

# Manzanita shrubs and specialist gall aphids on sites recovering from wildfire at Big Chico Creek Ecological Reserve



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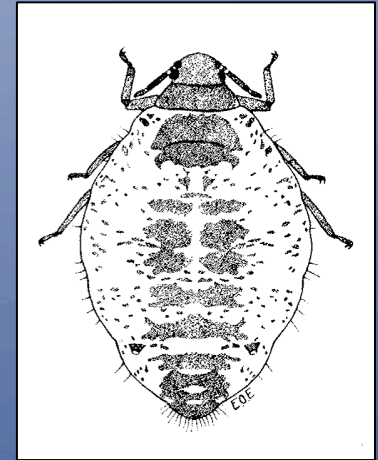


Santa Rosa Island manzanita (*Arctostaphylos confertiflora*),  
a federally listed endangered species

Photo by Don Miller

## Manzanita Gall Aphid, *Tamalia coweni*

- Described from the Colorado Rockies on *Arctostaphylos uva-ursi* by T.D.A. Cockerell (1905)
- *Tamalia* distinct from other gall-inducing aphid taxa
- Restricted to Nearctic, although *A. uva-ursi* ranges across Nearctic *and* Palaearctic
- In western North America, *Tamalia* lineage has radiated alongside its obligate host plant clade Arbutoideae (Ericaceae)
- Ecological studies of host plants and insects may throw light on origins of parasitism



Line drawing of gall-inducing female  
by E.O. Essig 1915

# Parasitism

- Brood parasitism
- Social parasitism

Young cuckoo (brood parasite)  
being fed by reed warbler host  
(smaller bird on right)



# Inquilinism

(sometimes) parasitic form of  
symbiosis

A myrmecophilous (ant-loving)  
socially parasitic inquiline beetle,  
*Paramyrmex foveipennis*  
(Histeridae)



# Aphids

- >5500 species
- Clonal reproduction: Matryoshka Doll Syndrome
- Cyclical parthenogenesis
- Complex life cycles




# Plant galls

- plant tumors or organized neoplasms
- many gall-inducing taxa
- collectible microcosms
- system well-defined

Fresh and old cynipid wasp galls on  
Blue Oak (*Quercus douglasii*)  
at Wurlitzer Ranch,  
Tehama County



Photo by Don Miller

A close-up photograph of a plant branch with several bright red, elongated, and curved galls. The galls are attached to the stems and are surrounded by green, rounded leaves. The background is dark and out of focus.

*Tamalia* aphid galls on  
*Arctostaphylos confertiflora*  
Santa Rosa Island, California  
May 2024

Photo by Don Miller

# Big Chico Creek Ecological Reserve (BCCER)

Straddles canyon in  
Cascade Range foothills  
above Chico, California



*Arctostaphylos manzanita*  
January 2015

Photo by Don Miller





*Arctostaphylos  
manzanita*

*Arctostaphylos  
viscida*

Year 1999: wildfire scorched study site  
(but 450 mature plants survive)

Year 2000: single cohort of 135  
new plants germinated

Year 2008: first galls appear  
on juvenile plants

Photo by Don Miller

Gall on *Arctostaphylos manzanita* induced by *Tamalia coweni*

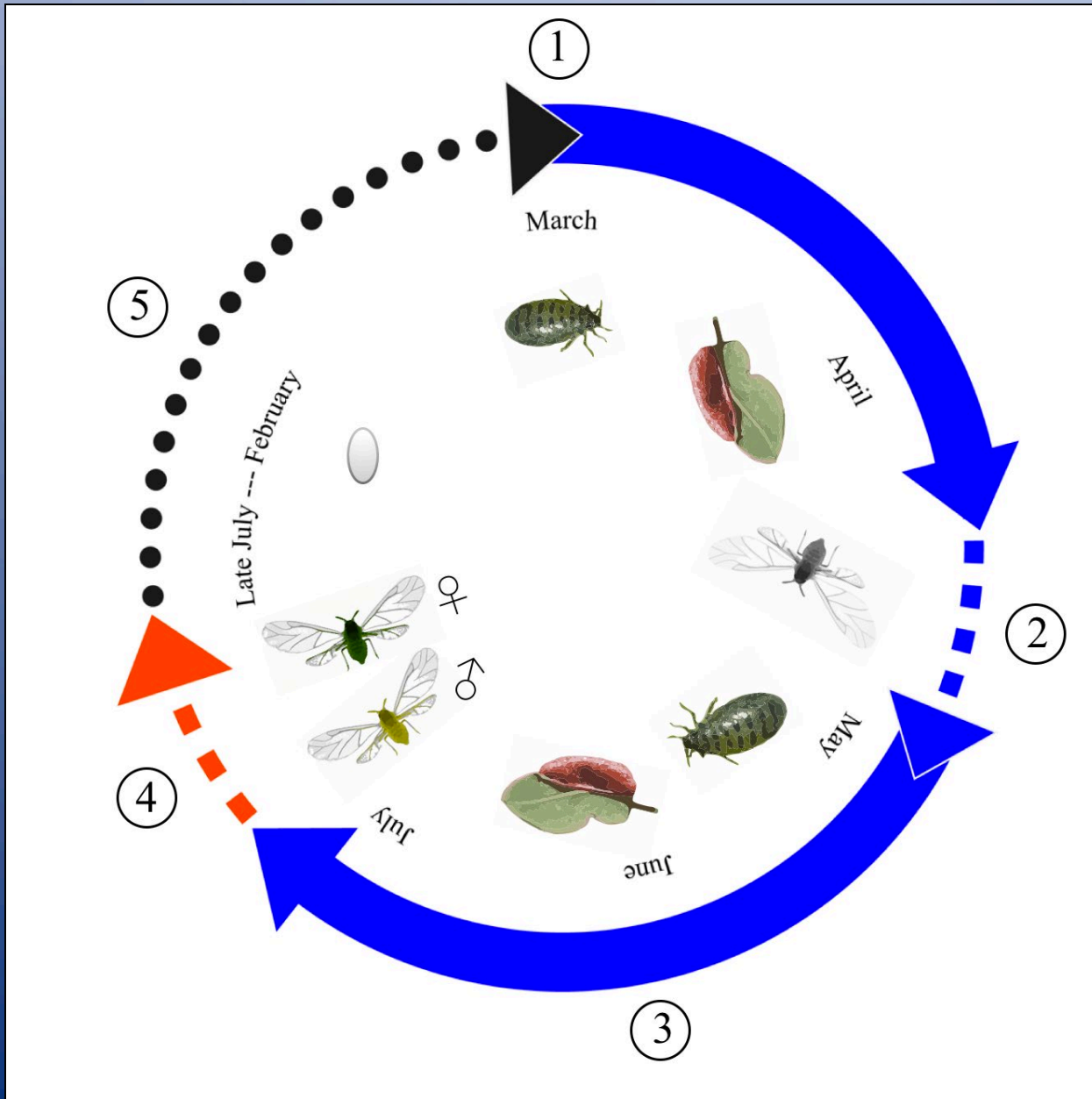




*Tamalia inquilinus* (above)  
& *Tamalia coweni* (below)  
sharing gall on *A. viscida*

Miller Ann. Ent. Soc. Am. **97** (2004)

Photo by Don Miller



**—————** Asexual,  
gall-inducing females

**-----** Asexual,  
dispersing females

**-----** Sexual, winged  
females & males

**.....** Eggs in diapause

# Evolution & Ecology of *Tamalia* aphids

- Geographic origin of lineage appears Madrean (central Mexico)
- Co-speciation of gall-inducers and inquilines broadly follows lines of host plant diversification
- Newly described species of *Tamalia* on *Arbutus* & *Comarostaphylis* spp.
- Inquiline arose in conjunction with colonization of *Arctostaphylos* spp.

# History of inquilinism in *Tamalia* galling aphids: preliminary evidence

- Gall-inducers and inquilines form monophyletic group
- Inquilines totally dependent on gall-inducers
- mtDNA substitution rates  $> 2.5$  times faster in inquilines...why?

Miller & Crespi J. Evol. Biol. **16** (2003)

Miller et al. Mol. Ecol. **24** (2015)

# Aerially-dispersing morph





Inquiline ambulatory  
dispersing morph



# How do winged aphids select/colonize new host plants?

- Plant vigor hypothesis
- Plant stress hypothesis
- **Apparency hypothesis**
- **Minimum dispersal distance hypothesis**

# Methods for tracking dispersal by flight

- Trimble GPS, arcGIS for mapping plants
- Sampling galls for dissection
- Annual gall census with undergraduate ecology students at Chico State
- Goal: detailed tracking of colonization patterns



Population ecology of  
*Tamalia* aphids at study site

Seasonal sampling of  
fresh galls (spring, summer)

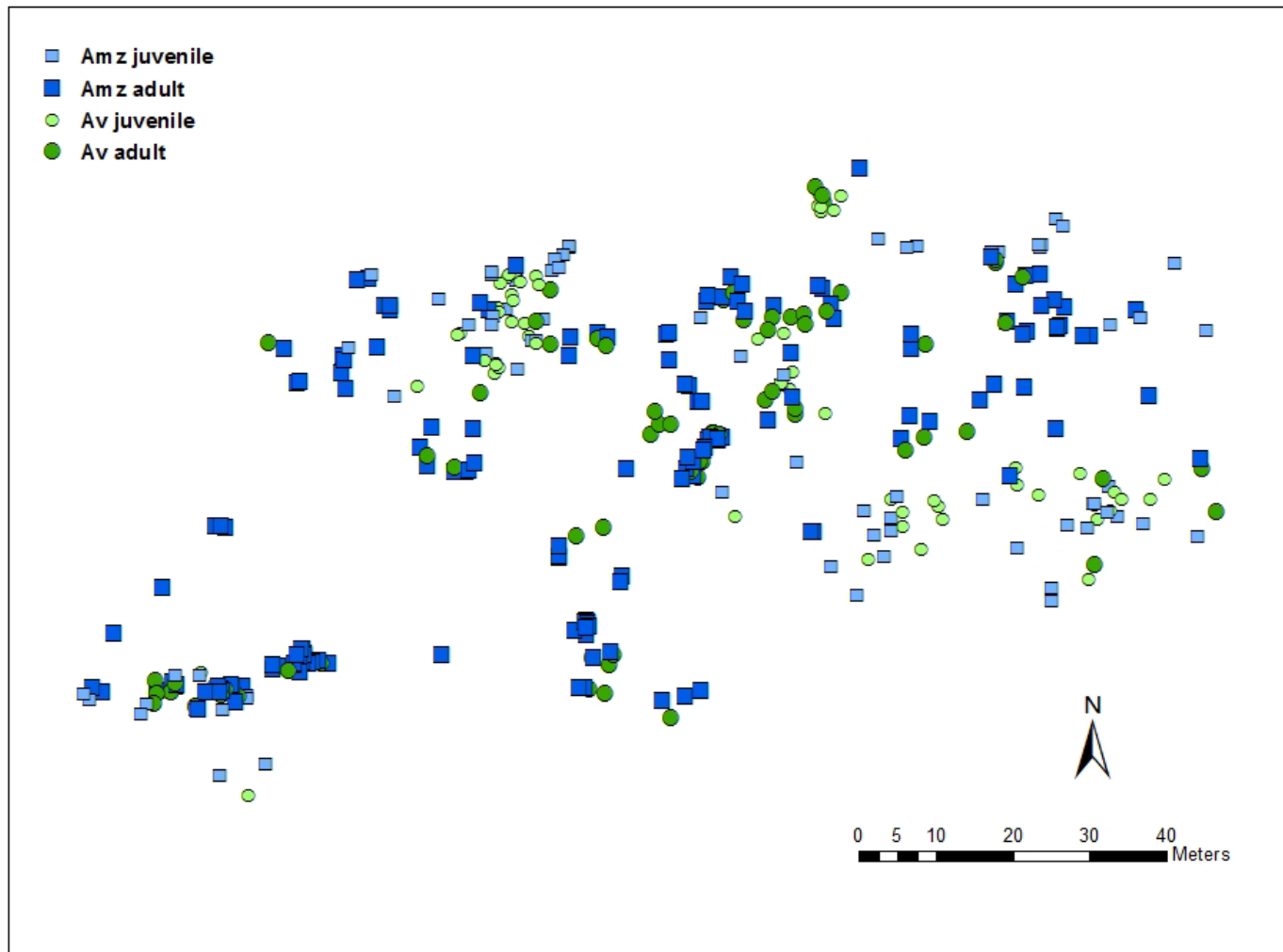
Annual fall gall census  
by ecology students

Dried galls on juvenile *Arctostaphylos viscida*

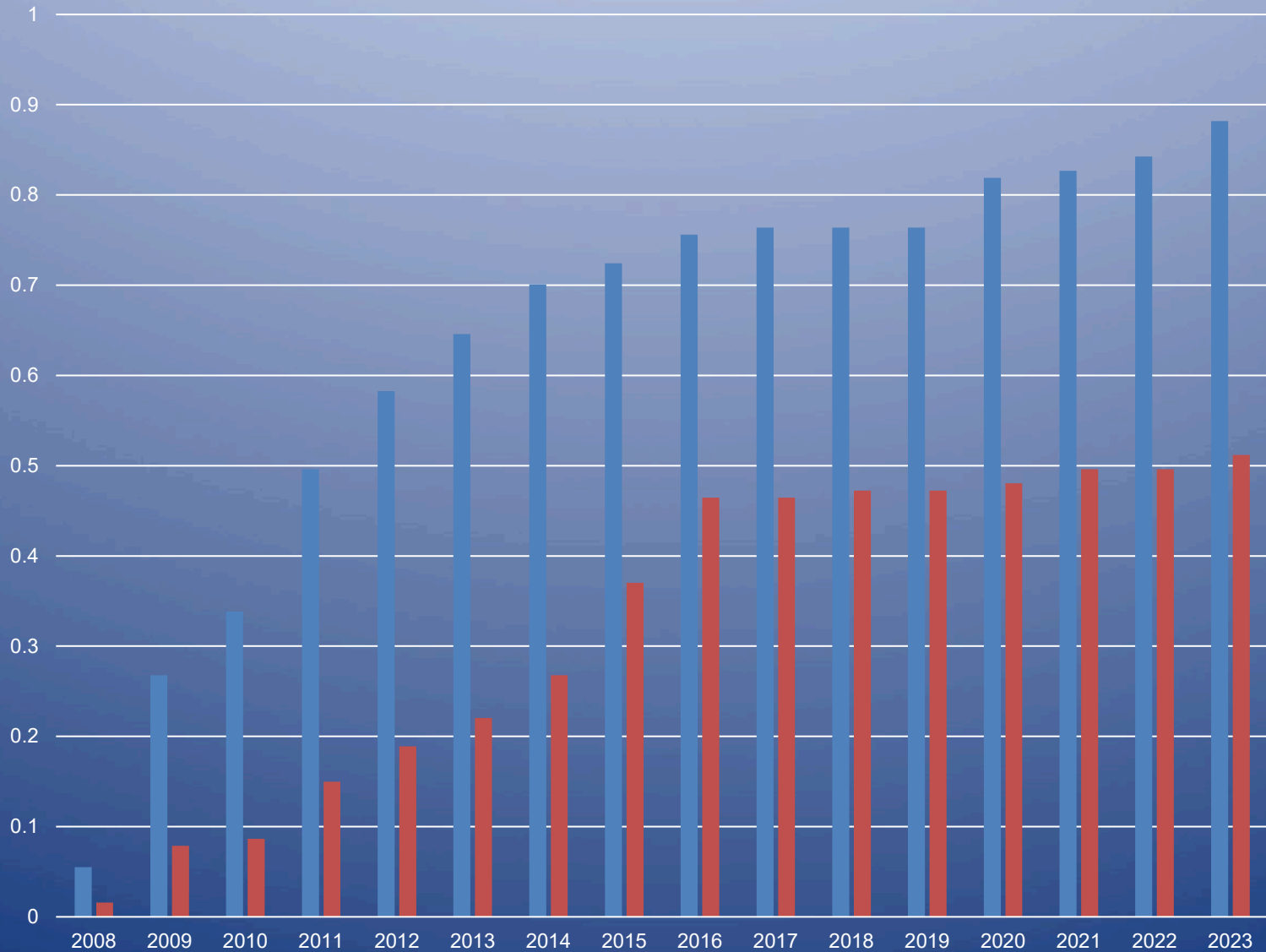


Photo by Don Miller 2015

# Species and age class of host plants in study population



# Cumulative colonization of host plants (n=135)



Mean lag between 1<sup>st</sup> galls and 1<sup>st</sup> inquilines: 2.75 yrs (n=60)  
In 18 cases, both detected in first year (no lag)

# Hypotheses on the ecology of gall-inducers and inquilines

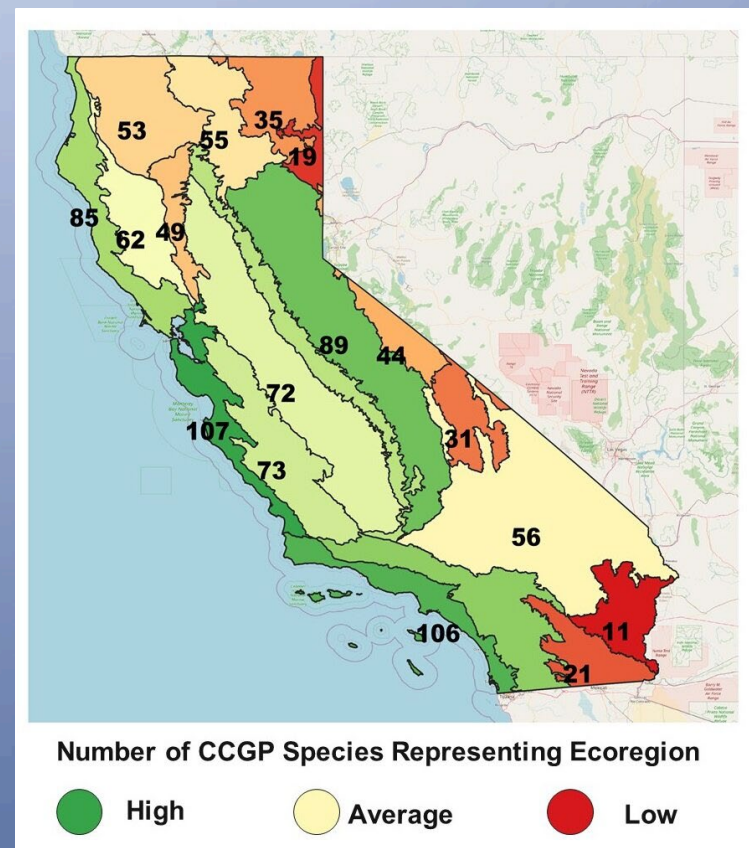
- Colonization may be function of minimum dispersal distance
- Life history strategy and small effective population size in inquilines may drive differential rates of evolution (bottleneck hypothesis)
- Population censuses may reveal dynamics of inducer and inquiline populations

# Building the most comprehensive genomic dataset ever assembled for conservation science

Project with Paul Nabity (Principal Investigator)  
Department of Botany & Plant Sciences  
UC Riverside

## Goals of California Conservation Genomics Project (CCGP):

1. Identify 150 populations with greatest genomic diversity in California's Ecoregions (including *Tamalia* gall aphids)
2. ID Ecoregions likely to be resilient under climate disruption and land-use patterns
3. Gather data on genomic structure of ecological keystone species

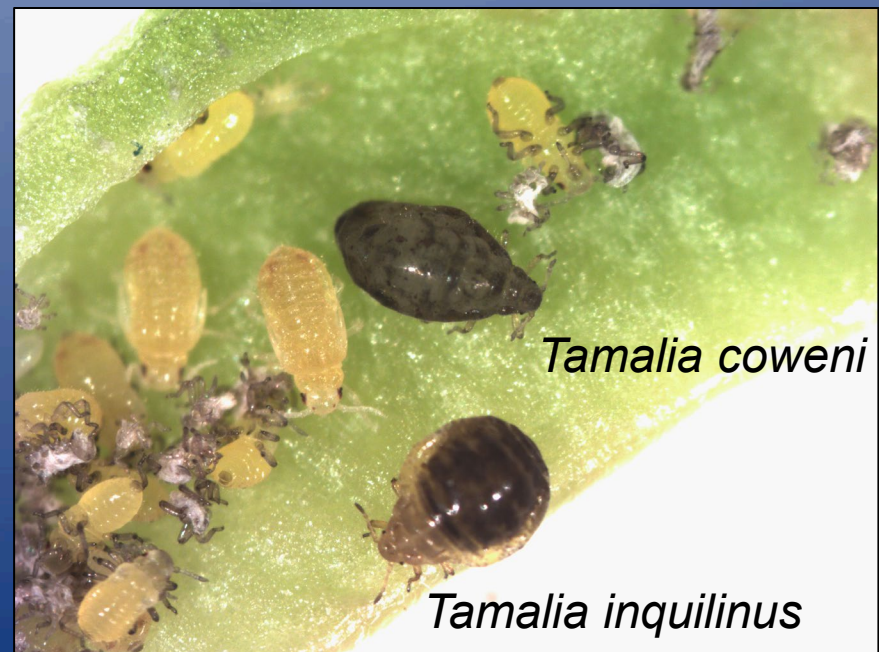




# Genomics update

- At 1.1Gb, *Tamalia coweni* genome larger than expected (likely largest aphid genome sequenced to date)
- *Tamalia inquilinus* genome considerably smaller than that of host aphid, at 700-850Mb

*Tamalia coweni* (gall-inducer) and *Tamalia inquilinus* (brood parasite) sharing gall



# Conclusions and future directions

- *Tamalia* gall aphids serve as unique example of bio-diversification along lineages of host plant, gall-inducer, & inquiline
- Both *Arctostaphylos* host plants and *Tamalia* aphids show robust recovery in the wake of fire
- Genetic and ecological diversity may be greatest where climatic and topographic features converge to promote narrow endemism
- Long-term study to be continued in wake of 2024 Park Fire



Aftermath of Park Fire (July 2024),  
a “natural experiment” in ecology

Photo by Don Miller  
January 2025

# Sunset over Granite Mountains, Mojave Desert



**CALIFORNIA  
CONSERVATION  
GENOMICS  
PROJECT**

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Photo by Don Miller