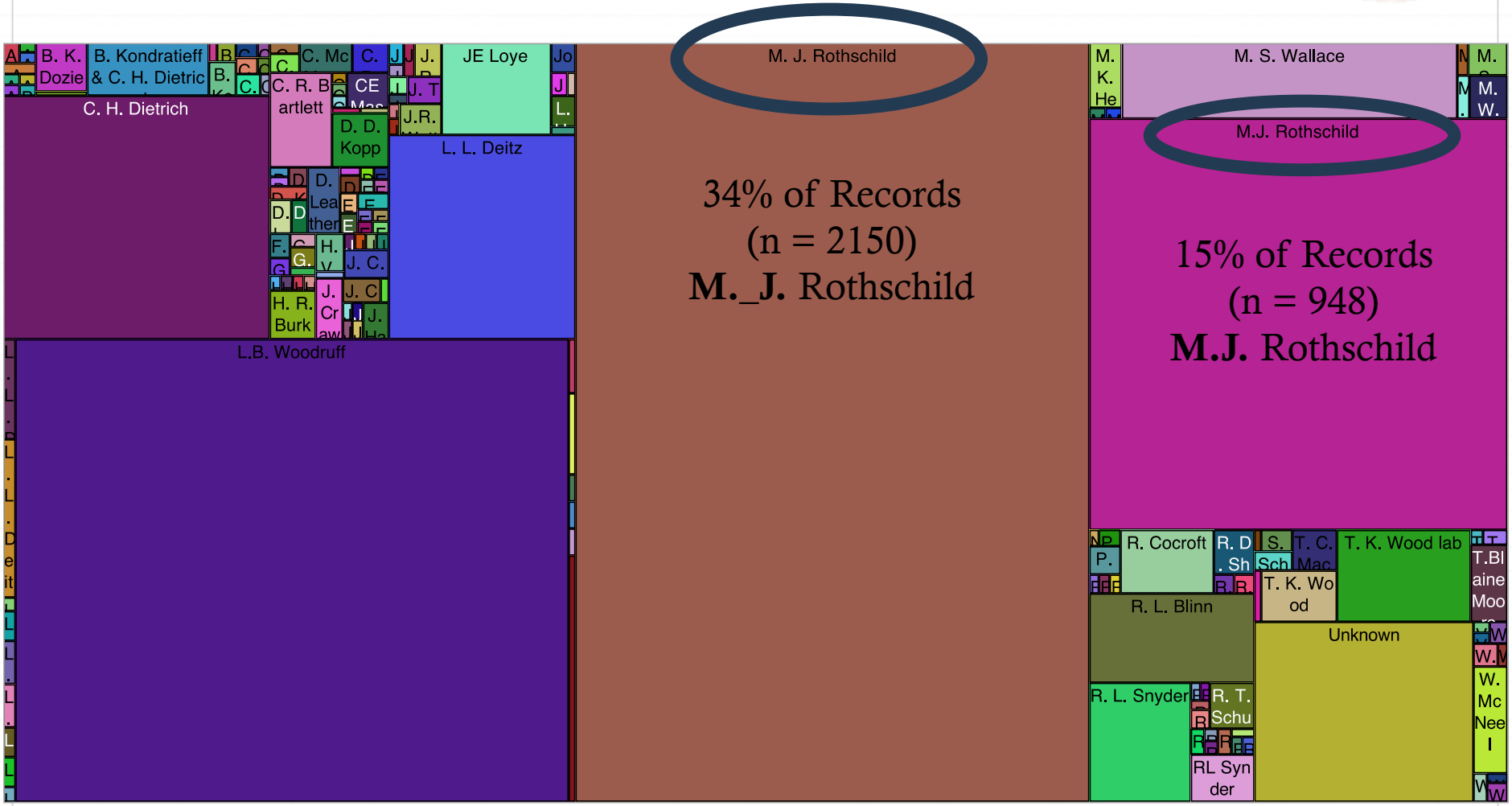
Example: Flora (*Quercus*) host species

Use Pivot (or any) Table to find Errors

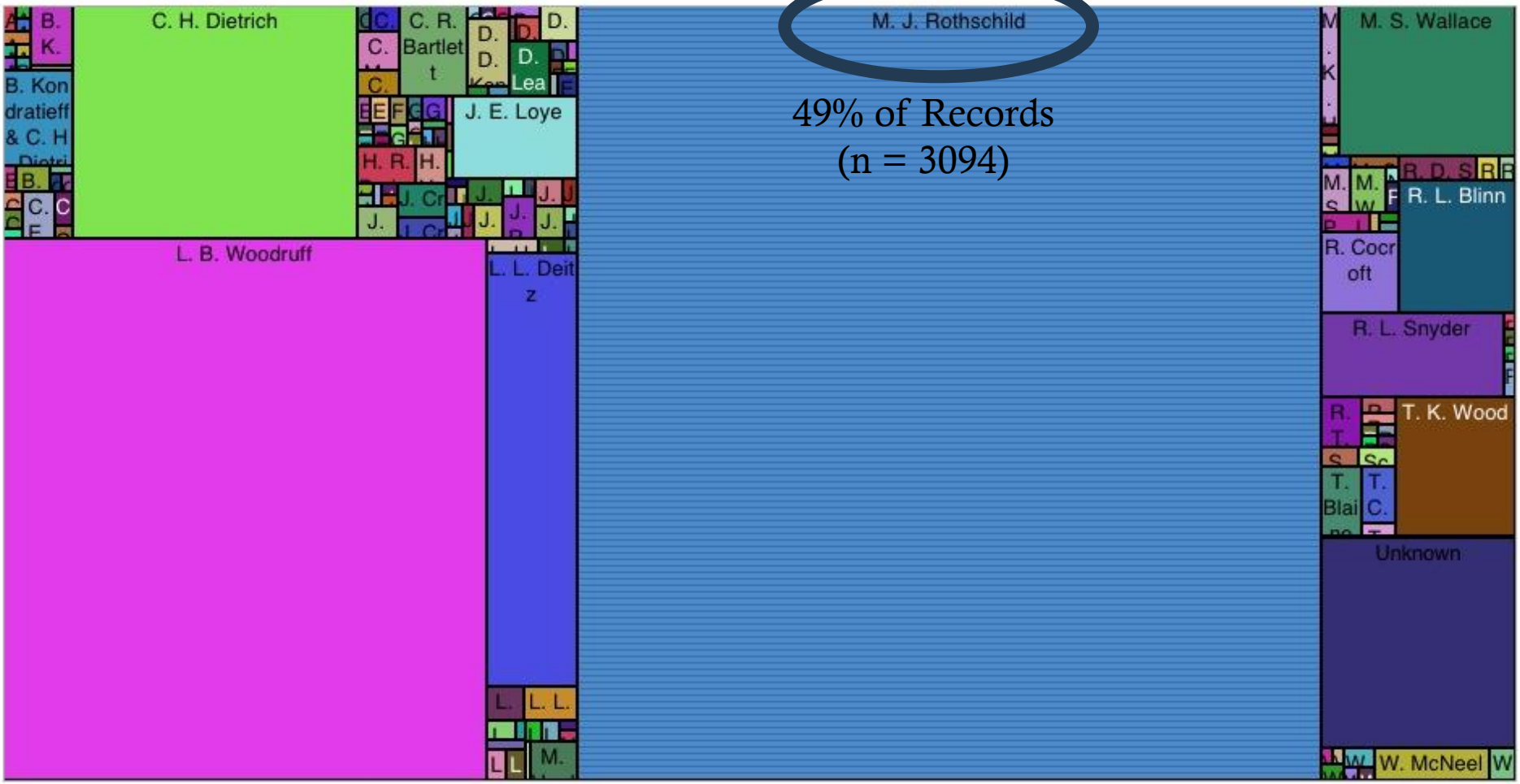
- Returns single instances of each taxon/locality/collector name etc.

Example: Collector Name

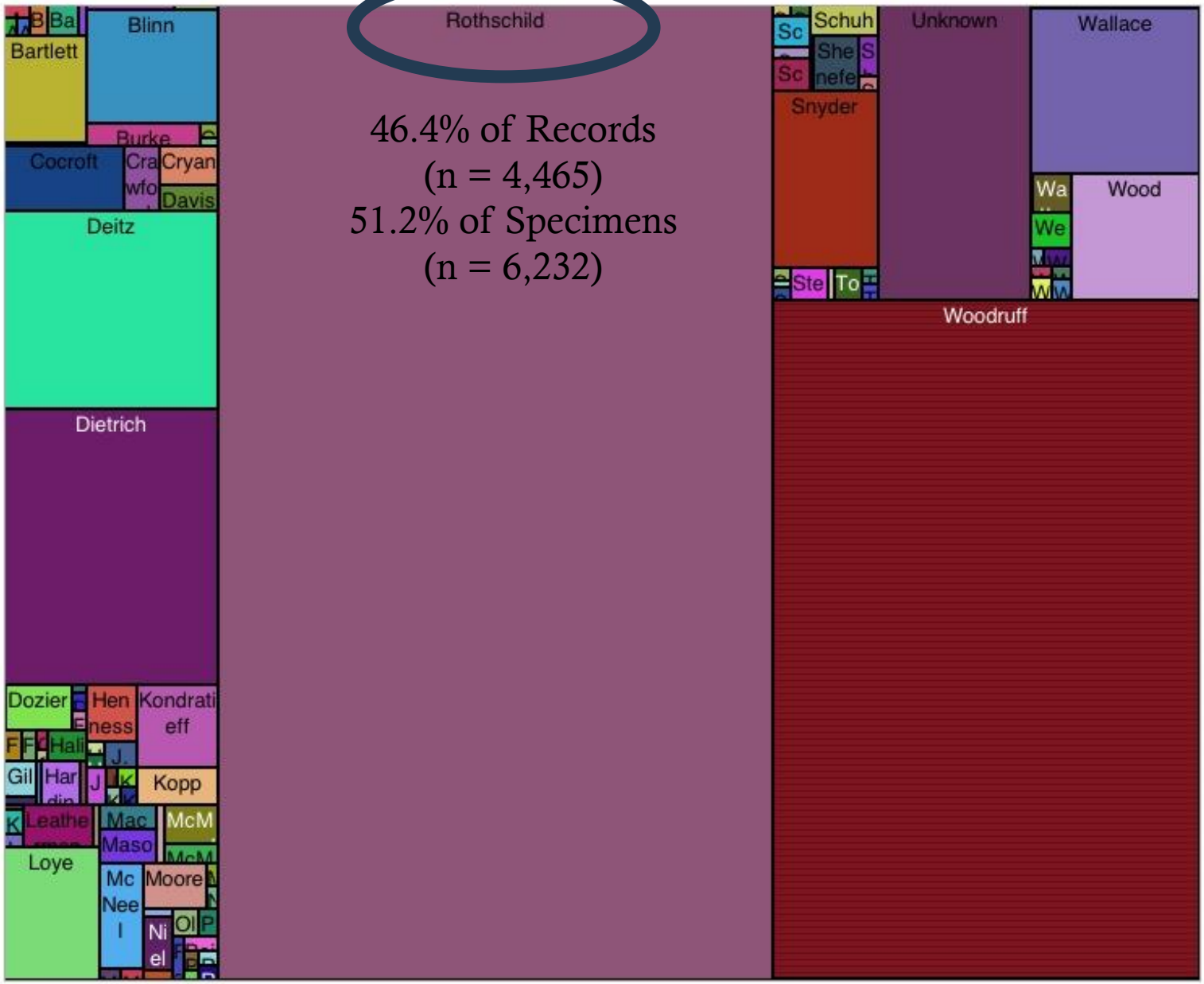
Number of Unique Collecting Events with which a Collector or Collector String was Associated

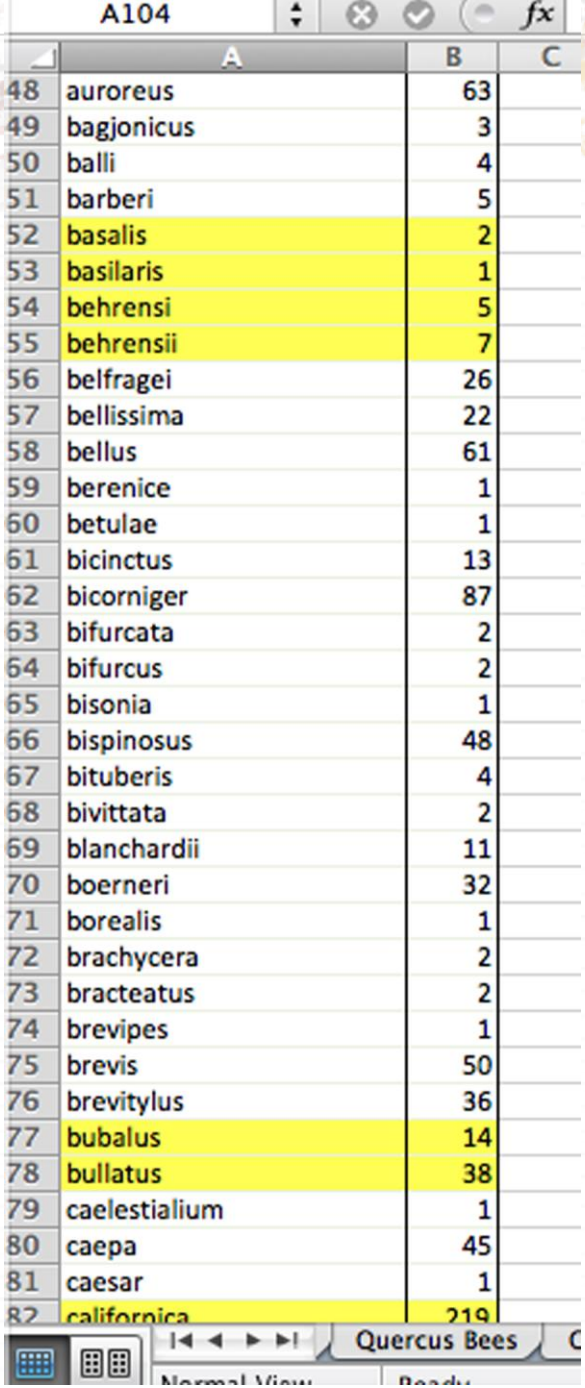


Number of Unique Collecting Events with which a Collector or Collector String was Associated



Number of Unique Collecting Events with Collector Name Binned





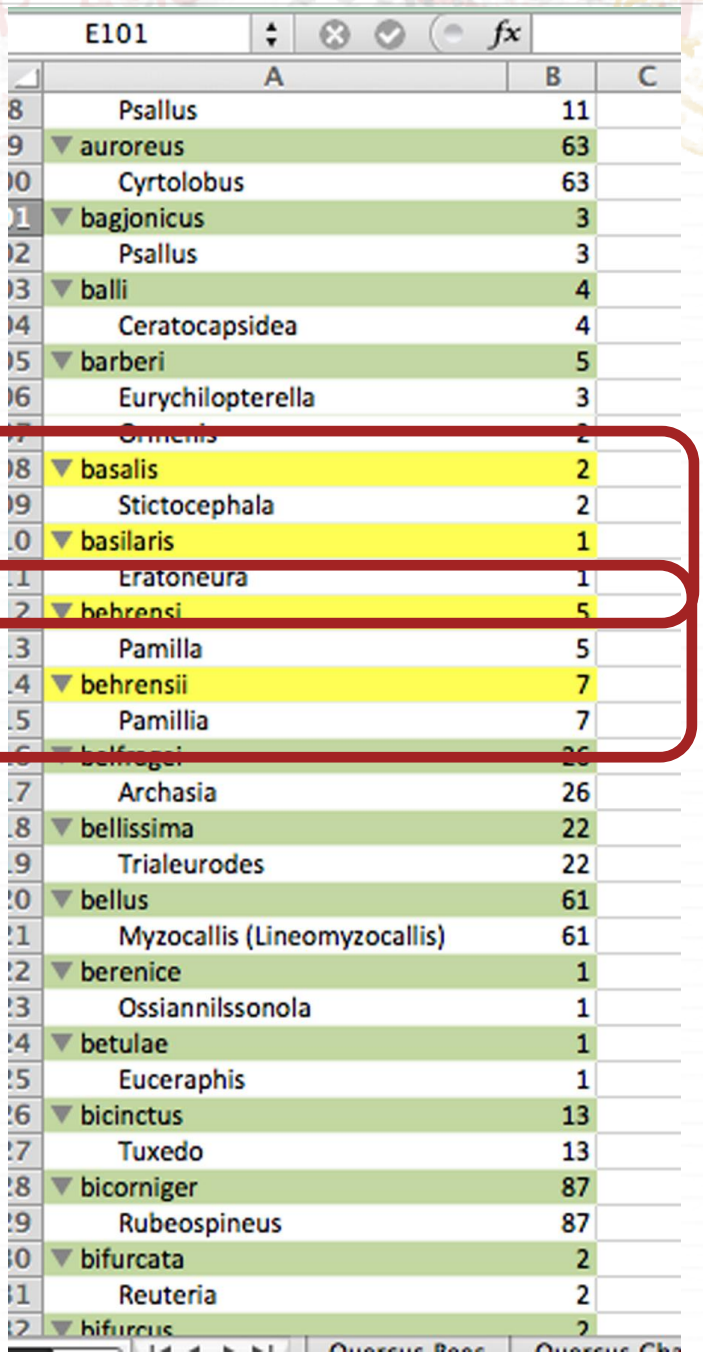
	A	B	C
48	auroreus	63	
49	bagjonicus	3	
50	balli	4	
51	barberi	5	
52	basalis	2	
53	basilaris	1	
54	behrensi	5	
55	behrensii	7	
56	belfragei	26	
57	bellissima	22	
58	bellus	61	
59	berenice	1	
60	betulae	1	
61	bicinctus	13	
62	bicorniger	87	
63	bifurcata	2	
64	bifurcus	2	
65	bisonia	1	
66	bispinosus	48	
67	bituberis	4	
68	bivittata	2	
69	blanchardii	11	
70	boerneri	32	
71	borealis	1	
72	brachycera	2	
73	bracteatus	2	
74	brevipes	1	
75	brevis	50	
76	brevitylus	36	
77	bubalus	14	
78	bullatus	38	
79	caelestialium	1	
80	caepa	45	
81	caesar	1	
82	californica	219	

Quercus Bees

Use Pivot Table to find Errors

- Returns single instances of each taxon/locality/collector name etc.
  - ***Different strategy*** because ***multiple genera*** ("misspelling" of species name may be name that belongs to another genus).

Example: Bug record species in many genera



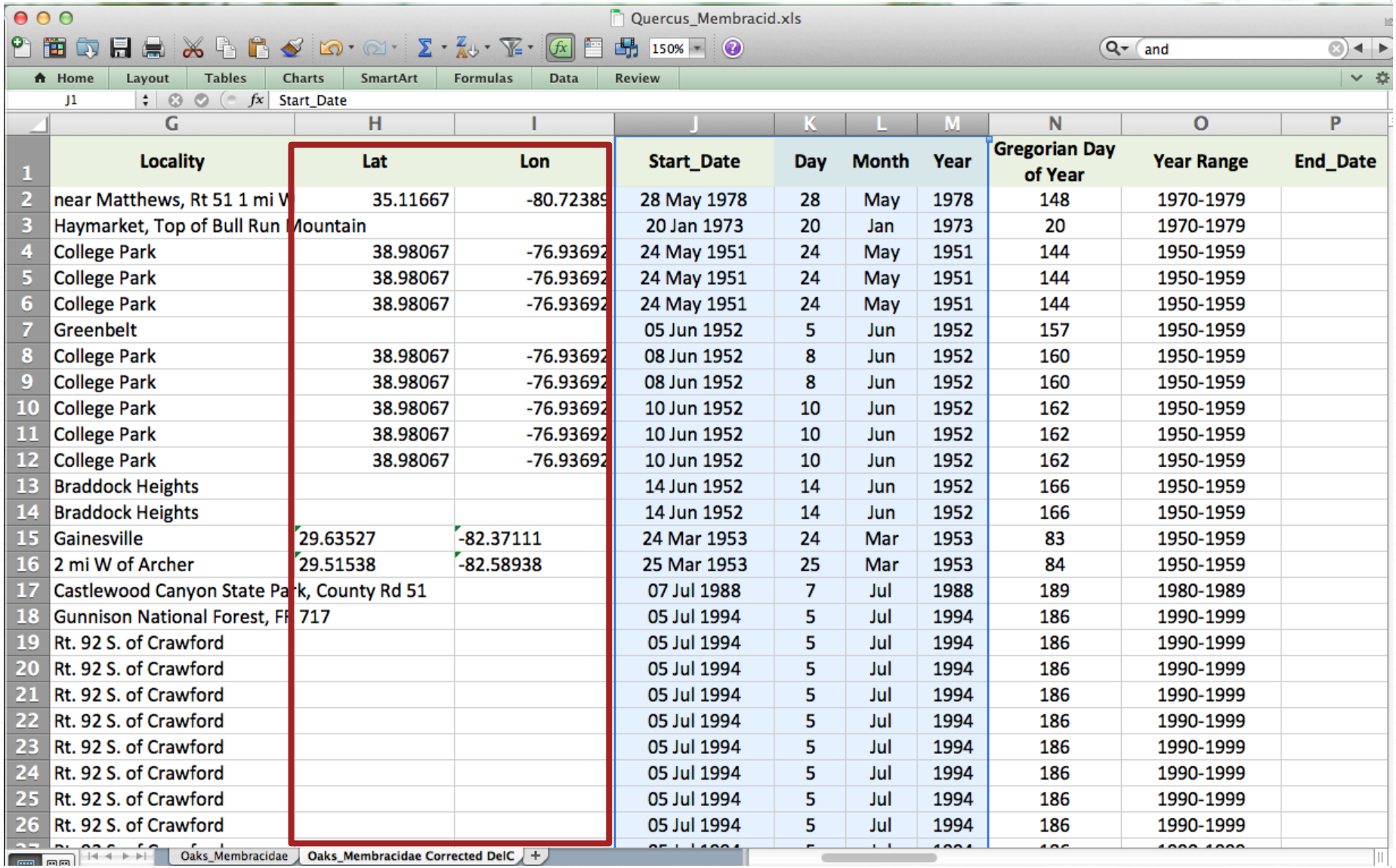
	A	B	C
8	Psallus	11	
9	auroreus	63	
0	Cyrtolobus	63	
1	bagjonicus	3	
2	Psallus	3	
3	balli	4	
4	Ceratocapsidea	4	
5	barberi	5	
6	Eurychilopterella	3	
8	basalis	2	
9	Stictocephala	2	
0	basilaris	1	
1	Eratoneura	1	
2	behrensi	5	
3	Pamilla	5	
4	behrensii	7	
5	Pamillia	7	
7	Archasia	26	
8	bellissima	22	
9	Trialeurodes	22	
0	bellus	61	
1	Myzocallis (Lineomyzocallis)	61	
2	berenice	1	
3	Ossiannilssonola	1	
4	betulae	1	
5	Euceraphis	1	
6	bicinctus	13	
7	Tuxedo	13	
8	bicorniger	87	
9	Rubeospineus	87	
0	bifurcata	2	
1	Reuteria	2	

Use Pivot Table to find Errors

- Returns single instances of each taxon/locality/collector name etc.
  - ***Different strategy*** because ***multiple genera*** ("misspelling" of species name may be name that belongs to another genus).
  - Add in genus name

californica	219
Irbisia	55
Notholopisca	129
Thelaxes	35
californicus	45
Tuberculatus (Pacificallis)	45

Missing Coordinate Data



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“Pseudo-replication” in Specimen Databases

- Data in databases may be a single collecting event (on a single plant, in a single nest etc.) but each specimen is databased
- 100 specimens may be collected from single plant, which may be independent individuals randomly on that plant or may be emergence of single brood (aggregate species)
- Create a single record from a single collection event with number of specimens collected.

Membracidae (Treehoppers)

Gregarious, plant feeders, strong host plant associations

Membracidae (Treehoppers)

Clustered immatures

Remove "Pseudo-replication"
Take "summary of data" to get unique string…

- Year
- Month
- Day

Date Info

- Locality String
- Latitude
- Longitude
- Elevation

Locality Info

- Collector
- Plant host species
- Plant host subspecies

Taxon Info: Host

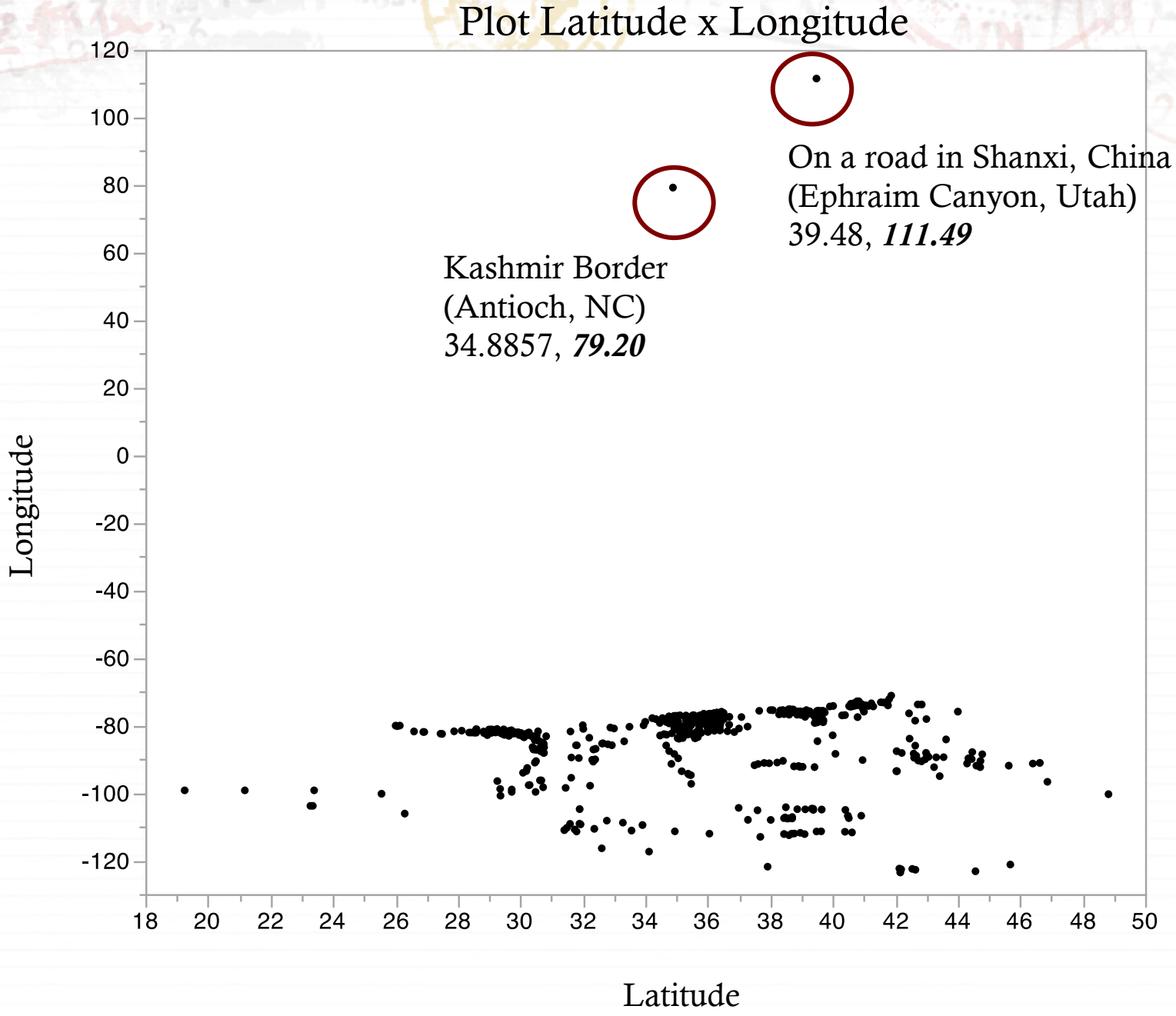
- Bug subfamily
- Bug tribe
- Bug genus
- Bug species

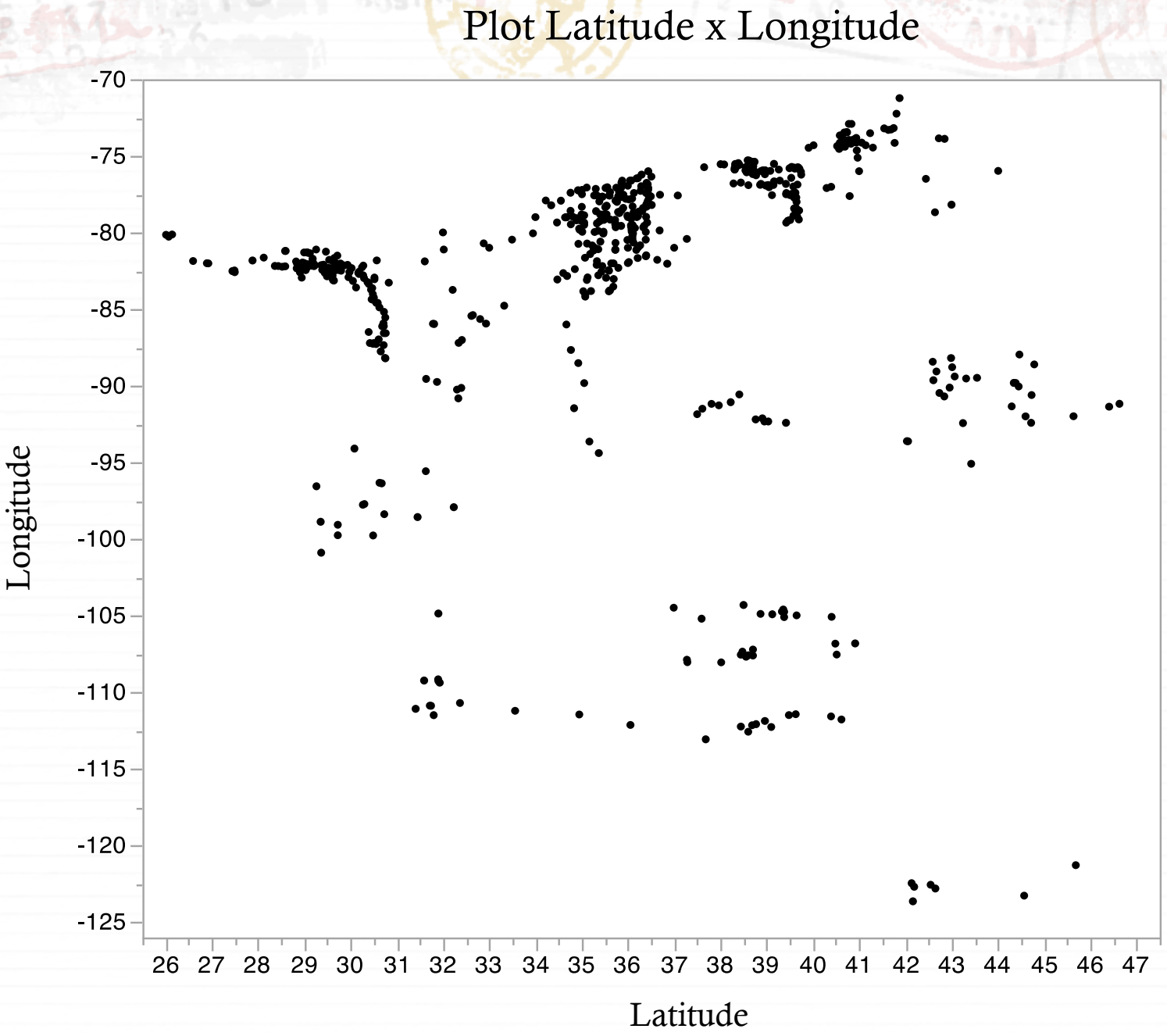
Taxon Info: Specimen

Remove "Pseudo-replication"
Take "summary of data" to get unique string…

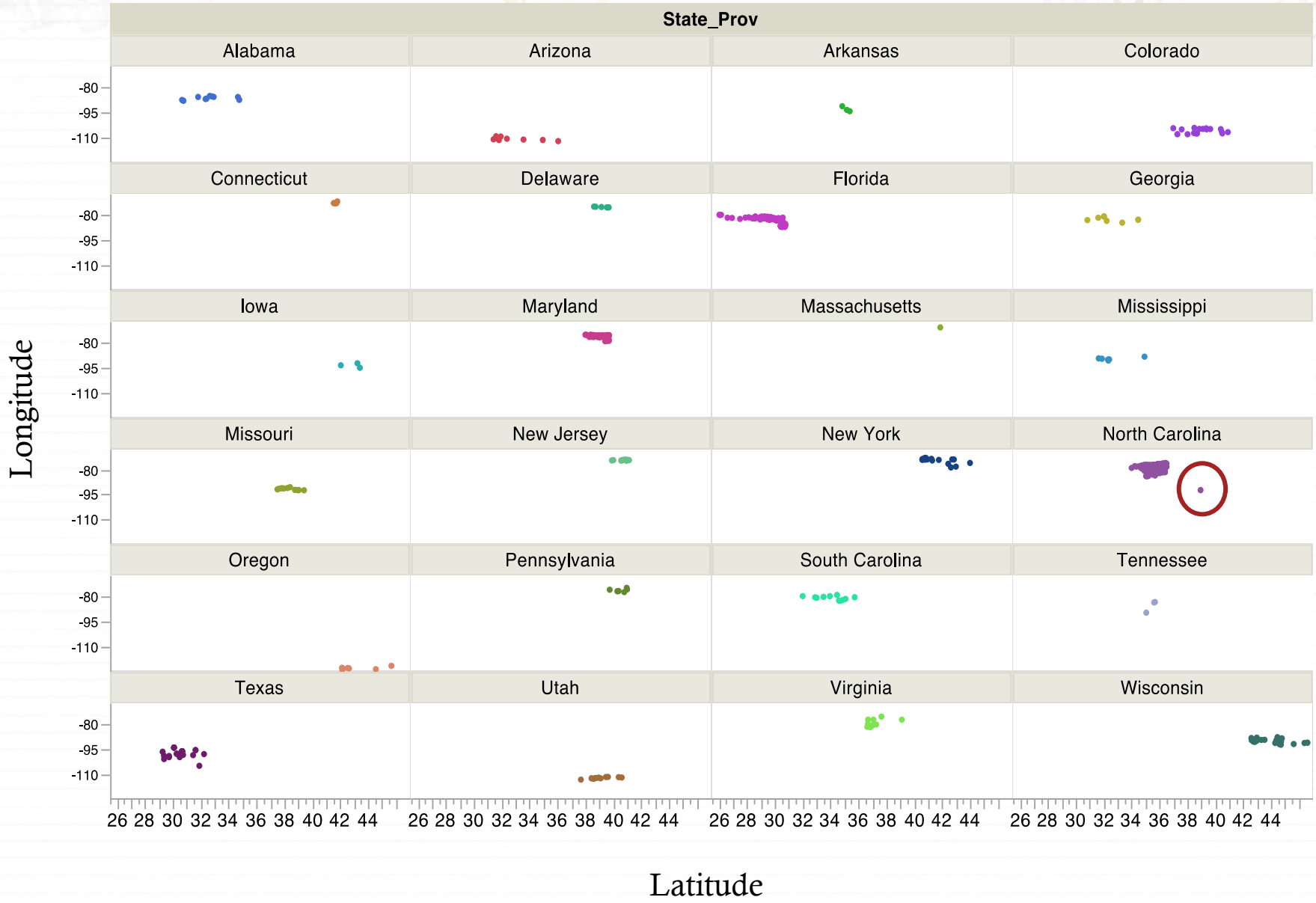
- Year
- Month
- Day
- Locality String
- Latitude
- Longitude
- Elevation
- Collector
- Plant host species
- Plant host subspecies
- Bug subfamily
- Bug tribe
- Bug genus
- Bug species

- *Specimen Number:*
  - *Sum*
  - *Proportion of Total*
- *Day of Year*
  - *Mean*
  - *Standard Deviation (should be nothing or 0)*
- *Year Range (Decade)*
- *Collector Bin*

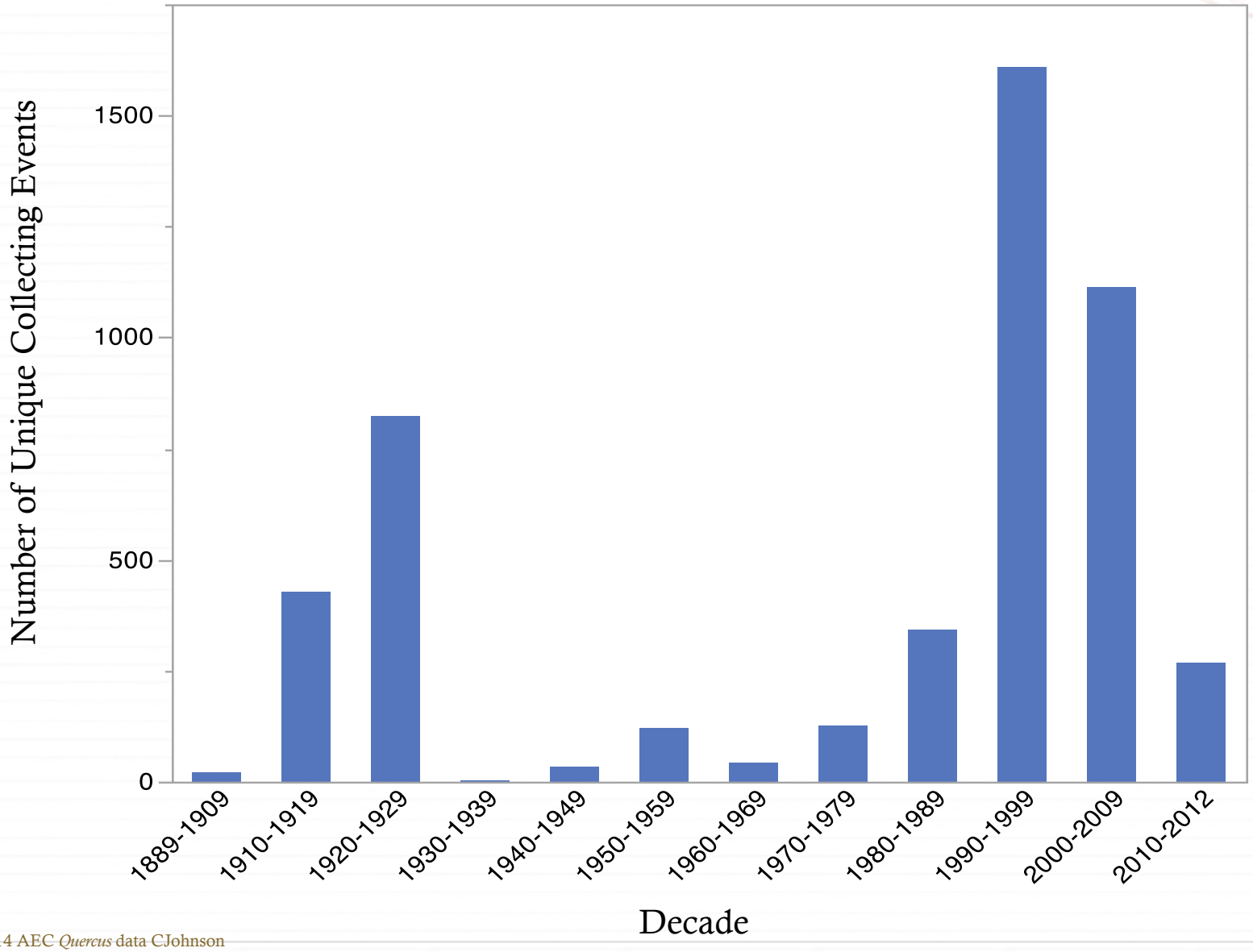

Plot Latitude x Longitude
On a road in Shanxi, China
(Ephraim Canyon, Utah)
39.48, 111.49
Kashmir Border
(Antioch, NC)
34.8857, 79.20
Longitude
Latitude
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50


Plot Latitude x Longitude
Longitude
-70
-75
-80
-85
-90
-95
-100
-105
-110
-115
-120
-125
26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47
Latitude

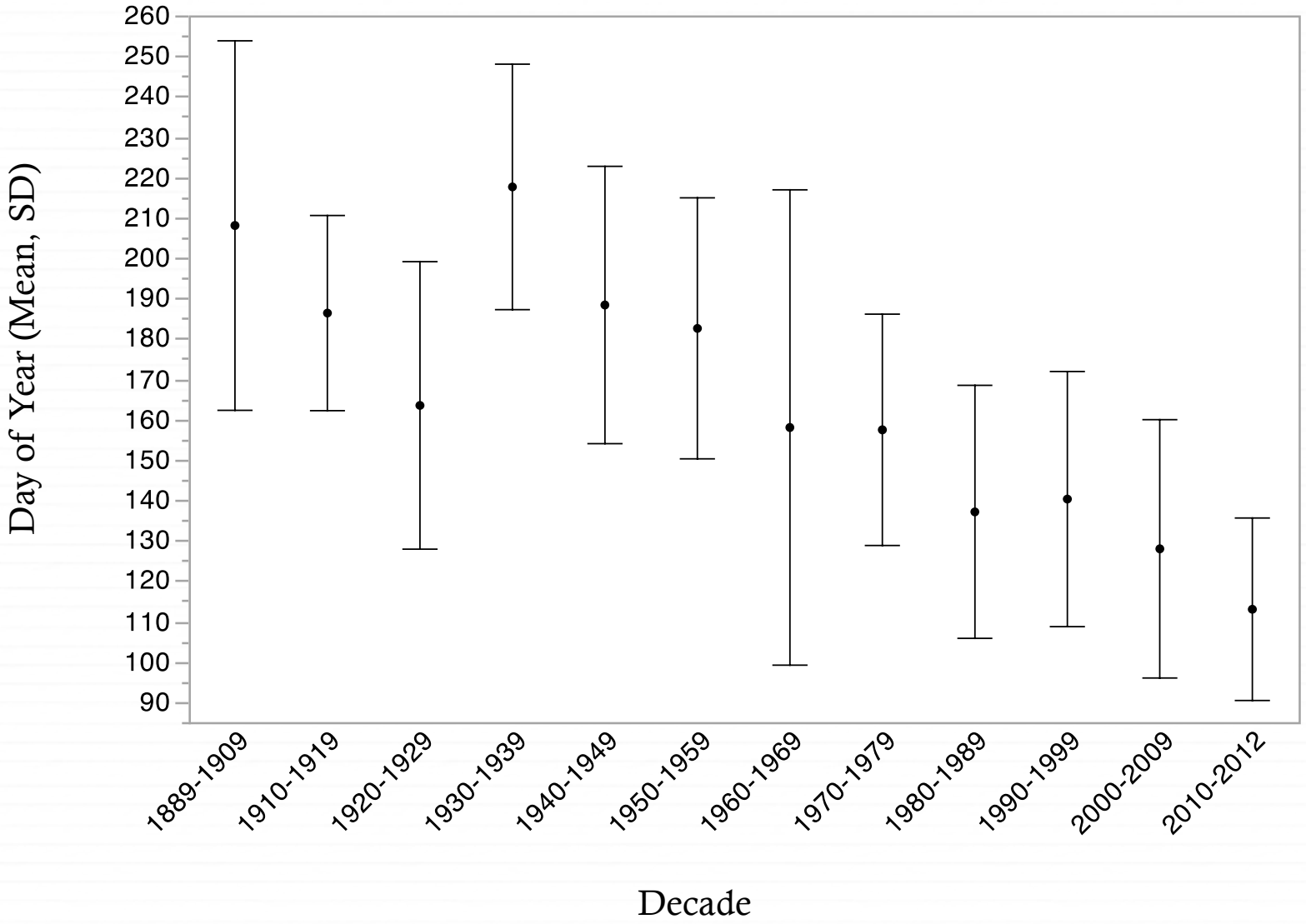
Plot Latitude x Longitude by State



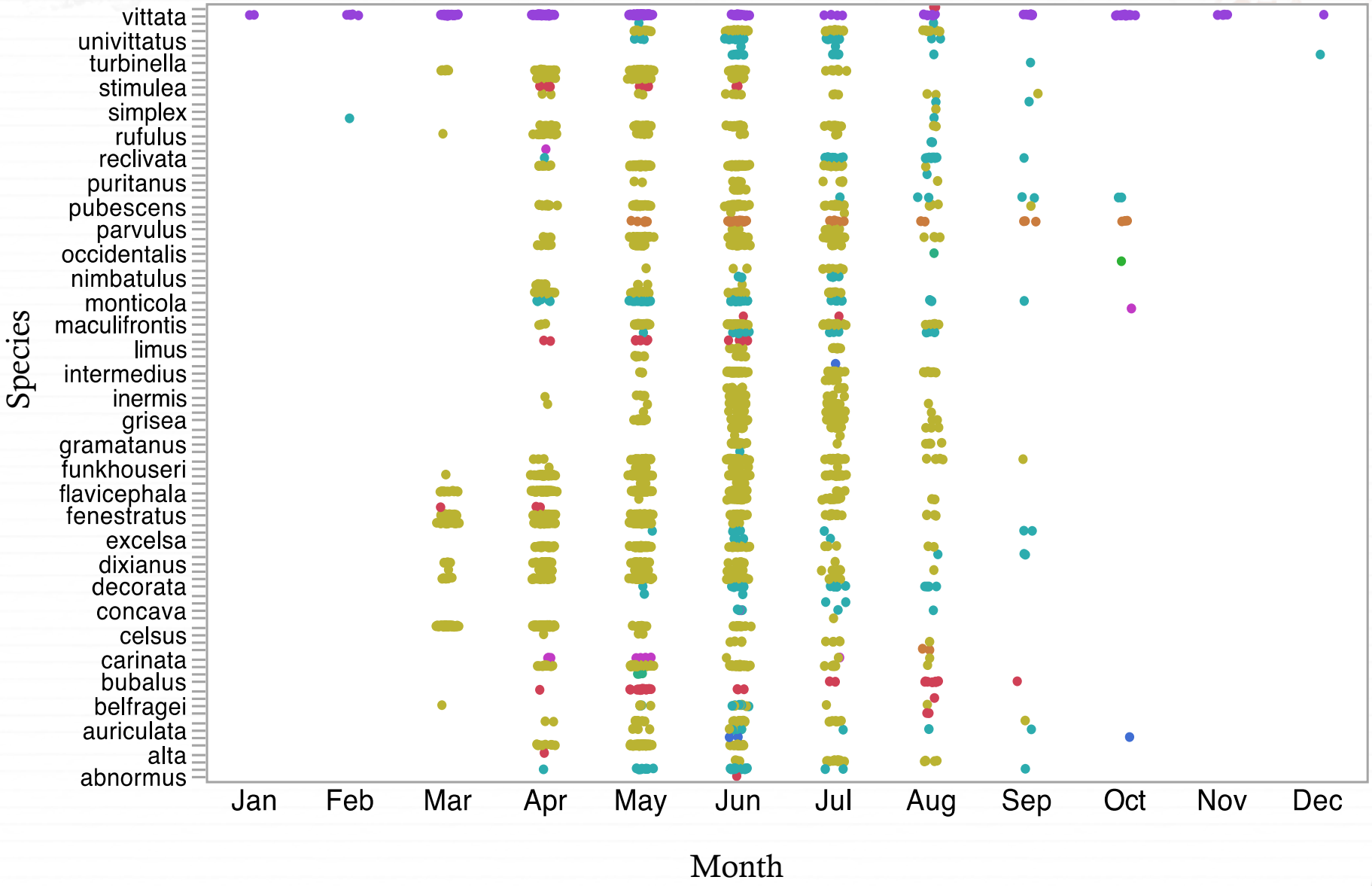
Number of Unique Collecting Events for Treehoppers Associated with Oaks Collected from 1889-2014 (N=4,972)



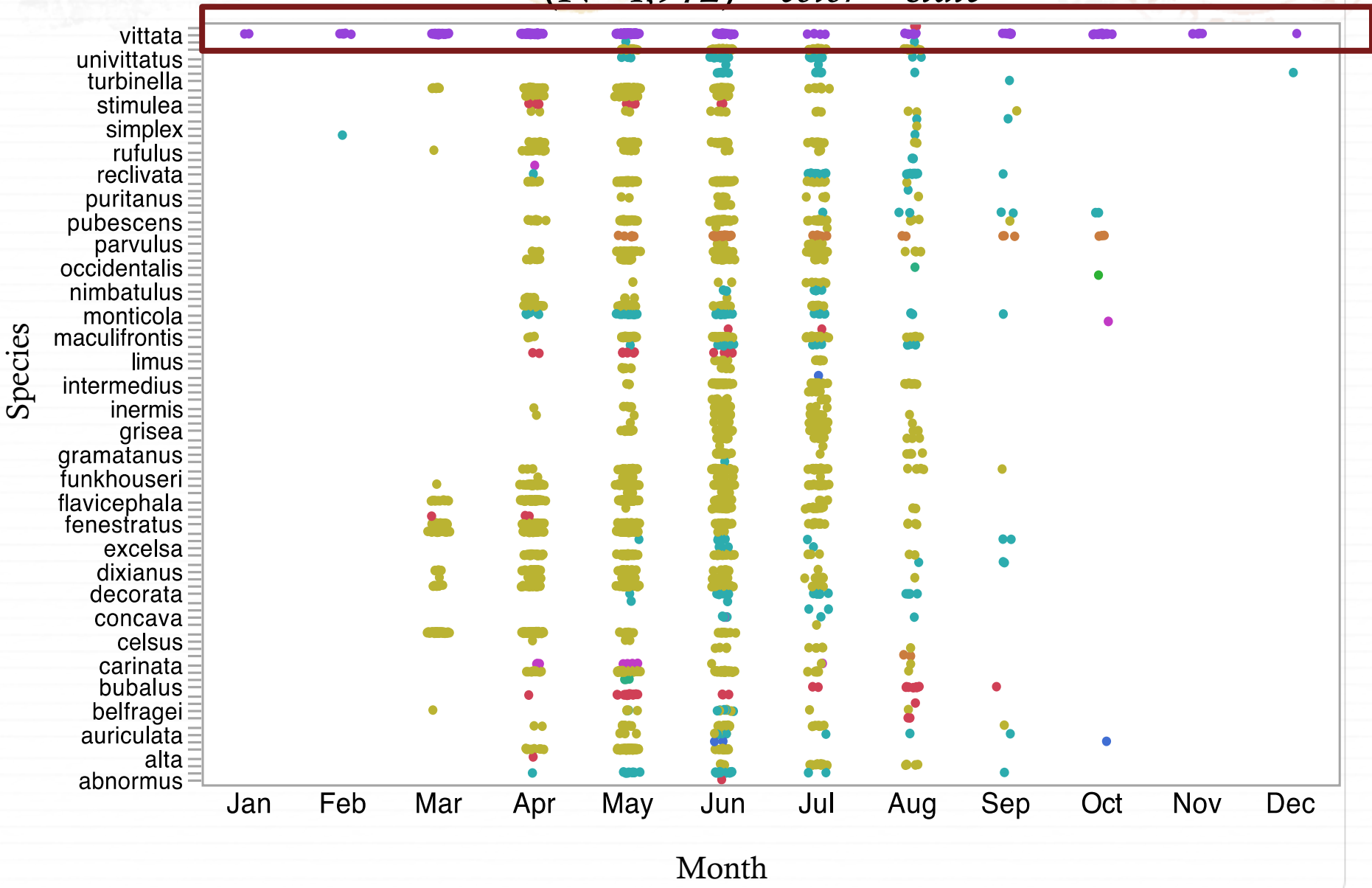
Mean Day of Year on which Specimens were Collected (N=4,972)



Month in which Species were Collected
(N=4,972) *color = state*

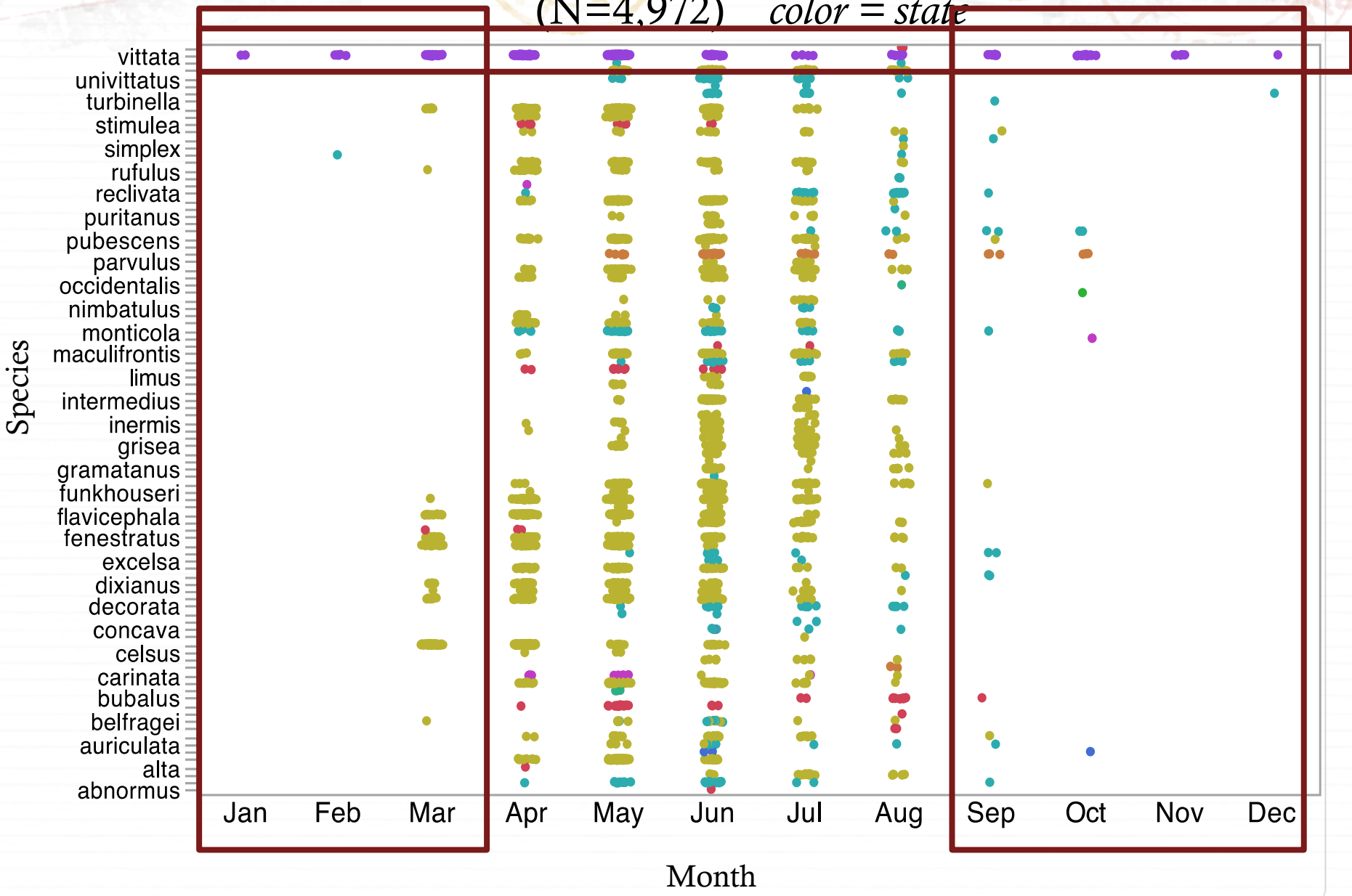


Month in which Species were Collected
(N=4,972) *color = state*



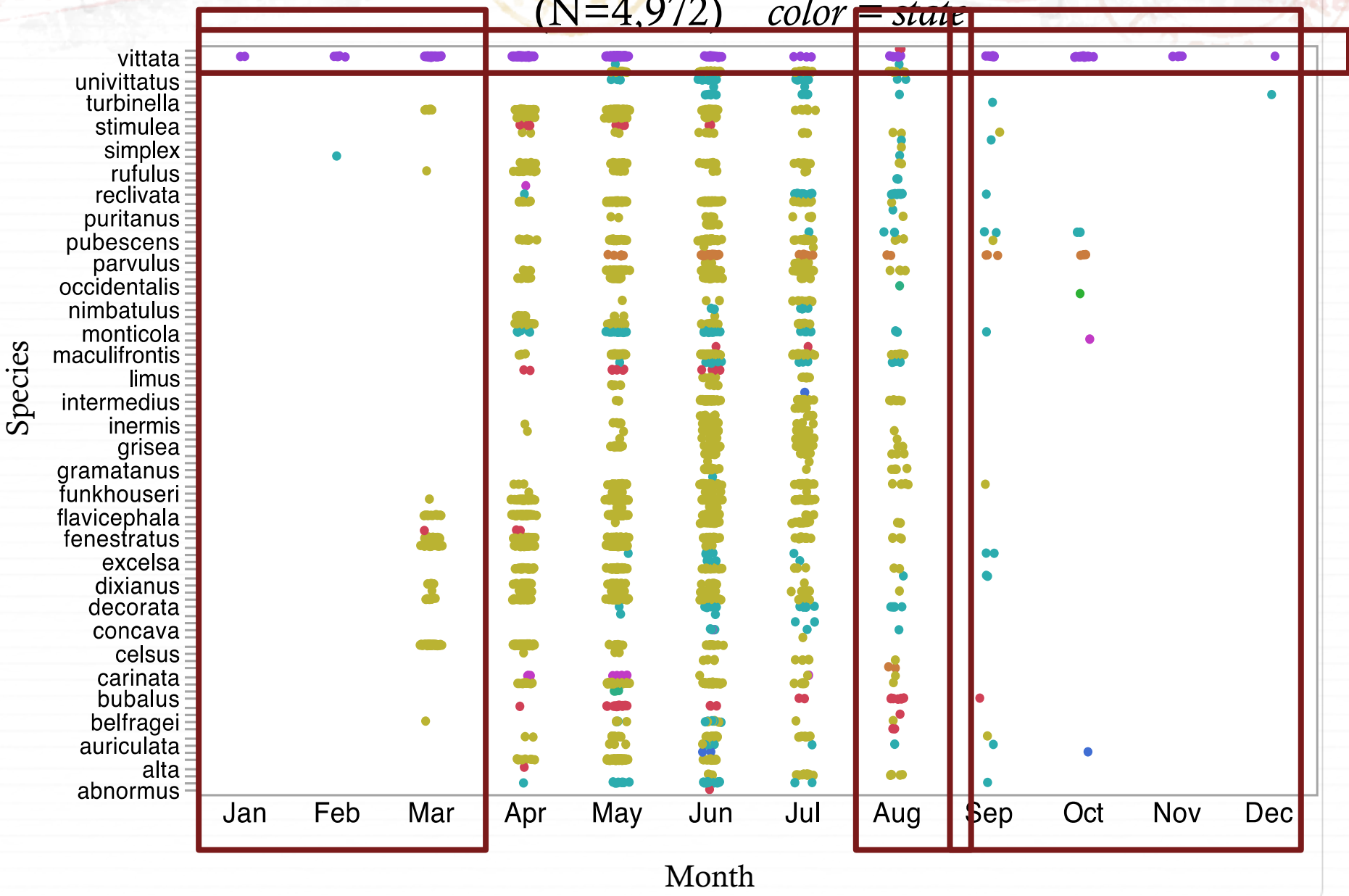
Month in which Species were Collected

(N=4,972) *color = state*

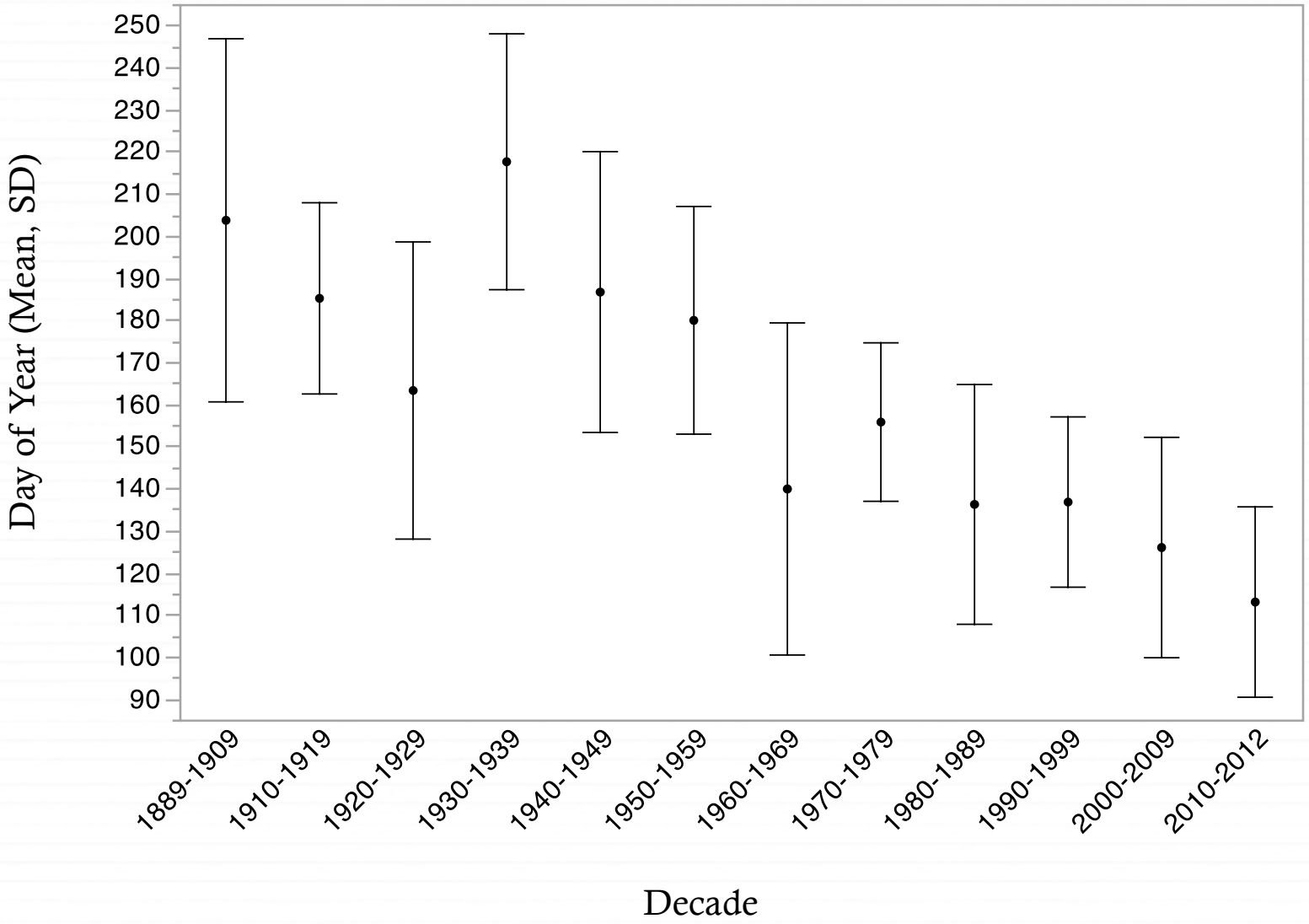


Month in which Species were Collected

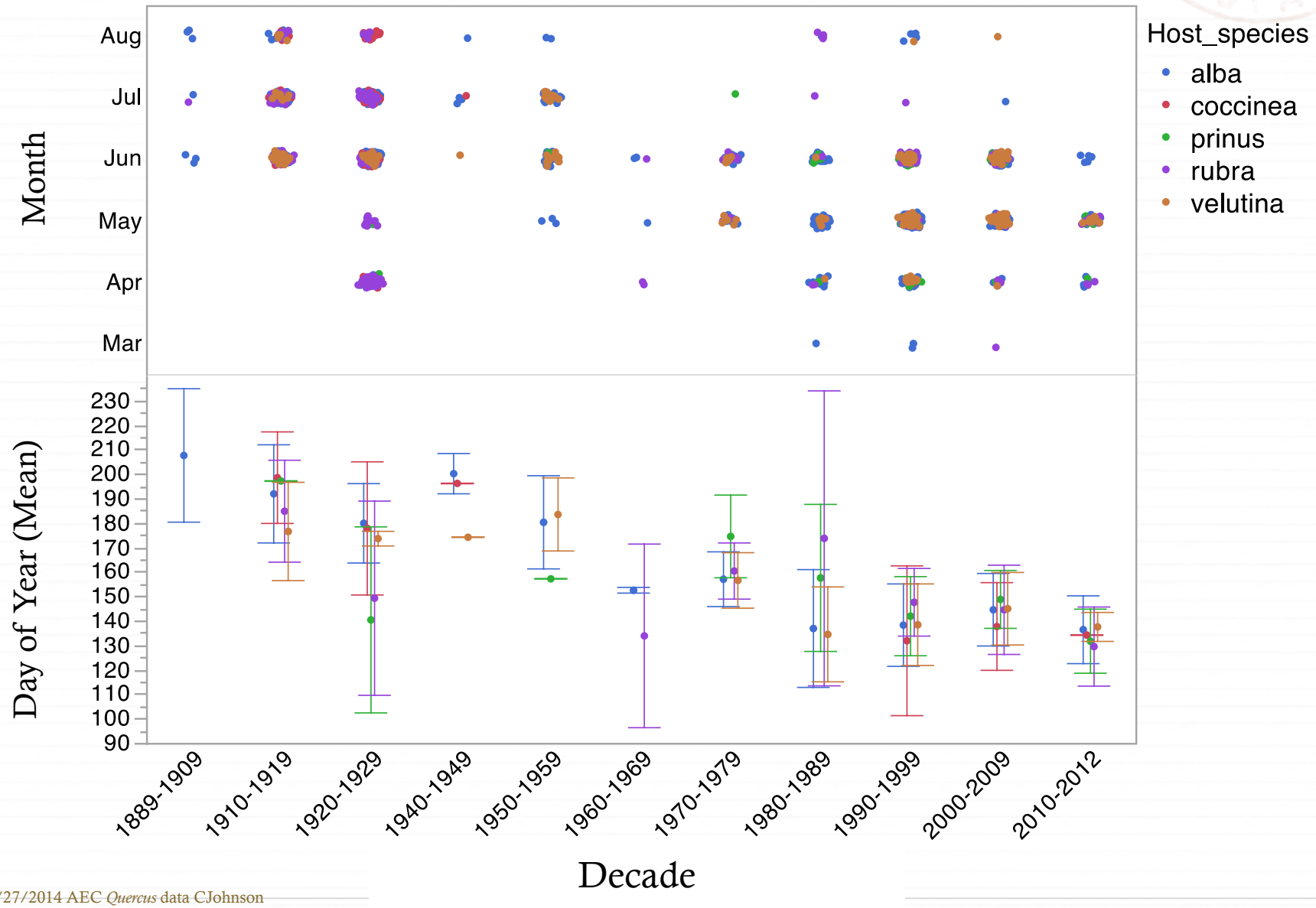
(N=4,972) *color = state*



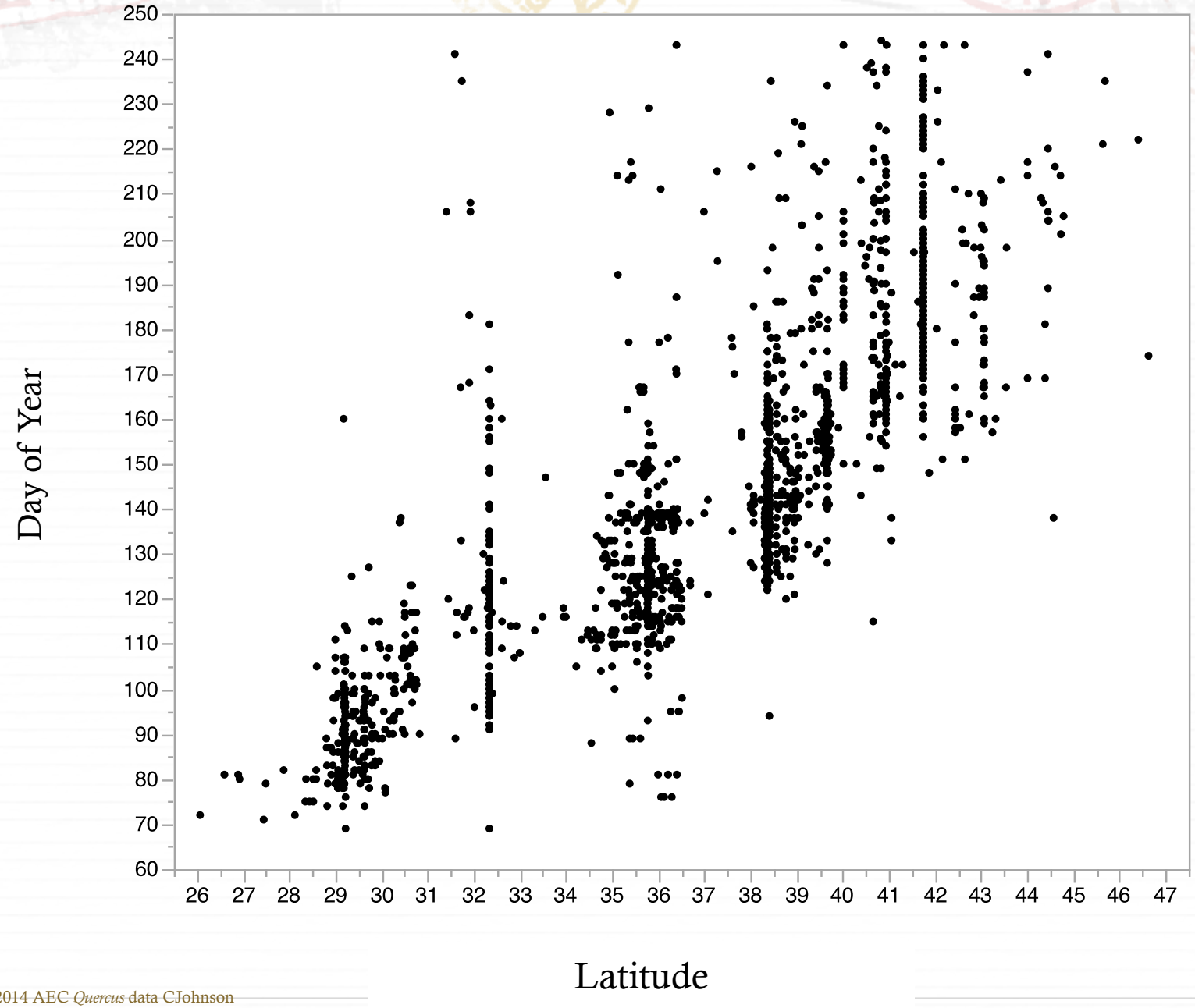
Mean Day of Year on which Specimens were Collected (N=4,879)



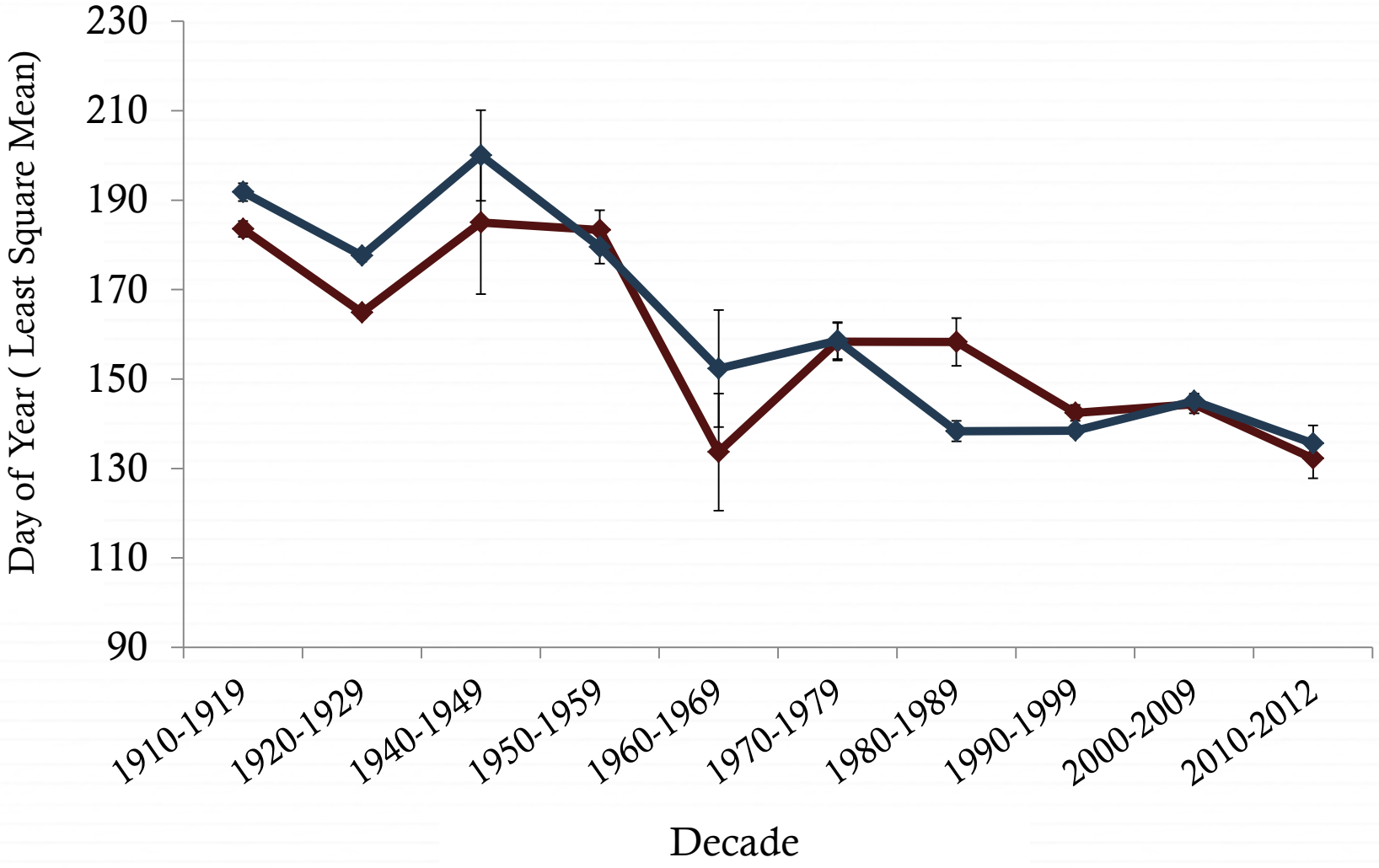
Mean Day of Year on which Specimens were Collected from *Red & White Oak Species Group* (n=2,827) *color = host tree*



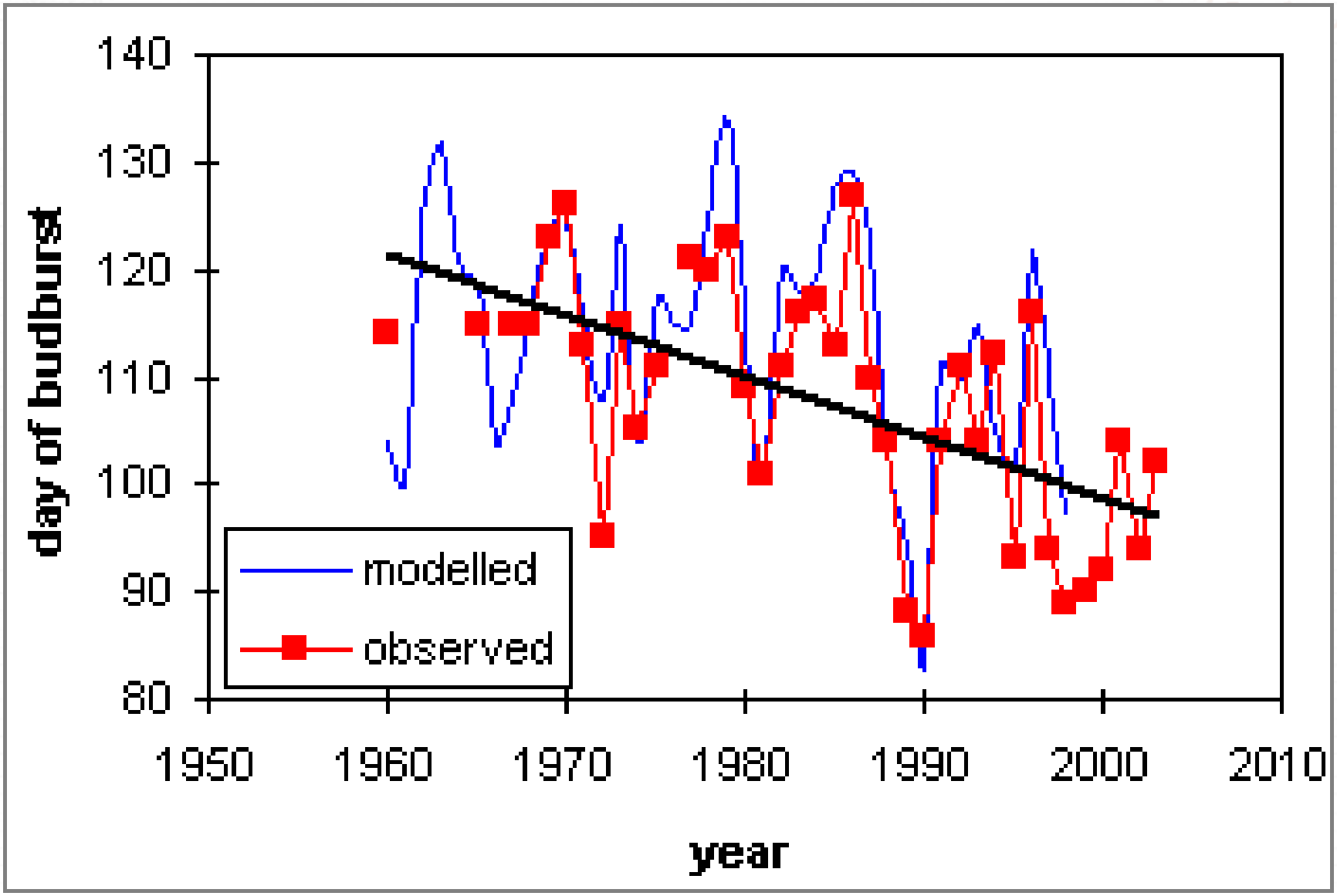
Relationship between Day of Year & Latitude



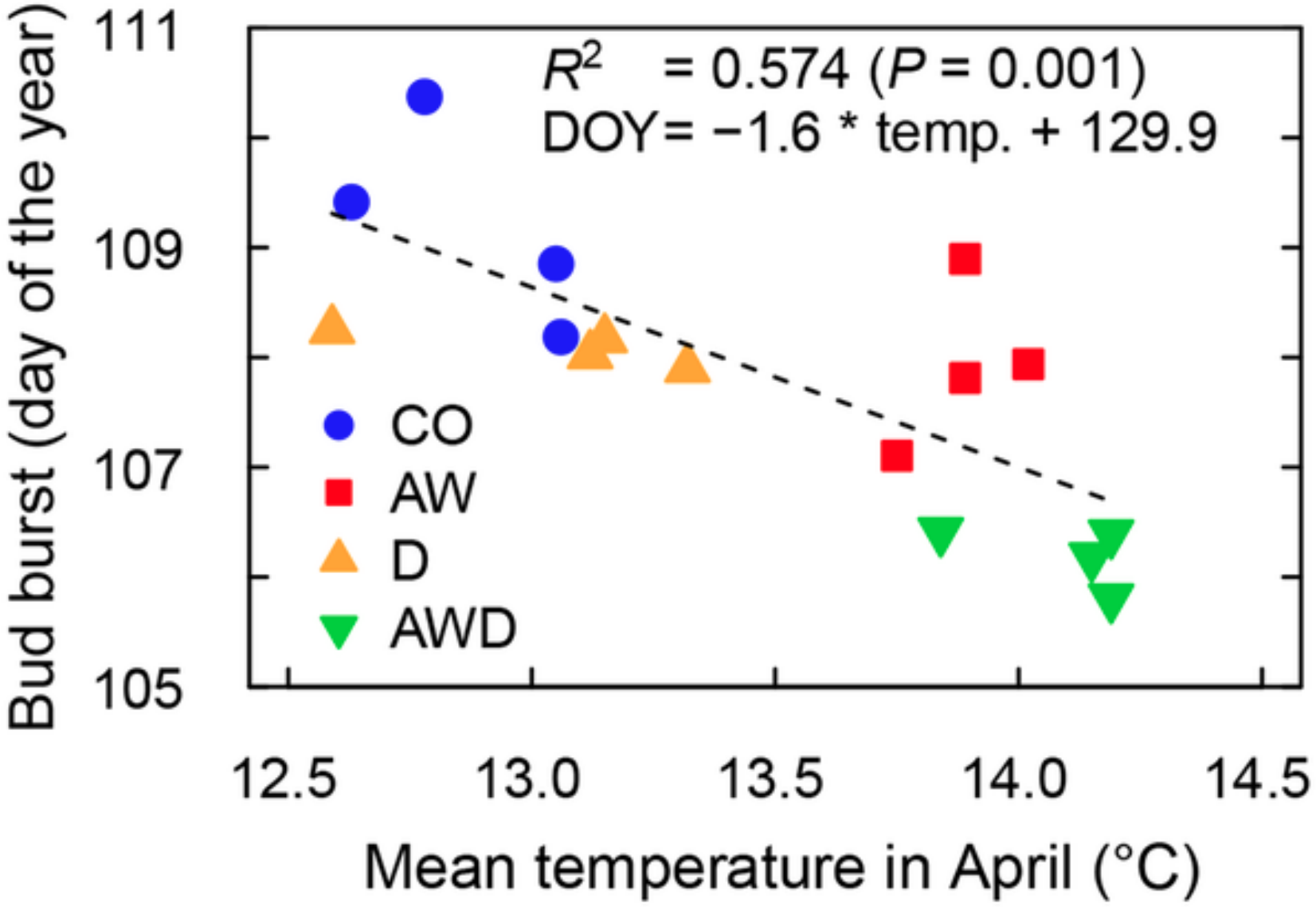
Mean Day of Year on which Specimens were Collected
from Red & White Oak Species Group (n=2,827) *color = host tree*



Scotland Forestry



A Phenological Timetable of Oak Growth under Experimental Drought and Air Warming. Plos One. 2014. Kuster et al.



From Museum Specimen Database to Ecological Statement:

Next steps

Climate change has an effect on the timing of bug "emergence"

- Look at temperature and precipitation patterns in areas of these particular collection
- Look at plant phenology
  - Is associated host plant leafing, budding, flowering earlier?

From Museum Specimen Database to Ecological Statement:

Know your data

Climate change has an effect on the timing of bug "emergence"

- All the tools to clean up data, but if you don't know where errors might be, you won't catch them
- Plotting gives a quick snapshot that often elucidates errors
- Our collections have data that are not available anywhere else
  - However, they have to be used with care

Acknowledgments

NSF-ADBC; *for funding this project*

iDigBio; *for building community*

All TCN partners, particularly Toby Schuh, Katja Seltmann, John Heraty, Bob Magill, Benjamin Normark, Melissa Tulig, Kim Watson, Christiane Weirauch; *for steering our TCN*

Barbara Thiers (Director, NYBG Herbarium); *for help with many aspects of this project*

John Pickering (Director, Discover Life); *for programming DL tools*

Our digitizers; *for their careful work and dedication to our mission*

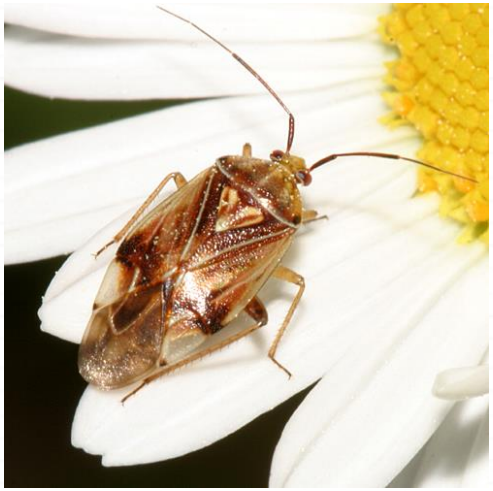
Tom Murray; *for sharing his photographs*

Remaining Challenges

1. Completion of databasing and imaging

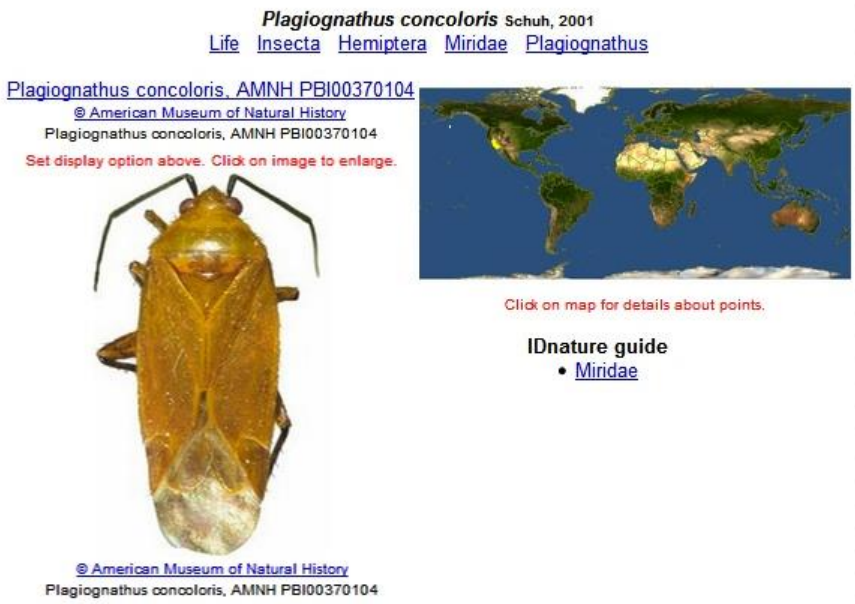
2. Population of botanical records from images

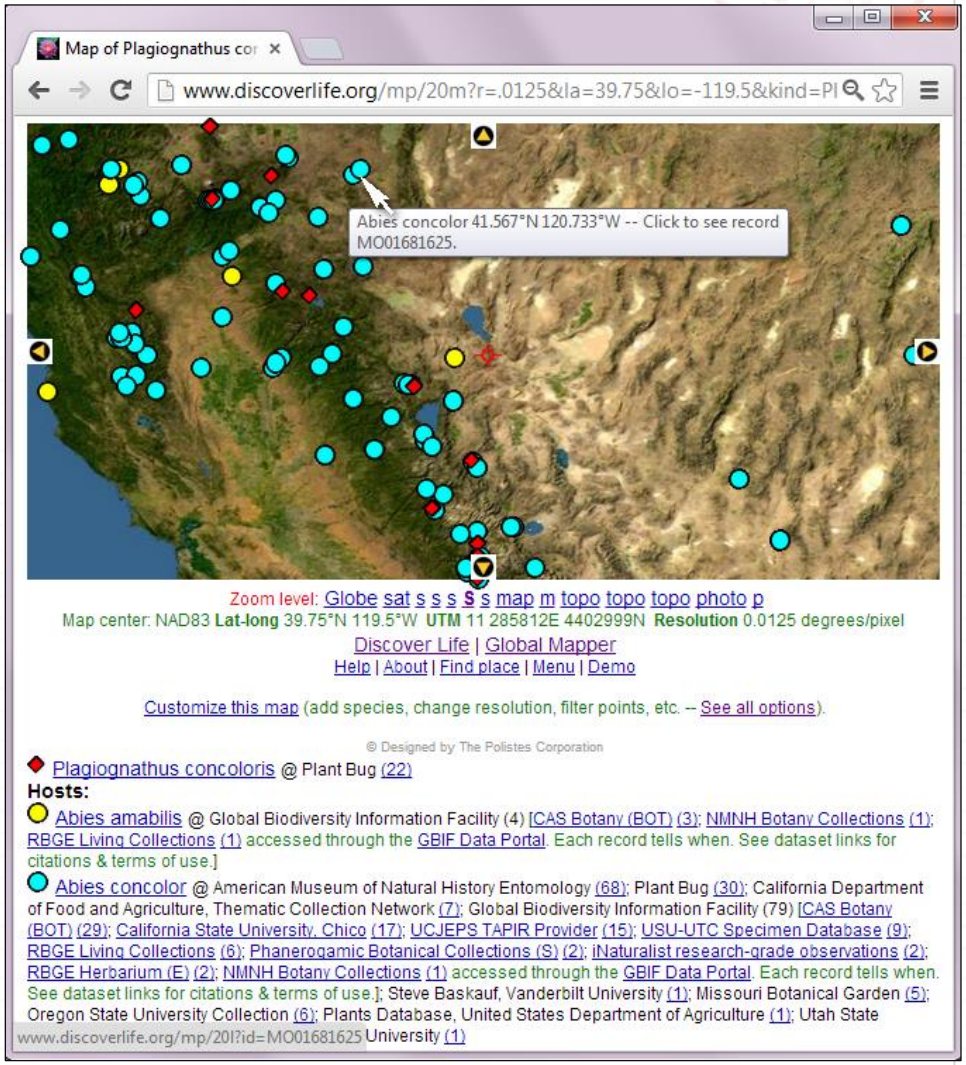
3. Integration of data sets across institutions and trophic levels



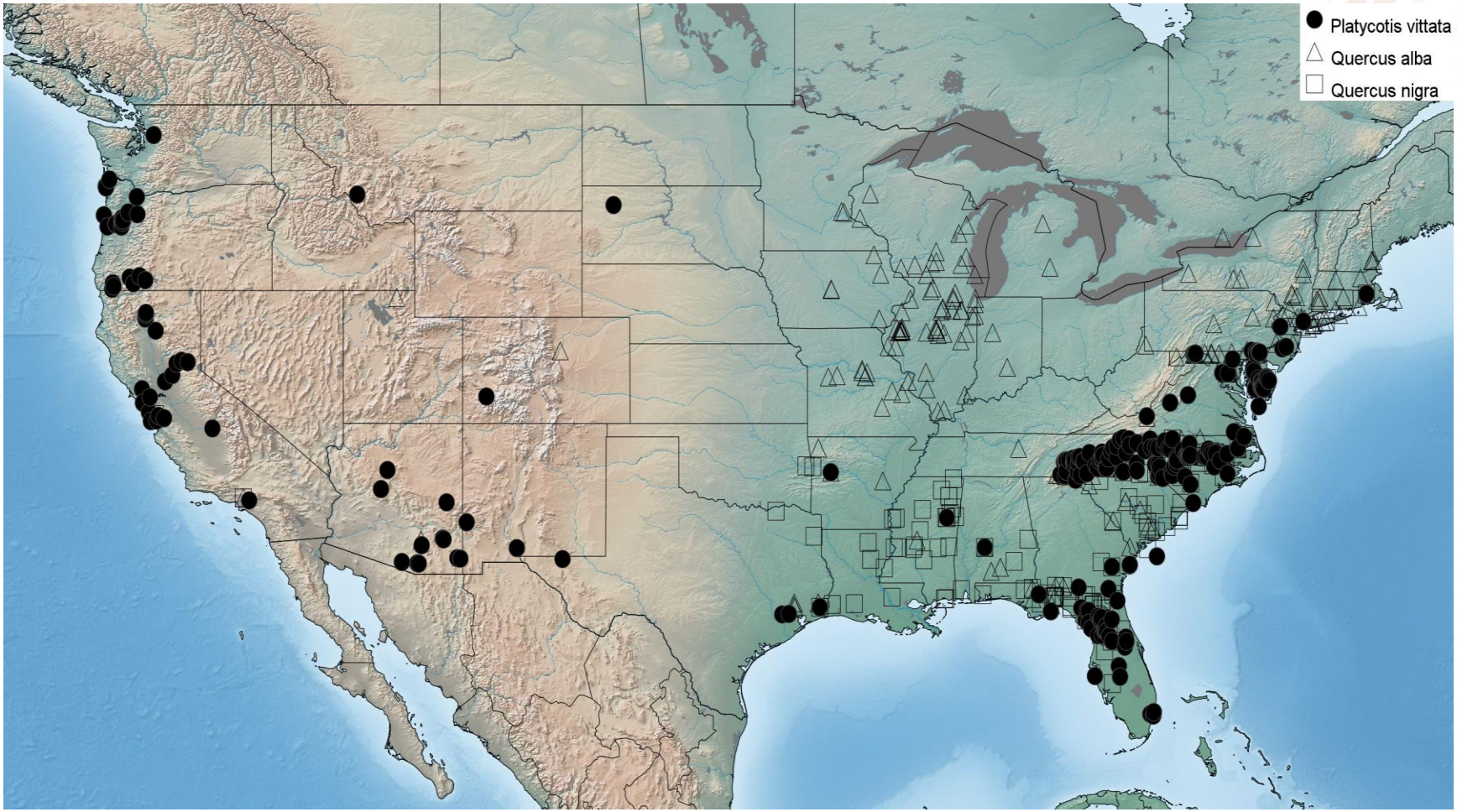
Integration of trophic datasets in Discover Life

- Generate species pages with specimen data, maps, and images
- Create a linkage between host/herbivore/parasitoid data
- Data updated every ±24 hours
- *Come to our demo describing DL capabilities.*





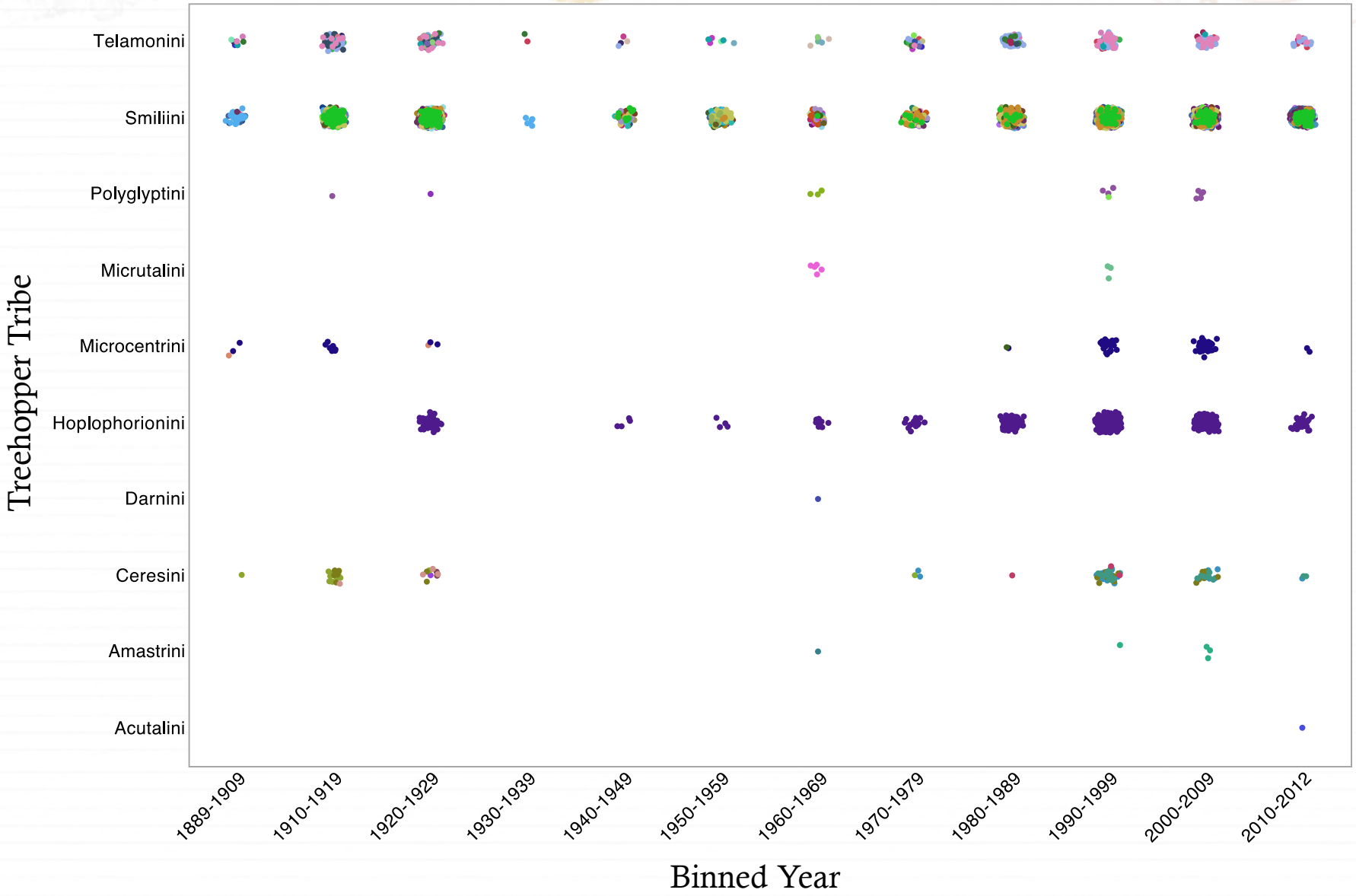
www.discoverlife.org/tttcn/


Platycotis vittata
Quercus alba
Quercus nigra

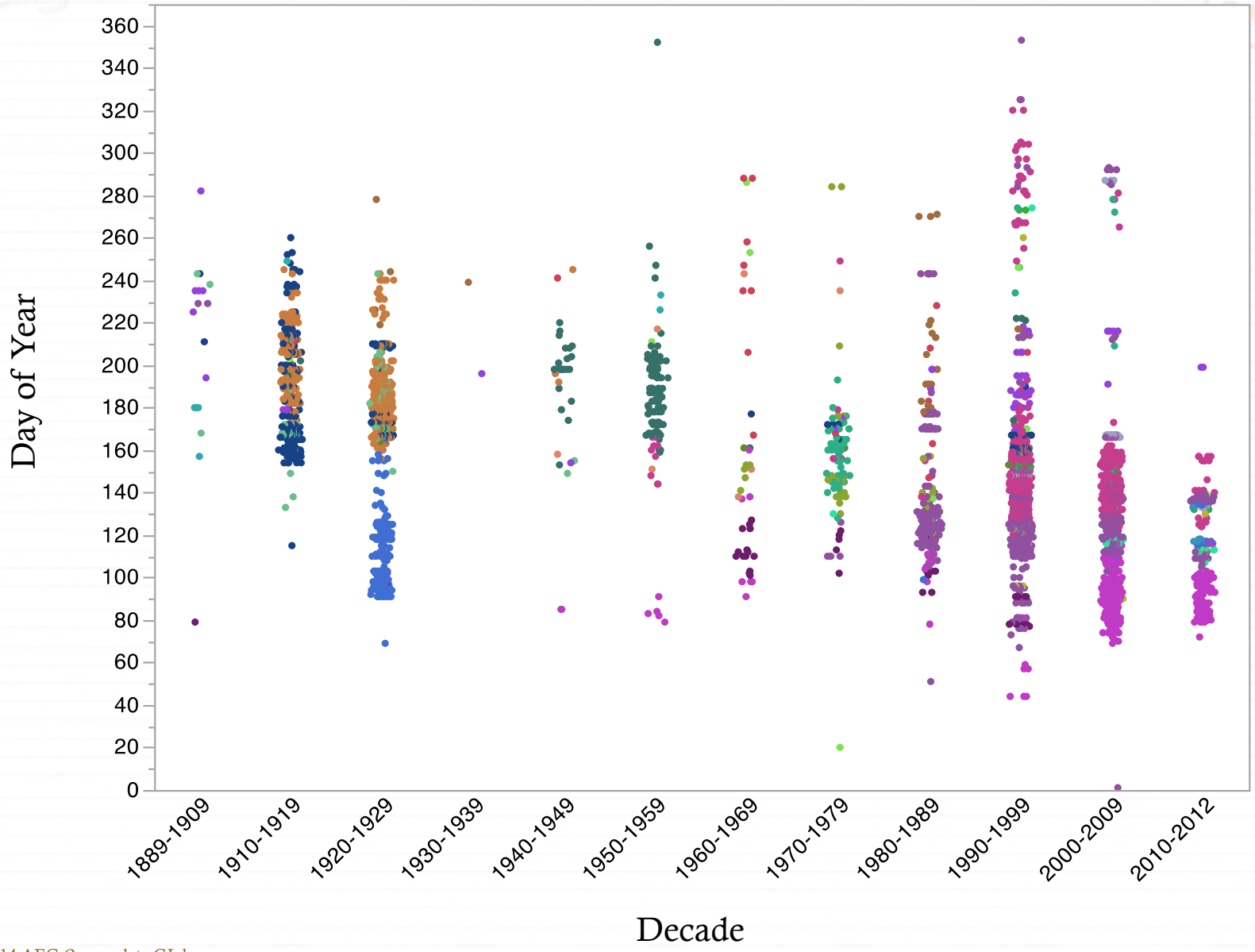
Membracidae (Treehoppers)

Gregarious, plant feeders, symbiotic ant associations

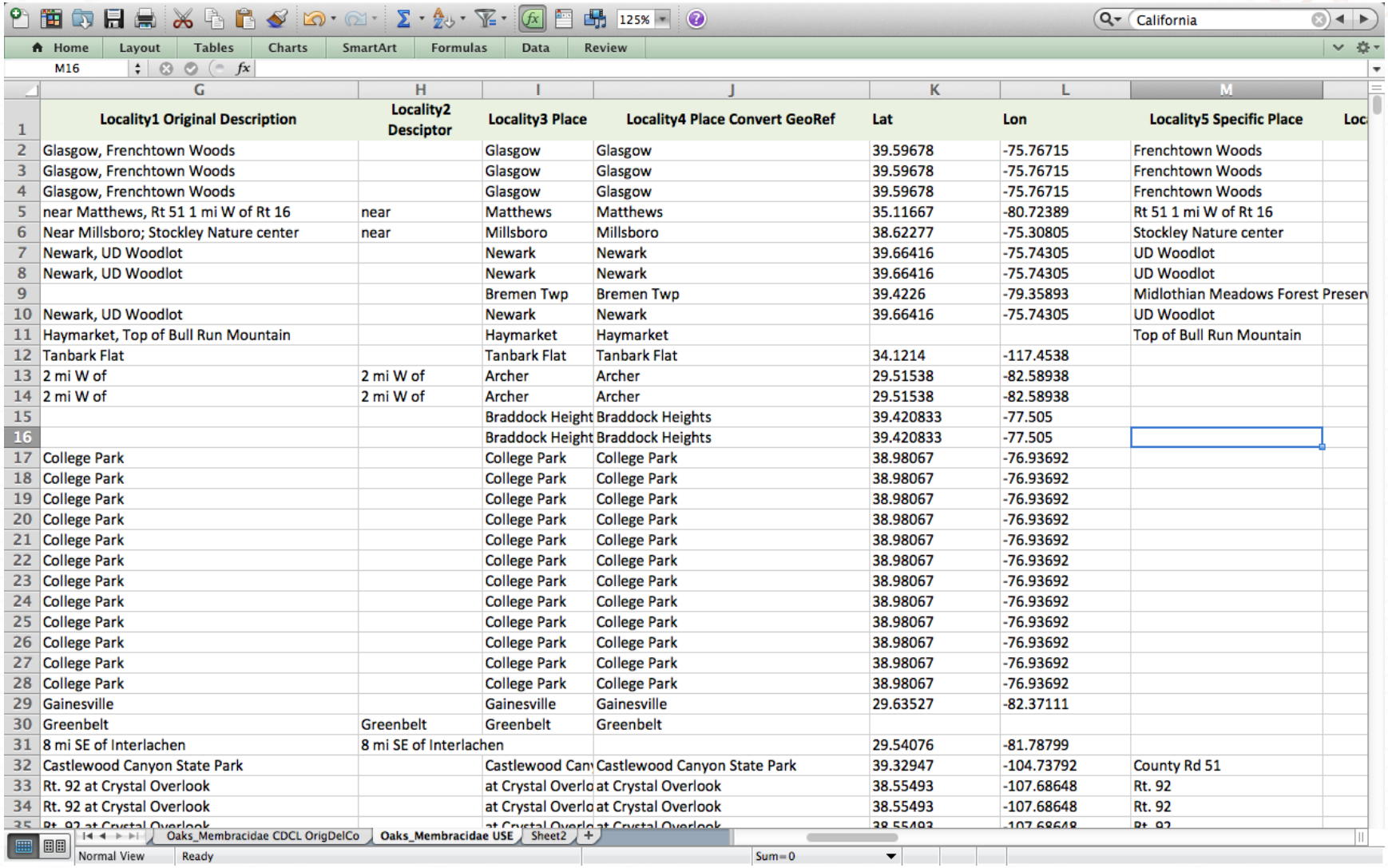
Number of Treehopper Records Associated with Oaks Collected from 1889-2014 (N=12,153) *overlay color = species*



Day of Year on which Specimens were Collected
(N=4,972) *color = state – remove "outliers"*



Missing Coordinate Data



	G	H	I	J	K	L	M
1	Locality1 Original Description	Locality2 Desciptor	Locality3 Place	Locality4 Place Convert GeoRef	Lat	Lon	Locality5 Specific Place
2	Glasgow, Frenchtown Woods		Glasgow	Glasgow	39.59678	-75.76715	Frenchtown Woods
3	Glasgow, Frenchtown Woods		Glasgow	Glasgow	39.59678	-75.76715	Frenchtown Woods
4	Glasgow, Frenchtown Woods		Glasgow	Glasgow	39.59678	-75.76715	Frenchtown Woods
5	near Matthews, Rt 51 1 mi W of Rt 16	near	Matthews	Matthews	35.11667	-80.72389	Rt 51 1 mi W of Rt 16
6	Near Millsboro; Stockley Nature center	near	Millsboro	Millsboro	38.62277	-75.30805	Stockley Nature center
7	Newark, UD Woodlot		Newark	Newark	39.66416	-75.74305	UD Woodlot
8	Newark, UD Woodlot		Newark	Newark	39.66416	-75.74305	UD Woodlot
9			Bremen Twp	Bremen Twp	39.4226	-79.35893	Midlothian Meadows Forest Preserv
10	Newark, UD Woodlot		Newark	Newark	39.66416	-75.74305	UD Woodlot
11	Haymarket, Top of Bull Run Mountain		Haymarket	Haymarket			Top of Bull Run Mountain
12	Tanbark Flat		Tanbark Flat	Tanbark Flat	34.1214	-117.4538	
13	2 mi W of	2 mi W of	Archer	Archer	29.51538	-82.58938	
14	2 mi W of	2 mi W of	Archer	Archer	29.51538	-82.58938	
15			Braddock Height	Braddock Heights	39.420833	-77.505	
16			Braddock Height	Braddock Heights	39.420833	-77.505	
17	College Park		College Park	College Park	38.98067	-76.93692	
18	College Park		College Park	College Park	38.98067	-76.93692	
19	College Park		College Park	College Park	38.98067	-76.93692	
20	College Park		College Park	College Park	38.98067	-76.93692	
21	College Park		College Park	College Park	38.98067	-76.93692	
22	College Park		College Park	College Park	38.98067	-76.93692	
23	College Park		College Park	College Park	38.98067	-76.93692	
24	College Park		College Park	College Park	38.98067	-76.93692	
25	College Park		College Park	College Park	38.98067	-76.93692	
26	College Park		College Park	College Park	38.98067	-76.93692	
27	College Park		College Park	College Park	38.98067	-76.93692	
28	College Park		College Park	College Park	38.98067	-76.93692	
29	Gainesville		Gainesville	Gainesville	29.63527	-82.37111	
30	Greenbelt	Greenbelt	Greenbelt	Greenbelt			
31	8 mi SE of Interlachen	8 mi SE of Interlachen			29.54076	-81.78799	
32	Castlewood Canyon State Park		Castlewood Can	Castlewood Canyon State Park	39.32947	-104.73792	County Rd 51
33	Rt. 92 at Crystal Overlook		at Crystal Overlo	at Crystal Overlook	38.55493	-107.68648	Rt. 92
34	Rt. 92 at Crystal Overlook		at Crystal Overlo	at Crystal Overlook	38.55493	-107.68648	Rt. 92