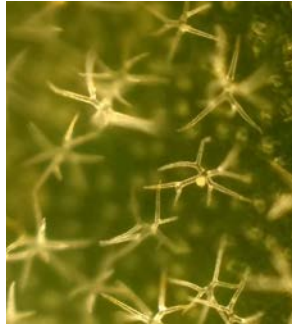


# The Rock Cress (*Boechea*) of San Diego County and Beyond



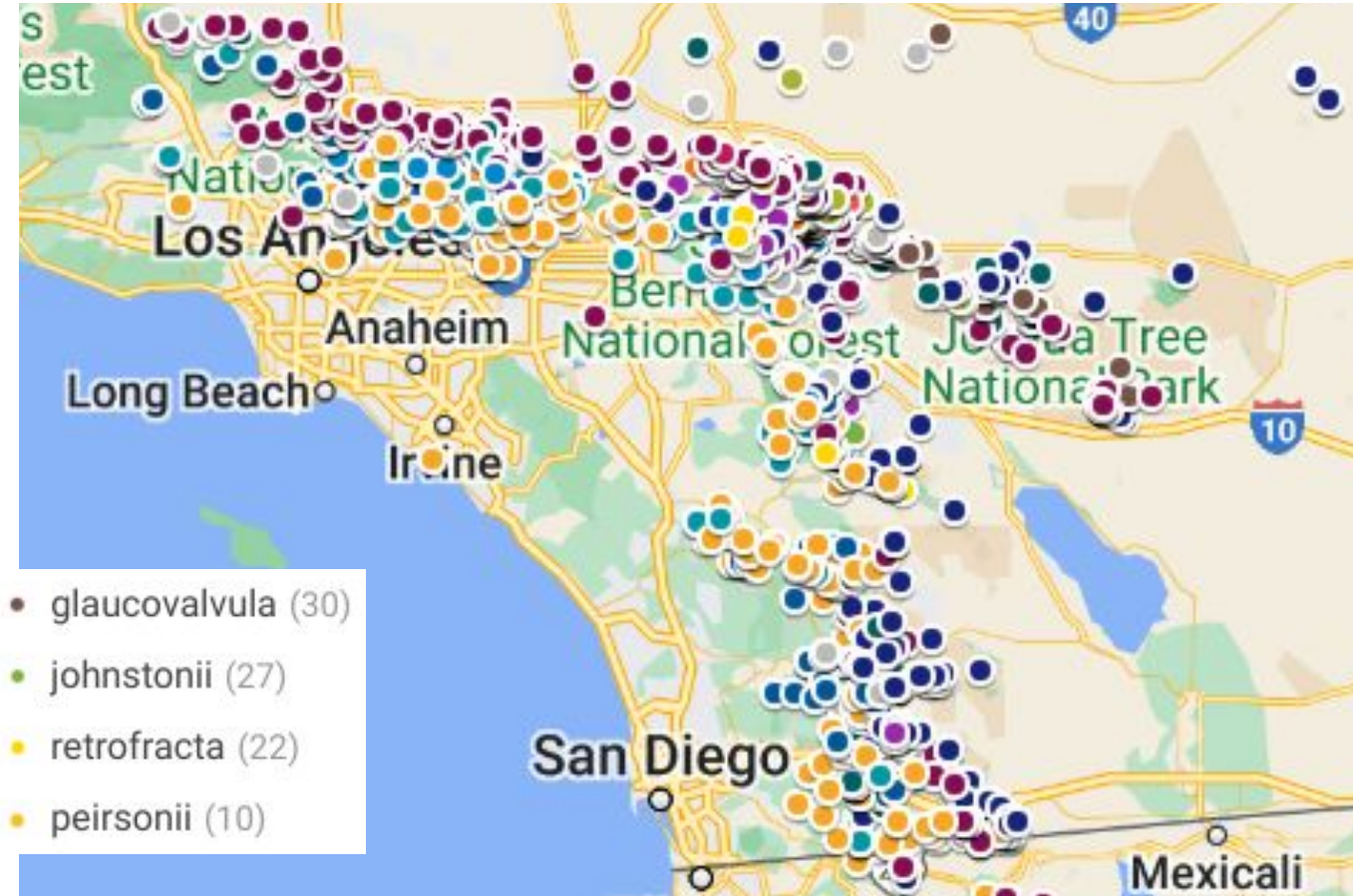
# *Boechea* Characteristics

- Brassicaceae
- mustard with small, four-petaled flower.
- purple, pink, white
- rosette body shape
- typically biennial, can live longer
- fruits are siliques
- social *Boechea* tend to be hairy



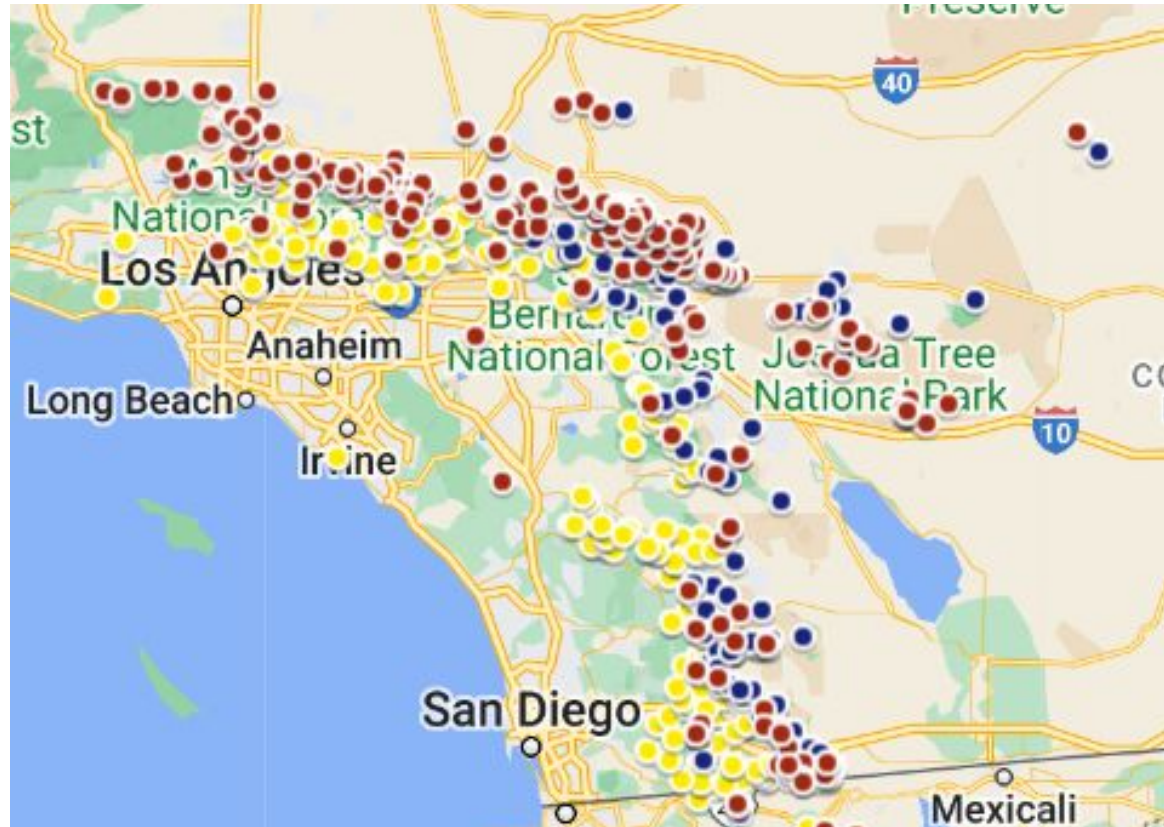
# Diverse *Boechera* species throughout in San Diego County

- pulchra (321)
- californica (279)
- perennans (205)
- parishii (192)
- sparsiflora (144)
- holboellii (135)
- platysperma (104)
- repanda (104)
- arcuata (77)
- dispar (76)
- xylopoda (64)
- shockleyi (63)



# Most common local *Boecheera*

- pulchra (321)
- californica (279)
- perennans (205)
- parishii (192)
- sparsiflora (144)
- holboellii (135)
- platysperma (104)
- repanda (104)
- arcuata (77)
- dispar (76)
- xylopoda (64)
- shockleyi (63)



*B. pulcra*



<https://sdplantatlas.org>

*B. californica*







<https://sdplantatlas.org>

*B. perennans*

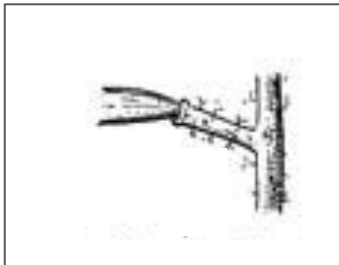


Calphotos,  
©2005 Michelle Cloud-Hughes

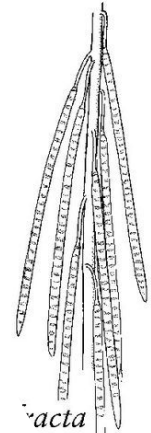
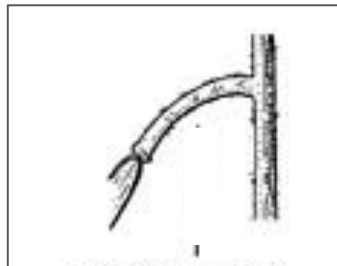
	Pedicle	Fruits	Seed	Body	Flowers
<b>B. pulcra</b>		strongly reflexed, generally appressed, 3.3--8 cm, <b>hairy.</b>	<b>2 rows</b>	Stem: generally 1 per caudex branch, from center of rosette elevated on woody base; generally 3--7.5 dm. Caudex woody.	sepals hairy; petals 9--16 mm, 2--5 mm wide, purple (white); pollen ellipsoid.
<b>B. californica</b>	 	pendent, not appressed, 6--12 cm, glabrous or sparsely hairy	<b>generally 1 row</b>	Stem: generally 1 per caudex branch. generally 3--7.5 dm. Caudex woody.	sepals hairy; petals 9--14 mm, 1.5--3 mm wide, purple (+ pink); <b>pollen spheric.</b>
<b>B. perennans</b>		pendent, not appressed, 3--7 cm, 1.7--2.1 mm wide, <b>glabrous</b>	<b>2 rows</b>	Stem: <b>generally 2--5 per caudex branch.</b> generally 2--7 dm. Caudex woody.	sepals hairy; petals 9--16 mm, 2--5 mm wide, purple (white); pollen ellipsoid.



*B. arcuata*



*B. californica* =  
B arc x arc x retro



*B. retrofracta*



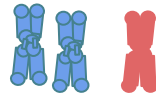
*B. arcuata*



$n = 7,$   
 $2n = 14$



*B. californica* =  
B arc x arc x retro



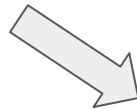
$3n = 21$



*B. retrofracta*

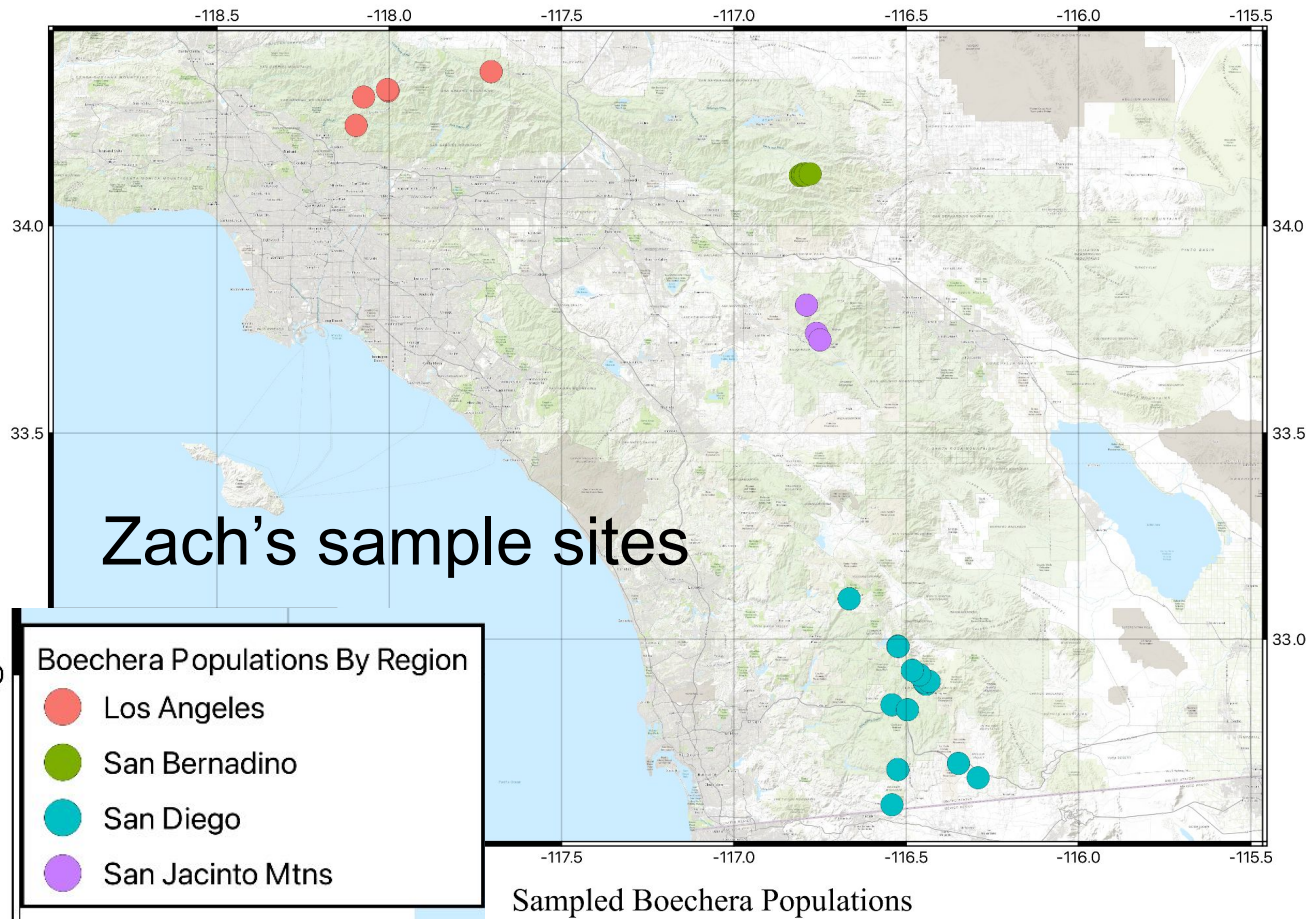
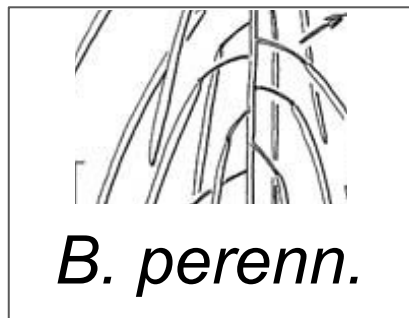
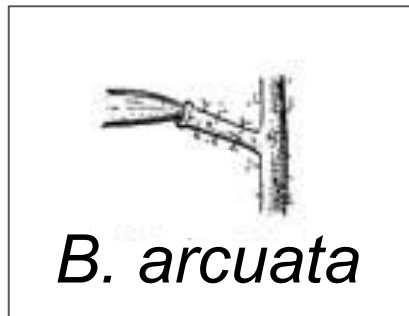


$n = 7,$   
 $2n = 14$

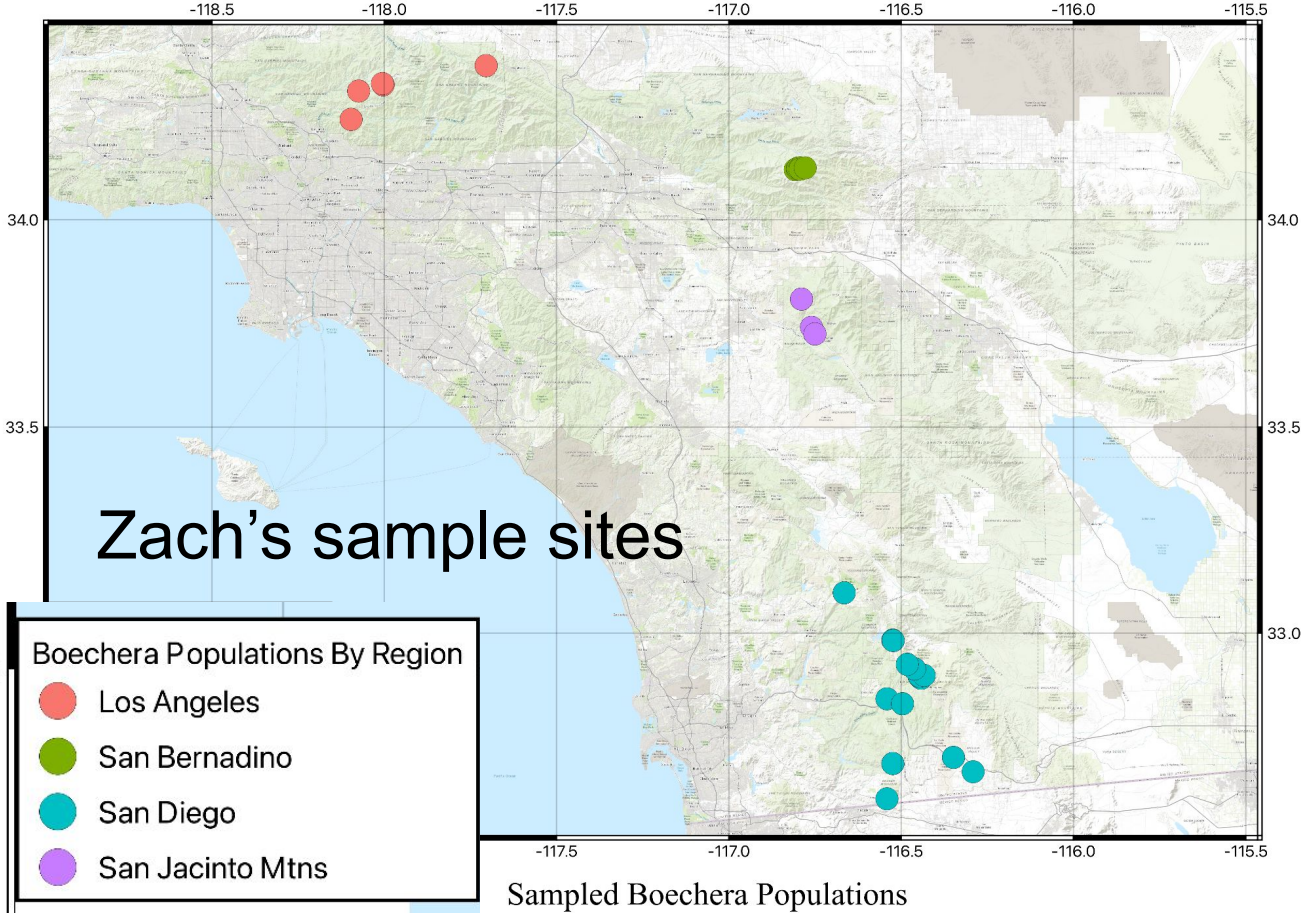
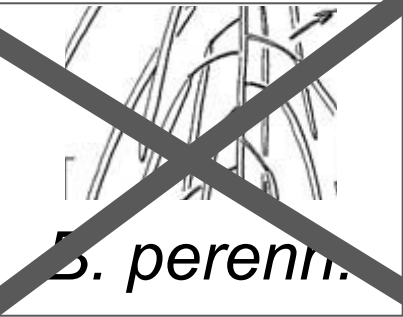
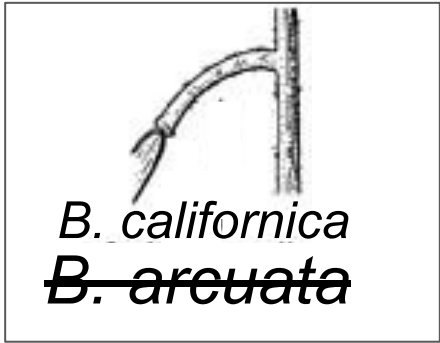




# Zach's study of *B. arcuata* and *perennans* population structure

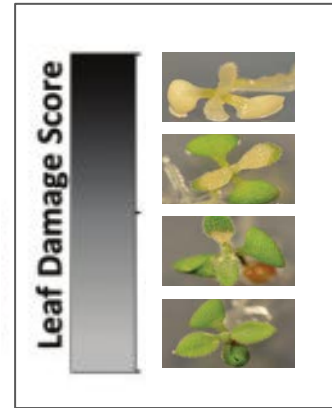
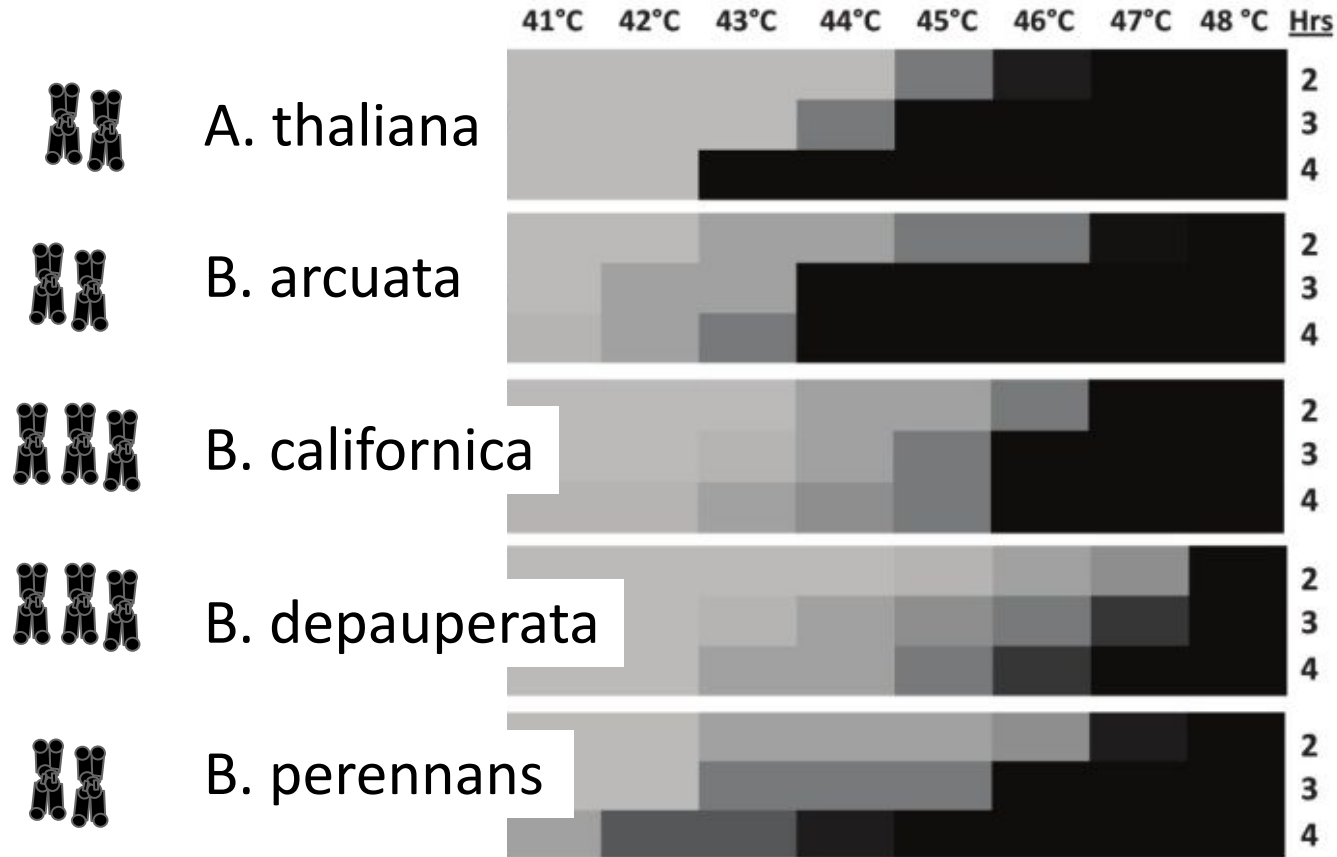


# Zach's study of *B. arcuata* and *perennans* population structure



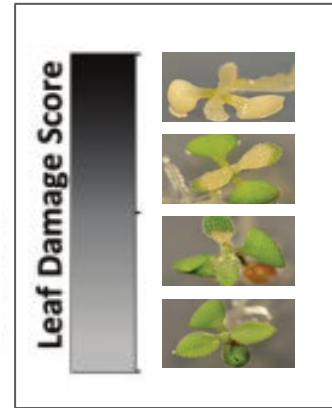
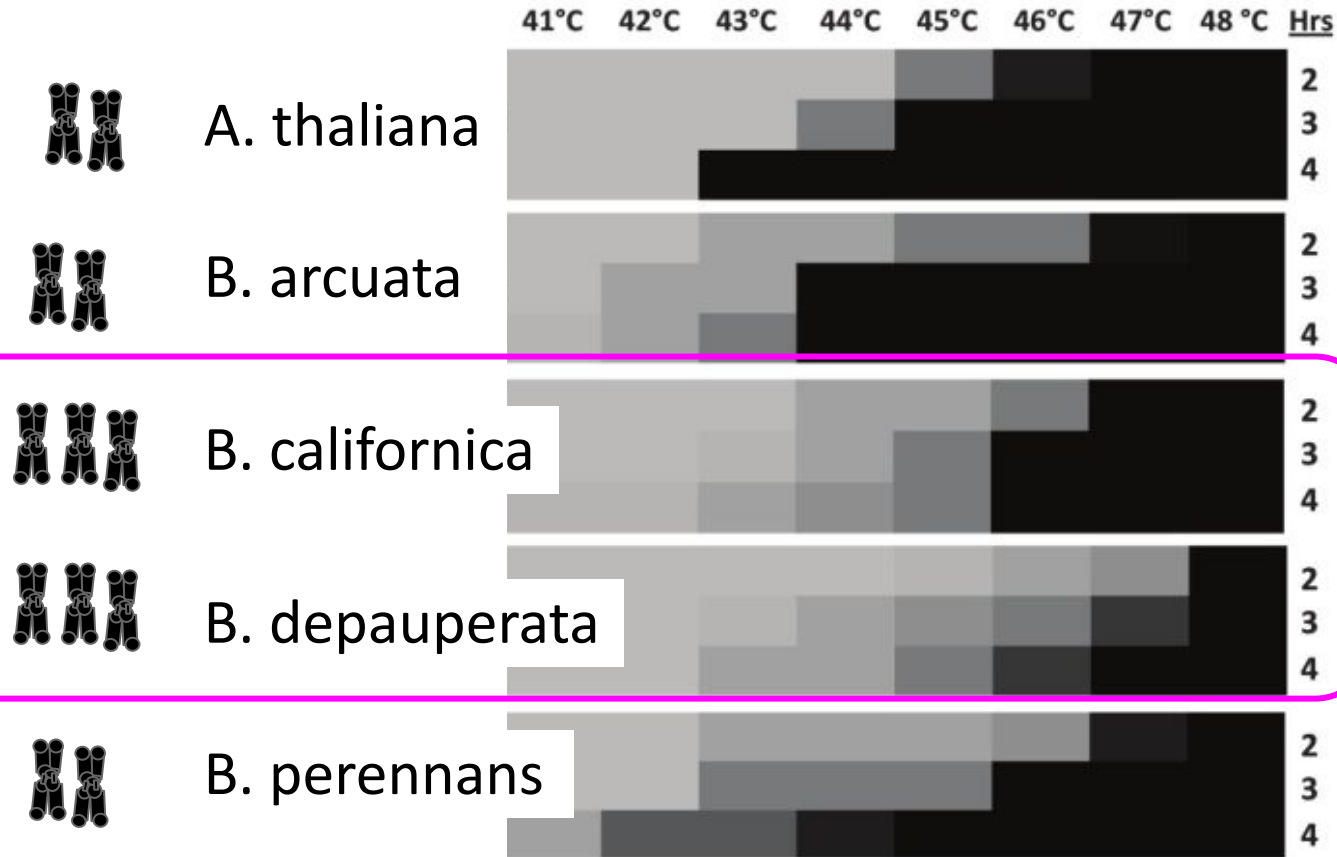
Zach Snider, unpublished. 2022

# Heat Stress Tolerance



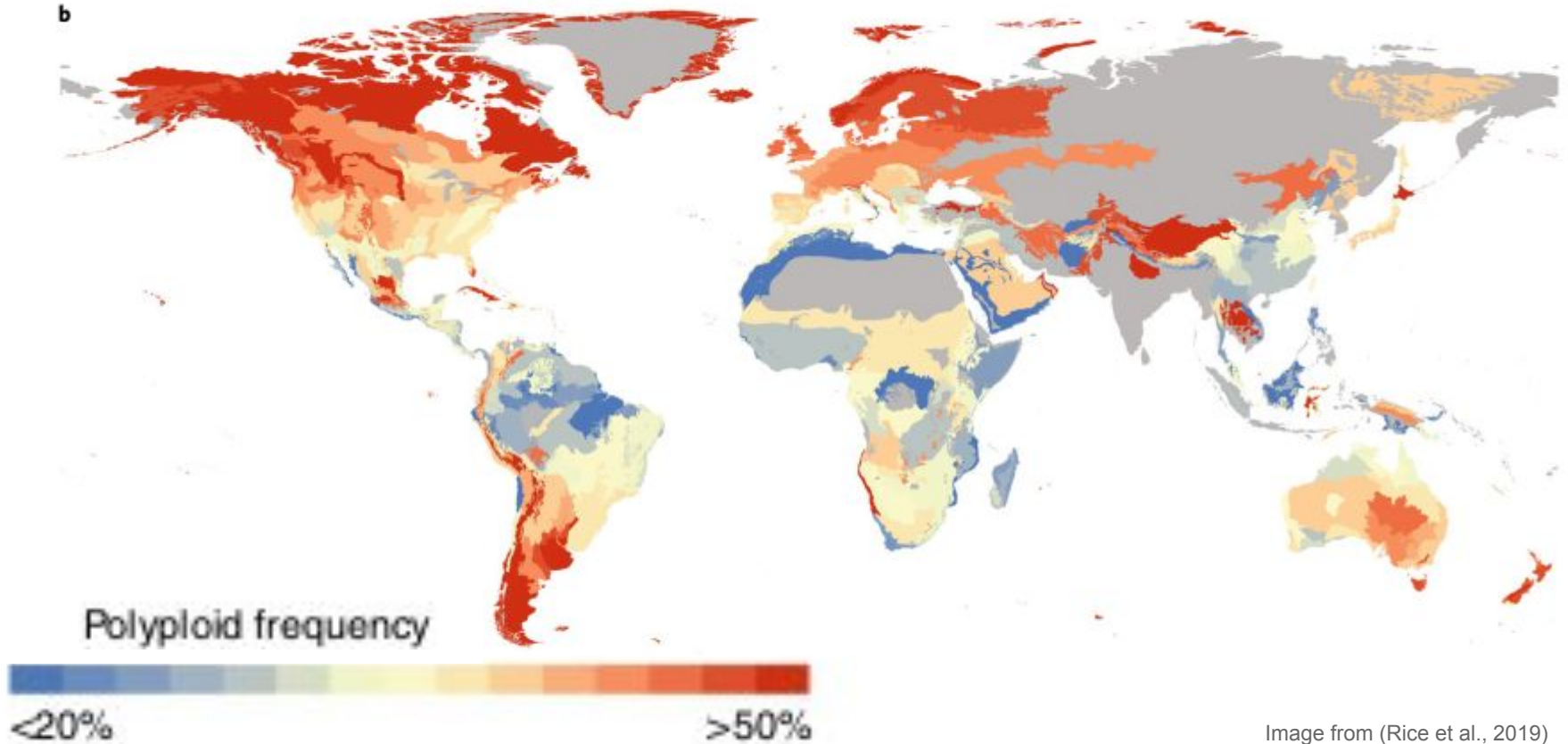
(Gallas and Waters, 2015; Halter et al., 2016)

# Heat Stress Tolerance



(Gallas and Waters, 2015; Halter et al., 2016)

# Polyploidy is more common in stressful or fragmented ecosystems



My research:

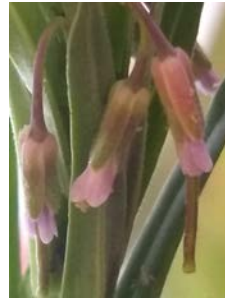
# The Evolution of a Novel Polyploid *Boecheera* of the Eastern Sierras



X



X



=



*B. lemmonii*

*B. paupercula*

*B. retrofracta*

*B. depauperata* var. *l-p-r*



$n=7$   
 $2n=14$

$n=7$   
 $2n=14$

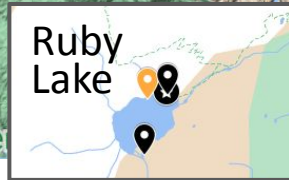
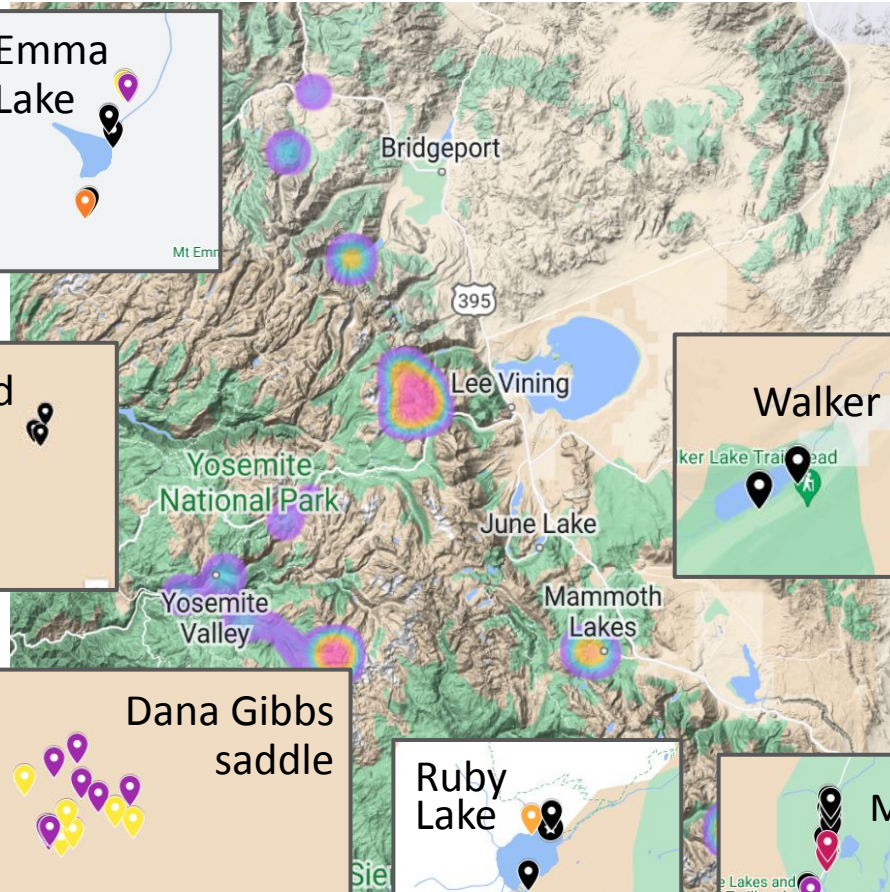
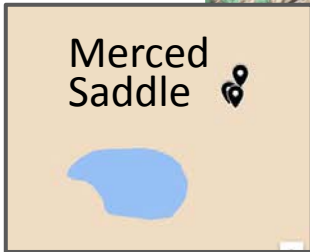
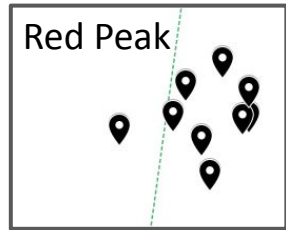
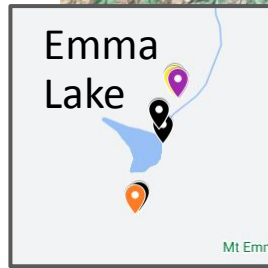
$n=7$   
 $2n=14$

$3n = 22$   
(not 21)\*

# The “*Boecheera depauperata*” triploid



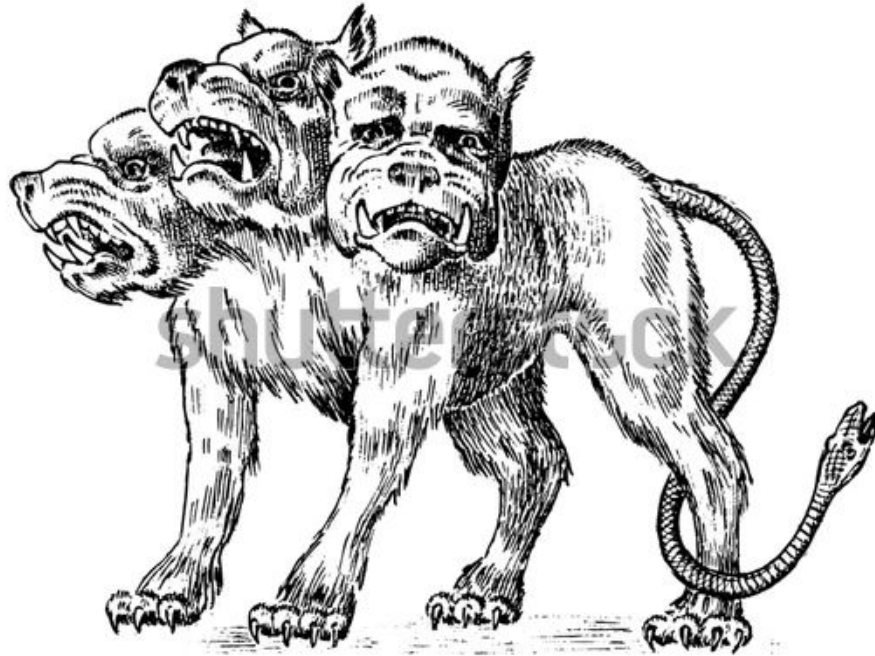
# Is *Boecheera depauperata* a rare hybrid? Or a new species?





# Why would THREE genomes be better than one?

(Nieto Feliner et al., 2020;  
Van de Peer et al., 2020; Zhang  
et al., 2020)

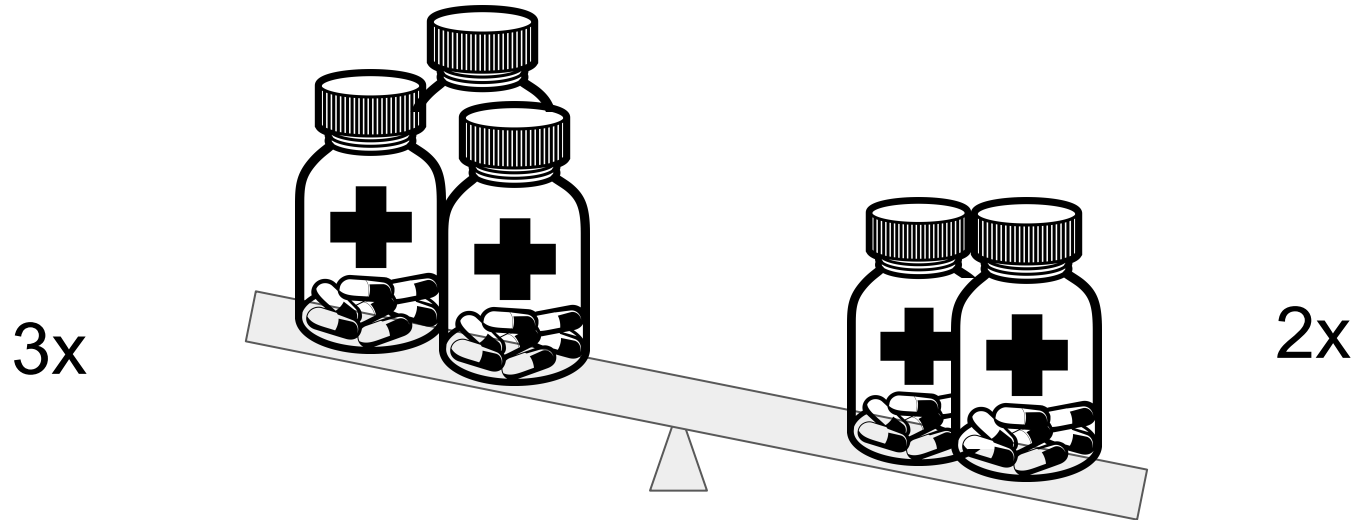


There are 3 leading hypotheses...

# Why would THREE genomes be better than one?

(Nieto Feliner et al., 2020;  
Van de Peer et al., 2020; Zhang  
et al., 2020)

H1: Maybe it's DOSAGE, and more of a particular gene product is simply better in high heat?

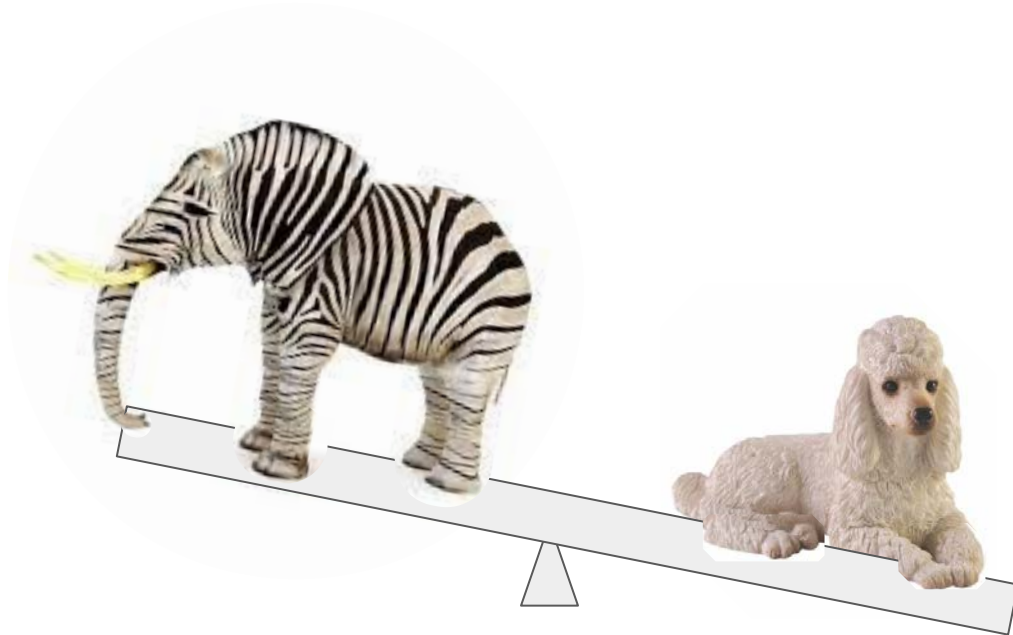


# Why would THREE genomes be better than one?

(Nieto Feliner et al., 2020;

Van de Peer et al., 2020; Zhang et al., 2020)

H2: Maybe it's HYBRID VIGOR, and dwindling diploid populations were becoming too inbred to survive on their own?



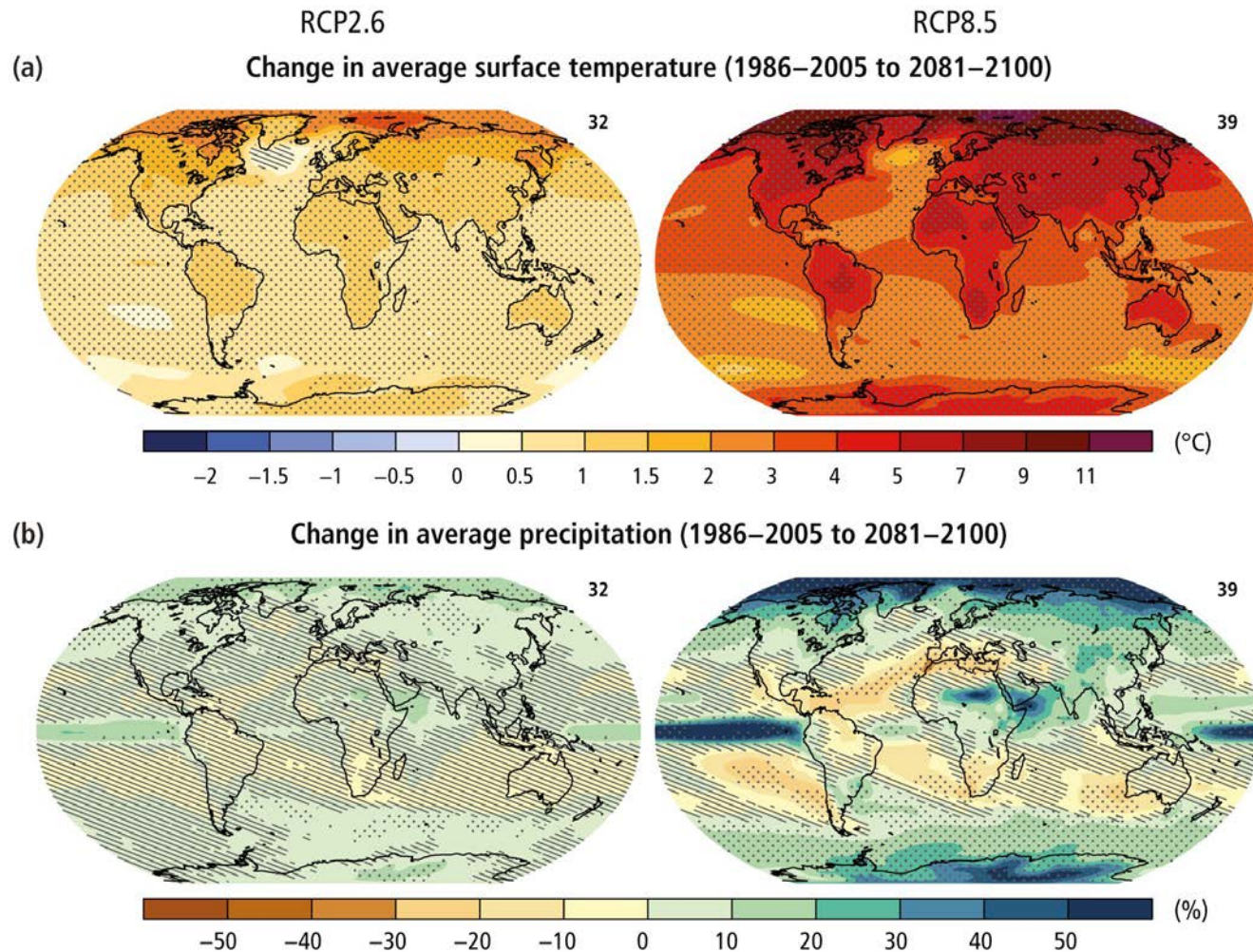
# Why would THREE genomes be better than one?

(Nieto Feliner et al., 2020;  
Van de Peer et al., 2020; Zhang  
et al., 2020)

H3: Maybe polyploidy is more UNSTABLE, and facilitates more mutations and novelty?

Eureka!





a



*ssp. pekinensis*  
Chinese cabbage



*ssp. chinensis*  
pak choi



*ssp. parachinensis*  
caixin



*ssp. rapa*  
turnip



*var. alboglabra*  
Chinese kale



*var. gongyloides*  
kohlrabi



*var l x p x r*



*ssp. chinensis var. purpurea* Bailey  
zicaitai



*ssp. narinosa*  
wutacai



*ssp. nipposinica*  
mizuna



*var. capitata*  
cabbage



*var. acephala*  
kale



*var. italica*  
broccoli



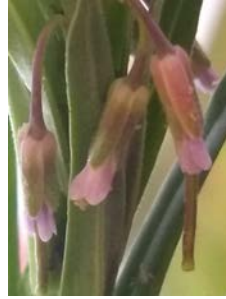
*var. botrytis*  
cauliflower



Genome resequencing and comparative variome analysis in a *Brassica rapa* and *Brassica oleracea* collection. Nature 2016

Tamsen Dunn and Dr Alison Colwell, Boechera hunting. 2021

# Acknowledgments



**Waters Lab:** Dr Liz Waters, Zach Snider, Talieh Ostevar, Jeff Campbell, Allana Leighton, Courtney Cameron, Chynna Bowman, Michaela Cato

**Committee Members:** Dr. Liz Waters, Dr. Danelle Seymour, Dr. Jason Stajich, Dr. Jeet Sukumaran

**Mentors:** Dr. Michael Windham, Dr. James Beck, Dr. Alison Colwell, Dr. Teri Mandekova, Dr. Arun Sethumaran, Dr. Michael Simpson, Dr. Lluvia Flores-Renteria

**Funding sources:** Waters lab funds, California Native Plant Society

## *Boecheera arcuata* (Nutt.) Windham & Al-Shehbaz

### NATIVE

**Habit:** Caudex +- woody. **Stem:** generally 1 per caudex branch, from center of basal rosette at ground surface or elevated on woody base; generally 3--8 dm, proximally with simple and short-stalked, 2-rayed hairs 0.4--1 mm. **Leaf:** basal 2--12 mm wide, generally entire, hairs generally short-stalked, 2--5-rayed, 0.4--0.8 mm; cauline 10--45, distal hairy, basal lobes 2--6 mm. **Inflorescence:** 12--70-flowered, 1-sided in fruit; fruit pedicel spreading-ascending (horizontal), +- recurved or straight, 8--22 mm, hairs +- appressed, 2--4-rayed. **Flower:** sepals hairy; petals 9--14 mm, 2--4 mm wide, purple; pollen ellipsoid. **Fruit:** spreading-ascending (horizontal), not appressed, 6--13 cm, 1.5--2.2 mm wide, glabrous or with few hairs; style < 0.5 mm; ovules 90--250. **Seed:** generally in 1 row, 1.5--1.7 mm; wing 0.1--0.2 mm wide.

**Ecology:** Rocky hillsides, cliffs, in pine forest, chaparral; **Elevation:** 300--2000 m. **Bioregional Distribution:** SNF, s SCoR, SCo, TR.

## *Boecheera pulchra* (M.E. Jones ex S. Watson) W.A. Weber

### NATIVE

**Habit:** Caudex woody. **Stem:** generally 1 per caudex branch, from center of rosette elevated on woody base; generally 3--7.5 dm, proximally with short-stalked, generally 4--7-rayed hairs 0.1--0.3 mm. **Leaf:** basal 1--3 mm wide, entire; hairs short-stalked, 4--9-rayed, 0.1--0.3 mm; cauline 10--30, distal hairy, basal lobes 0 (to < 0.5 mm). **Inflorescence:** 8--25-flowered, occasionally generally +- 1-sided in fruit; fruit pedicel reflexed, abruptly recurved at base, 8--16 mm, hairs appressed, branched. **Flower:** sepals hairy; petals 9--16 mm, 2--5 mm wide, purple (white); pollen ellipsoid. **Fruit:** strongly reflexed, generally appressed, 3.3--8 cm, 2.5--4 mm wide, hairy throughout; style 0.1--0.3 mm; ovules 68--106. **Seed:** in 2 rows, 1.7--2.8 mm; wing 0.25--0.65 mm wide.

**Ecology:** Rocky, gravelly, sandy slopes in chaparral, sagebrush scrub, evergreen woodland; **Elevation:** 600--2800 m. **Bioregional**

**Distribution:** e&s SN, s GV, s SCoR, TR, PR, SNE, DMoj

## *Boecheera californica* (Rollins) Windham & Al-Shehbaz

### NATIVE

**Habit:** Caudex woody. **Stem:** generally 1 per caudex branch, from center of basal rosette on elevated woody bases; generally > 3.5 dm, proximally with short-stalked, 2--4 rayed hairs 0.3--0.9 mm. **Leaf:** basal 3--13 mm wide, entire (minutely dentate), hairs short-stalked, 4--8-rayed, 0.2--0.5 mm; cauline 12--55, distal hairy, basal lobes 1--6 mm. **Inflorescence:** 30--120-flowered, not 1-sided in fruit; fruit pedicel descending to horizontal, +- recurved (straight), 4--20 mm, hairs appressed, 3--7-rayed. **Flower:** sepals hairy; petals 9--14 mm, 1.5--3 mm wide, purple (+- pink); pollen spheric. **Fruit:** pendent, not appressed, 6--12 cm, 1.5--2.5 mm wide, glabrous or sparsely hairy throughout; style < 0.3 mm; ovules 140--180. **Seed:** generally in 1 row, 1.7--2 mm; wing 0.2--0.4 mm wide.

**Ecology:** Rocky slopes, gravelly soil, in chaparral, oak woodland; **Elevation:** 350--2300 m. **Bioregional Distribution:** CCo, SW;



## *Boechera perennans* (S. Watson) W.A. Weber

### NATIVE

**Habit:** Caudex woody. **Stem:** generally 2--5 per caudex branch, arising laterally below sterile shoot or leaf rosette, generally elevated on woody base; generally 2--7 dm, proximally with short-stalked, 2-rayed hairs 0.2--0.4 mm, generally mixed with 3--5-rayed (or simple) hairs. **Leaf:** basal generally 3--15 mm wide, dentate; hairs short-stalked, 3--6-rayed, 0.2--0.4 mm; cauline 4--17, distal glabrous, basal lobes 0.5--3.5 mm.

**Inflorescence:** 16--35-flowered, not 1-sided in fruit; fruit pedicel +- horizontal near base, generally +- recurved near tip, 6--25 mm, glabrous or hairs few. **Flower:** sepals hairy; petals 5--9 mm, 1--1.5 mm wide, white to +- purple; pollen ellipsoid. **Fruit:** pendent, not appressed, 3--7 cm, 1.7--2.1 mm wide, glabrous; style 0.05--0.4 mm; ovules 60--96. **Seed:** in 1 row, 1.1--1.5 mm; wing 0.1--0.2 mm wide. **Chromosomes:**  $2n=14$ .

**Ecology:** Rocky slopes, gravelly soil, desert, chaparral, low montane habitats; **Elevation:** 500--2000 m. **Bioregional Distribution:** e SNH, SnGb, SnBr, e PR, SNE, D;

