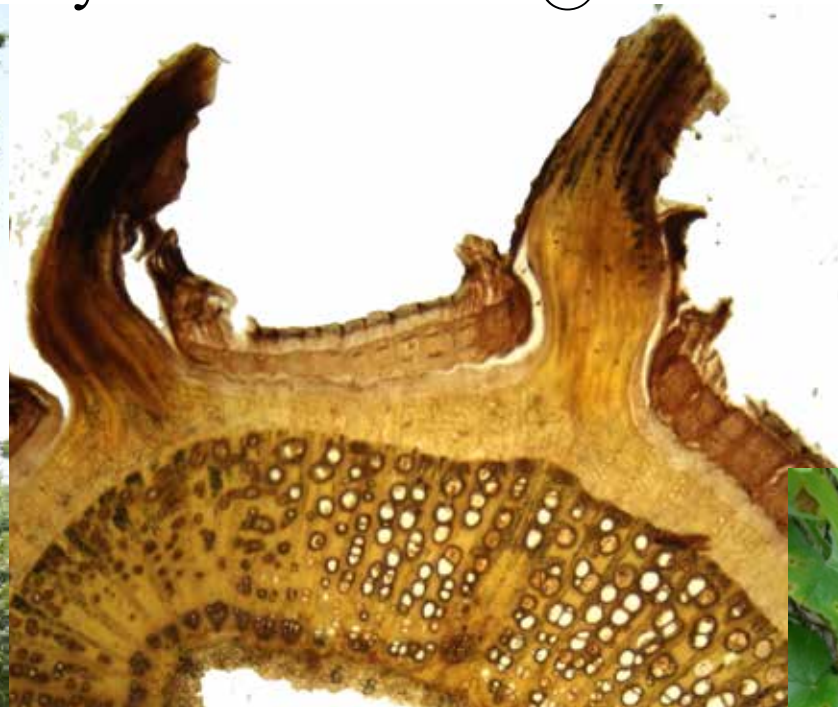


Can We Breed Better Drought and Salt Resistance into Grape Rootstocks

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Acknowledgements

- California Grape Rootstock Improvement Commission / California Grape Rootstock Research Foundation
- CDFA NT, FT, GV Improvement Advisory Board
- California Table Grape Commission
- American Vineyard Foundation
- E&J Gallo Winery
- Louis P. Martini Endowed Chair in Viticulture

Rootstock Origin



- First developed to address grape phylloxera in the late 1800s
- The French came to the US to collect species resistant to phylloxera
- Took back cuttings of many, but only *V. riparia* and *V. rupestris* rooted well from dormant cuttings
- Later added *V. berlandieri* for lime tolerance

V. riparia



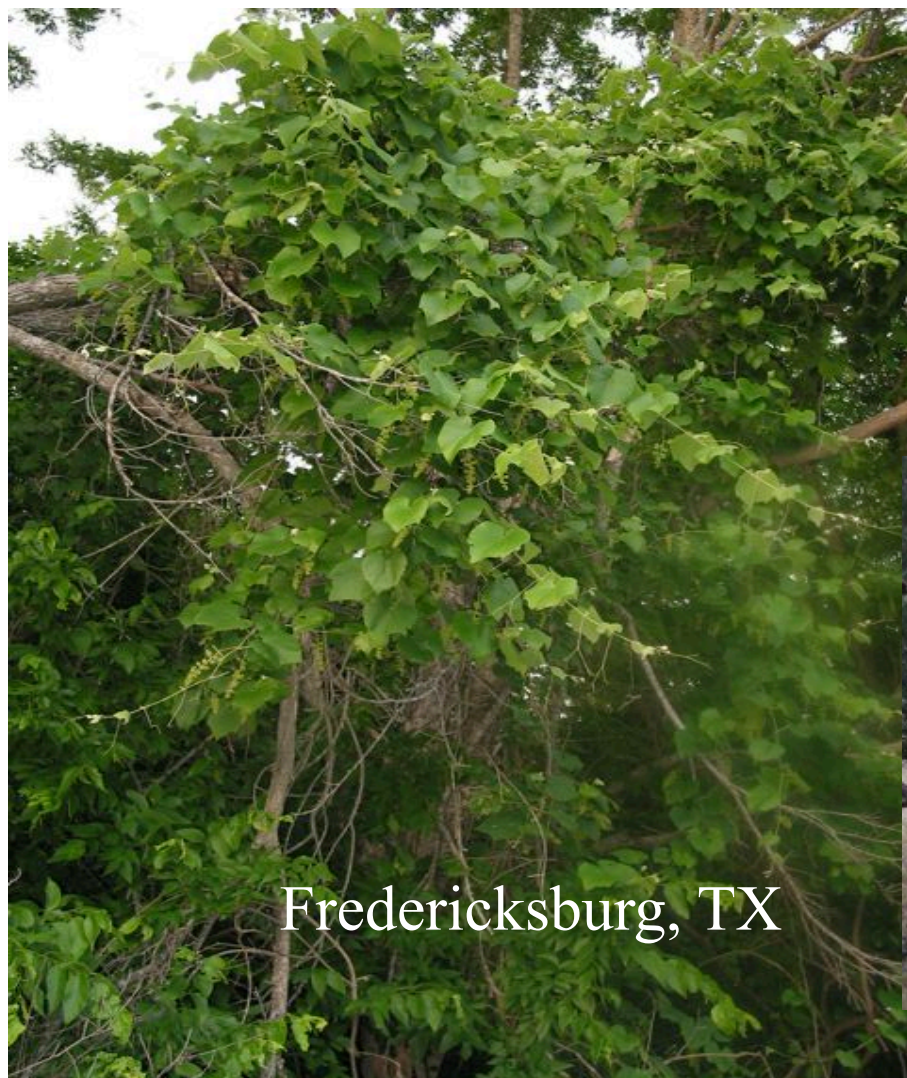
Missouri River

V. rupestris



Jack Fork River, MO

V. berlandieri



Which rootstock to choose?

- *riparia* based – shallow roots, water sensitive, low vigor, early maturity:
 - 5C, 101-14, 16161C (3309C)
- *rupestris* based – broadly distributed roots, relatively drought tolerant, moderate to high vigor, midseason maturity:
 - St. George, 1103P, AXR#1 (3309C)

Which rootstock to choose?

- *berlandieri* based – deeper roots, drought tolerant, higher vigor, delayed maturity:
 - 110R, 140Ru (420A, 5BB)
- Site trumps all... soil depth, rainfall, soil texture, water table

Drought Resistance: What is needed?

- Understanding drought adaption vs drought resistance
- Can we un-couple rooting depth from drought adaptation/resistance?
- What is the relationship of seasonality to rooting depth and rootstock parentage?
- Kevin Fort, Jake Uretsky, Jean Dodson, Joaquin Fraga, Cecilia Osorio

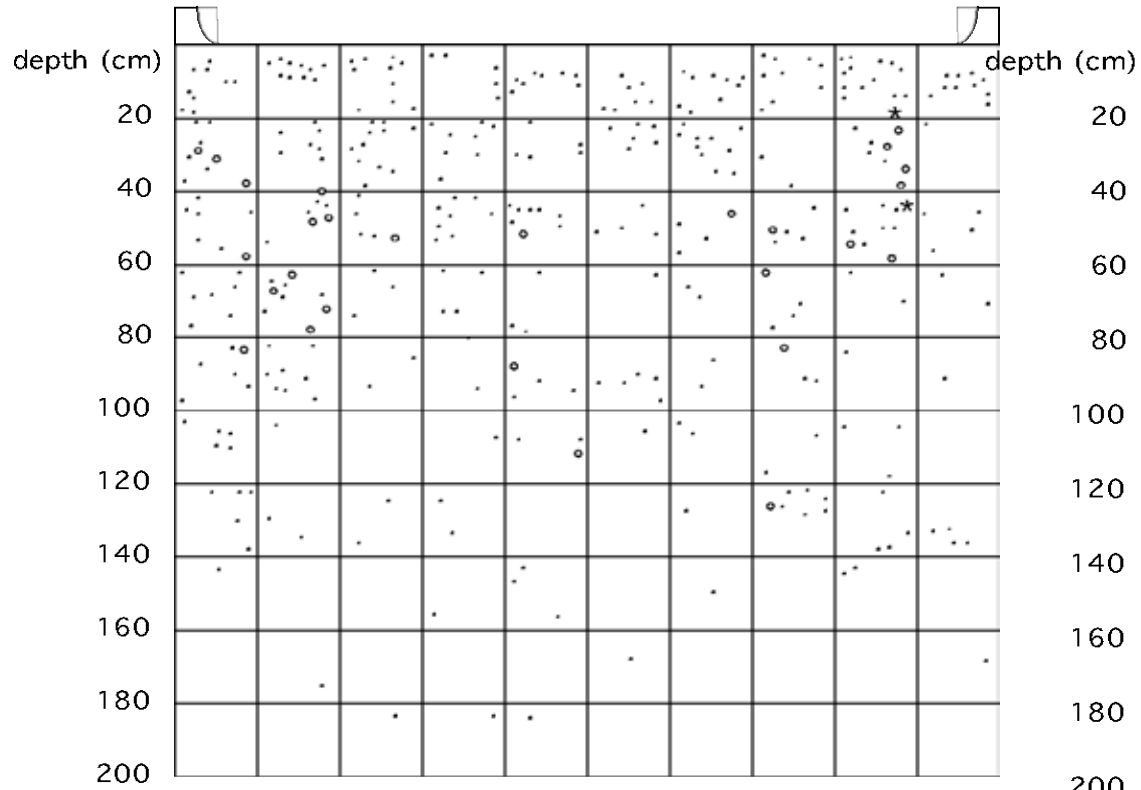
Breeding Rootstocks to Tolerate Drought, and Control Growth and Phenology

- In collaboration with Andrew McElrone
- Root architecture – shallow to deep rooting angles
- Root density – two tiered to even distributions
- Fine root recovery after drought
- Hydraulic lift
- Structural roots – which persist
- Control of vigor and leaf longevity

Root architecture

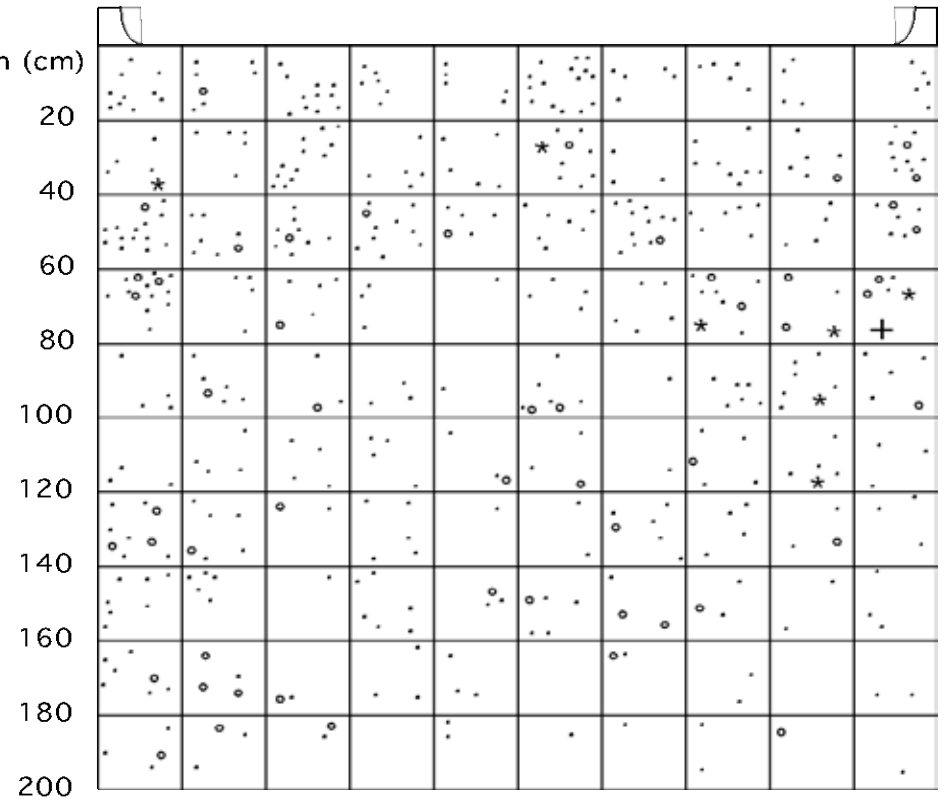
- The root system of rootstocks can be deeply penetrating or shallow – reflects its water needs and utilization
- The density of roots in the soil profile also varies
 - Evenly distributed
 - Primarily deep
 - Primarily shallow

420 A



- = < 2 mm
- = ≥ 2 and < 5 mm
- * = ≥ 5 and < 12 mm
- + = ≥ 12 mm

110 R

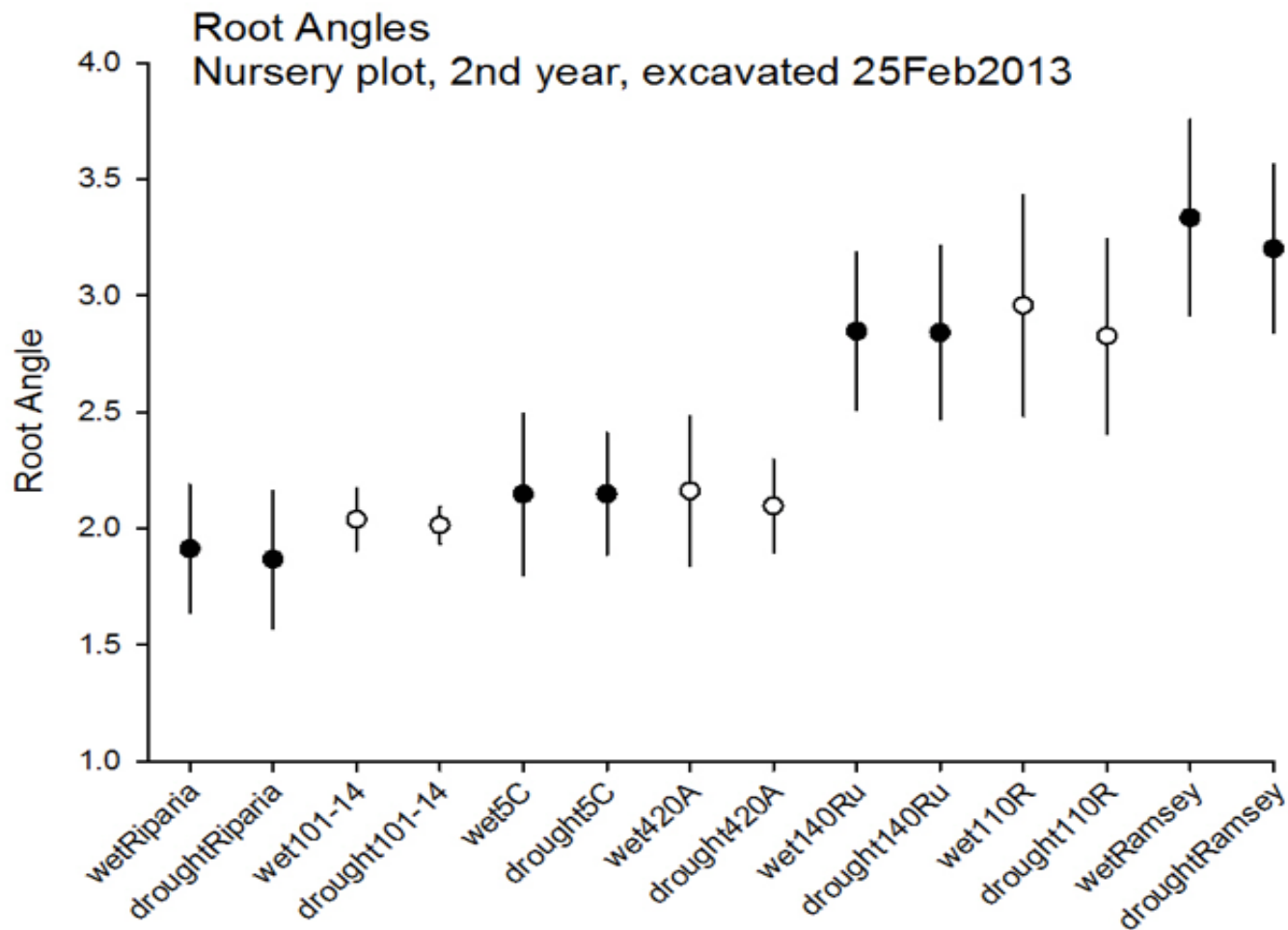


- = < 2 mm
- = ≥ 2 and < 5 mm
- * = ≥ 5 and < 12 mm
- + = ≥ 12 mm

Root architecture from field-grown vines: Cecilia Osorio / Kevin Fort



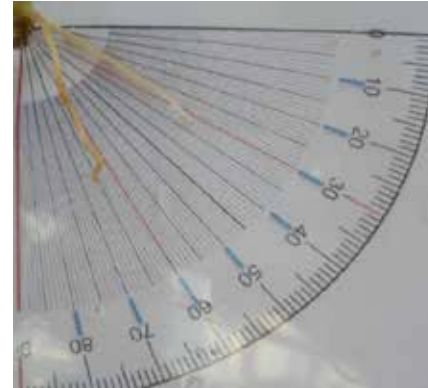
Root angles from field-grown vines: Stable root architecture regardless of watering regime



Rooting angles reflect drought resistance and vigor



Riparia Gloire / Ramsey

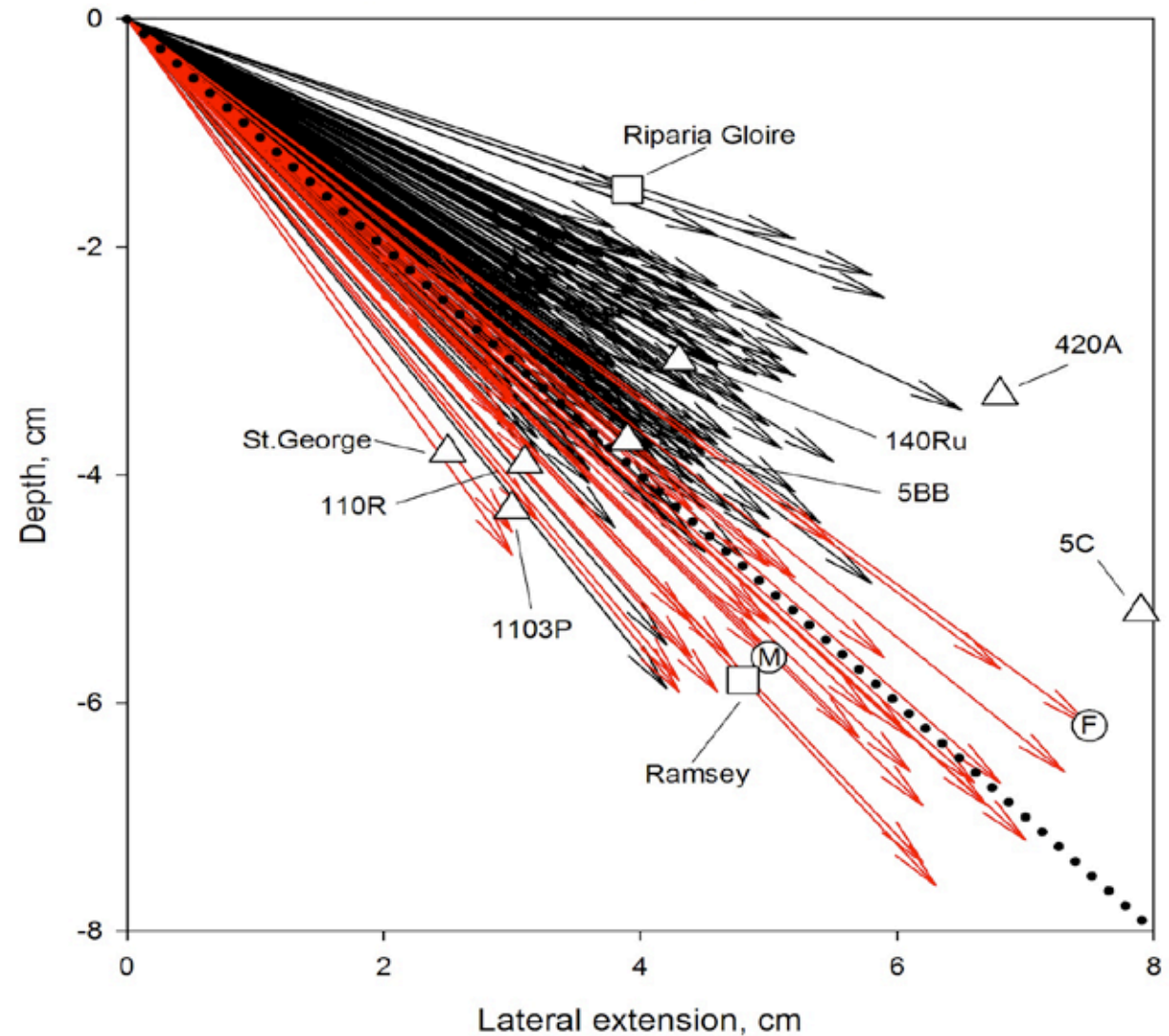


1.1	2.1	3.1	4.1	5.1	6.1	7.1	8.1	9.1	10.1	11.1	12.1	13.1	14.1	15.1	16.1	17.1	18.1	19.1	20.1
2.2	3.2	4.2	5.2	6.2	7.2	8.2	9.2	10.2	11.2	12.2	13.2	14.2	15.2	16.2	17.2	18.2	19.2	20.2	21.2
3.3	4.3	5.3	6.3	7.3	8.3	9.3	10.3	11.3	12.3	13.3	14.3	15.3	16.3	17.3	18.3	19.3	20.3	21.3	22.3
4.4	5.4	6.4	7.4	8.4	9.4	10.4	11.4	12.4	13.4	14.4	15.4	16.4	17.4	18.4	19.4	20.4	21.4	22.4	23.4
5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	19.5	20.5	21.5	22.5	23.5	24.5
6.6	7.6	8.6	9.6	10.6	11.6	12.6	13.6	14.6	15.6	16.6	17.6	18.6	19.6	20.6	21.6	22.6	23.6	24.6	25.6
7.7	8.7	9.7	10.7	11.7	12.7	13.7	14.7	15.7	16.7	17.7	18.7	19.7	20.7	21.7	22.7	23.7	24.7	25.7	26.7
8.8	9.8	10.8	11.8	12.8	13.8	14.8	15.8	16.8	17.8	18.8	19.8	20.8	21.8	22.8	23.8	24.8	25.8	26.8	27.8
9.9	10.9	11.9	12.9	13.9	14.9	15.9	16.9	17.9	18.9	19.9	20.9	21.9	22.9	23.9	24.9	25.9	26.9	27.9	28.9
10.10	11.10	12.10	13.10	14.10	15.10	16.10	17.10	18.10	19.10	20.10	21.10	22.10	23.10	24.10	25.10	26.10	27.10	28.10	29.10
11.11	12.11	13.11	14.11	15.11	16.11	17.11	18.11	19.11	20.11	21.11	22.11	23.11	24.11	25.11	26.11	27.11	28.11	29.11	30.11
12.12	13.12	14.12	15.12	16.12	17.12	18.12	19.12	20.12	21.12	22.12	23.12	24.12	25.12	26.12	27.12	28.12	29.12	30.12	31.12
13.13	14.13	15.13	16.13	17.13	18.13	19.13	20.13	21.13	22.13	23.13	24.13	25.13	26.13	27.13	28.13	29.13	30.13	31.13	32.13
14.14	15.14	16.14	17.14	18.14	19.14	20.14	21.14	22.14	23.14	24.14	25.14	26.14	27.14	28.14	29.14	30.14	31.14	32.14	33.14
15.15	16.15	17.15	18.15	19.15	20.15	21.15	22.15	23.15	24.15	25.15	26.15	27.15	28.15	29.15	30.15	31.15	32.15	33.15	34.15
16.16	17.16	18.16	19.16	20.16	21.16	22.16	23.16	24.16	25.16	26.16	27.16	28.16	29.16	30.16	31.16	32.16	33.16	34.16	35.16
17.17	18.17	19.17	20.17	21.17	22.17	23.17	24.17	25.17	26.17	27.17	28.17	29.17	30.17	31.17	32.17	33.17	34.17	35.17	36.17

1. Initial finding: F1 generation is 100% “dominant down”
2. Current work: attempting to recover the shallow phenotype in the F2 generation

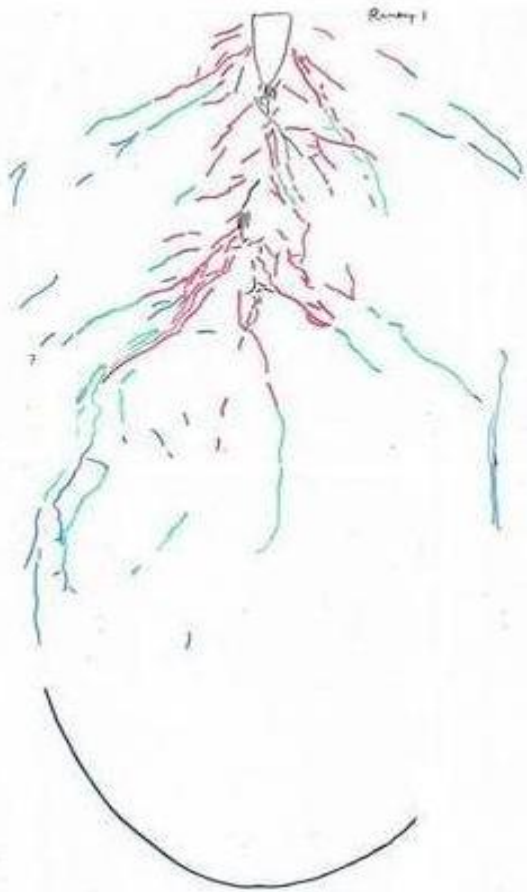
**Commercial
rootstocks
perform
according to
expectation with
this assay, and
provide
perspective for
the hybrid
analysis**

Mean root angle vector,
Ramsey x Riparia hybrids
159 F2 genotypes (black)
40 F1 genotypes (red)
dotted line is 45 degree reference line
Circles are F2 parents (M = male parent, F = female parent)

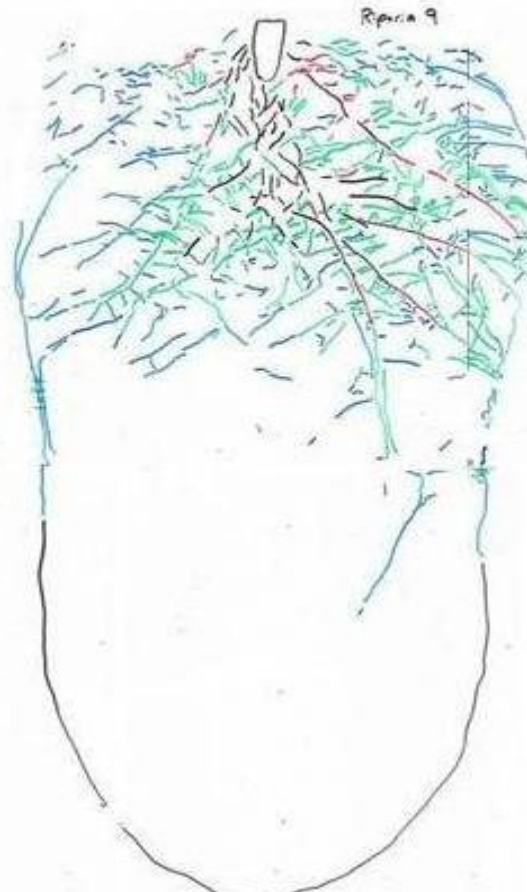


Rhizotrons: Charting root development

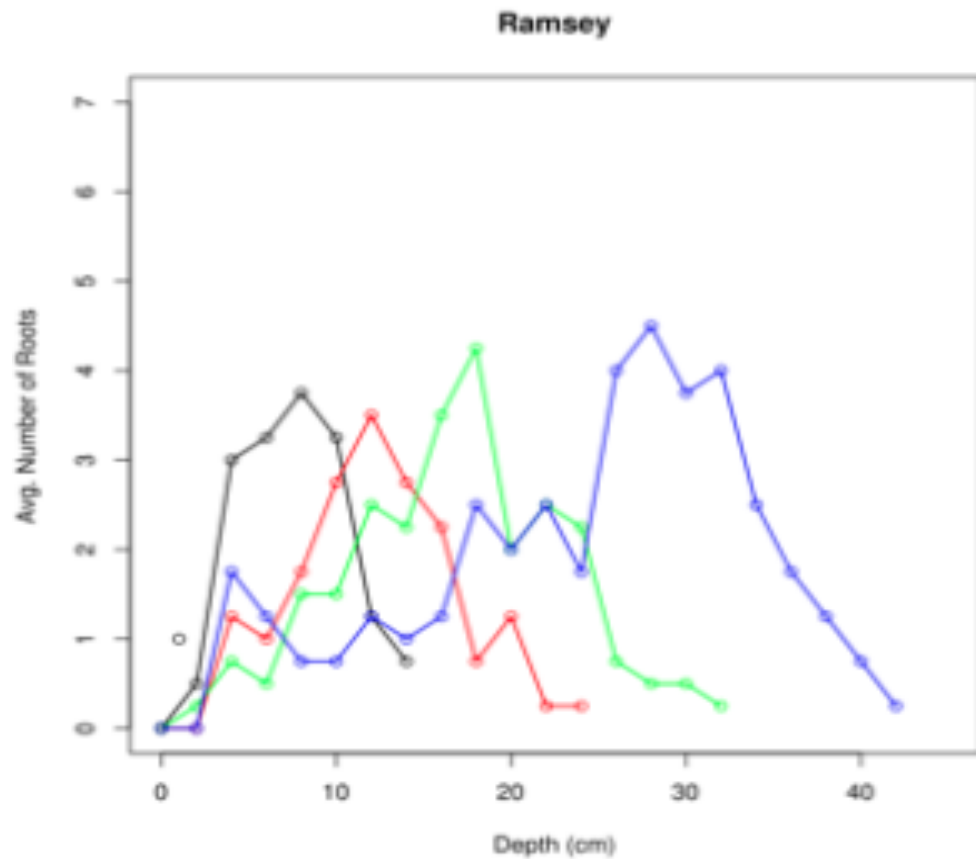
Ramsey



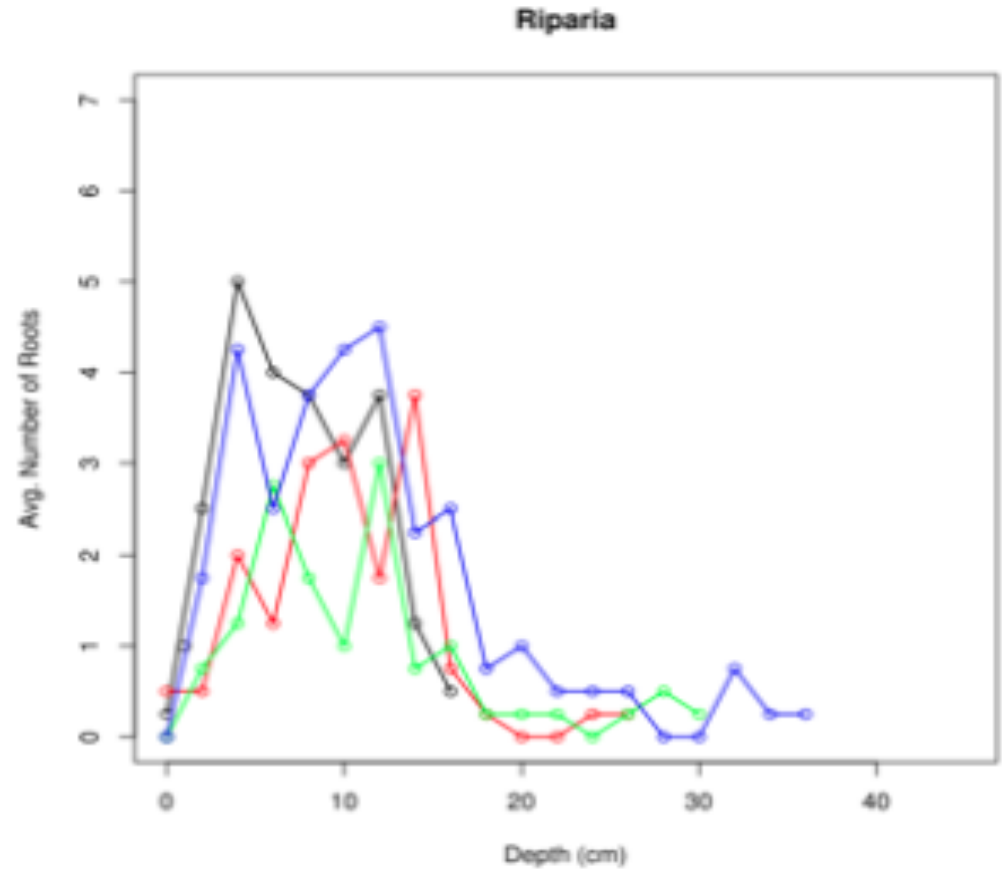
Riparia Gloire



Rhizotrons: root development over time

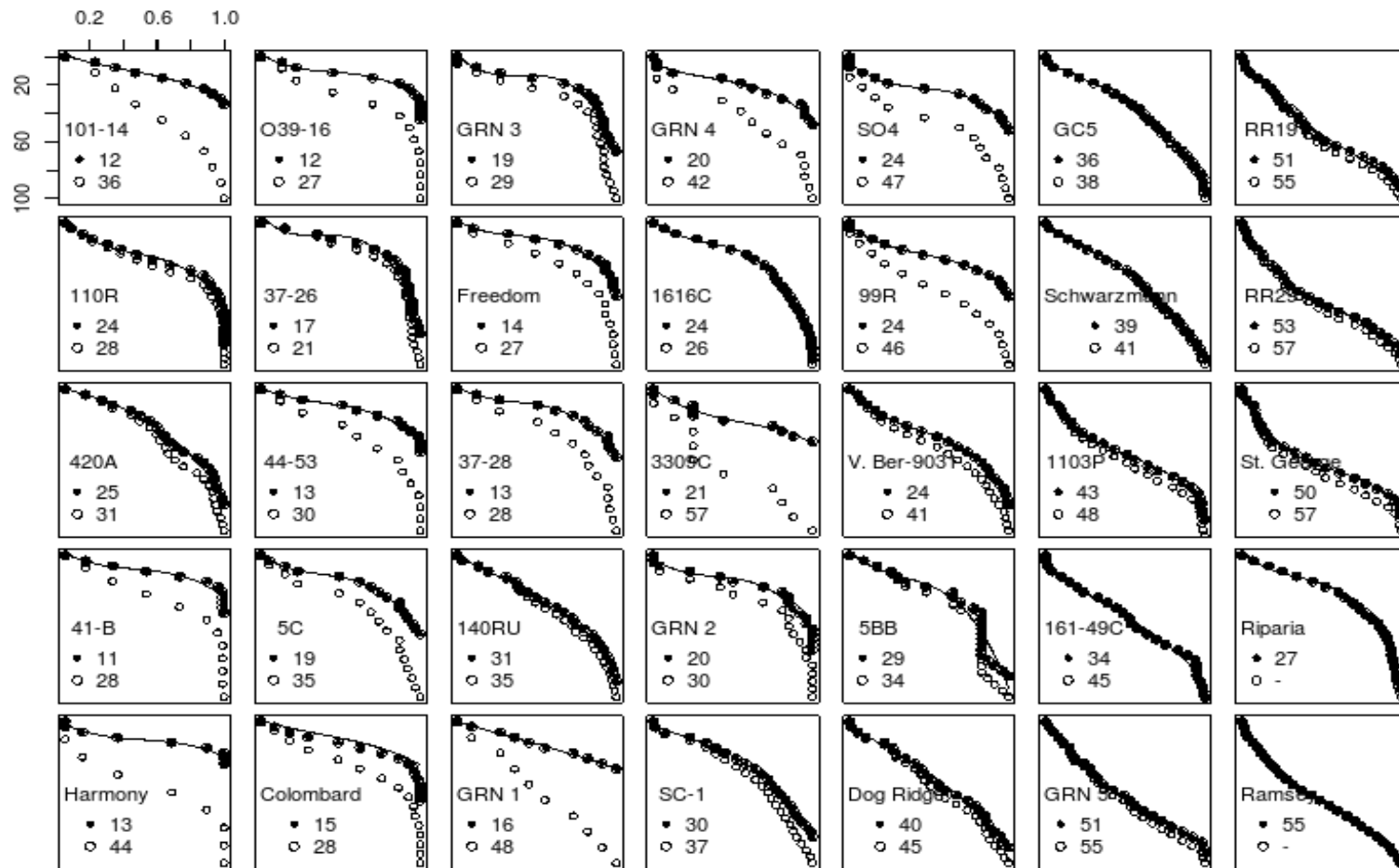


Ramsey



Riparia

Rhizotron root characterizations for all commercial rootstocks: Joaquin Fraga



Cumulative root fractions, absolute and normalized

Drought Resistance – Anatomy

- Cecilia Osorio and the McElrone lab
- What anatomical traits influence drought tolerance?
- Root angle
- Xylem diameter / distribution
- Storage capacity



“Isn’t there a cactus gene out there that might help?”

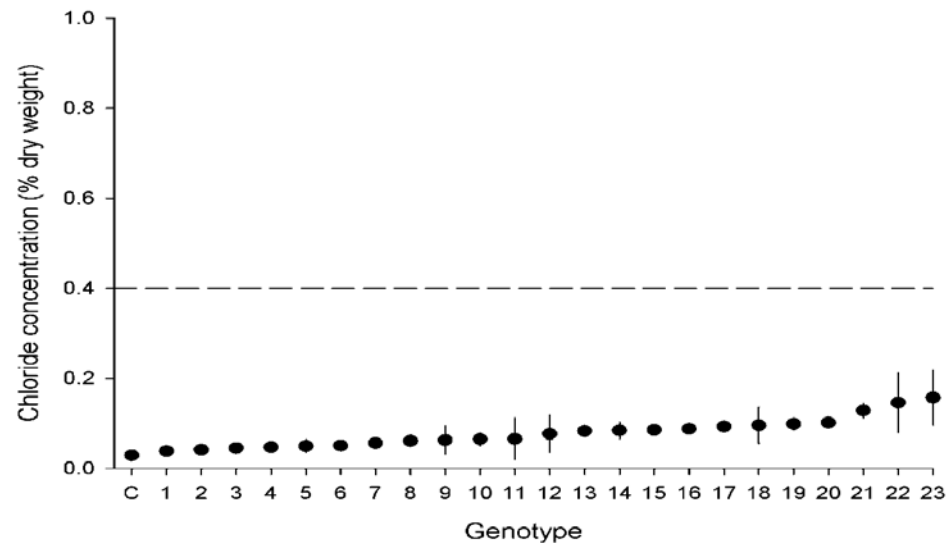


Salt Resistance— Kevin Fort



- Salt and drought resistant rootstocks exist, but need better forms of resistance
- Salt resistance assay now matches Australian field data
 - Ramsey is good; St. George and 140Ru are better; and selections of *acerifolia*, *arizonica*, *berlandieri*, *doaniana* and *girdiana* are better yet
- Working closely with Andrew McElrone to understand mechanisms... screen more accurately
- Pursuing the genetics of salt resistance in *V. berlandieri*

Pursuing *V. berlandieri* chloride exclusion 2012 cross, 2013 assay

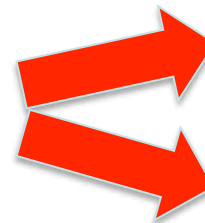


V. vinifera x *V. berlandieri*
(rr x RR)



V. vinifera / *V. berlandieri*
Hybrids are all resistant – Rr

(*V. vinifera* / *V. berlandieri*) x *V. vinifera*



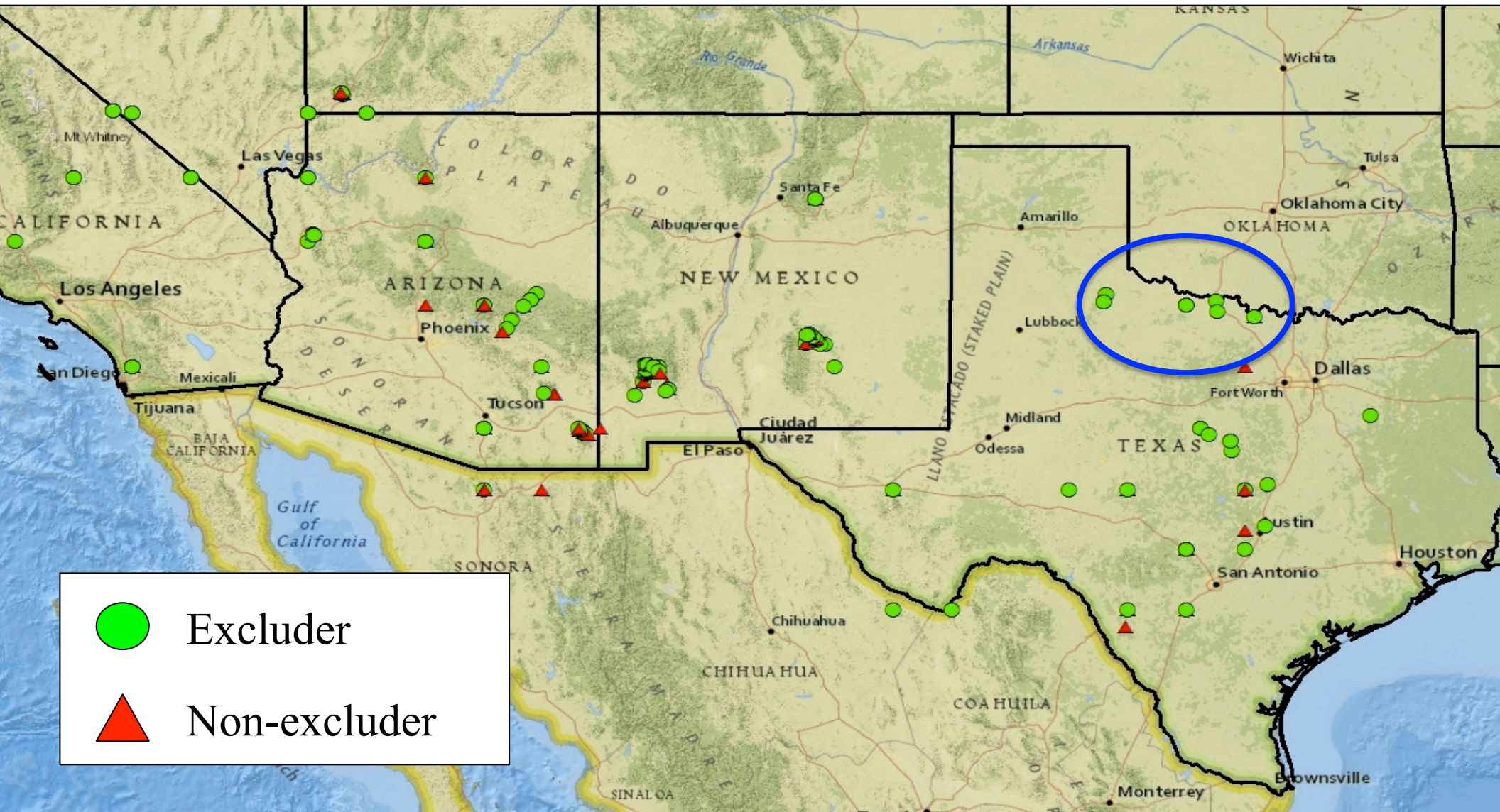
50% susceptible – rr

50% resistant – Rr

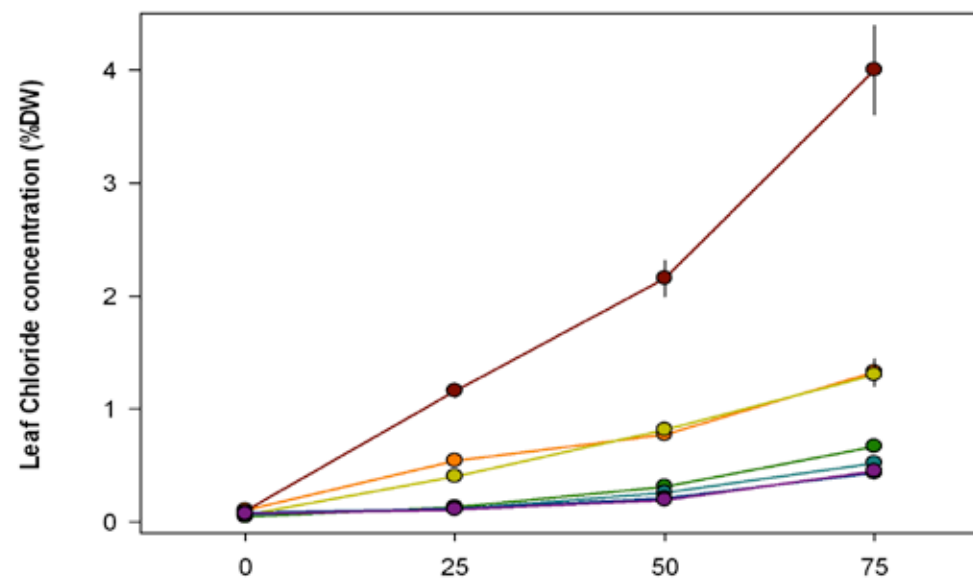
Salt Resistance in SW *Vitis* – Claire Heinitz

- Plant material from the southwest U.S. has been the source of resistance to:
 - PD, *X. index*, salt (chloride exclusion), drought
- Taxonomic relationships are unclear:
 - *V. arizonica* a complex group of hybrids with other species
 - *V. doaniana* and intermediates

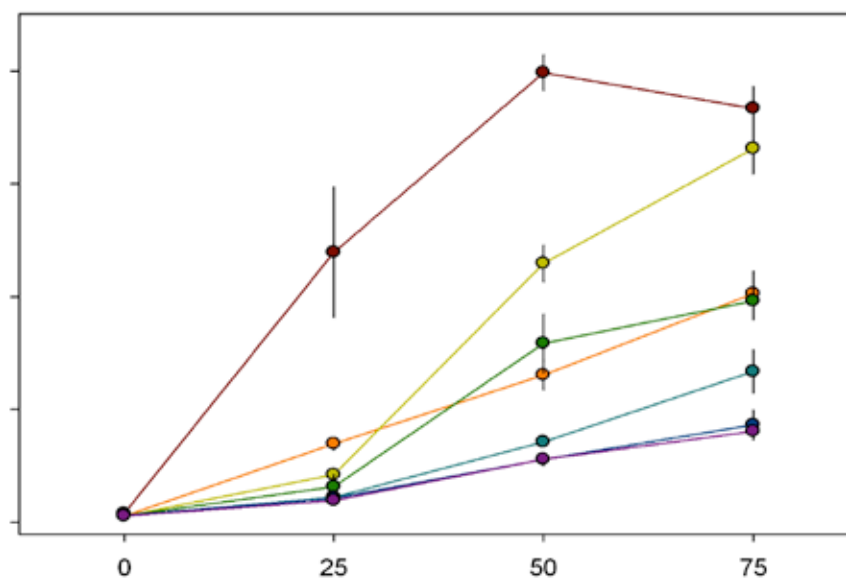
Distribution of chloride exclusion



3 weeks



6 weeks

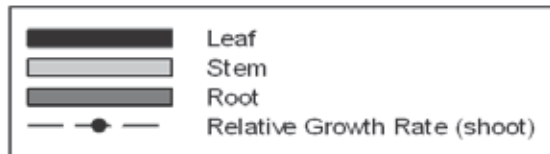
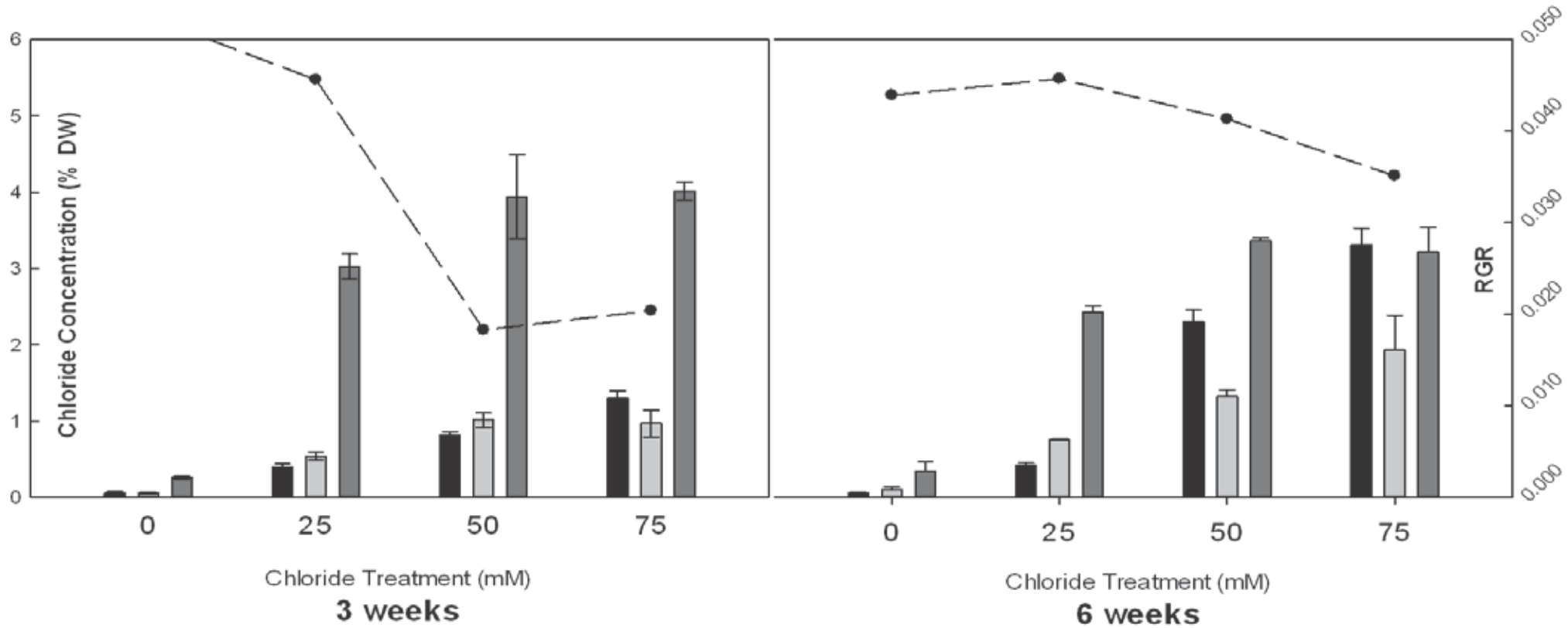


Chloride Treatment

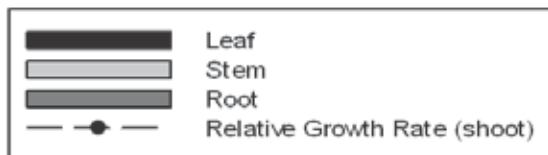
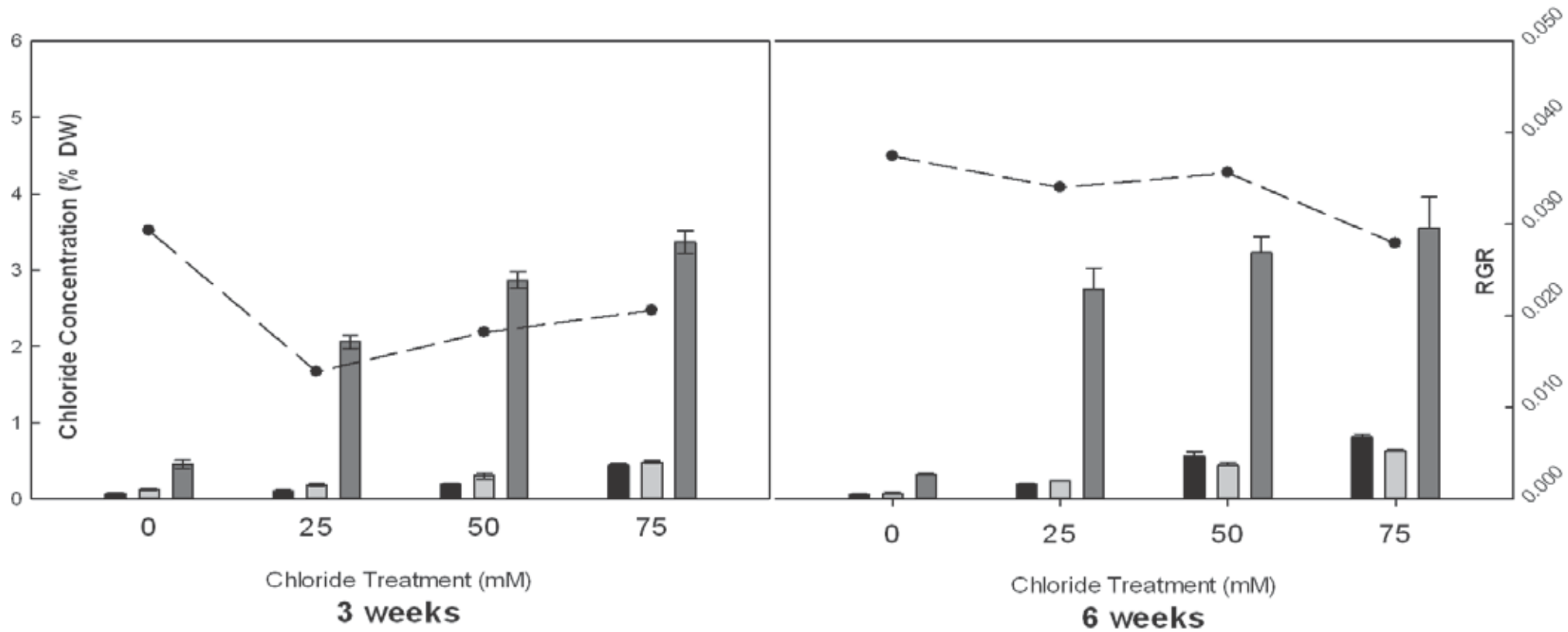
- pumpstation
- Thompson
- Ramsey
- St. George
- berlandieri 9031
- SC2
- SC1

Accession	Species	Exclusion pattern	Tentative exclusion category
St. George	<i>V. rupestris</i>	Leaves low Roots high	Typical Exclusion
Thompson Seedless	<i>V. vinifera</i>	Leaves high Roots high	Typical Non-exclusion
"Pumpstation"	<i>V. rupestris</i>	Leaves <i>very</i> high Roots low	Hyper-accumulation
SC 1	<i>V. girdiana</i>	Leaves low Roots low	Double Exclusion
SC 2	<i>V. girdiana</i>	Leaves low Roots low	Double Exclusion
9031	<i>V. berlandieri</i>	Leaves low Roots high	Typical Exclusion with potential single-gene inheritance
Ramsey	<i>V. champinii</i>	Leaves moderate Roots high	Typical Exclusion with potential multi-gene inheritance

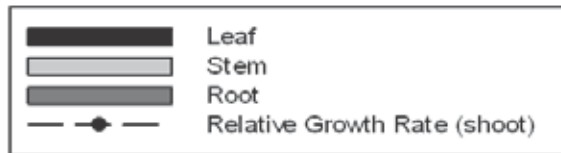
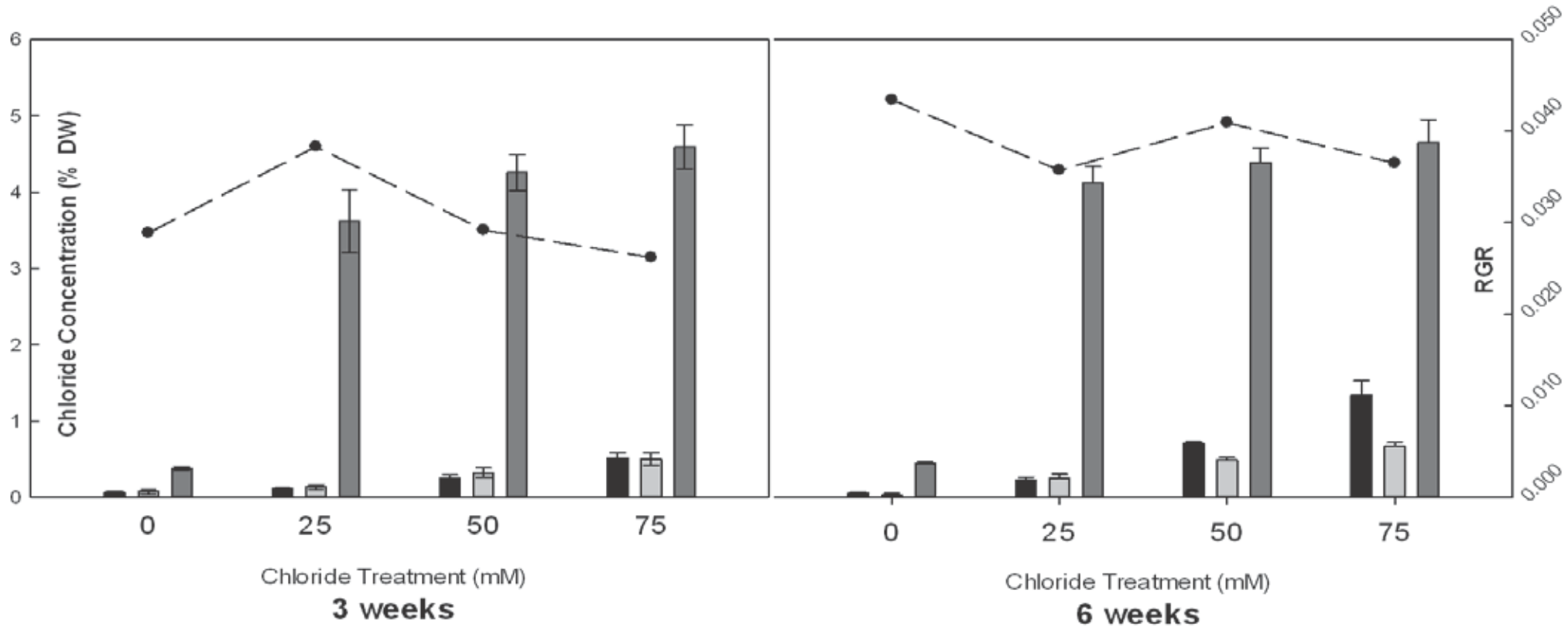
Ramsey



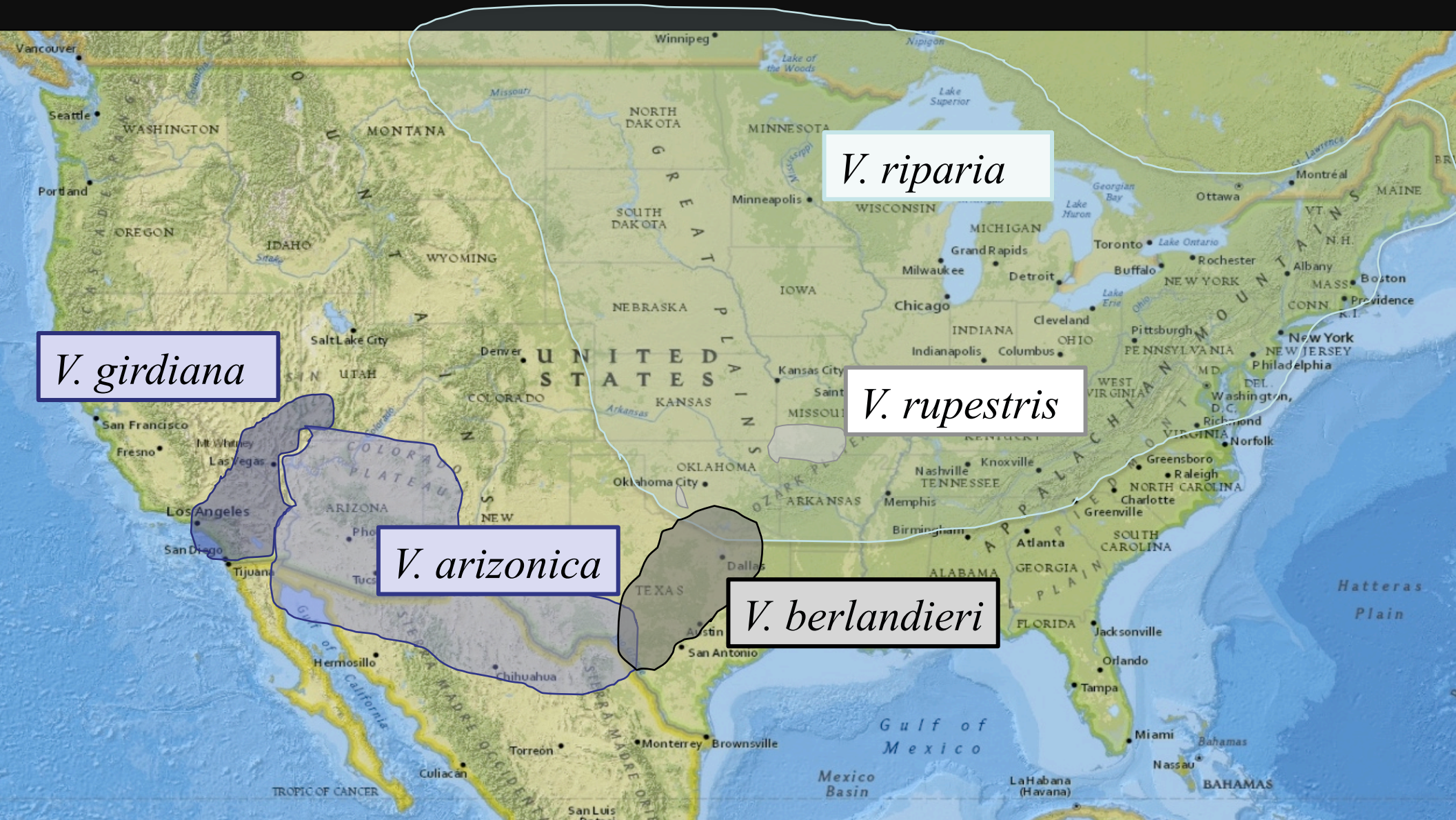
SC1



berlandieri 9031



North American *Vitis*



V. riparia

V. girdiana

V. rupestris

V. arizonica

V. berlandieri

North American *Vitis*



Salt Resistance in SW *Vitis* – Claire Heinitz

- Plant material from the southwest U.S. has been the source of resistance to:
 - PD, *X. index*, salt (chloride exclusion), drought
- Taxonomic relationships are unclear:
 - *V. arizonica* a complex group of hybrids with other species
 - *V. doaniana* and intermediates

Beautiful Red River



Red River Collections

- 41 individuals
 - 5 *V. candicans* (*mustangensis*) yellow
 - 6 *V. acerifolia* red
 - 20 *V. X doaniana* yellow/red
 - 10 intermediate types green
- Genotyped at 20 microsatellite loci

Why characterize/ conserve this material?

- Lack of understanding of taxonomy and population dynamics
- Threat of genetic erosion
- Potential use in rootstock breeding
 - Chloride exclusion

“Here then is another wild treasure,
from which may spring a grand
family of grapes for the arid regions
of the West.”

- Munson 1909

Thanks!

