



# Tumamoc Hill Steward Orientation

The Desert Laboratory on Tumamoc Hill  
University of Arizona

**Chemagagi Du'ag**  
(Tohono O'odham: Horned Lizard Mountain)



- ▶ As a Tumamoc Steward, you will encounter differing and sometimes contradictory perspectives about Tumamoc Hill.
- ▶ Different ways of understanding Tumamoc provide diverse ways of engaging the public.
- ▶ In addition to the educational content you share, your behaviors and attitudes can model thoughtful and respectful relationships to this landscape.



# Cultural Landscape

- ▶ Shaped by culture (humans) + time
  - ▶ Includes past and present interactions
- ▶ Evidence of interactions between humans and their environment may be visible, hard to see, or “invisible.”
- ▶ Understanding of the landscape varies according to one’s culture.
- ▶ Understanding a cultural landscape requires time, patience, and understanding multiple perspectives.
- ▶ The Tohono O’odham Nation and other Native nations have the longest continuous relationships with this landscape, and Tumamoc Hill is culturally significant to these nations.





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Community

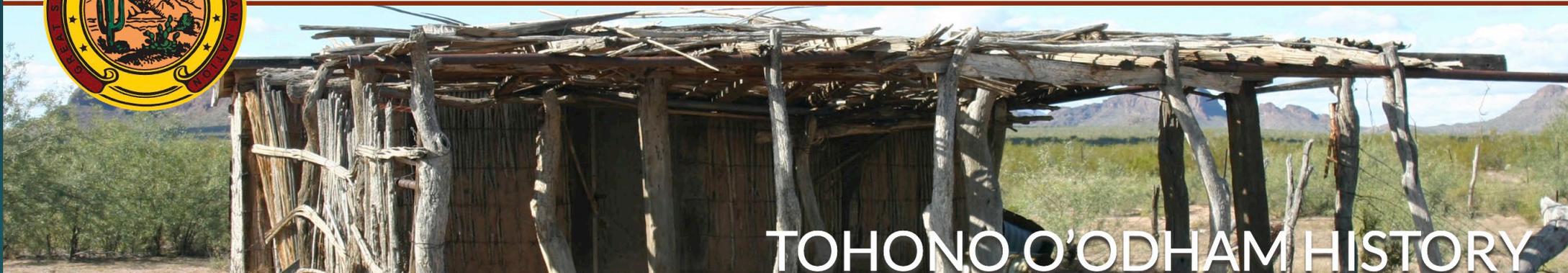
History & Culture

Economic Development

Executive Offices

Employment

Directory



# TOHONO O'ODHAM HISTORY

Our origins are linked to our homeland, the Sonoran Desert. Thousands of years ago, our predecessors, the Hohokam, settled along the Salt, Gila, and Santa Cruz Rivers. The Hohokam were master dwellers of the desert, creating sophisticated canal systems to irrigate their crops of cotton, tobacco, corn, beans, and squash. They built vast ball courts and huge ceremonial mounds and left behind fine red-on-buff pottery and exquisite jewelry of stone, shell, and clay.



Tohono O'odham History

Cultural Center & Museum

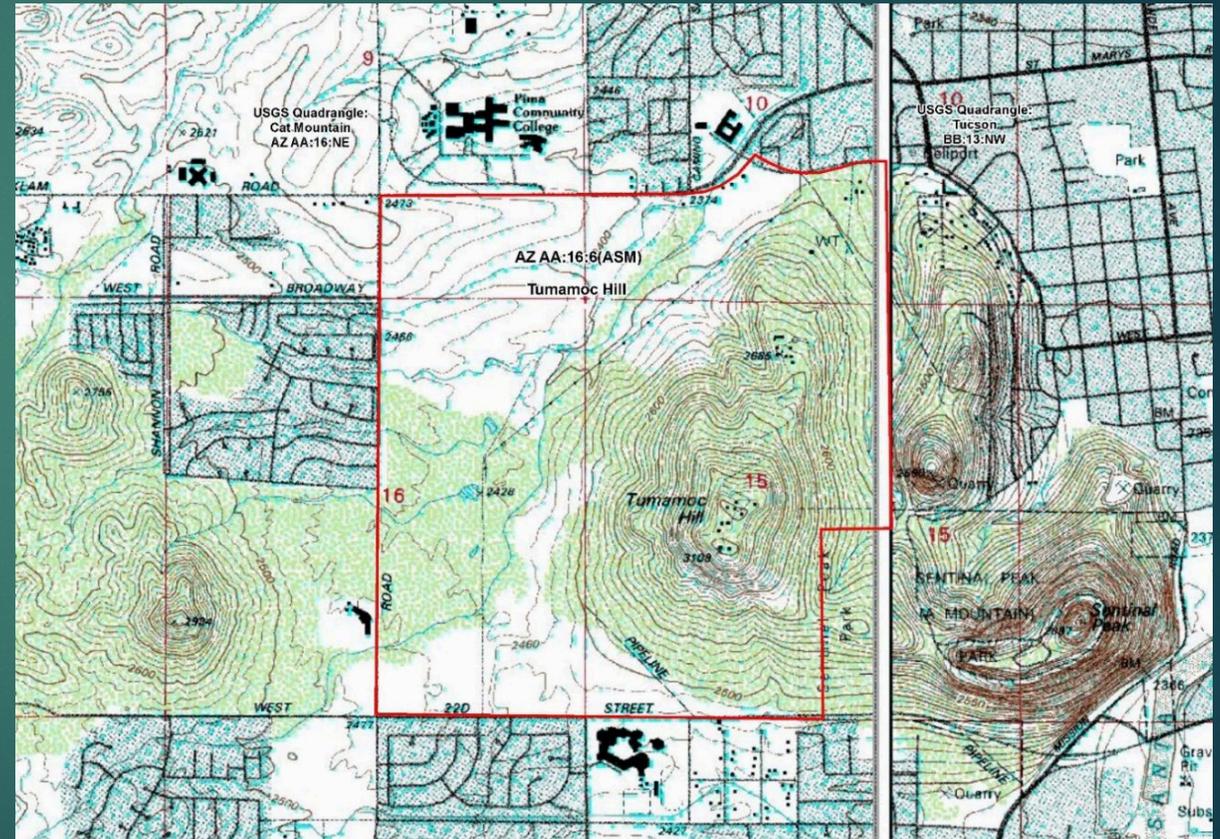
# National Historic Landmark

- ▶ Building, district, object, site, or structure that is officially recognized by the United States government for its outstanding historical significance.
- ▶ Desert Laboratory



# An Archaeological District

- ▶ Tumamoc Hill is an archaeological district.
- ▶ A place where evidence of human activity is preserved, and which has been investigated via archaeology.
- ▶ Artifacts, architecture, features, landscape modifications, and other forms of material culture.
- ▶ A timeline of human interactions with and residence in a particular place.



## Middle Archaic\* 5000–1700 BCE

Maize cultivation in the Tucson Basin  
ca. 4100 years ago



Santa Cruz River, 1904

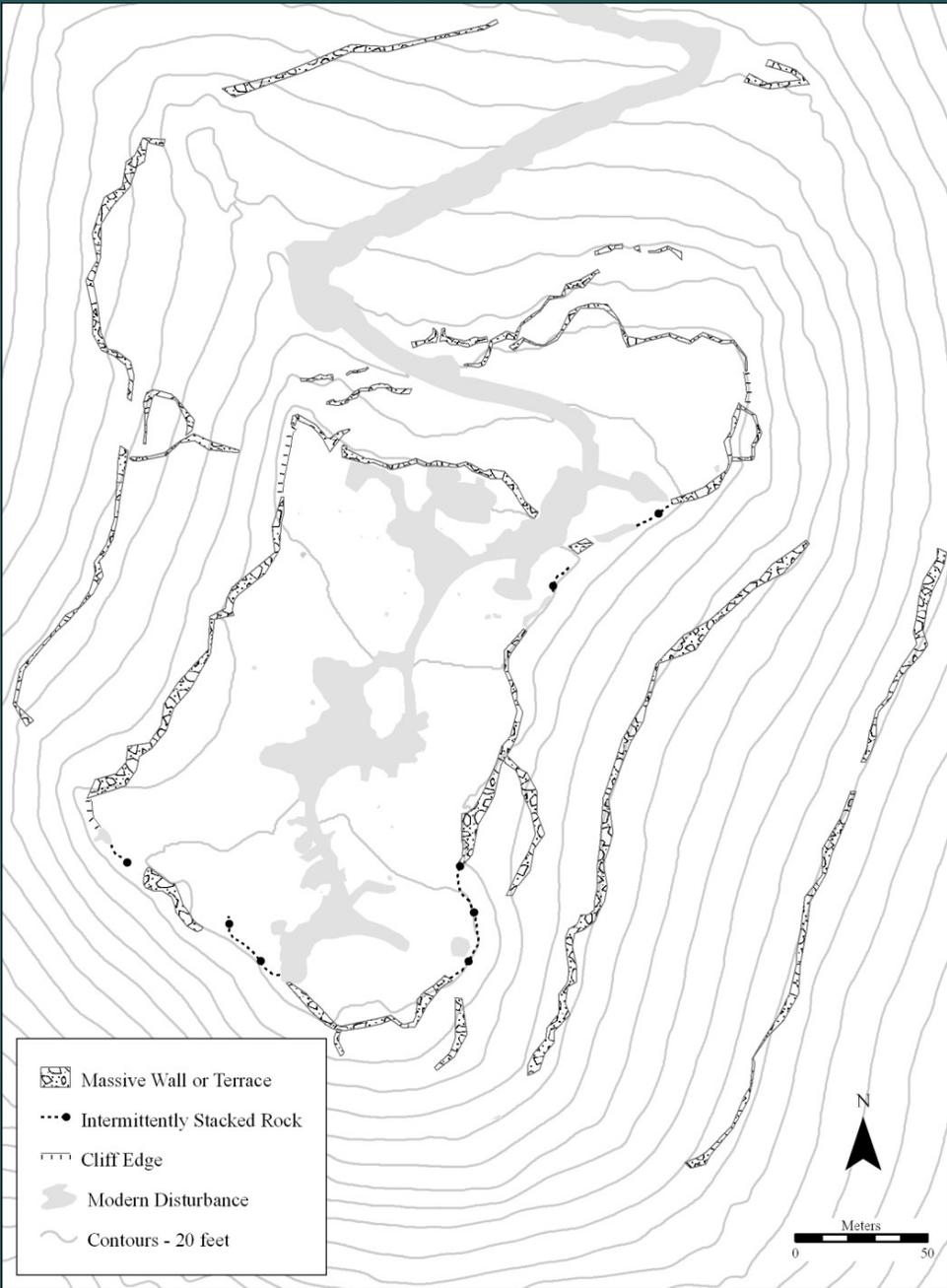
\*Archaeological timeline and phases from  
[tumamoc.arizona.edu](http://tumamoc.arizona.edu)

## Early Agricultural 2100 BCE–50 CE

- Construction of the *trincheras* on Tumamoc Hill
  - 2.3 km long
- A village site on top of Tumamoc Hill



Photo: Paul Mirocha





# Tortolita Phase 400–500 CE

- ▶ Settlements shift from the floodplains to adjacent river terraces
- ▶ There is a large village on the top of Tumamoc Hill
- ▶ Only known Tortolita-phase hilltop settlement + only settlement surrounded by massive stone walls

# Hohokam Culture 700–1450 CE

- Extensive agave (*Agave murpheyi*) farming at the base of Tumamoc Hill
- No settlements on the top of the Hill, closest was in the area of Saint Mary's hospital







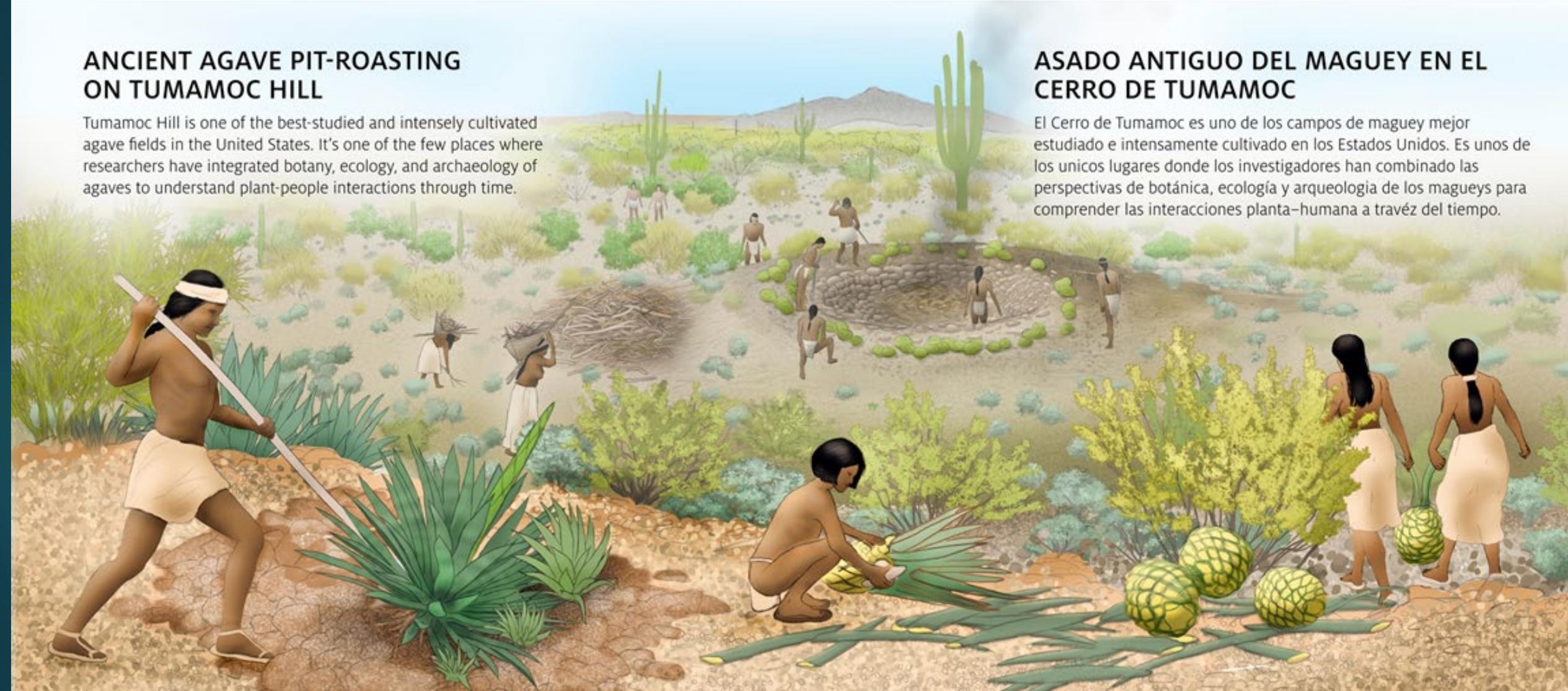
Photo: Suzanne and Paul Fish

## ANCIENT AGAVE PIT-ROASTING ON TUMAMOC HILL

Tumamoc Hill is one of the best-studied and intensely cultivated agave fields in the United States. It's one of the few places where researchers have integrated botany, ecology, and archaeology of agaves to understand plant-people interactions through time.

## ASADO ANTIGUO DEL Maguey EN EL CERRO DE TUMAMOC

El Cerro de Tumamoc es uno de los campos de maguey mejor estudiado e intensamente cultivado en los Estados Unidos. Es uno de los únicos lugares donde los investigadores han combinado las perspectivas de botánica, ecología y arqueología de los magueys para comprender las interacciones planta-humana a través del tiempo.



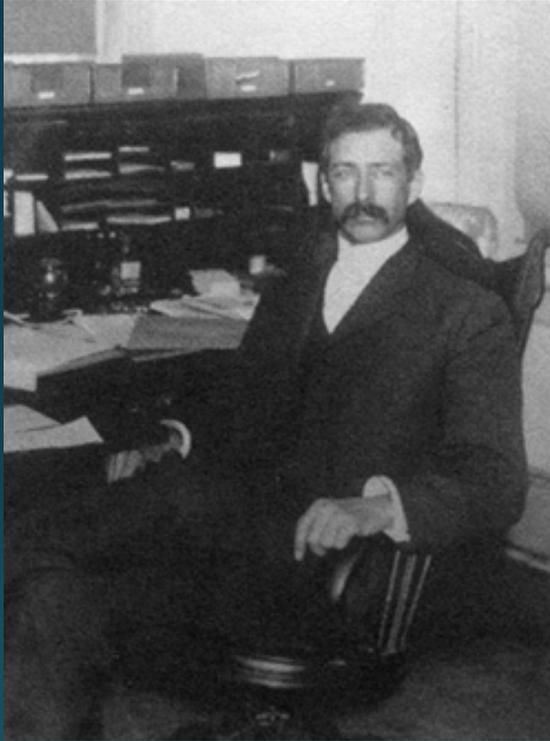
- 
- ▶ Keeping visitors to Tumamoc Hill on the paved road and other designated areas protects the archaeology of Tumamoc Hill.
    - ▶ Also protects the ecology of the Hill.
  - ▶ The top of Tumamoc Hill is dense in archaeological features and is culturally significant; pedestrians should not be beyond the gate at any time.
  - ▶ Any damage/vandalism to any aspect of the site should be taken seriously, per Federal and State laws.

# Timeline of the Desert Laboratory





CARNEGIE INSTITUTION OF  
WASHINGTON  
1902



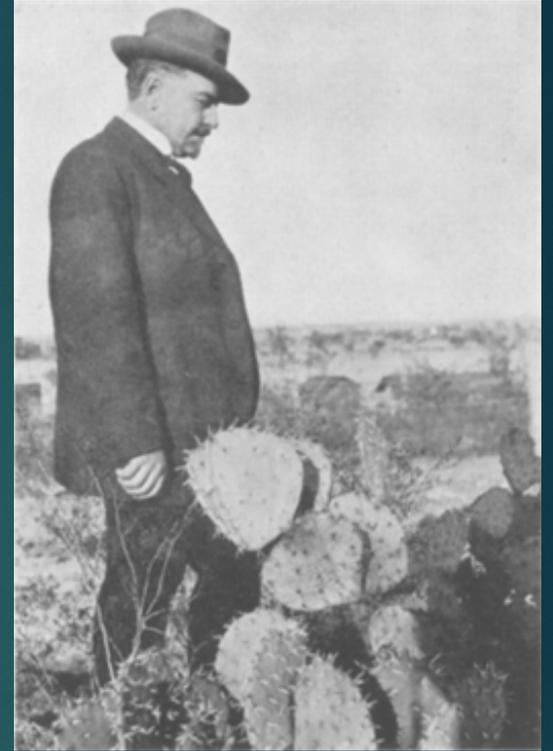
Frederick V.  
Coville



Andrew  
Carnegie



Theodore  
Roosevelt



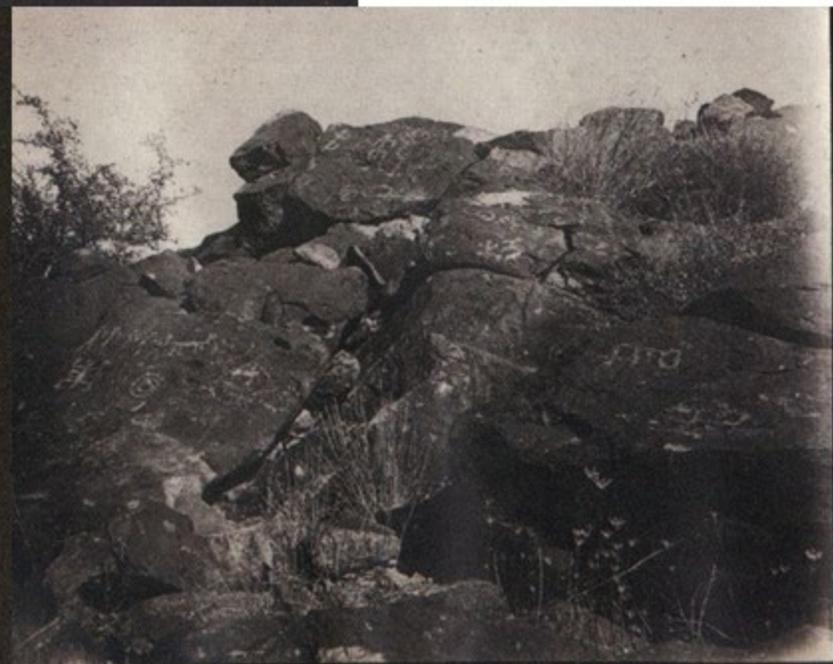
Daniel T.  
MacDougal



BURTON R. BRUCE ~ 1903



On road to Desert Lab.



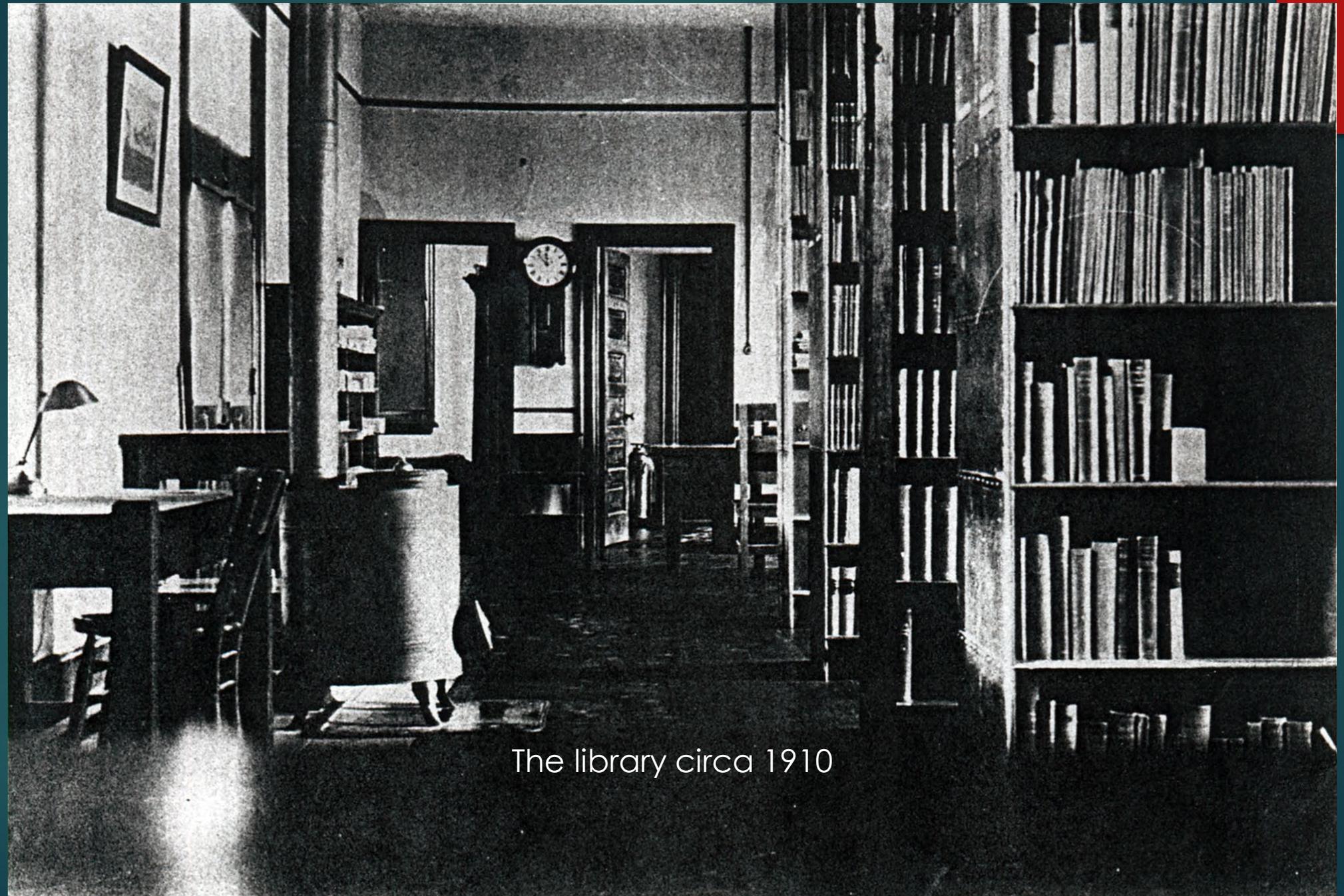
Picture Rocks - Tumamoc

# Desert Botanical Laboratory



October 7, 1903

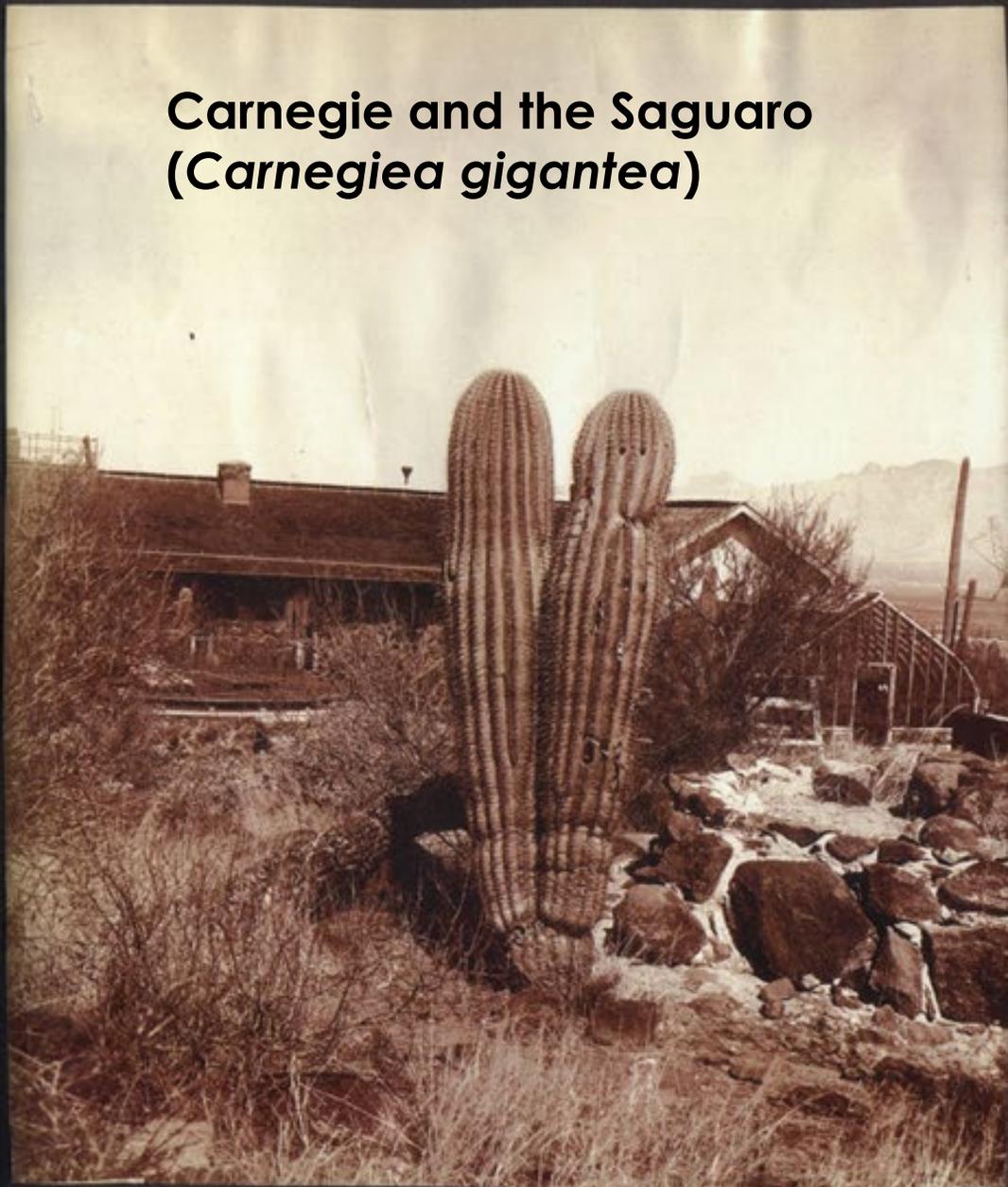
MacDougal 1903–1928



The library circa 1910



**Carnegie and the Saguaro  
(*Carnegiea gigantea*)**



*Desert Lab*

# Greenhouse built in 1906



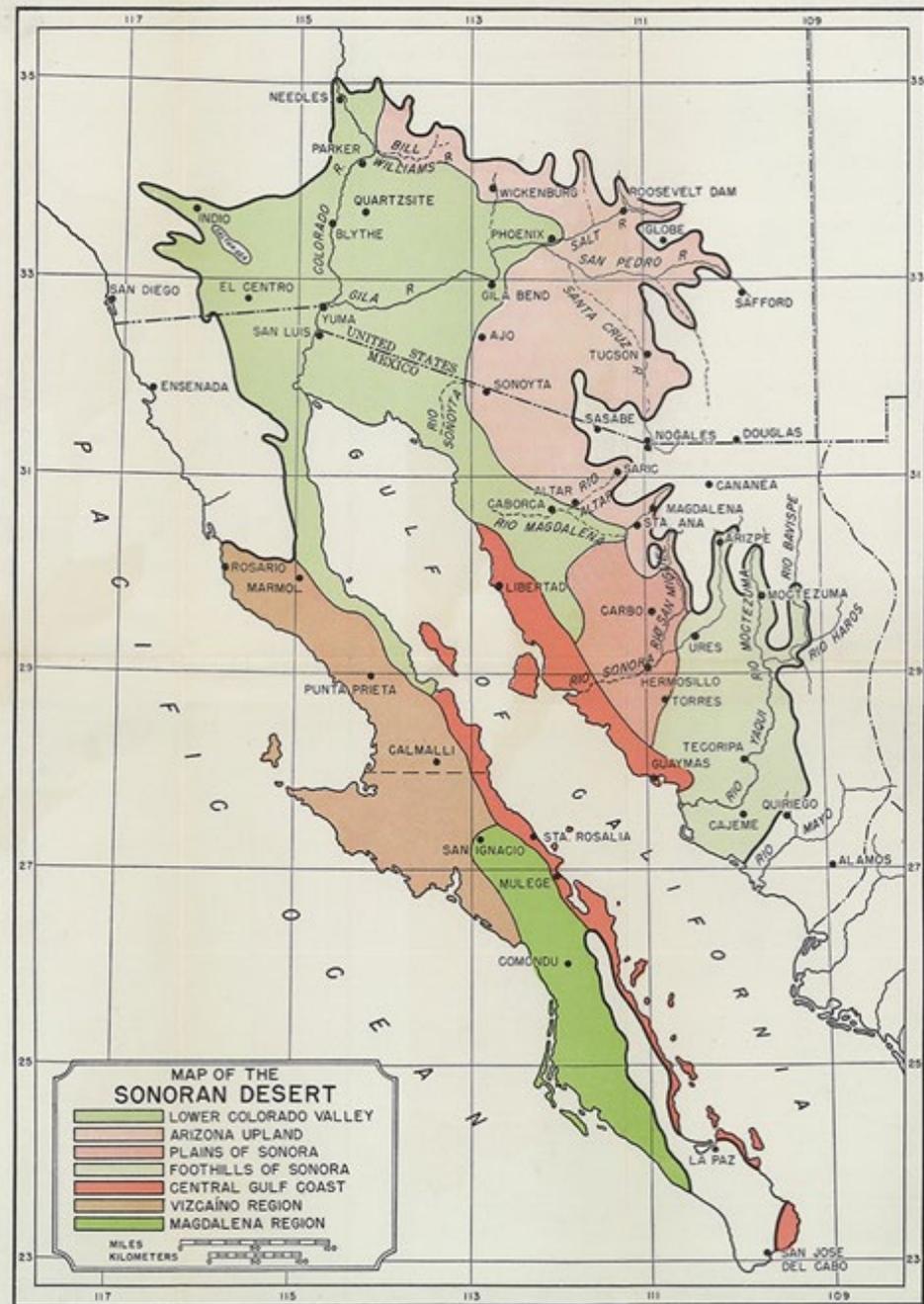
# Greenhouse today





Godfrey Sykes



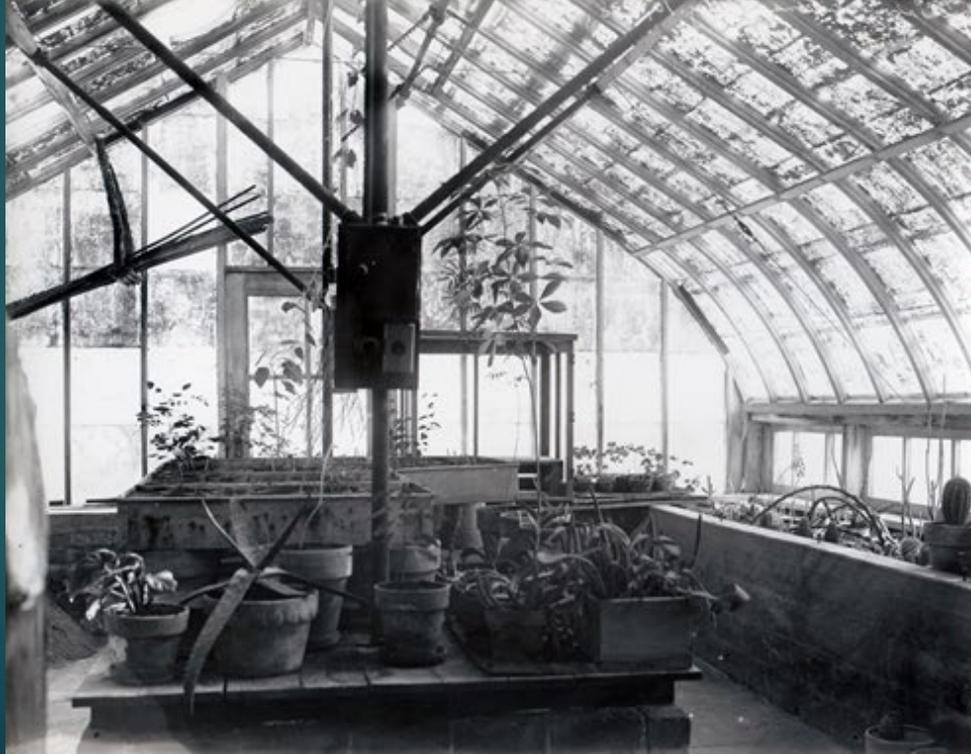
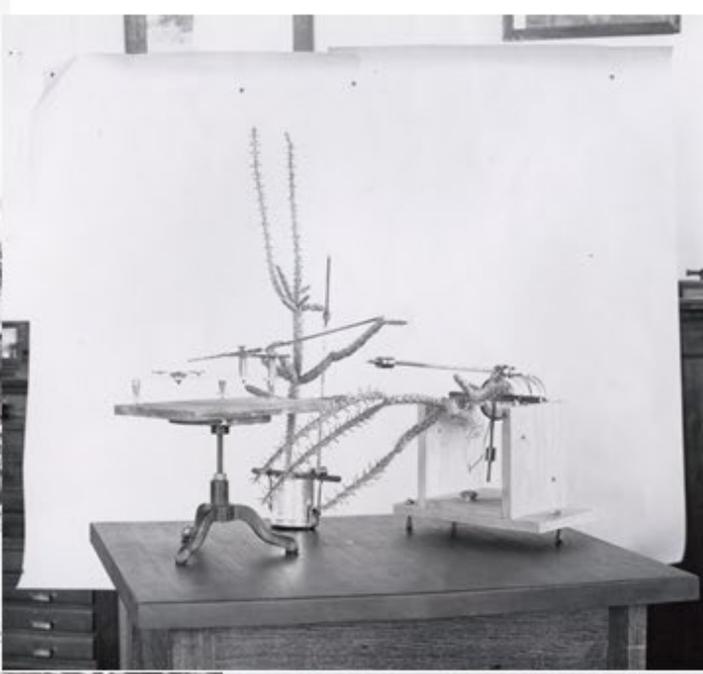


MAP 1. THE SONORAN DESERT AND ITS VEGETATIONAL SUBDIVISIONS



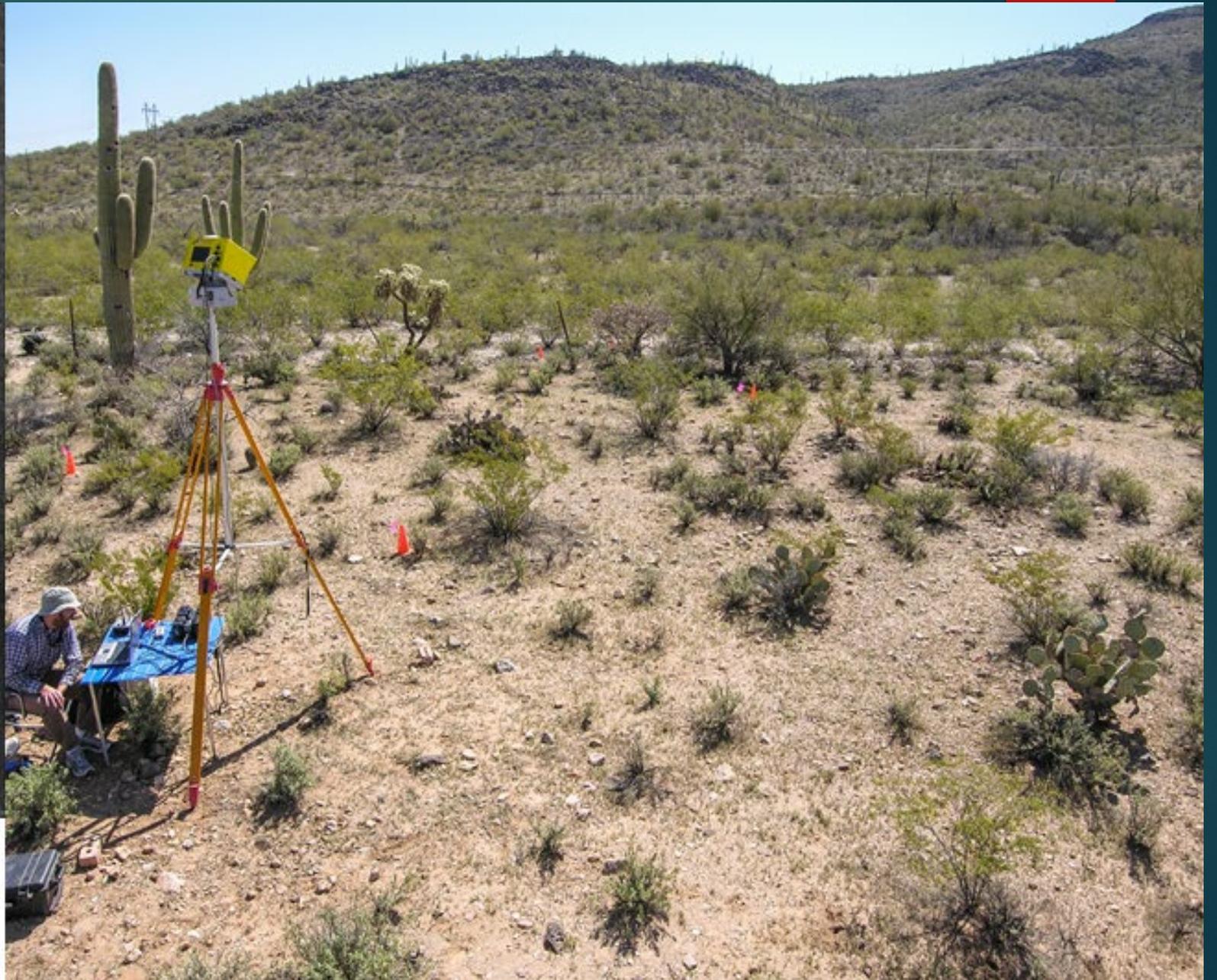
Forest Shreve  
(1878–1950)  
Joins Lab in 1908

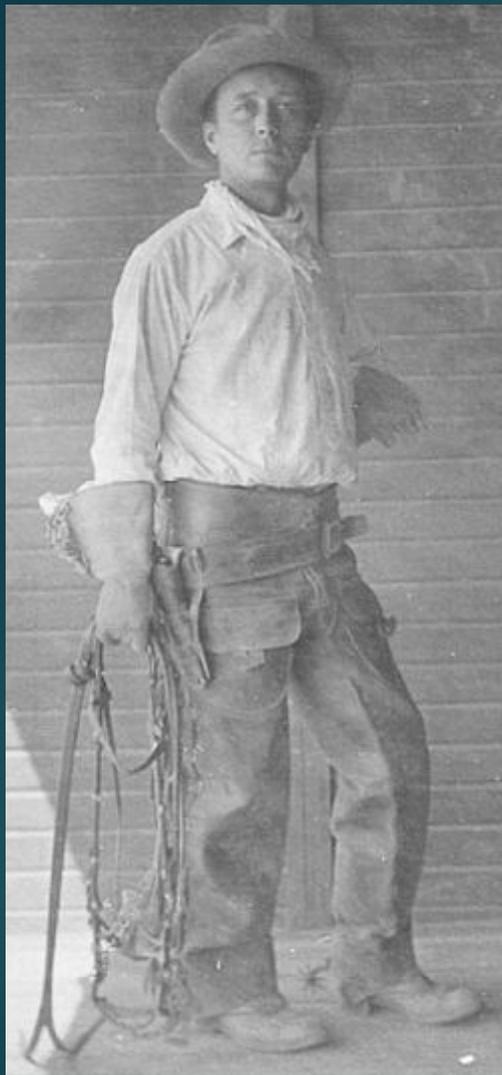




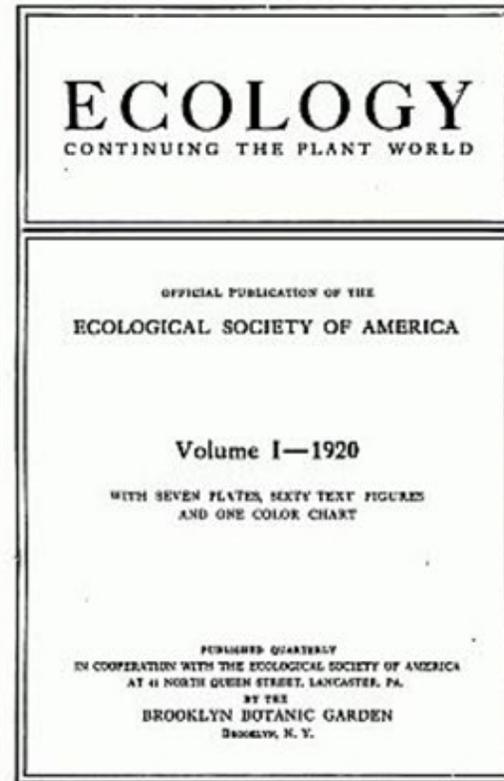
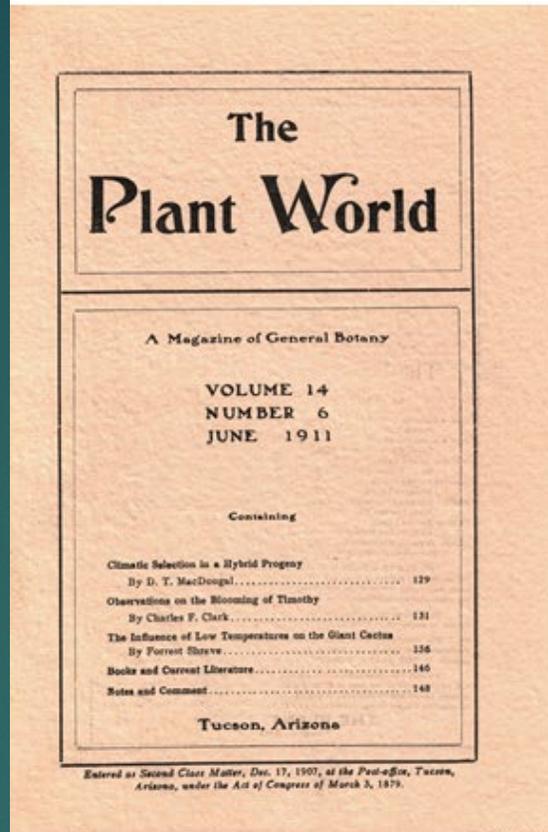


Volney Spalding

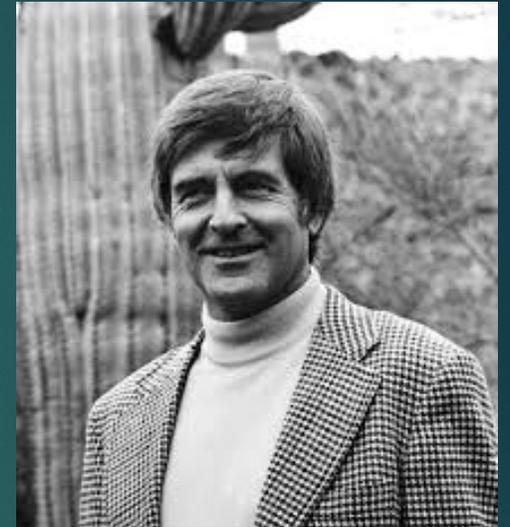
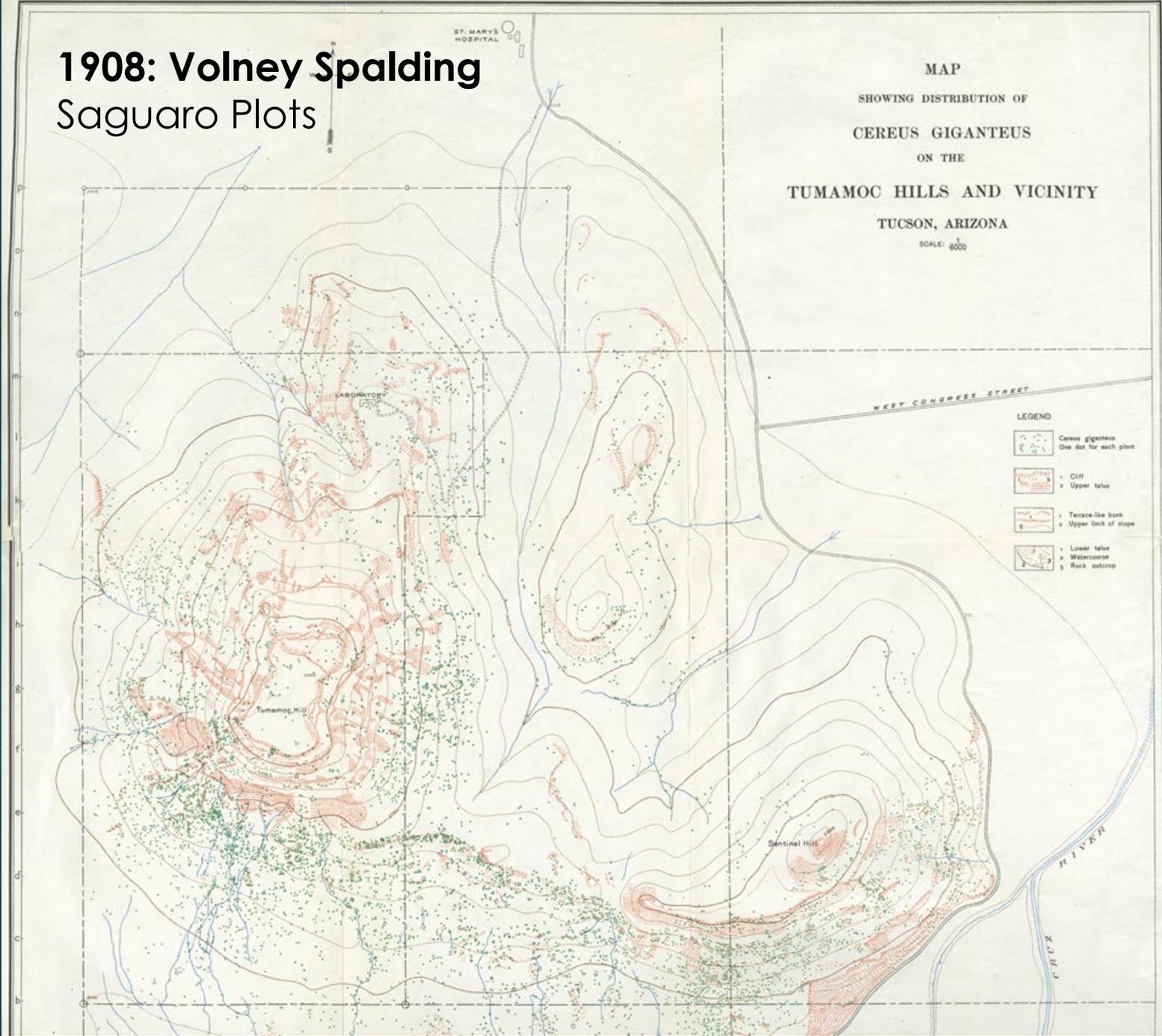




Francis E. Lloyd

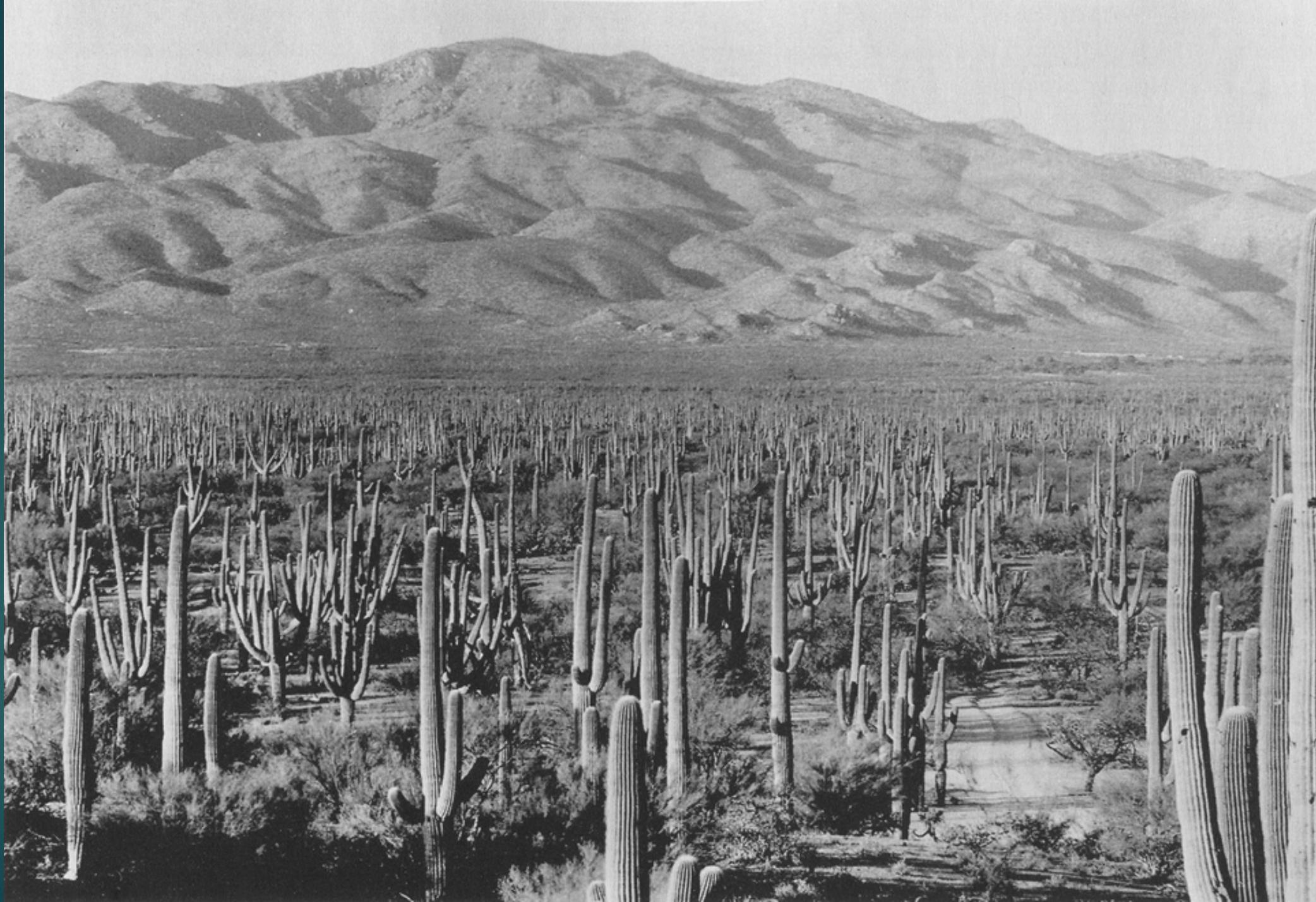


# 1908: Volney Spalding Saguaro Plots



1964: Ray Turner and  
J.R. Hastings re-  
establish Spalding's  
Saguaro study

1935



1960



1998



**1938:** Carnegie funding is drastically cut.  
Shreve and a small staff remain at the Lab



**1940:** Tumamoc sold to the US Forest Service for \$1

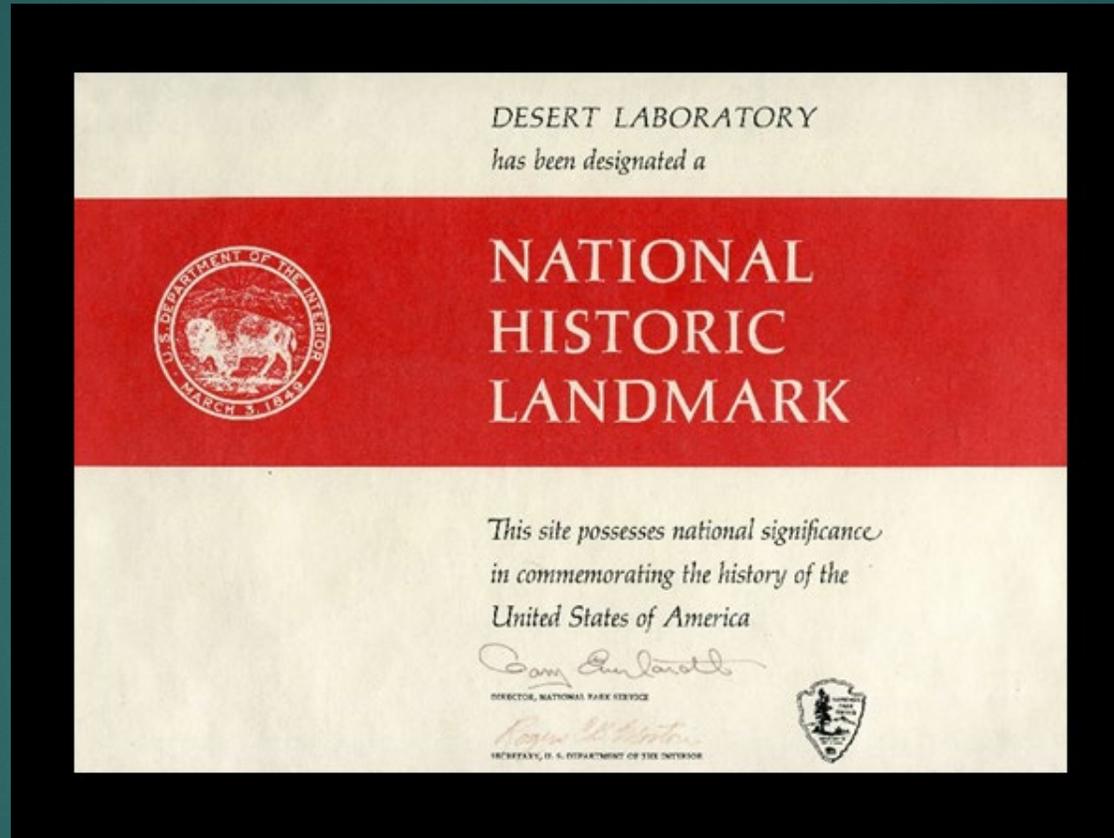
# U.S. Forest Service 1940–1960



# University of Arizona (1956)

**1966:** The road is extended to the top for the Steward Observatory Astrograph, and Telescope – as well as the communications facilities

**2009:** Pima County purchases part of the land



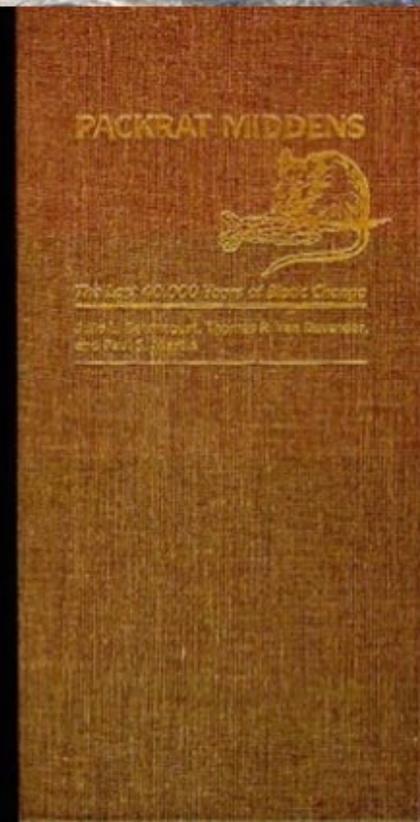
1976



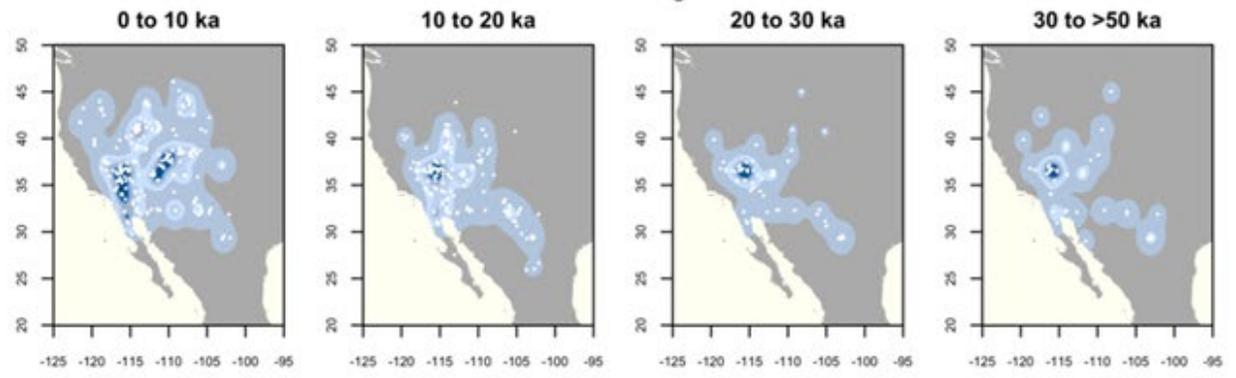
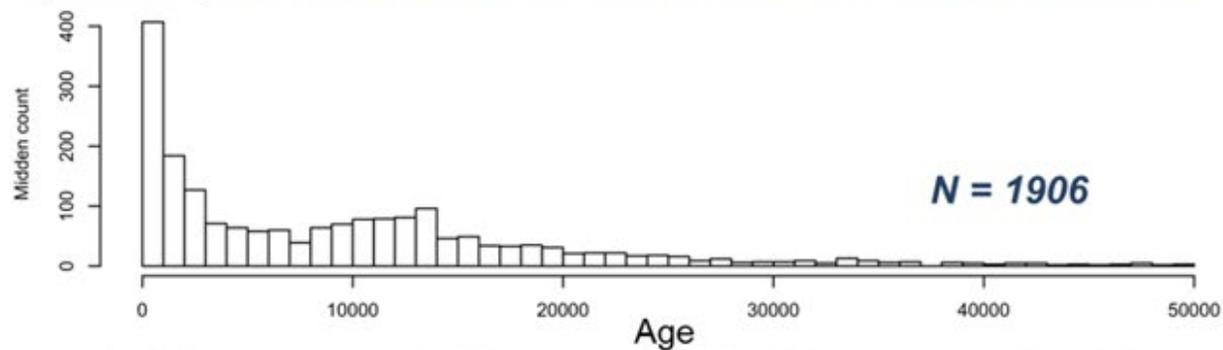


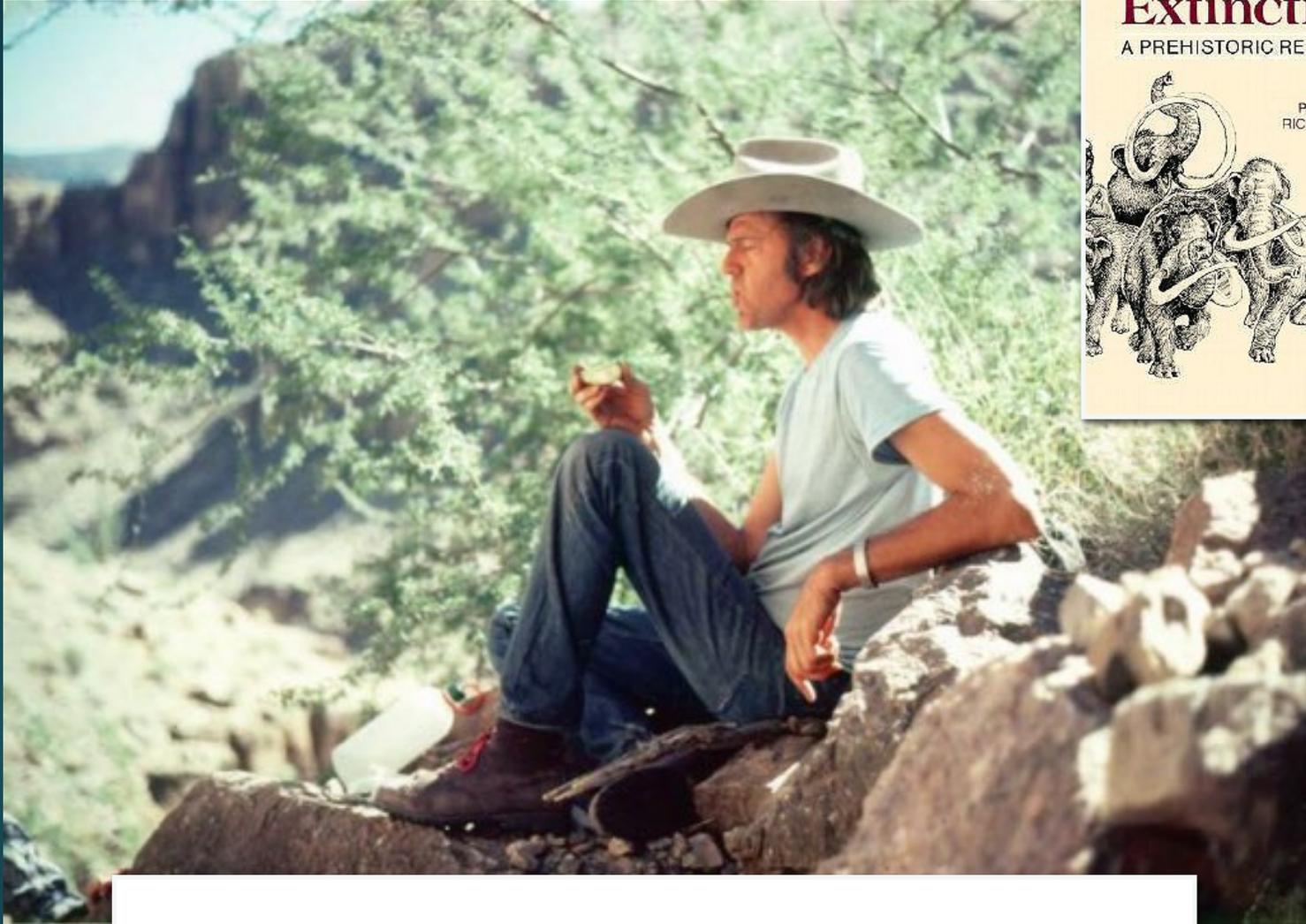
## Fossil Packrat Middens





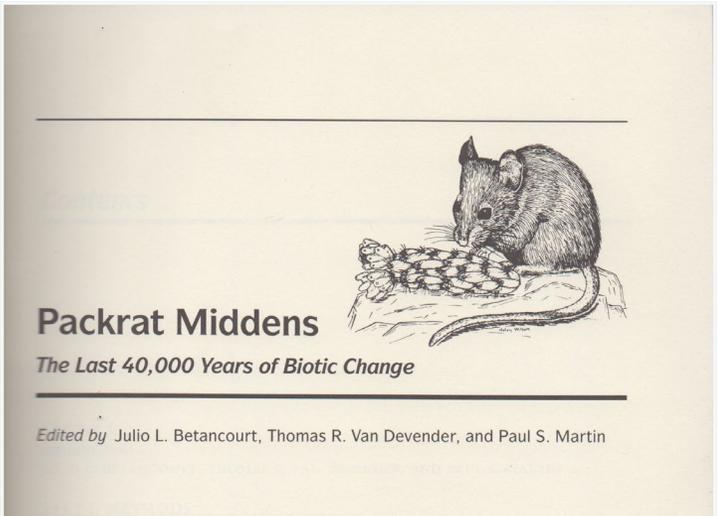
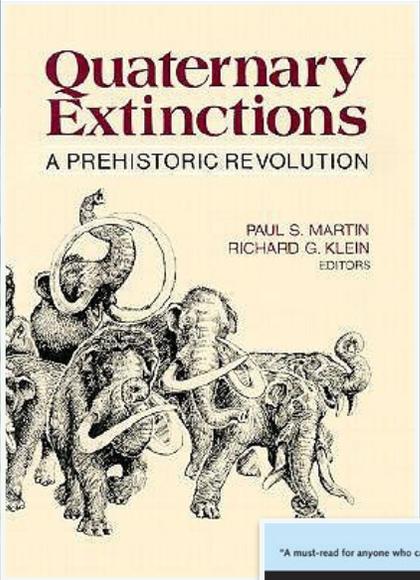
### Spatiotemporal distribution of North American Packrat Middens





# Neotropical Anachronisms: The Fruits the Gomphotheres Ate

Daniel H. Janzen and Paul S. Martin



"A must-read for anyone who cares about practical conservation."—DAVID RAINS WALLACE, author of *Beasts of Eden*

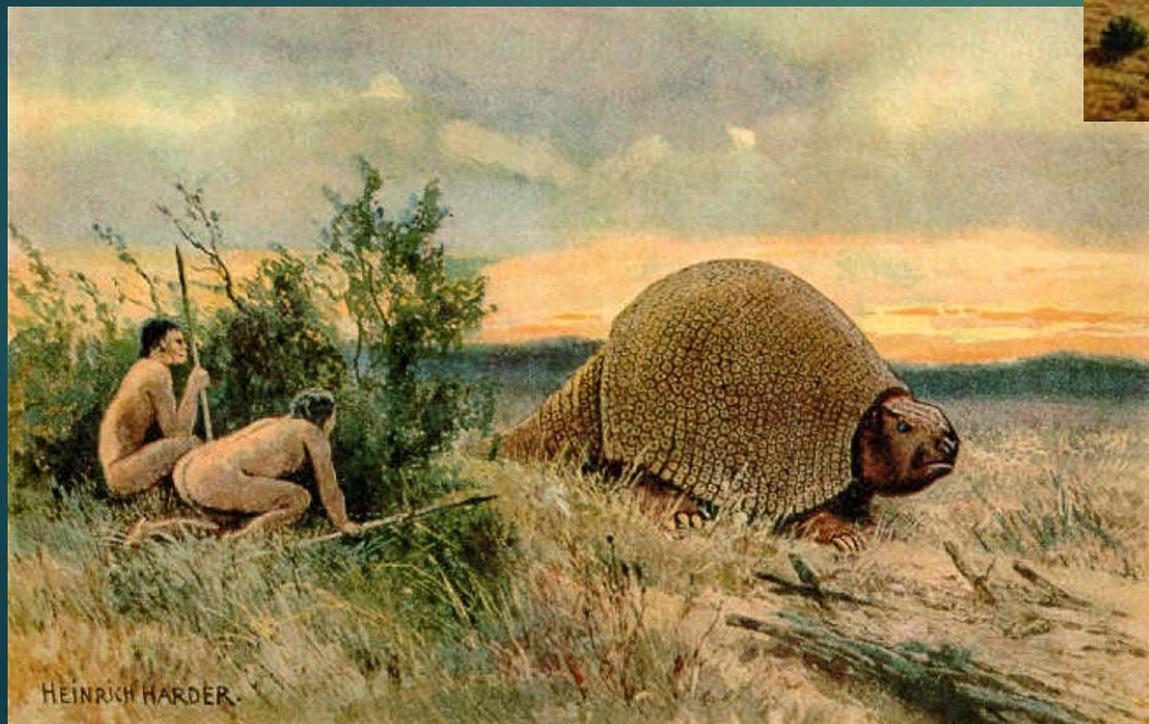
# TWILIGHT OF THE MAMMOTHS



ICE AGE EXTINCTIONS AND THE REWILDING OF AMERICA

PAUL S. MARTIN  
FOREWORD BY HARRY W. GREENE

# Rancholabrean 240,000–11,000 ya



# Research at the Desert Lab



# Research at the Desert Lab

Common School  
Trust Land-320 acres

Bowers, J.E. 2010. A debt to the future: Achievements of the Desert Laboratory, Tumamoc Hill, Tucson, Arizona. *Desert Plants* 26:25-39.

Webb, R.H. and R.M. Turner. 2010. A debt to the past: Long term and current plant research at Tumamoc Hill (The Desert Laboratory) in Tucson, Arizona. *Desert Plants* 26:3-18.

# Permanent plots on Tumamoc

- I. Spalding-Shreve plots: established in 1906 (plots 1-19) and 1928 (Areas A, B) to study vegetation change in perennial vegetation
- II. Saguaro plots: established in 1964 to study changes in saguaro populations by Rod Hastings and Ray Turner
- III. Desert annual plots: established 1982 by Larry Venable to study population dynamics of desert annuals

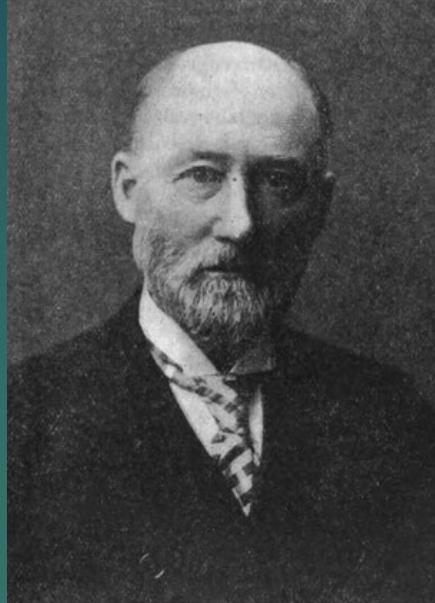
# Why are the permanent plots so important?

Document changes in vegetation (composition, structure) over time so can relate to environmental change

Follow fate of individual plants: survival, growth, and recruitment (demography) so we can develop models of population dynamics and project future changes

The Spalding plots are the oldest plots in the world where individual plants are mapped

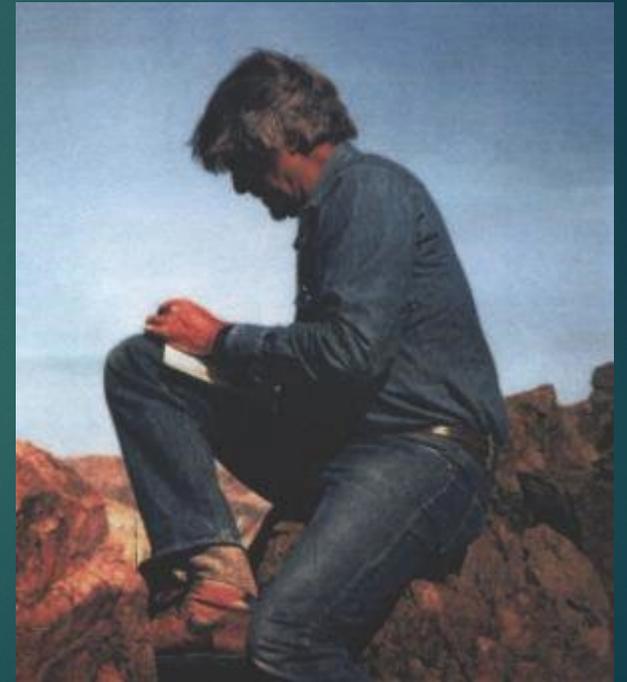
1906: Volney Spalding established 19 permanent plots, 10m x 10m, as a “debt to the future” (same year as entire area fenced)



1928: Forest Shreve established two additional plots, areas A and B. Area A was for counts only



1957: Ray Turner (UA, USGS) took over responsibility for plots

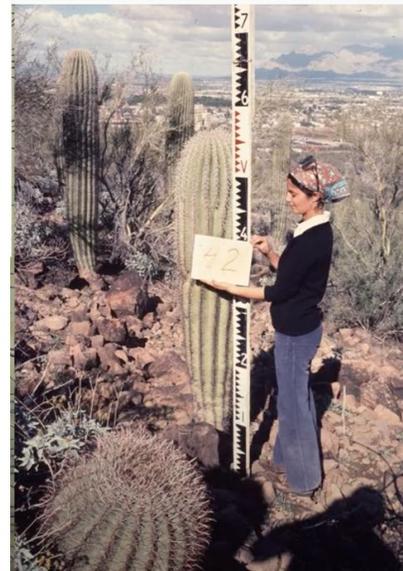




# Spalding-Shreve plot map years

And all mapped again in 2010 and/or 2012

Plot	Year of mapping											Times mapped		
	1906	1910	1928/29	1936	1948	1957	1959/60	1968/69	1974/75	1978	1984/85		1993	2001
4	x									x	x		x	5
7	x									x	x		x	5
9	x									x	x		x	5
10	x									x			x	4
11	x	x	x							x	x	x	x	12
12	x		x							x	x		x	10
14	x									x	x		x	5
15	x	x	x							x	x		x	12
16	x		x							x	x	x	x	12
17	x		x							x				4
Area B			x							x	x		x	8
Plots mapped	10	2	1				4	17	4	17	16	2	17	



## CHANGES IN DESERT VEGETATION

FORREST SHREVE

*Desert Laboratory, Carnegie Institution of Washington, Tucson, Arizona*

*Ecology*, 67(3), 1986, pp. 695–712  
© 1986 by the Ecological Society of America

## VEGETATION CHANGE AND PLANT DEMOGRAPHY IN PERMANENT PLOTS IN THE SONORAN DESERT<sup>1</sup>

DEBORAH E. GOLDBERG

*Division of Biological Sciences, University of Michigan, Ann Arbor, Michigan 48104 USA*

AND

RAYMOND M. TURNER

*United States Geological Survey, WRD, Federal Building FB-44, 300 West Congress Street,  
Tucson, Arizona 85701-1393 USA*

*Ecology*, 91(4), 2010, pp. 1132–1139  
© 2010 by the Ecological Society of America

Facilitation drives  
in the

BRADLEY J. BUTTERFIELD,<sup>1,4</sup> JULIO L.



**Charlotte Brown, Ike Russell  
Postdoctoral Fellow at  
Tumamoc, 2021-3**

# ECOLOGY

VOL. 18

OCTOBER, 1937

No. 4

## THIRTY YEARS OF CHANGE IN DESERT VEGETATION

FORREST SHREVE AND ARTHUR L. HINCKLEY

*Desert Laboratory of the Carnegie Institution of Washington*

2023

## 106 years of change in a Sonoran Desert plant community: impact of climate anomalies and 5 trends in species sensitivities

Charlotte Brown, Susana Rodriguez Buritica,  
Deborah E. Goldberg, Frank Reichenbacher, D.  
Lawrence Venable, Robert H. Webb, Benjamin T.  
Wilder.

*Ecology*: in press

## Teams

## Biosphere 2 Honors Teams

## Environment and Resilience Teams

Agrivoltaics: Food, Energy, and Water Solutions

Applied International Development Economics (AIDE) Lab

Arizona Streamgage Catalog (AZStreamCAT)

Assessing Resilience of Arizona Grasslands to Changes in the North American Monsoon

BEST-CLIM: Best Ecosystem Structure for CLimate Mitigation

Coral Reef Resilience: Biosphere 2 Science at Scale

Desert Laboratory on Tumamoc Hill

Environmental and Social Justice

Healthy Harvesters

Heat, Housing, and Health+: Understanding Vulnerability and

## Desert Laboratory on Tumamoc Hill: The future of life in the desert



### Goals

Research at the Desert Laboratory on Tumamoc Hill aims to integrate culture, science, and community to advance knowledge on sustaining the future of life in the desert. This VIP will build on the long-term plant ecology research of Tumamoc Hill, starting with permanent plots first mapped 115 years ago. It will integrate these data with multiple inter-related research programs aimed at understanding the dynamics of how life adapts and responds to aridity and climate change. More specifically, students will answer one or more of the following questions:

- How are desert plants responding to changing climate?
- How can we use modern technology to improve methods for documenting changes in vegetation?
- What are the rates of recovery following extreme climate events?
- What plant characteristics predict how different species respond to climate?
- How are interactions between animals and plants (for instance, pollination, seed dispersal, and herbivory) changing over time?

## VIP: Vertically Integrated Project Undergraduate research team

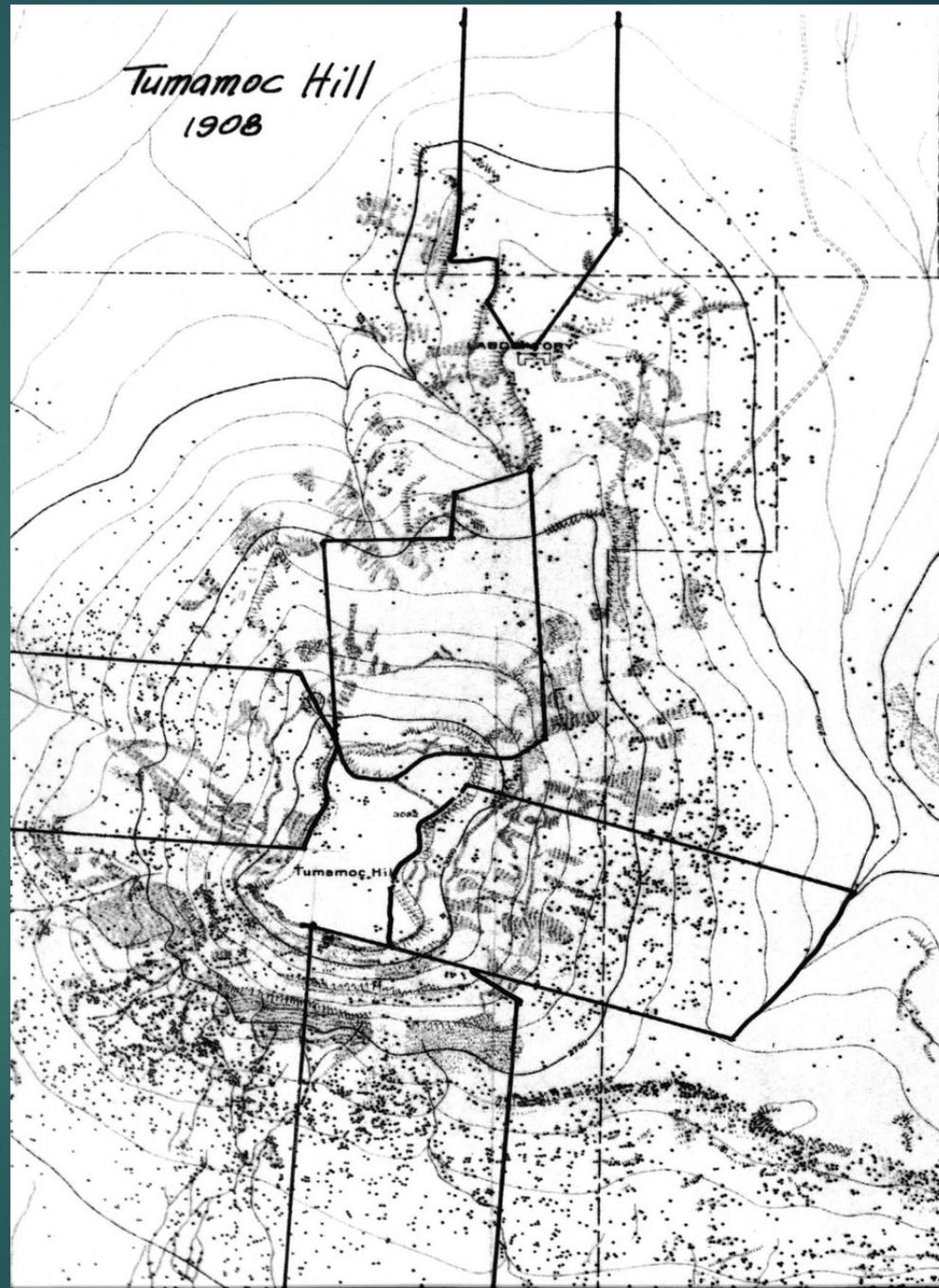
- CURE (Course-based Undergraduate Research Experience)
- We started fall 2021
- 15 students involved to date
- 38 species with data on at least one trait

# VIP (Vertically Integrated Projects) Program



## II. Saguaro plots

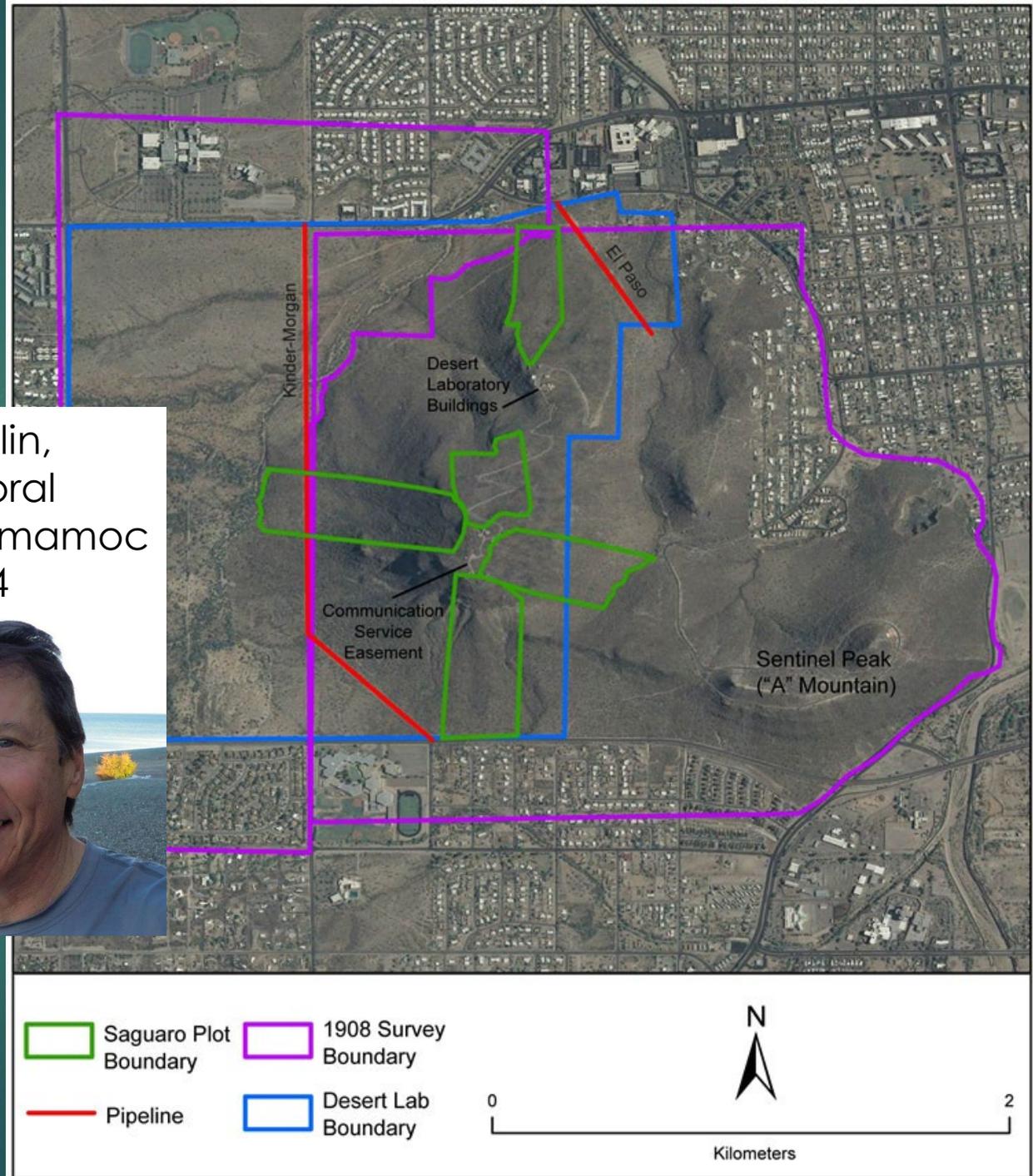
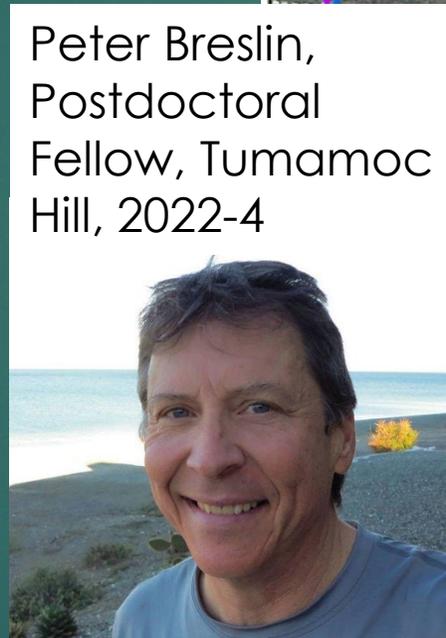
1908: Spalding mapped ALL saguaros on Tumamoc and Sentinel Hill



1964: Rod Hastings and Ray Turner established four plots overlain on the Spalding map

Numbered, marked and measured all individuals in plots

Remapped in 1970, 1993, 2010-12, 2022-3, adding new recruits



# Digitized and archived

**Susana Rodriguez-Buritica, Helen Raichle, Trevor Birt, Robert H. Webb, Raymond N. Turner, Elizabeth A. Pierson, and D. Lawrence Venable. 2013. Population dynamics of Sonoran Desert saguaro cactus (*Carnegiea gigantea*) at the Desert Laboratory (Tucson, Arizona). *Ecology* 94:1660. <http://dx.doi.org/10.1890/13-0182.1>**

*Ecology*, 79(8), 1998, pp. 2676–2693  
© 1998 by the Ecological Society of America

1998

## AN 85-YEAR STUDY OF SAGUARO (*CARNEGIEA GIGANTEA*) DEMOGRAPHY

ELIZABETH A. PIERSON<sup>1</sup> AND RAYMOND M. TURNER

*United States Geological Survey and University of Arizona Desert Laboratory at Tumamoc Hill,  
Tucson, Arizona, USA 85745*

esa 2019

ECOSPHERE

Local temporal trajectories explain population-level responses to  
climate change in saguaro (*Carnegiea gigantea*)

SUSANA RODRIGUEZ-BURITICA,<sup>1,2</sup> DANIEL E. WINKLER<sup>3</sup>,<sup>†</sup> ROBERT H. WEBB,<sup>4</sup> AND D. LAWRENCE VENABLE<sup>1</sup>



# Some other current Tumamoc research projects

Conducting any research, education, or other activities on Tumamoc outside of building areas requires a permit to ensure that no damage is done to the cultural or natural systems on the Hill.

No ground disturbance of any kind is allowed.

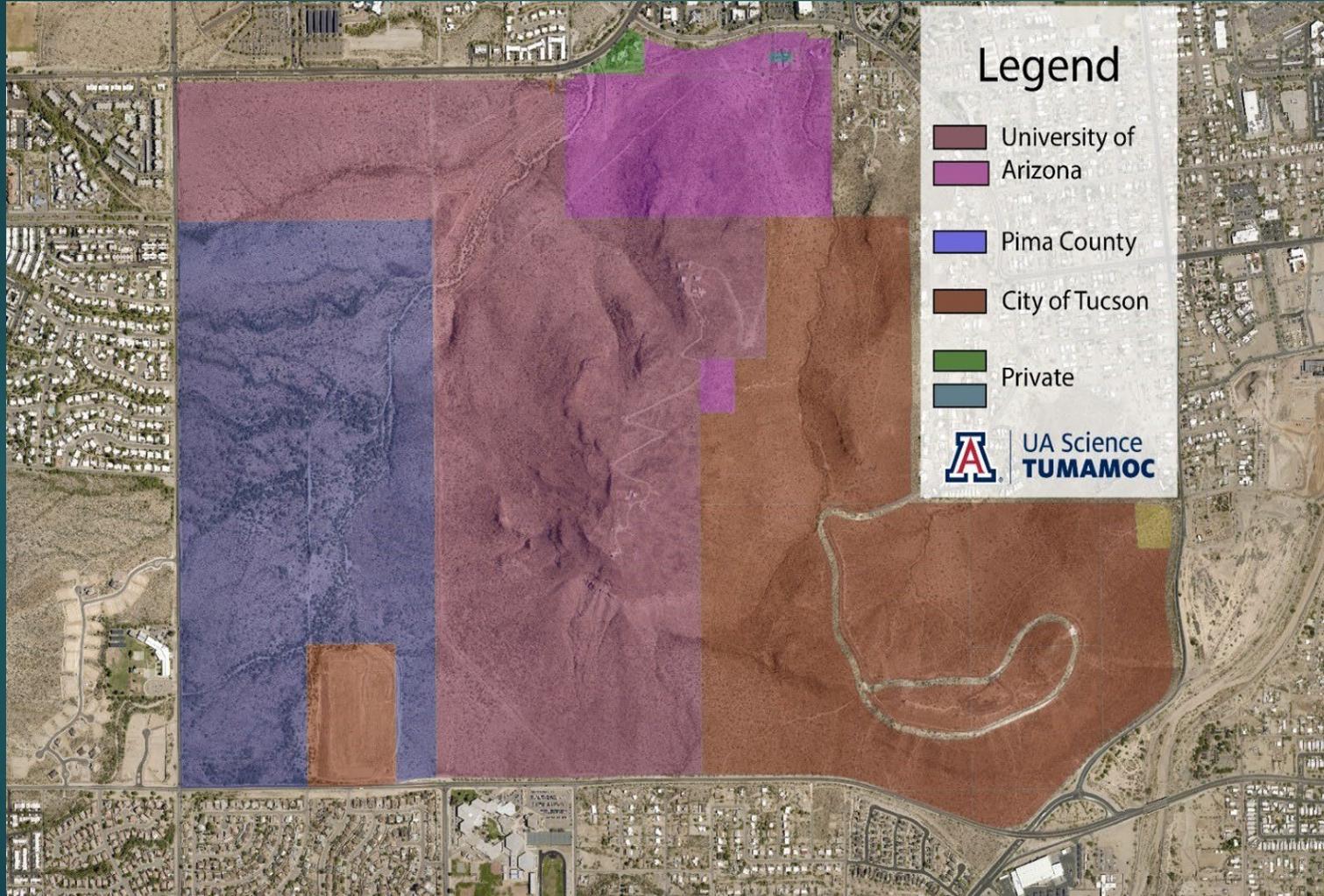
# Some other current Tumamoc research projects

- ▶ Using pollinator DNA left on flowers to survey saguaro pollinator communities (Johnson)
- ▶ Resurveying saguaro permanent plots (Breslin)
- ▶ Monitoring Tumamoc globeberry, a formerly (and currently?) endangered plant (Reichenbacher)
- ▶ Testing novel imaging techniques (Wiley/Driggers)
- ▶ Monitoring buffelgrass demography across environments to build population dynamics models (Hovanes)
- ▶ The role of the gut microbiome in native bee health (Buchmann)
- ▶ Exploring variability in saguaro genotypes and collecting seeds as part of larger study of ecotypic variation in saguaros across its range (Copetti)
- ▶ Engaging with art installations on Tumamoc and how it influences community thinking about the ecology of Tumamoc Hill and its climate future

# Tumamoc context and policies



# Tumamoc Hill Ownership Boundaries



- National Historic Landmark
- Archaeological district of Arizona
- Natural Environmental Study Area

# Walking Community



- On average Tumamoc Hill has 1,000 walkers per day
- The hike is a 1.5 mile walk from base to the top of the hill
- 3 mile round trip
- There is an approximate 700ft rise in elevation from the bottom to the top
- The grade is gentler on the bottom road, steeper on the upper road

# Rules and Regulations

- ▶ Hours are 4am-10pm daily.
- ▶ Firearms are prohibited on all University of Arizona facilities.
- ▶ Do not bring *pets* on to the preserve.
- ▶ Stay on the paved road and please do not wander into the ecology reserve—this includes the top of the Hill.
- ▶ Do not go beyond the fence or cables—this is a sensitive archaeological and cultural area.
- ▶ Please step to the side when vehicles approach.
- ▶ Please bring a refillable water bottle—a refill station has been provided for your use.

# Rules and Regulations

- ▶ Please use the garbage and recycling containers at the midpoint of the Hill to dispose of any unwanted items. Please help us maintain the health of the Hill by picking up other people's garbage.
- ▶ Smoking is strictly prohibited. Please extinguish cigarettes or any other burning object prior to entering the site.
- ▶ For the consideration of others and the wildlife, please do not listen to amplified music or sound.
- ▶ Bicycles and skateboards are not permitted on the Hill. For the safety and pleasure of everyone using the hill, secure your bicycle at the bicycle rack at the entrance and please leave skateboards and all skates at home.
- ▶ Please help protect the plants and animals of the hill by not handling, harming, or removing them from their natural setting.
- ▶ Do not bring any plant material or animals on to the hill.

# Community Outreach and Engagement



# Community Outreach and Engagement



THE UNIVERSITY OF ARIZONA  
ARIZONA INSTITUTE FOR RESILIENCE  
**TUMAMOC**  
Desert Laboratory

## FALL 2023 TUMAMOC TALKS



### THE IMPACTS OF WINTER SNOW AND SUMMER MONSOON RAINS ON FOREST WATER STRESS ACROSS THE SOUTHWESTERN US: A STORY OF THE PAST AND FUTURE

Join Dr. Hu to learn about the effects of monsoon rains on Ponderosa pine forests across the Southwest. By sampling cores in 17 tree populations, Dr. Hu and her lab have reconstructed forest responses to changes in precipitation and atmospheric aridity from the 1960's to present day. She will focus on the most recent megadrought (year 2000 - present) and how forest responses seem to have shifted in their ability to deal with changes in climate.

Jia Hu, PhD

Thursday, October 12th, 5:30pm-6:30pm  
Tumamoc Hill Boathouse

### THE ANCIENT OASIS: 5,000 YEARS OF AGRICULTURE AND IRRIGATION IN TUCSON

Join Dr. Mabry to learn about the story of water management in Tucson, including the earliest known irrigation canals built in Aridamerica, the social organizations of enduring irrigation communities, the change in water rights and water development schemes during the late 19th century. What happened to the river to make it the dry and deep channel of today? And the effects of transferring water from the Colorado River, and alternative futures of the Santa Cruz watershed.



Jonathan Mabry, PhD

Thursday, November 16th, 5:30pm-6:30pm  
Tumamoc Hill Boathouse



### NATURAL INFRASTRUCTURE IN DRYLAND STREAMS (NIDS) ESTABLISH REGENERATIVE WETLANDS THAT CAN REVERSE DESERTIFICATION AND STRENGTHEN CLIMATE RESILIENCE

Dr. Norman will present the science she has documented that demonstrates how rock detention structures can restore natural feedback cycles between (i) ecological processes, (ii) the soil carbon sponge, and (iii) the hydrological budget of dryland ecosystems. This presentation will also discuss how ancient cultures utilized these rock detention structures as sustainable solutions to farming in the North American Southwest.

Laura M. Norman, PhD

Wednesday, December 13th, 5:30pm-6:30pm  
Tumamoc Hill Boathouse

RSVP: [tumamoc-hill@arizona.edu](mailto:tumamoc-hill@arizona.edu)

For more information, scan QR code or visit:  
[tumamoc.arizona.edu/tumamoc-institute/lecture-series](http://tumamoc.arizona.edu/tumamoc-institute/lecture-series)



THE UNIVERSITY OF ARIZONA  
ARIZONA INSTITUTE FOR RESILIENCE  
**TUMAMOC**  
Desert Laboratory

## LECTURES AT THE DESERT LABORATORY



### INDIGENOUS INGENUITY: WHAT CAN WE LEARN?

Dr. Michael Kotutwa Johnson will talk about the lessons learned as a traditional Hopi dry-land farmer.

Wednesday, March 29th, 6–7pm  
Tumamoc Hill Boathouse



### SONORAN DESERT PLANTS IN A CHANGING CLIMATE: WHAT DO LONG-TERM DATA TELL US?

Tumamoc Saguaros Through Time: The Story of Six Decades of Resilience and Change Dr. Peter Breslin

How is climate changing Tumamoc's plant communities? Dr. Charlotte Brown

Thursday, April 13th, 6–7pm  
Tumamoc Hill Boathouse

RSVP: [tumamoc-hill@arizona.edu](mailto:tumamoc-hill@arizona.edu)

For more information, scan QR code or visit:  
[tumamoc.arizona.edu/tumamoc-institute/lecture-series](http://tumamoc.arizona.edu/tumamoc-institute/lecture-series)



# Community Outreach and Engagement



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**TUMAMOC**  
Desert Laboratory

## Venomous Reptiles of Tumamoc Hill



Western Diamond-backed Rattlesnake

How to avoid conflict with various species

Pop-up engagement at the entrance to the Tumamoc Hill Boathouse



Gila Monster

For more information visit:  
<https://tumamoc.arizona.edu/calendar>

Photos courtesy of the Tucson Herpetological Society



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## Walk with a Naturalist



Meeting point:  
Entrance to Tumamoc Hill

Join Desert Laboratory Community Outreach Assistant, Robert Villa on a walk from the entrance to Tumamoc Hill to the Desert Laboratory parking lot. Along the way he will talk about some of the plants, animals, and natural history of Tumamoc Hill, as well as do his best to answer your questions.

RSVP to [tumamoc-hill@arizona.edu](mailto:tumamoc-hill@arizona.edu)



Robert is a native Tucsonan and Sonoran Desert naturalist who has worked on a variety of projects in our borderlands, and the state of Sonora since 2004. He is president of Tucson Herpetological Society (amphibians and reptiles), a board member of the Tucson Cactus and Succulent Society, and consultant on a variety of projects and topics.

# Community Outreach and Engagement

- ▶ Past Steward field trips to:
  - ▶ Arizona State Museum
  - ▶ Mission Garden
  - ▶ UA Campus Arboretum



# Your role as a Tumamoc Steward

- ▶ Commit to 2 hours, 2x/month of being a presence on the Hill
- ▶ Being a physical presence on the Hill representing the Desert Lab
- ▶ Sharing information as needed about respecting the rules and policies of the Hill
- ▶ Attend monthly Tumamoc Stewards In-Service Workshops
- ▶ Become a Friend of Tumamoc
  - ▶ \$25/yr donation to the Desert Laboratory to support our programming

Questions?

