



Herbaria, their data, and data uses

Plant Diversity and specimen types

- Aquatic plants-marine and freshwater
- Terrestrial non-vascular plants
 - I. Bryophytes: Mosses and liverworts: Unmounted in packets
 - II. Vascular plants:
 1. Mounted on paper sheets-labels
 2. Pollen and spores: slides-data related to sheets
 3. Wood: Unmounted: data related to sheets
 4. Seeds: Unmounted in vials: data related to sheets
 5. Pickled in jars: stems and flowers: related to sheets

Lichen specimen



Vascular plant specimen



Woody Angiosperm specimen



Herbarium collections



Species numbers- Described species

- Lichens: 17,000- fungi+algae
- Algae: Red and Green: ~10,000
- Bryophytes: ~16,000
- Vascular Plants: 311,000

Plant collecting

- Specimens collected in field, each taxon numbered and data recorded in field book.
- Specimen duplicates
- Pressed in Plant Press
- Dried, temp $< 40^{\circ}$ C
- Glued to special paper sheets, affix label with data from field notes
- Convert 3-dimensional organisms to 2-dimensional specimens as possible

Databasing

- Electronic capture of label data
 1. Manual entry: keystrokes
 2. Imaging of labels: Optical Character Recognition: Herbis, Salix etc.-not perfected
Handwritten labels problematic
 3. Images of specimen
- Georeferencing of specimens

Data types

- Label data: Herbarium is a giant card file
 1. Locality
 2. Habitat
 3. Associated plants
 4. Pollinators
 5. Soil
 6. Date
 7. Collector and number

Data type

- Plant specimen

Data from non-destructive sampling

A. Phenotype

1. Morphology: micro and macro

2. Phenology: vegetative, flowering, fruiting

Data from Destructive Sampling

B. Genotype: DNA

C. Chemistry: chemical compds, stable isotopes

D. Anatomy-stomate density, C3 vs. C4

E. New data type

Future Collections

- Innovations in sampling- collection of “fragments”, pasted to 3X5 cards-DNA analysis for ID if necessary
- Collection of accessory material tied to vouchers for DNA, Stable Isotope Analysis

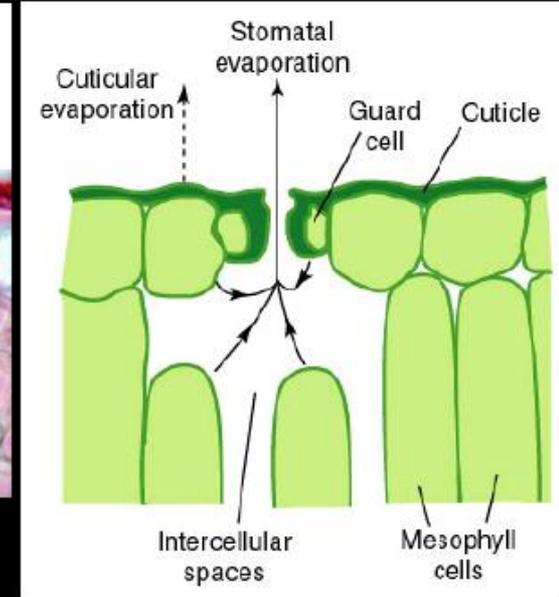
Future of Herbarium

- Image analysis: lessening need for loans but not eliminating
- Overlaying databased information of plant specimens with those of consumers (herbivores, pollinators, pathogens)
- Destructive sampling of specimens to analyze fungal, bacterial, and viral endophytes.
- Modeling
- Combining specimen databases with non-specimen databases

Non-traditional uses of herbarium specimens

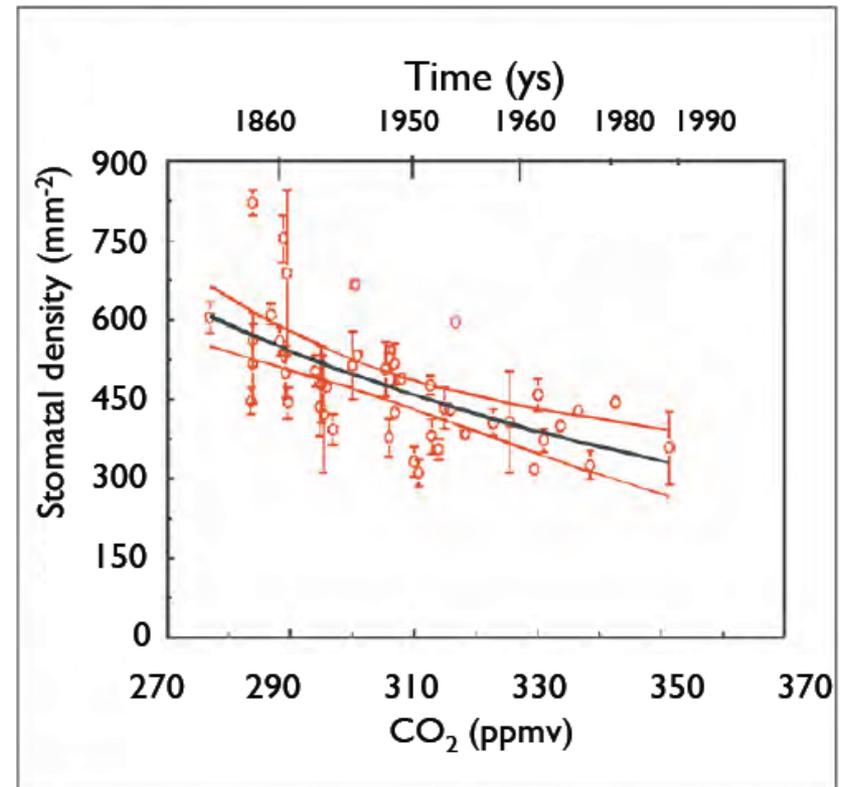
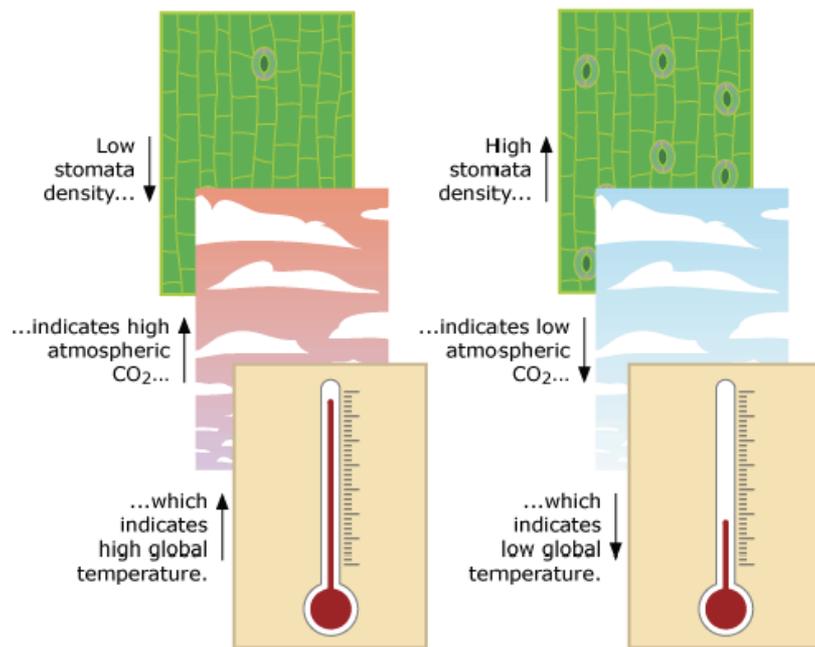
- functional Morphology(*Ephedra*)
- phenology and climate change (D. Ackerly - UC Berkeley)
- georeferencing and distribution modeling (D. Ackerly - UC Berkeley)
- connecting specimen and non-specimen databases

Stem anatomy



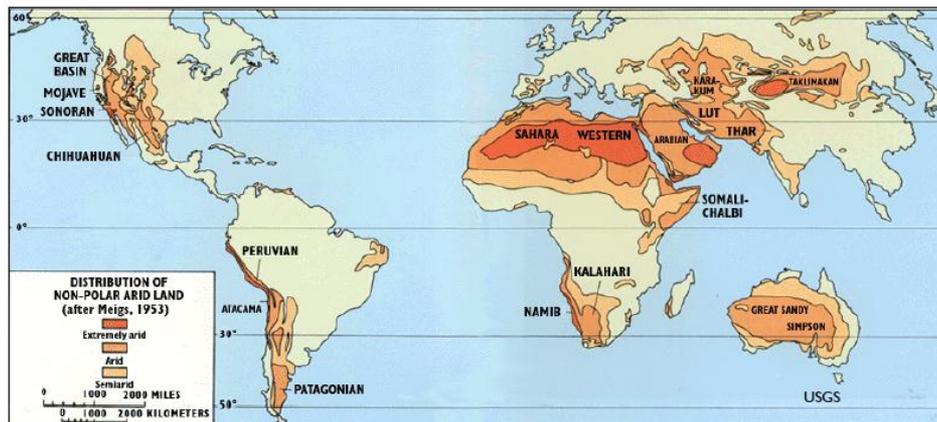
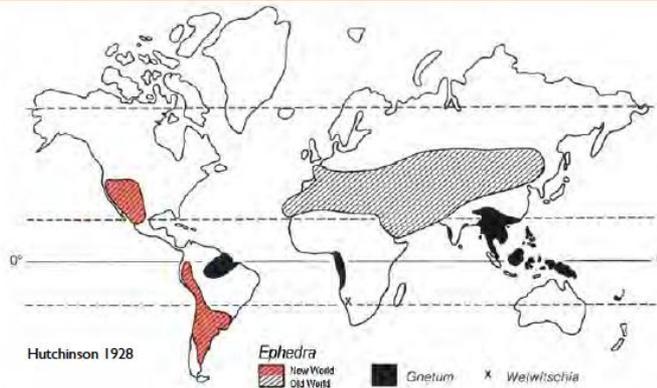
Climate Change

Stomatal Density and CO₂ / Climate



Biogeographic Analysis

Biogeographic Distribution and Deserts

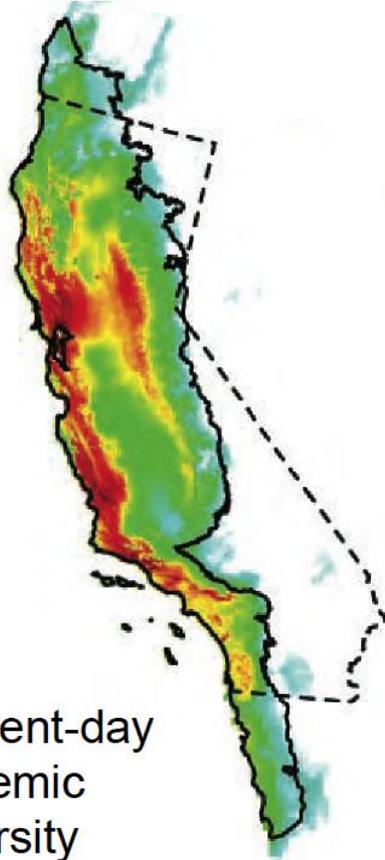


***Hyperarid**
 (P/PET < 0.03)

***Arid**
 (P/PET ranges from 0.03 - 0.2)

***Semiarid**
 (P/PET ranges from 0.2-0.5)

Climate change modeling



present-day
endemic
diversity

Climate change and the future of California's endemic flora

Collaborators:

Scott R. Loarie (Duke)

Ben Carter (UCB, Cal Poly SLO)

Sean McMahon (Duke)

Katherine Hayhoe (Texas Tech)

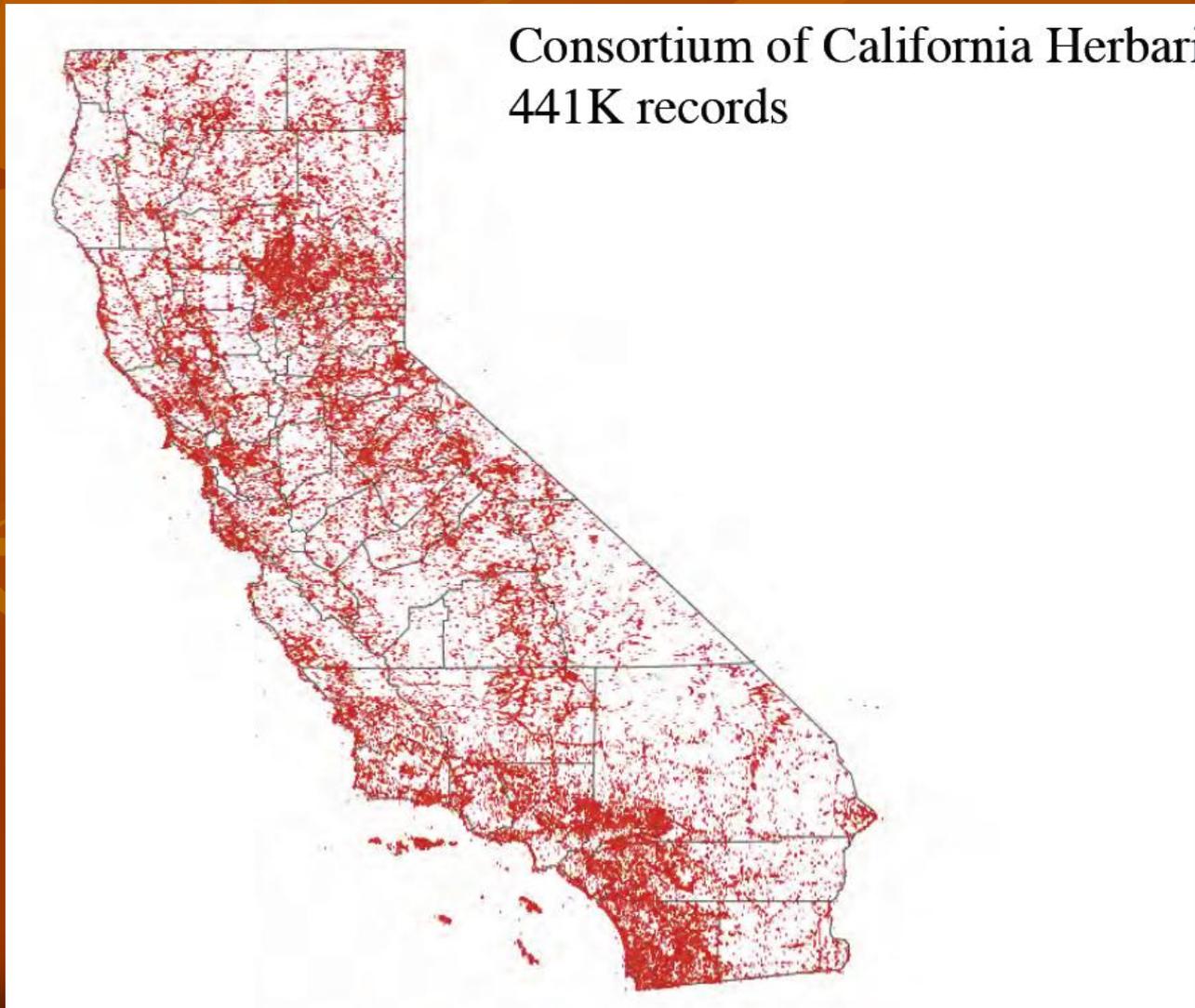
Richard Moe (Jepson Herbarium, UCB)

Charles Knight (Cal Poly SLO)

David Ackerly (UCB)

Loarie et al. (2008) PLoS-One
google: plos california flora

Plant specimen coverage of Calif. Herbaria

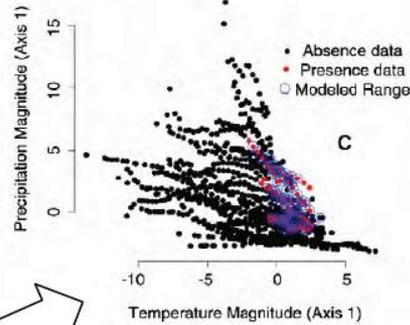


Modeling Procedure

distribution
(observed)



climate-niche model



future climate

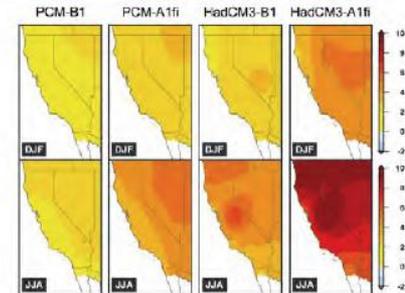
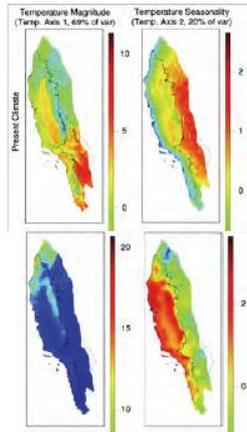
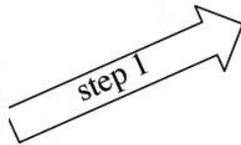


Fig. 1. Downscaled future (DJF and summer (JJA) temperature change (°C) for 2070-2099, relative to 1950-1979 for a 1° grid. Stochastic GCMs (SGCMs) B1 and A1fi, winter temperature projections for the rest of the century are 2.2-3°C and 2.3-4°C for PCM and HadCM3, respectively, compared with previous projections of 1.2-3°C and 3.5-5°C for PCM and HadCM3, respectively. Had-CM3-B1 is an All-IP scenario temperature conditions are 2.2-4°C and 4.8-8.3°C for PCM and HadCM3, respectively, compared with previous projections of 1.2-3°C and 2.3-4°C for PCM and HadCM3, respectively (11-14).



current climate



present range
(modelled)



future range
(modelled)

Species Modeling

California Bay
Umbellularia californica

Current Range



■ Current range ○ Herbarium specimens

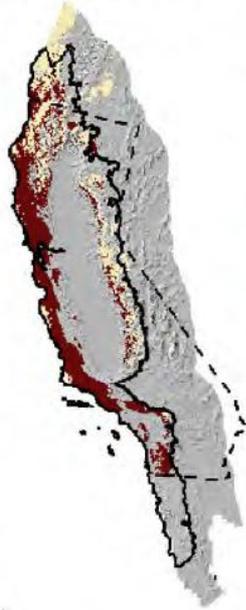
Less sensitive simulation
Lower emissions



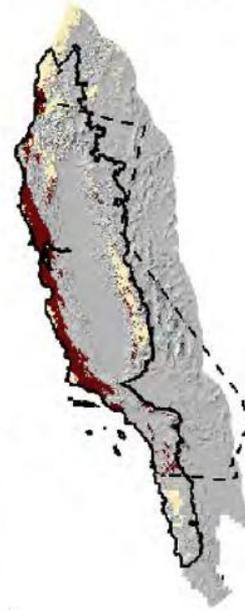
Less sensitive simulation
Higher emissions



More sensitive simulation
Lower emissions



More sensitive simulation
Higher emissions

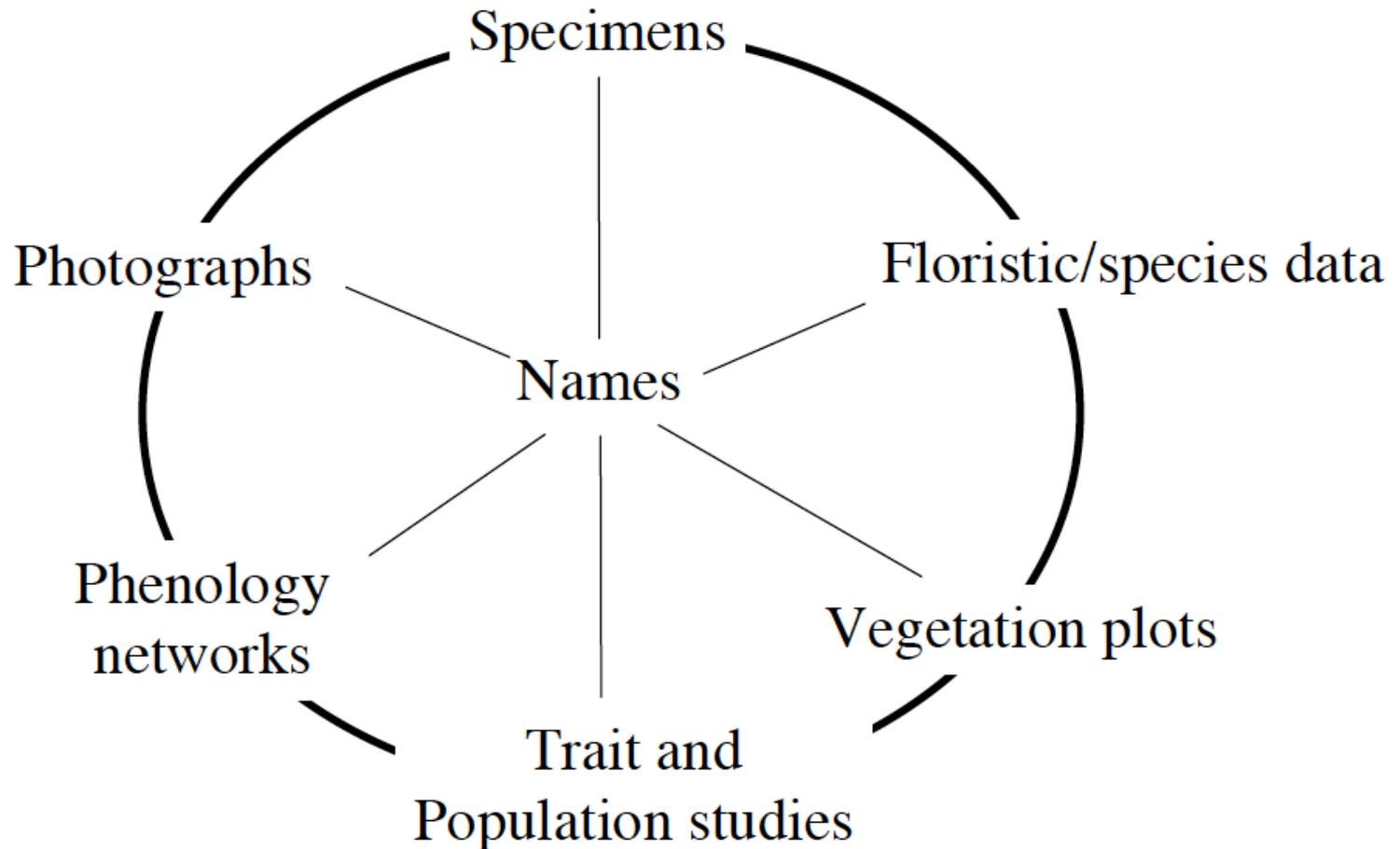


■ Future range

■ Future range (pending dispersal)



Connecting specimen and non-specimen data (bases)



Non-specimen database

Ecological trait databases



UCJEPS: Ecological Flora Means Data



Ecological Flora Pilot

Rhamnus mean values

Rhamnus alnifolia	Low elevation	1700 m	(N=1)
Rhamnus alnifolia	High elevation	1900 m	(N=1)
Rhamnus californica	Annual seed production per plant (c)	516000 -	(N=1)
Rhamnus californica	Low elevation	0 m	(N=1)
Rhamnus californica	High elevation	2300 m	(N=1)
Rhamnus californica ssp. californica	Blade area (c)	10.7 cm ²	(N=10)
Rhamnus californica ssp. californica	Specific leaf area	11.7 mm ² mg ⁻¹	(N=10)
Rhamnus californica ssp. californica	Blade length (c)	5.56 cm	(N=9)
Rhamnus californica ssp. californica	Blade width (c)	2.21 cm	(N=9)
Rhamnus californica ssp. californica	Leaf thickness	221 micron	(N=1)
Rhamnus californica ssp. californica	Leaf type	simple	(N=9)
Rhamnus californica ssp. californica	Seed mass	95.3 mg	(N=1)
Rhamnus californica ssp. californica	Wood density	0.496 g cm ⁻³	(N=1)

Vegetation plots

(important source of absence data)

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INW28314	
» Citation URL: http://vegbank.org/cite/VB.Ob.16900.INW28314	
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Author Plot Code	INW28314
Author Observation Code	INW28314
Location Fields: MAP: TopoZone MapQuest	
Confidentiality Status	0
Latitude	41.66 °
Longitude	-121.74 °
Location Narrative	Legal description to qq-section
State or Province	California
Country	United States
Named Places	county: Siskiyou region/state/province: California arealcountry/territory: United States
Layout Fields:	
Area	400 m ²
Permanence	not permanent
Environment Fields:	
Elevation	1000.0

Taxa occurring on this plot-observation								
Change plant label:								
<input type="text" value="-- Choose a value --"/>								
Change Strata Shown: <input type="text" value="show strata + overall"/>								
ord	Current Interpretation, Scientific Name without authors	Stratum	Cover	Original Cover Code	Basal Area	Biomass	Inference Area	Stem Diameters (graphically):
1	Purshia tridentata	-all-	20 %					
2	Pinus ponderosa	-all-	10 %					
3	Artemisia tridentata	-all-	3 %					
4	Bromus tectorum	-all-	1 %					
5	Ceanothus prostratus	-all-	1 %					
6	Festuca idahoensis	-all-	1 %					