Rootstock Research for Current and Future Options

Andy Walker

awalker@ucdavis.edu

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Thanks!

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

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Walker Lab

Dan Ng	Summaira Riaz	Alan Tenscher
Rong Hu	Nina Romero	Cecilia Agüero
Kevin Fort	Brian Ramirez	Claire Heinitz
Cecilia Osorio	Evan Goldman	Cassie Bullock
Joaquin Fragga	Jake Uretsky	Tarana Shaghasi
Inés Hugalde	Philippe Venghiattis	
Howard Ferris	Liang Zheng	Jeff Granett
Andrew McElrone		Dario Cantu

Rootstock Breeding

- Genetic mapping to allow MAS and stacking / combining traits
- Add salt and drought resistance to the GRN rootstocks
- Add ring resistance from *rotundifolia*
- Add vigor control and virus tolerance
- Campus rootstock trials with 101-14 and 1103P standards
- Field trials (in collaboration with farm advisors/ growers) and pre-release to FPS

New Rootstock Releases

- Resist 3 strains of root-knot including two that feed on Harmony and Freedom, and *Xiphinema index*.
- Resist all the above in one inoculum
- Resist all the above at high soil temperatures
- And …

GRN Parentages

- GRN-1 = 8909-05 *rupestris* x *rotundifolia* 'Cowart'
- GRN-2 = 9363-16 (*rufotomentosa* x (Dog Ridge x Riparia Gloire)) x Riparia Gloire
- GRN-3 = 9365-43 (*rufotomentosa* x (Dog Ridge x Riparia Gloire)) x *champinii* c9038
- GRN-4 = 9365-85 (*rufotomentosa* x (Dog Ridge x Riparia Gloire)) x *champinii* c9038
- GRN-5 = 9407-14 (Ramsey x Riparia Gloire) x *champinii* c9021

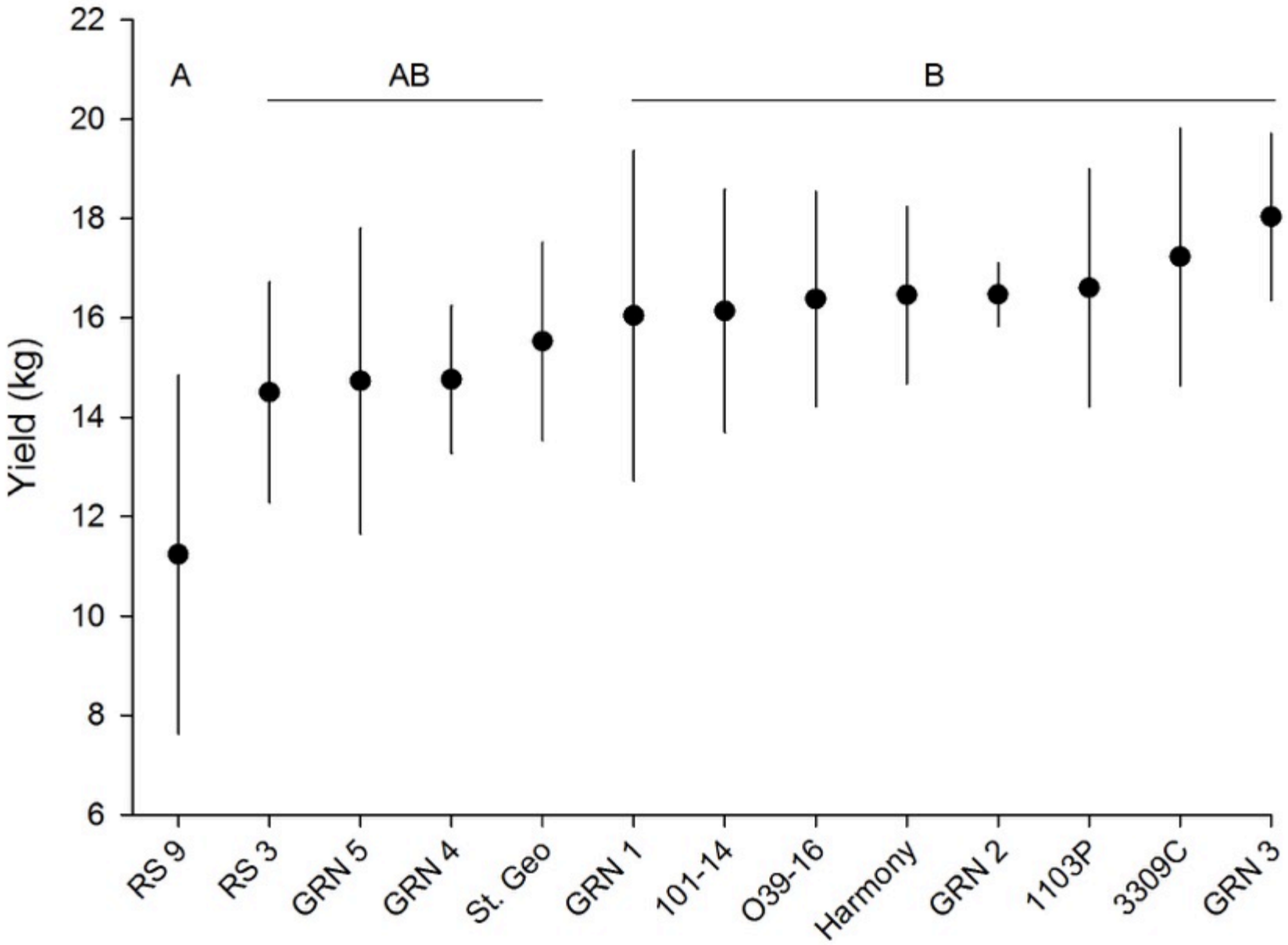
GRN Rootstock Summary

	Citrus Nematode	Ring Nematode	Phylloxera Nodosities	Rooting Depth
GRN-1	R	R	HR	D
GRN-2	MS	S	HR	S
GRN-3	R	S	R	M
GRN-4	R	MS	R	M
GRN-5	R	MR	MS	D

They all resist all 3 strains of root-knot, *X. index*, these combined, and at high temperatures

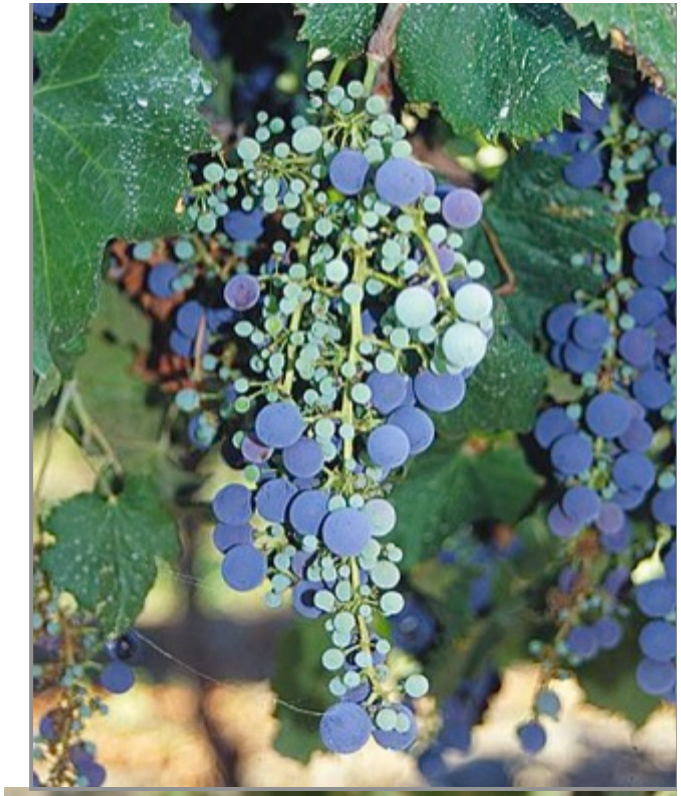
Rootstock	Yield (kg), 29Sep14	Cluster number, 29Sep14
RS 9	11.2 A	88.2
RS 3	14.5 AB	99.5
GRN 5	14.7 AB	95.5
GRN 4	14.7 AB	87.7
St. Geo	15.5 AB	98.3
GRN 1	16.0 B	86.5
101-14	16.1 B	99.3
O39-16	16.3 B	100.5
Harmony	16.4 B	95.9
GRN 2	16.4 B	102.1
1103P	16.6 B	96.9
3309C	17.2 B	97.9
GRN 3	18.0 B	104.5

Gallo Lodi – 2011, Malbec, Wye trellis 6x10, randomized with five 5-vine reps; *X. index* and *X. americanum* (low), high ring, mod – high root-knot; low lesion

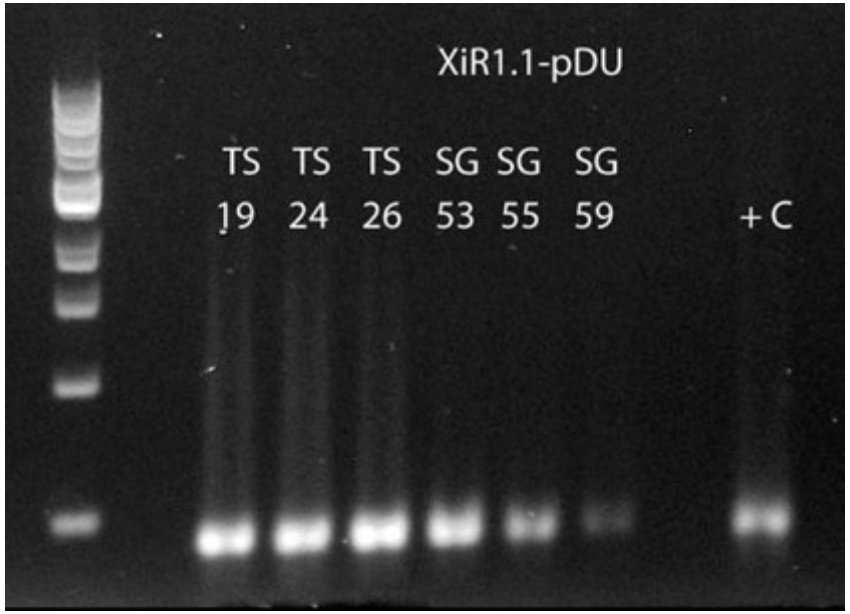

22
20
18
16
14
12
10
8
6
Yield (kg)
A
AB
B
RS 9
RS 3
GRN 5
GRN 4
St. Geo
GRN 1
101-14
O39-16
Harmony
GRN 2
1103P
3309C
GRN 3

Fanleaf Degeneration

- GFLV/*Xiphinema index* disease complex
- O39-16 (VR hybrid) – it induces tolerance to fanleaf disease
- GRN resistance? Induced tolerance – GRN-1?
- O39-16 as a nematicide and root longevity

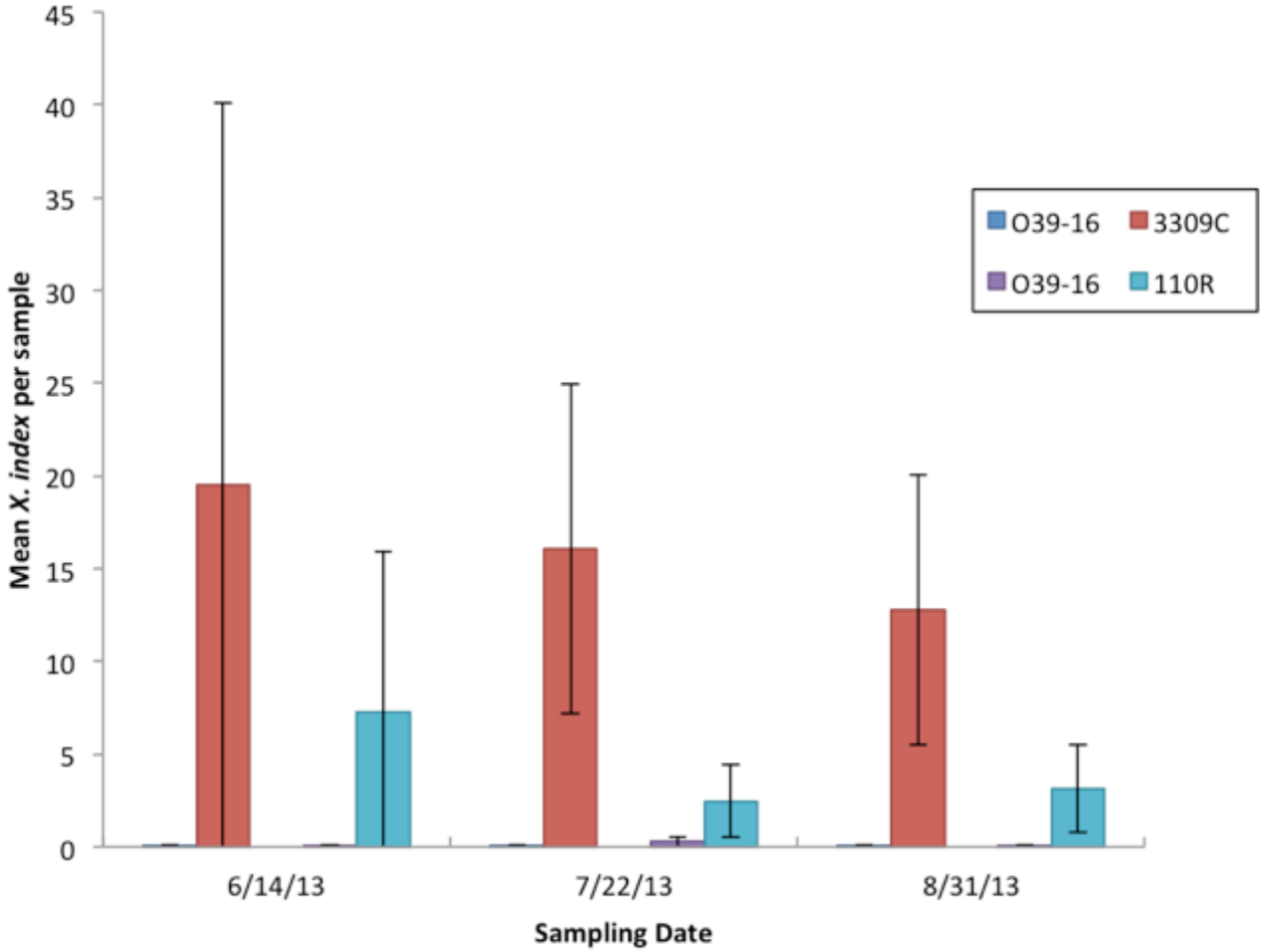


Genetic transformation of *V. rupestris* St George and *V. vinifera* Thompson Seedless with *XiR1.1* and *XiR1.2*

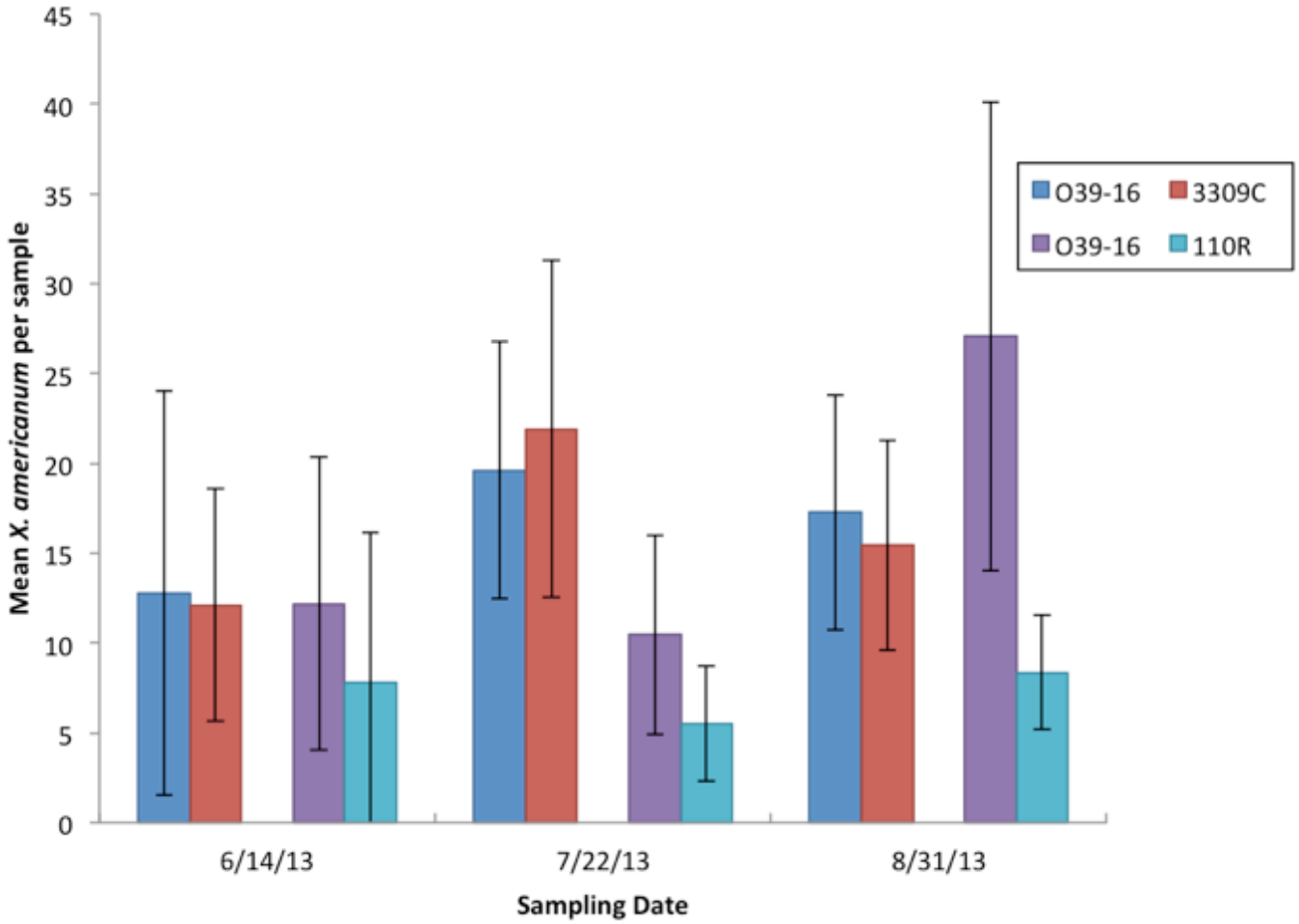


Inoculations Fall 2014

Evan Goldman
Xi /Xa Population Sampling



Evan Goldman–
Xi / Xa Population Sampling



Fanleaf Degeneration – Cecilia Agüero

- Have a resistant *vinifera* x *rotundifolia* rootstock – O39-16
- What O39-16 root-based feature compensates for the impact of GFLV on set?
- Is this factor a cytokinin or cytokinin precursor?
- We are evaluating xylem metabolites
- We need a genetic or biochemical marker for fanleaf tolerance
- Dario Cantu to take “omics” approach

Rotundifolia-based populations

- Resist root-knot, dagger, ring, citrus, lesion, phylloxera … and fanleaf disease
- GRN-1 (*rupestris* x *rotundifolia*)
- 101-14Mgt/161-49C/5BB/Dog Ridge x *M. rotundifolia* 'Trayshed'
- Search for fertility – very rare event … thousands of failed crosses
- Testing fertile *vinifera* x *rotundifolia* (VR) hybrids – phylloxera resistance and rooting to overcome the breeding "dead-end"

New Sources of Ring Nematode (*Mesocriconema xenoplax*) Resistance

Selection	Parents	Nemas/ g root	HarmA& C egg m/g root
11137-01	161-49C x *doaniana* T9	0	2.5
11138-02	5BB x *rotundifolia* Tray	1	0
11137-19	161-49C x *doaniana* T9	4	1.5
11138-01	5BB x *rotundifolia* Tray	7	0
GRN1	*rupestris* x *rotundifolia* Tray	7	0
11133-13	*acerifolia* OKC1S03 x St. George	17	3.4
11115-13	161-49C x *rotundifolia* Tray	24	0
Harmony	1613C op x Dog Ridge op	679	27.1
St. George	*rupestris*	1209	38.9
Colombard	*vinifera*	1891	28.6

100 selections from 400 seedlings, tested for rooting, root-knot and *X. index*; 4 replicates; 1,000 nematodes / pot; 3 months of feeding

2013 & 2014 Rootstock Crosses

Purpose of Cross	Parentage	#Seeds <Crosses>
Salt resistance and root angle	Ramsey x Riparia	>1800
Salt and drought resistance	Riparia x 140Ru	>500
Soil pest resistance	Ramsey x Trayshed	60
Rotundifolia resistance	Fertile VR x rootstocks	<100s>

2014 Selections

Purpose of Cross	Parentage	Resistant Selections
Improve GRN5; HarmA&C and Xi	101-14 X GRN5	2
Reduce GRN vigor; HarmA&C, Xi	101-14 x GRN2 and 4	6
PD rootstocks; resist HarmA&C; Xi	5BB X b40-14 or R8916-22	3
PD rootstocks; resist HarmA&C; Xi	08314-31 X Schwarzmann	3
Resist HarmA&C and Xi; rotundifolia parentage	T6-42; 161-49C; 5BB X St. George or Trayshed	6

Breeding Rootstocks to Tolerate Drought

- The ability to continue growth when exposed to water stress
- Adaptation vs. resistance
- Root architecture – shallow to deep rooting angles
- Root density – two tiered to even distributions
- Fine root recovery after drought
- Structural roots – which persist?
- Hydraulic lift
- Water uptake and permeability of structural roots
- In collaboration with Andrew McElrone

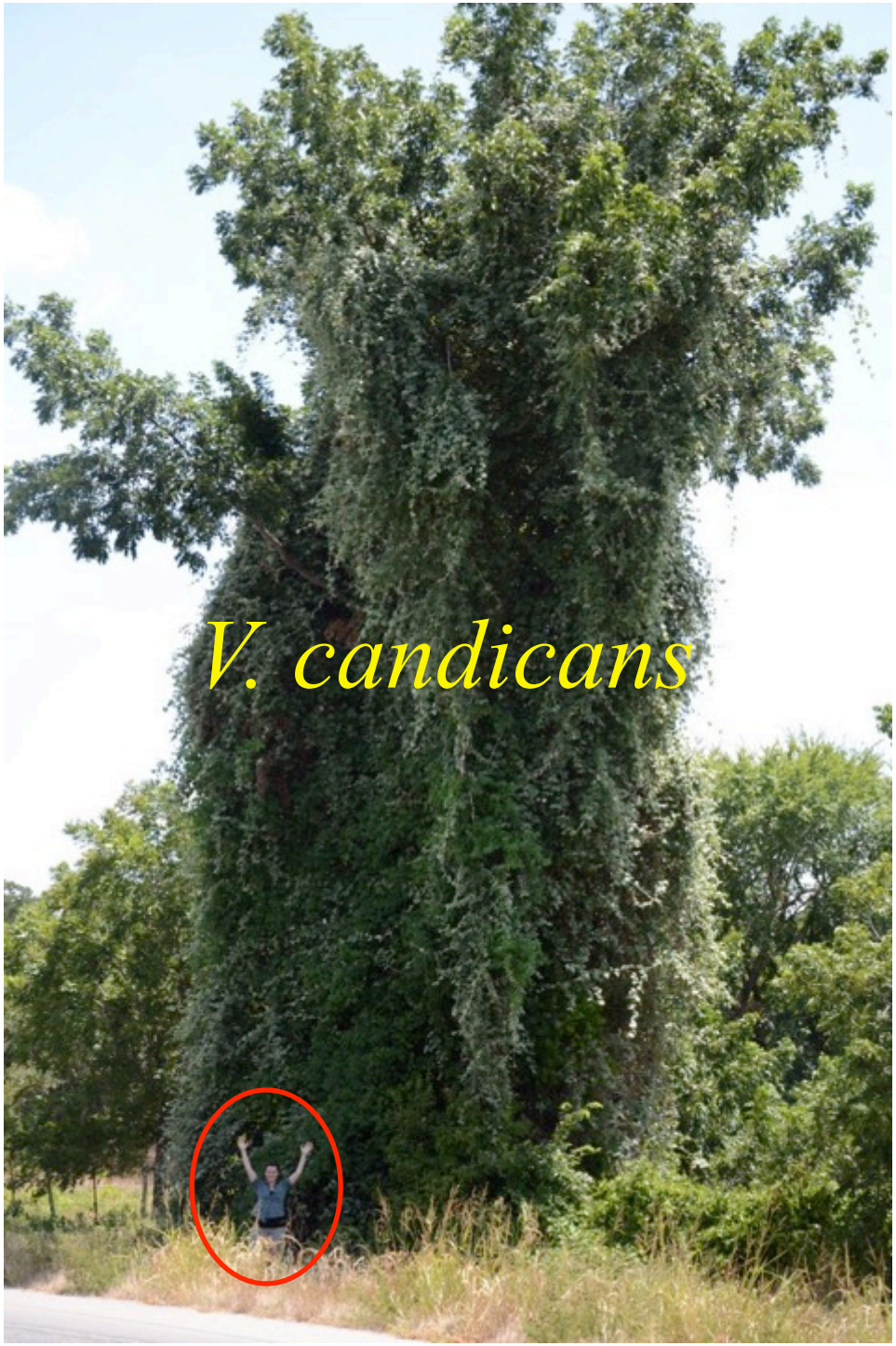
V. riparia

V. rupestris

Jack Fork River, MO
Wichita Refuge, OK

V. berlandieri

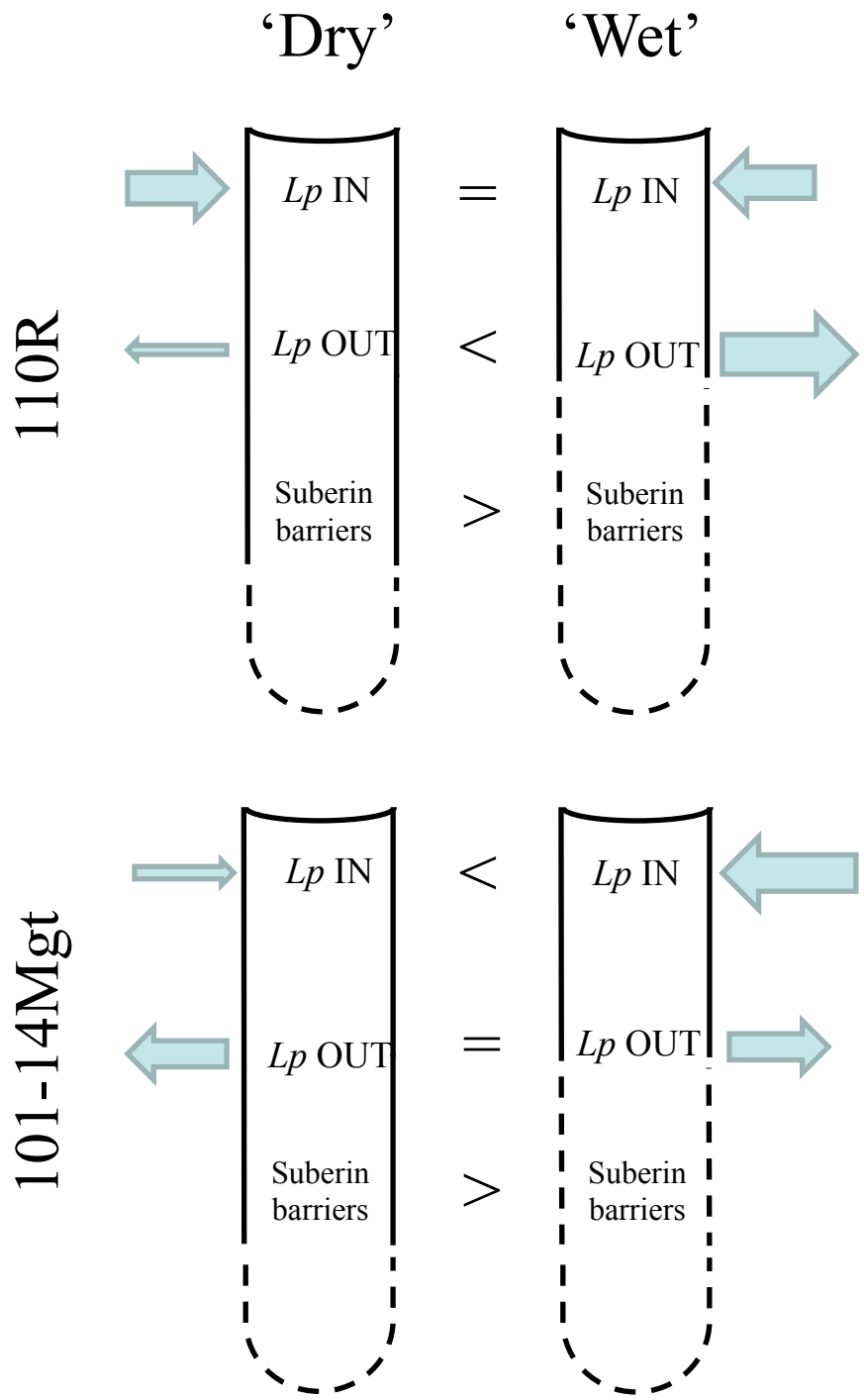

V. monticola


V. candicans

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

V. berlandieri

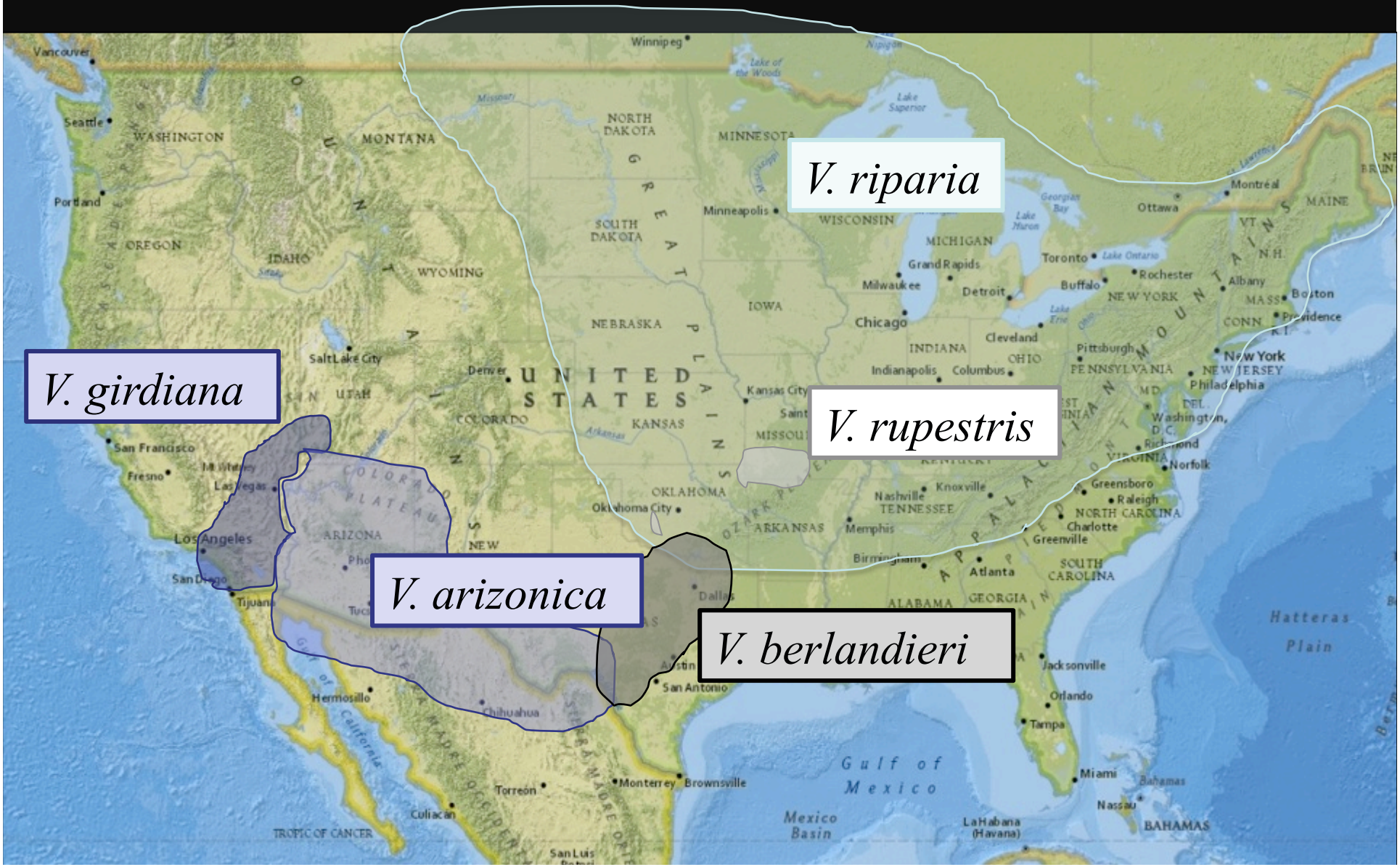


McElrone Collaboration

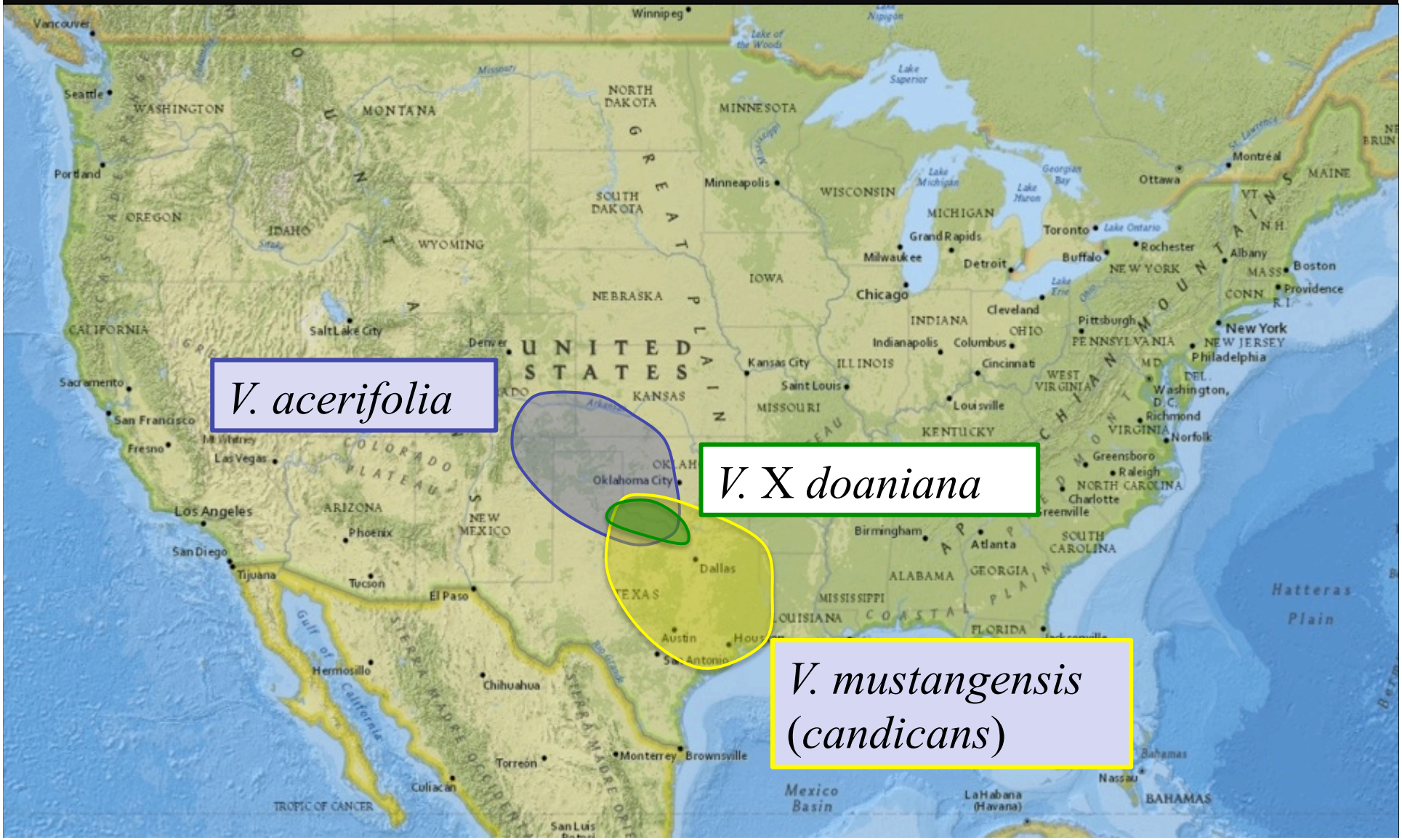
<u>110R</u> maintains water permeability into roots, but limits leakiness under drought

<u>101-14</u> water permeability decreases into roots, but maintains leakiness under drought

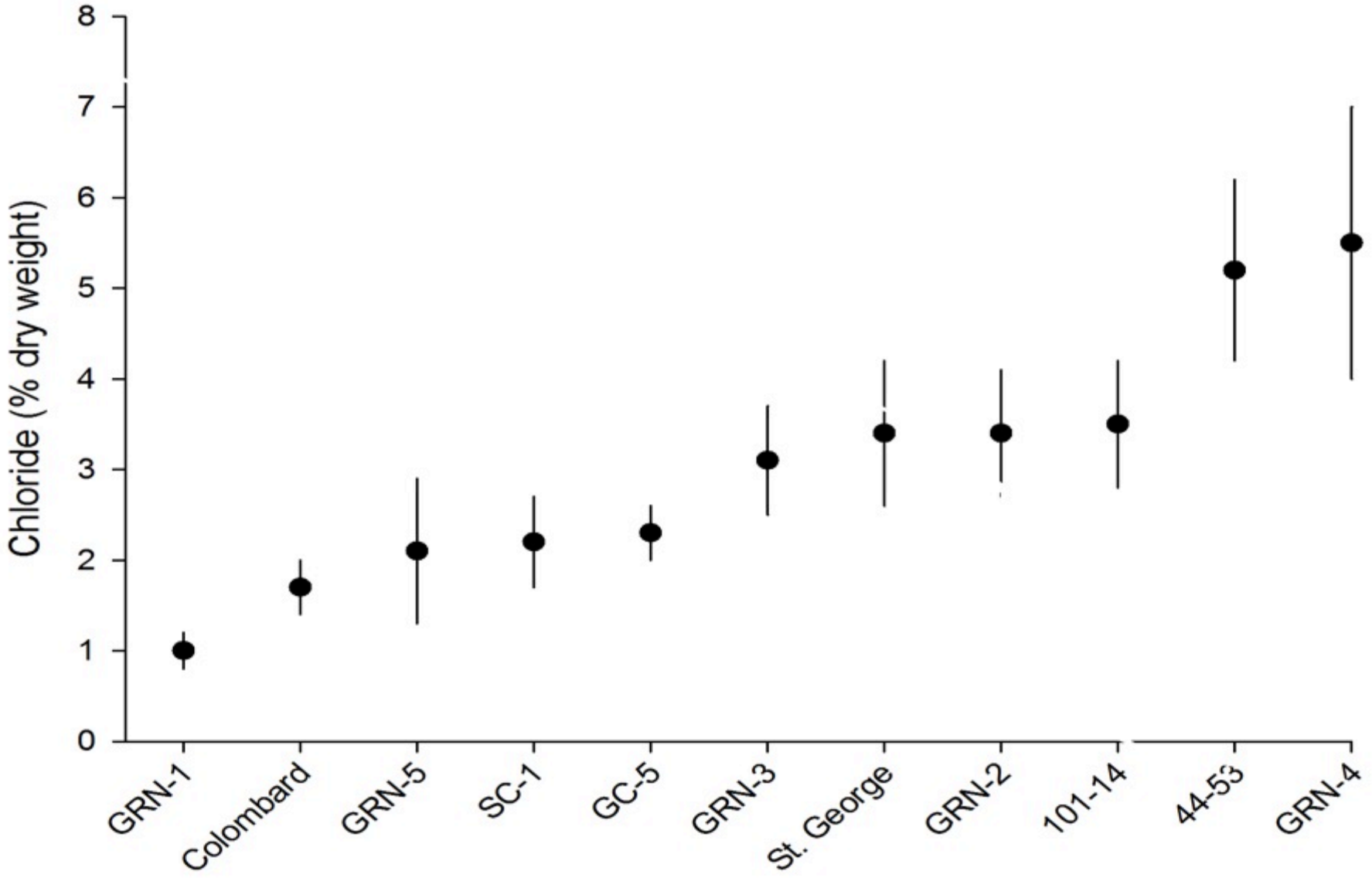
North American *Vitis*



North American *Vitis*



Salt resistance– GRNs



Salt resistance – 150mM, 2 weeks

Selection	Parentage	#Salt resistant
12-102-03	101-14 x NM03-17 (*treleasei*)	13
12-108-28	101-14 x 9028 (*doaniana*)	3
12-125-03	OKC-1 SO1 (*acerifolia*) x GRN-2 9363-16	4
12-126-02	OKC-1 SO1 (*acerifolia*) x GRN-4 9365-85	1
12-126-08	OKC-1 SO1 (*acerifolia*) x GRN-4 9365-85	2
12-129-22	OKC-1 SO1 (*acerifolia*) x St. George	4
12-142-04	*girdiana*-11 x *arizonica* A56	7
12-143-09	*girdiana*-22 x *arizonica* A56	2
12-144-01	*girdiana* Scotty's Castle x *arizonica* A56	9

Salt resistance – 150mM, 2 weeks

Selection	Parentage	#Salt resistant
12-153-18	Ramsey x 9028 (*doaniana*)	1
12-154-13	Ramsey x St. George	1
12-154-28	Ramsey x St. George	4
12-158-17	161-49C x St. George	1
12-185-03	GRN-3 9365-43 x *berlandieri* 9031	2
12-189-17	Dog Ridge x 140 RU	1
12-190-14	Dog Ridge x St. George	3
Vru 2	*rupestris* from Missouri	
Vru 85	*rupestris* from Missouri	


Thanks!

Virus Tolerance – Cecilia Agüero, Dario Cantu

- Leaf roll strains/ species and interactions?
- Corky bark and others
- Red blotch
- AXR#1, St. George?, fertile VR (*vinifera* x *rotundifolia*) hybrids
- Can we breed for “red leaf” virus tolerance?

Grape roots

- Many perennial root systems mimic top growth – grape roots are vine-like
- Grape roots are sparsely scattered in the soil profile without drip or with adequate rainfall

Grape roots

- Grape roots are poor sinks – shoot tips; fruit; trunk; and then roots
- Species and rootstocks vary in their ability to produce/regenerate feeder roots

Grape roots

- Some species/rootstocks produce abundant fine roots, others do not – 110R, 1103P vs 101-14
- Some species/rootstocks produce more structural roots

Grape roots

- Some hydraulically lift water – redistribute it within the roots
- Root behavior/structure will have an impact on downwardly mobile insecticides

RS-3 & RS-9 (Ramsey x Schwarzmann)

- Bred by David Ramming, selected by Mike McKenry; released in 2003 limited trial data
- RS-3 (1103P+) is more vigorous than RS-9 (101-14Mgt)
- Good nematode resistance RKN and *X. index*
- Designed to have better nematode and phylloxera resistance than Freedom/Harmony, but less vigor than Ramsey/Dog Ridge

USDA Rootstock Selections

- 10-17A = Edna (America (sdlg Jaeger 70 (*lincecumii* x *rupestris*) x **Malaga**) x male *simpsonii*
- 10-23B = *V. doaniana*
- 6-19B = 10-6B x 9-22C

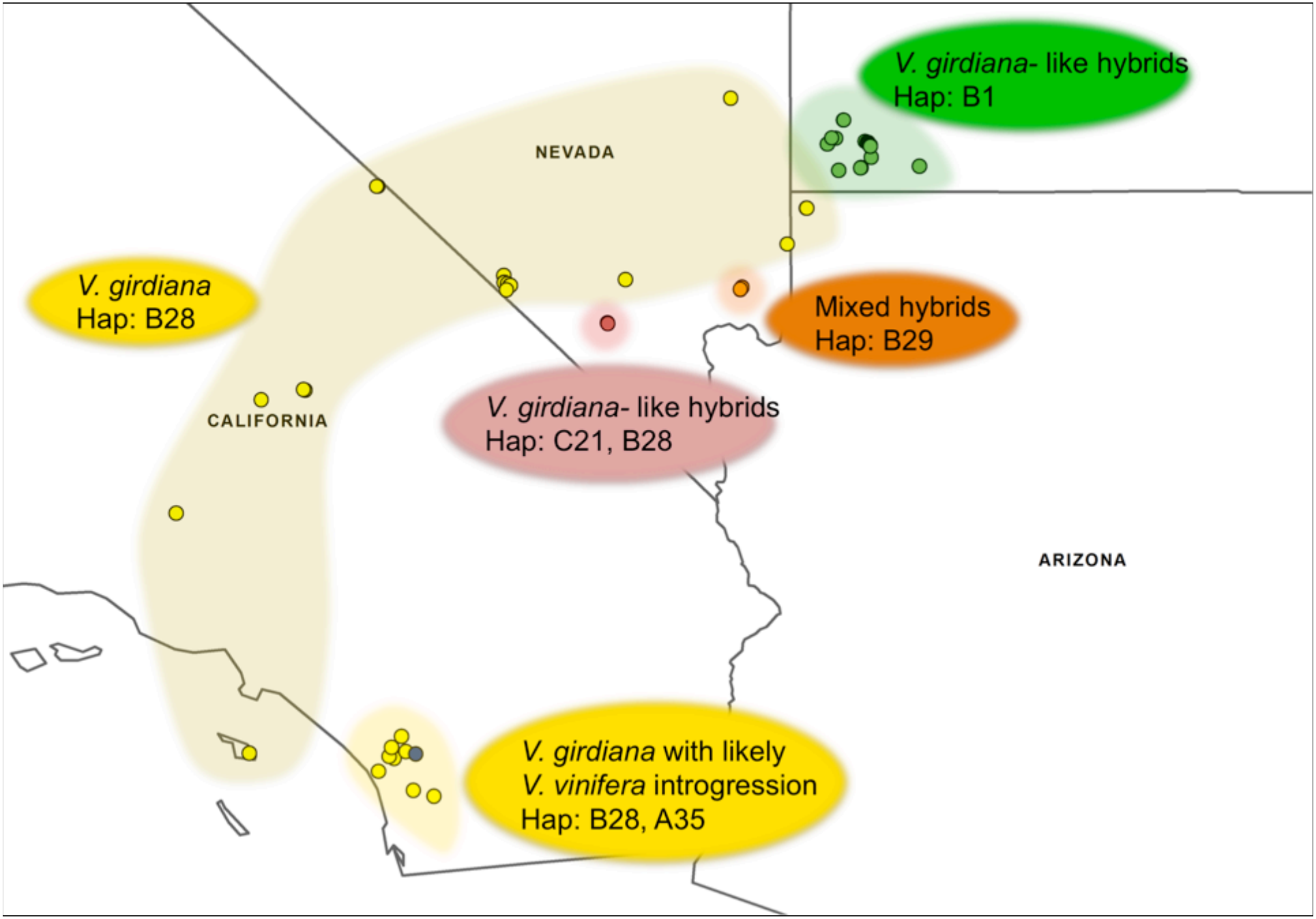
  10-6B and 9-22C = GA 3-4-5 x Dog Ridge 5

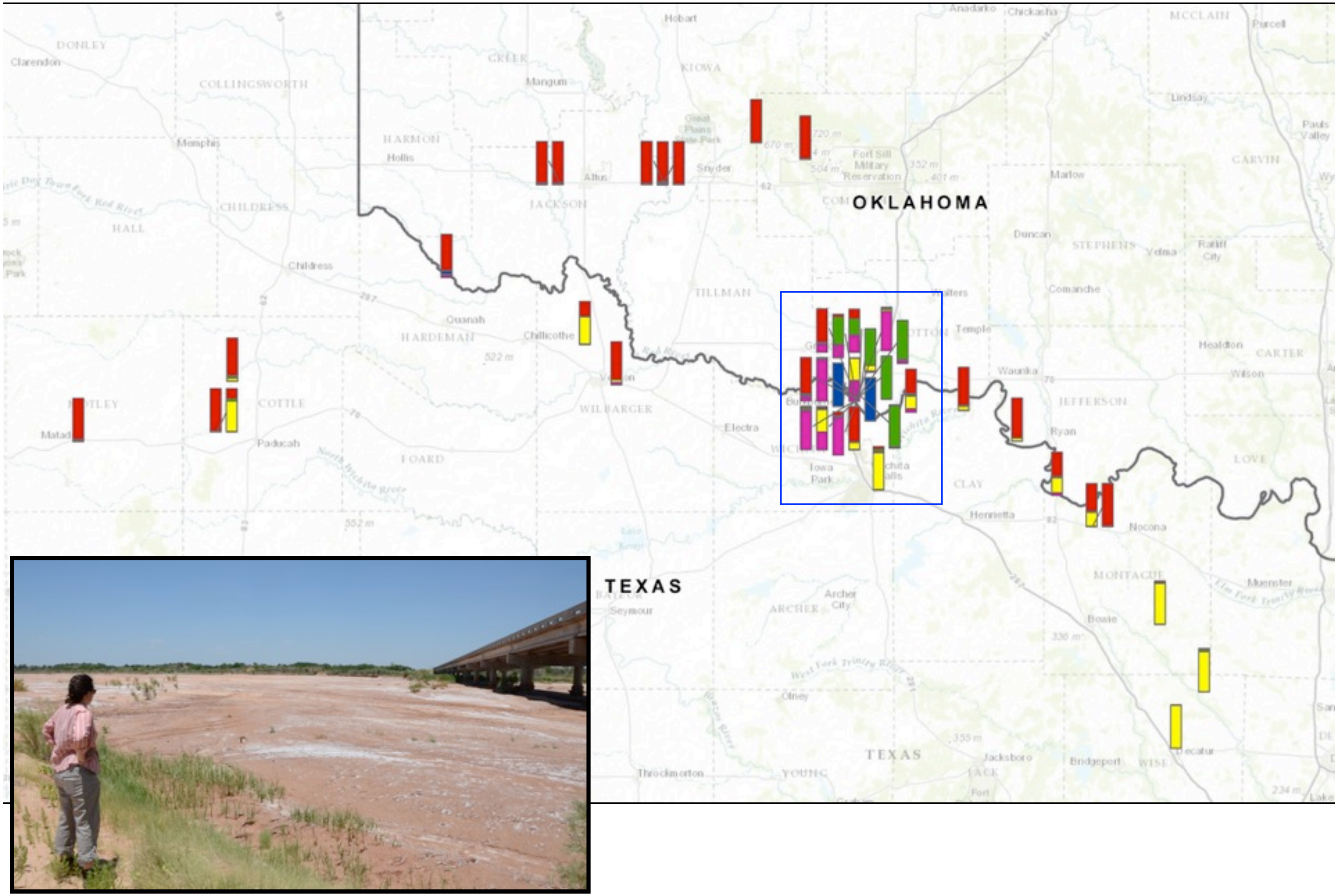
Peter Cousins USDA Rootstocks

- Released in 2010 as alternatives to Freedom
- **Matador** and **Minotaur** – siblings from a cross of 101-14 Mgt x 3-1A (*candicans* x *rupestris*)
- **Kingfisher** – 4-12A (Dog Ridge x *rufotomentosa*) x *V. riparia*
- Resistant to Harmony and Freedom strains of root-knot nematode
- Field testing at UC Kearney Station

Other Sources of Nematode Resistance

- 1616C, Riparia Gloire, Börner
- 101-14Mgt 5C, 5BB
- 1103P
- Harmony, Freedom, Ramesy, Dog Ridge


V. girdiana- like hybrids
Hap: B1
NEVADA
V. girdiana
Hap: B28
Mixed hybrids
Hap: B29
CALIFORNIA
V. girdiana- like hybrids
Hap: C21, B28
ARIZONA
V. girdiana with likely
V. vinifera introgression
Hap: B28, A35


OKLAHOMA
TEXAS
DONLEY
Clarendon
COLLINGSWORTH
Memphis
CHILDRESS
Childress
HALL
GREER
Mangum
HARMON
Hollis
JACKSON
Altus
KIOWA
Hobart
Snyder
Anadarko
Chickasha
MCCLAIN
Purcell
Lindsay
GARVIN
Marlow
Duncan
STEPHENS
Velma
Comanche
Fort Sill Military Reservation
TILLMAN
Walters
Temple
Waurika
JEFFERSON
Ryan
Healdton
CARTER
Wilson
LOVE
HARDEMAN
Quanah
Chillicothe
WILBARGER
Electra
COTTLE
Paducah
FOARD
CLAY
Henrietta
Nocona
MONTAGUE
Bowie
Muenster
ARCHER
Archer City
Seymour
Olney
Iowa Park
Jacksboro
Bridgeport
WISE
Decatur
Throckmorton
YOUNG