Grape Rootstock Development –

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Walker Lab Projects

- Breeding rootstocks with resistance to phylloxera, nematodes, drought, salt and tolerance to grape viruses
- Pierce's disease (PD)
- Powdery mildew
- Classical breeding, genetic mapping of resistance traits
- Marker-assisted selection to expedite classical breeding
- Resistance gene characterization

History of Rootstock Breeding

- 1840s powdery and downy mildew imported into France – by horticulturists and plant collectors
- 1860s phylloxera imported into France (Christy Campbell – “The Botanist and the Vintner”)
- Black rot and other diseases followed

- All came on American *Vitis* species or hybrids like Catawba and Concord

History of Grape Breeding

- Attempts to control downy led to the Bordeaux Mix of copper, lime and sulfur
- Powdery mildew controlled by sulfur
- Phylloxera
  - Carbon bisulfide
  - Hybrid Direct Producers (French Hybrids)
  - Rootstocks

History of Grape Breeding

- Hybrid Direct Producers (French Hybrids)
- Complex hybrids of American *Vitis* spp. and *vinifera* cultivars
- Most trace back to same source Jaeger 70 a cross of *V. lincecumii* and *V. rupestris* made by Herman Jaeger in Missouri – a female vine first used by Seibel
- Seibel, Seyve-Villard, J. Seyve, Castel, and many others

History of Grape Breeding – Rootstocks

- Grafting — ancient practice noted in China 1560 BC; by Greeks 350 BC; Romans
- Used with ornamentals and fruit trees
- Connecting 2 pieces of tissue together – usually dormant shoots (canes) – rootstock and scion
- When done with dormant canes at a bench or table – called bench-grafting
- When a bud is grafted to a field-grown rootstock – called budding

History of Grape Breeding – Rootstocks and Phylloxera

- Went to the US (scene of the crime) and collected American species with evolved resistance to phylloxera
- The species vary in resistance, but no pure American species has collapsed to phylloxera feeding
- Only 2 American species root well from dormant cuttings – *riparia* and *rupestris*

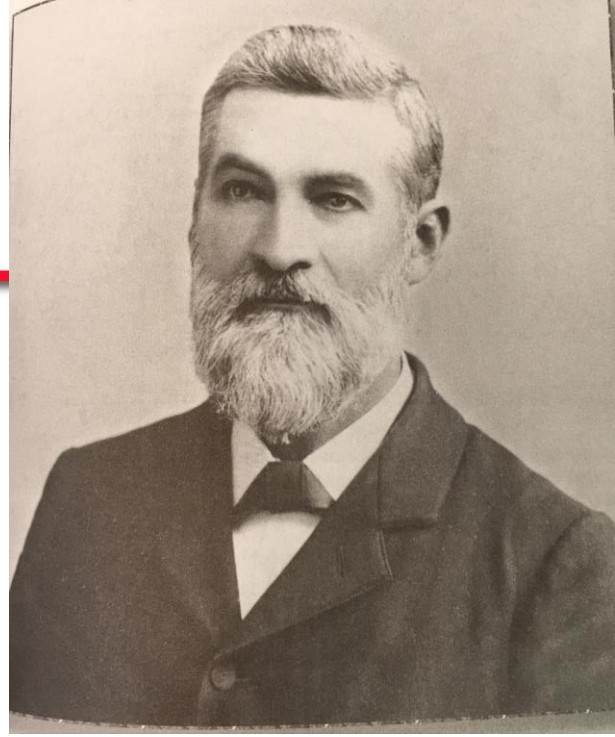
History of Grape Breeding

- Reconstituted vineyards on resistant *riparia* and *rupestris* rootstocks and their hybrids
- Grew well for a few years and then collapsed on calcareous soils due to lime-induced chlorosis
- Unable to take up enough iron on calcareous soils for the *vinifera* scions

History of Grape Breeding

- Back to the US and worked with T.V. Munson who directed them to *berlandieri* from the limestone hills of Texas
- But *berlandieri* roots poorly from dormant cuttings so hybridized it with *riparia* and *rupestris*
- Large numbers of rootstock produced between 1890 and 1925 … very few since
- Amazing example of pest resistance

T.V. Munson



- Father of American Viticulture
- Grape species collector and expert
- Wrote “Foundations of American Grape Culture”
- https://archive.org/details/foundationsofame00munsrich

Rootstock Development

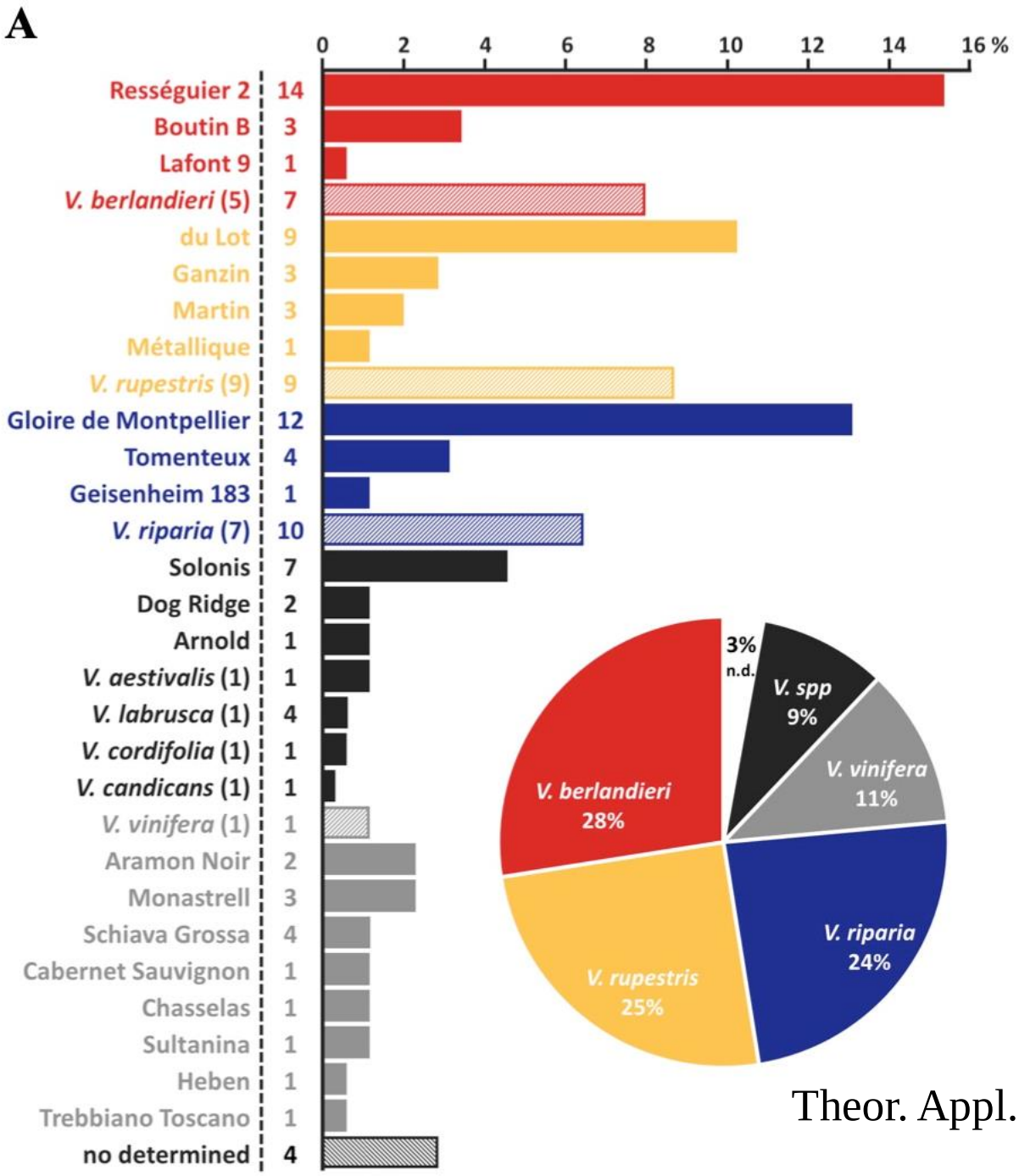
- What else were they selecting for?
- Cane length, diameter, limited lateral production, early ripening of canes and scions
- Adaptation to dry or wet conditions
- Deep large diameter roots or shallow fibrous roots

V. riparia

V. rupestris

Jack Fork River, MO

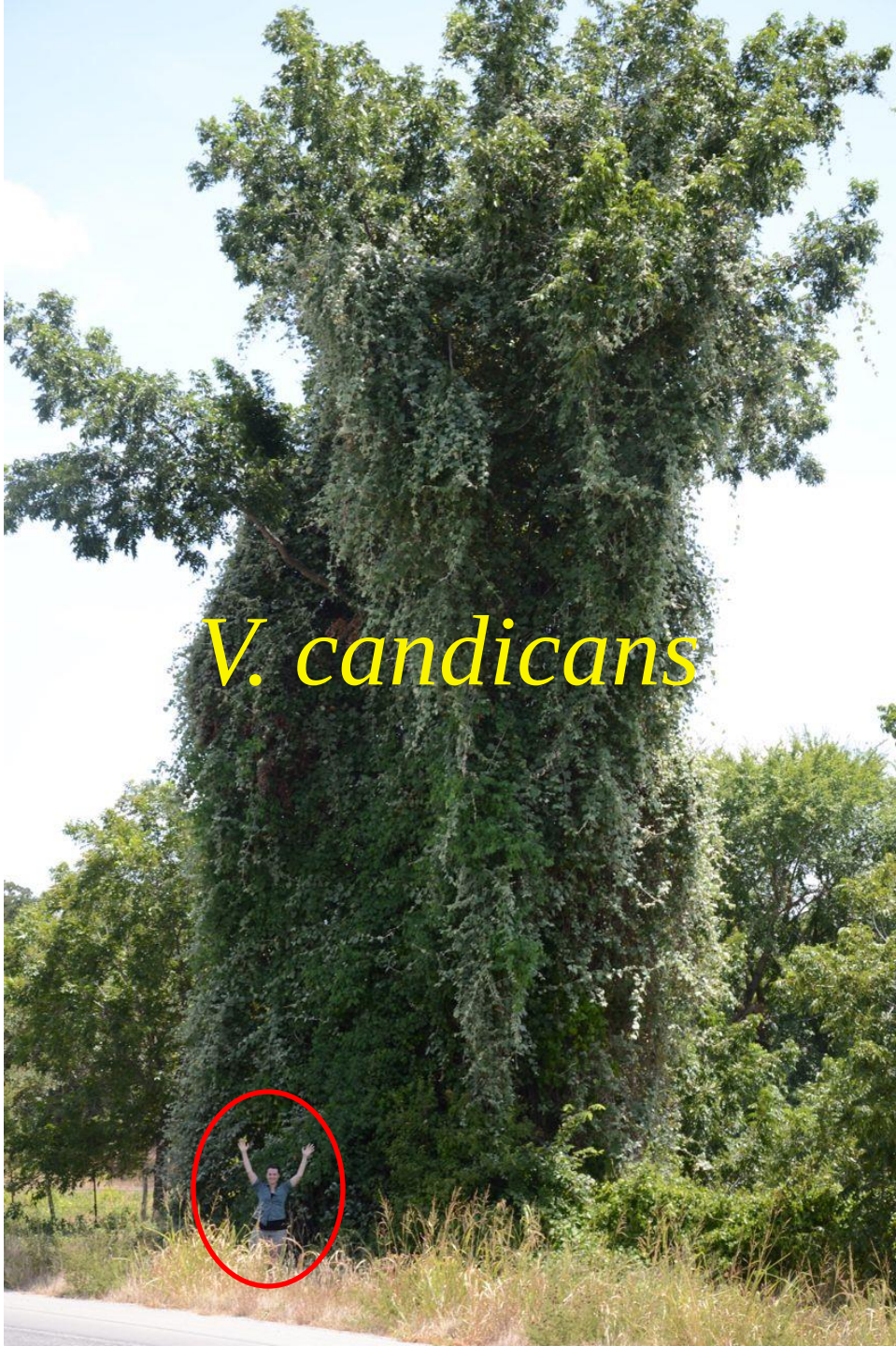
V. berlandieri



Rootstocks have a very narrow genetic base. Numbers to the right of the dashed lines represent the number of rootstocks in this study derived from the respective accession. The pie chart presents estimated species representation in the hybrid rootstocks.

Theor. Appl. Genet. 132:1847-1860 (2019)


V. monticola

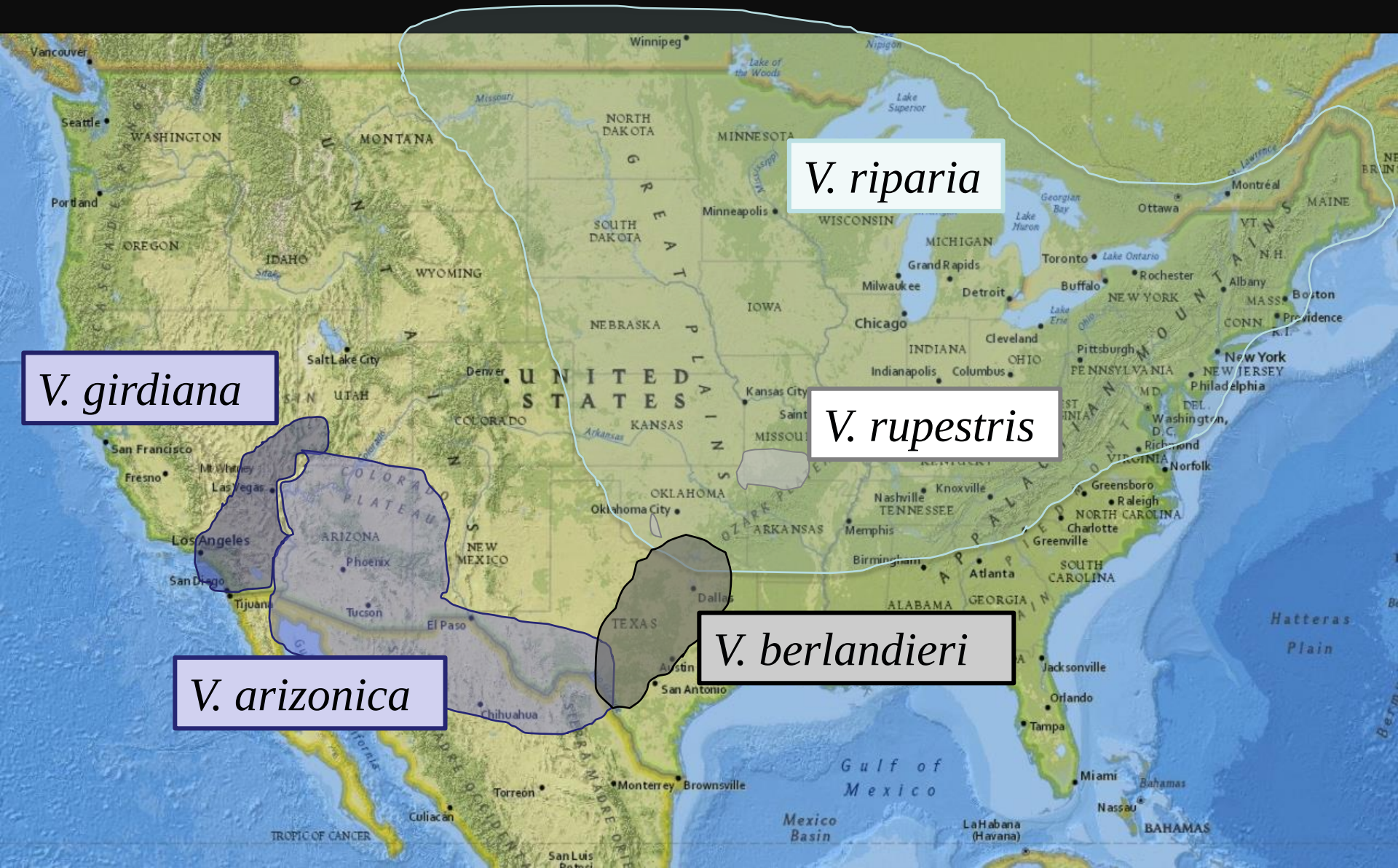

V. candicans

V. girdiana and *V. arizonica*

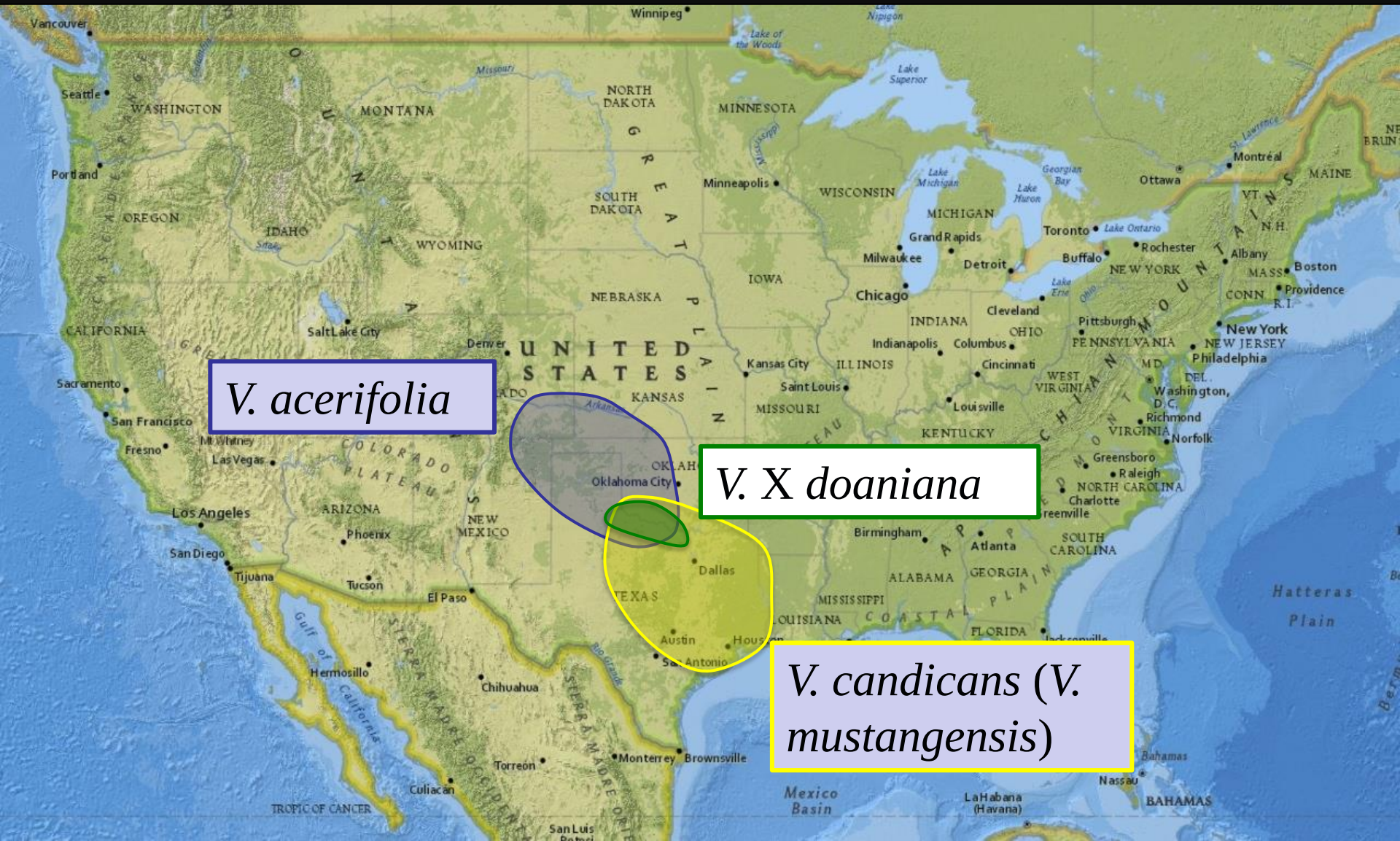
Lake Mead, NV

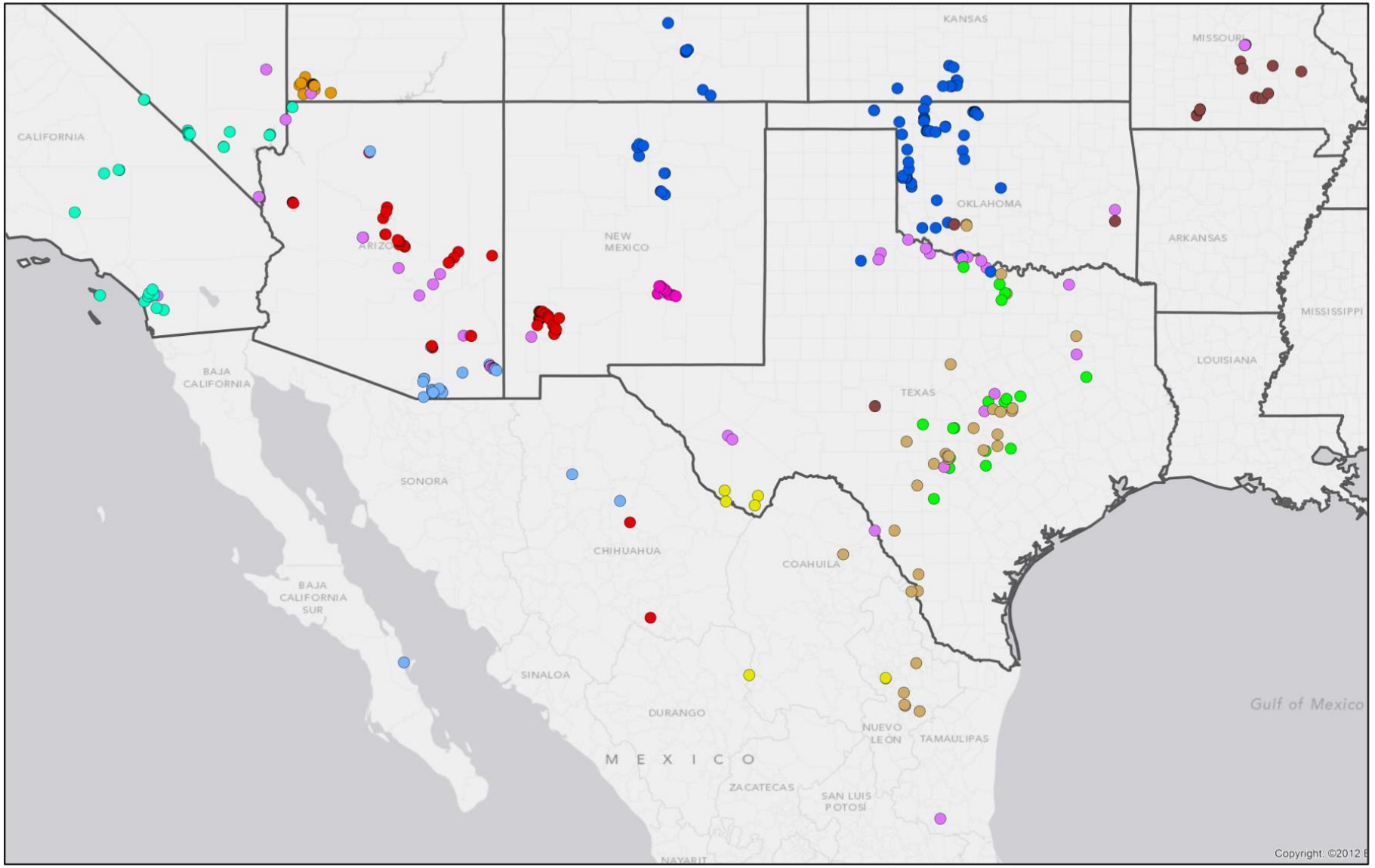
Lake Mead, NV

North American *Vitis*



North American *Vitis*





V. girdiana

V. arizonica

V. berlandieri, V. cinerea

V. mustangensis

V. riparia, V. acerifolia

V. rupestris

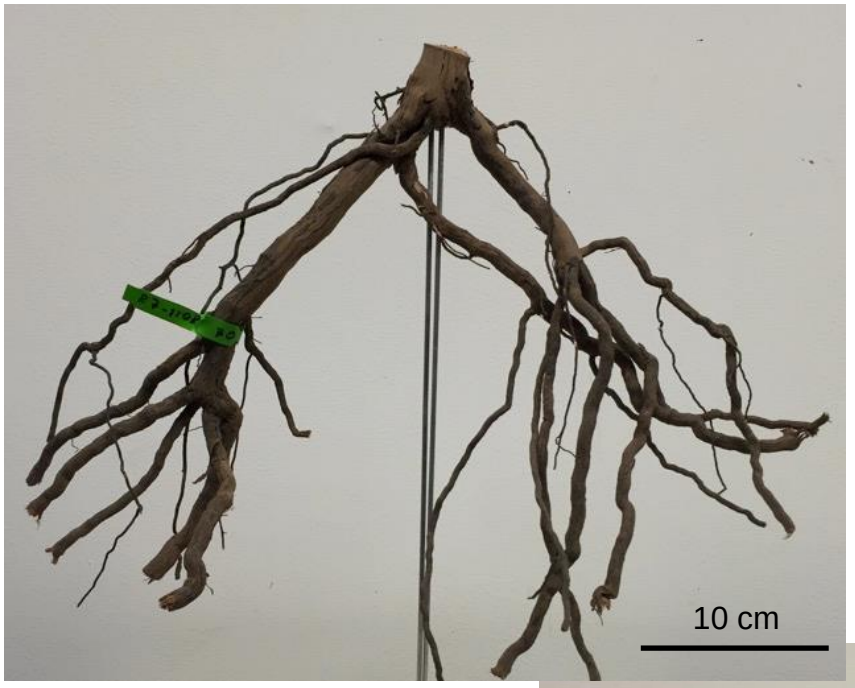
Hybrid

Claire Heinitz

Beautiful Red River

Breeding Drought Resistant Rootstocks

- Understanding drought adaption vs. drought resistance
- The ability to continue growth and maintain crop yield with less water
- Can we un-couple rooting angle/depth from drought adaptation/resistance?
- What about root architecture, root density, fine root recovery, uptake through structural and suberized roots, hydraulic lift?
- Kevin Fort, Jake Uretsky, Claire Heinitz, Jean Dodson, Joaquin Fraga, Andrew McElrone



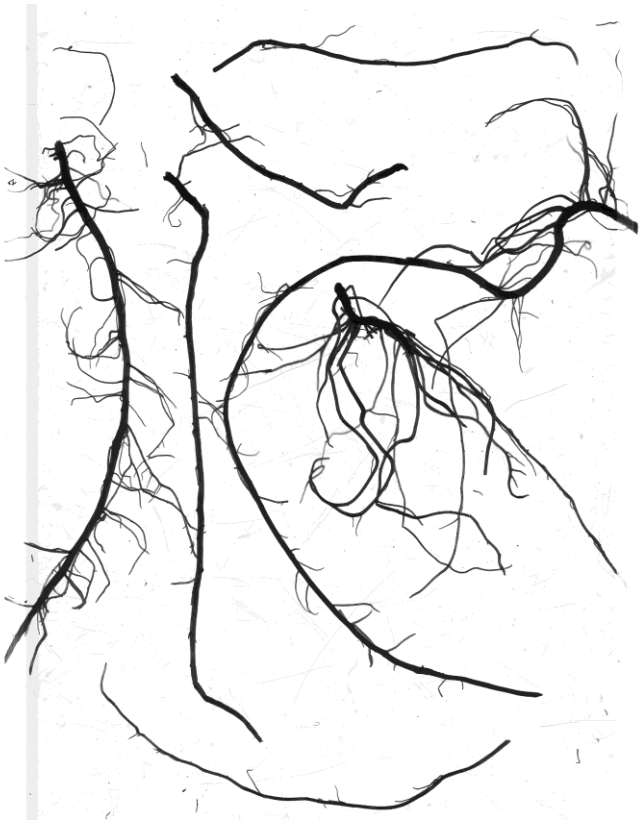
110R produces thick main roots with limited lateral branching.

101-14 Mgt produces finer main roots and abundant lateral branching.

Root fibrosity as a predictor of drought tolerance

Riparia Gloire

Ramsey



Digitized root system

GRN Rootstock Summary

	Citrus Nematode	Ring Nematode	Phylloxera Nodosities	Lesion/Pin Nematode
GRN-1	R	R	HR	MR/MR
GRN-2	MS	MS	HR	MRMR
GRN-3	MR(R)	MR	R	R/MR
GRN-4	MR(R)	MR	R	MR/MS
GRN-5	MR(R)	MR(R)	MS	MR/MR

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

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
- Released in 2009

What rootstocks do we need?

- Better nematode resistance – ring, lesion, dagger (*X. americanum*)
- Better drought tolerance
- Better salt tolerance
- Better virus tolerance
- But most of these traits are in "alternative" species and lots will be warmer climate – *arizonica*, *cinerea*, *rufotomentosa*, *candicans*, *champinii*, *doaniana*

V. riparia x *V. rupestris*

- Useful on fertile, non-calcareous soils
- Root system spaced evenly in the soil profile
- Nematode resistance varies
- Easy to root and graft, mothervines vary – some with short canes and abundant laterals, others with long canes and few laterals
- But not able to take up enough Fe on calcareous soils

V. berlandieri x *V. riparia*

- Selected for phylloxera resistance, lime tolerance and moderate vigor
- Generally shallow to moderate rooting depth
- Most derived from the Teleki hybrids - a Hungarian banker / breeder (1880s)
- Many have moderate to good nematode resistance
- Excellent mothervines with long canes, few internodes
- Graft and root moderately well - 420A Mgt difficult

V. berlandieri x *V. rupestris*

- This group was developed for drought and lime tolerance in warmer, drier parts of Europe
- Have deeper root systems to avoid drought
- Limited nematode resistance, good phylloxera resistance
- Most are shrubby mothervines and produce short canes and many laterals
- Some are more difficult to root and graft

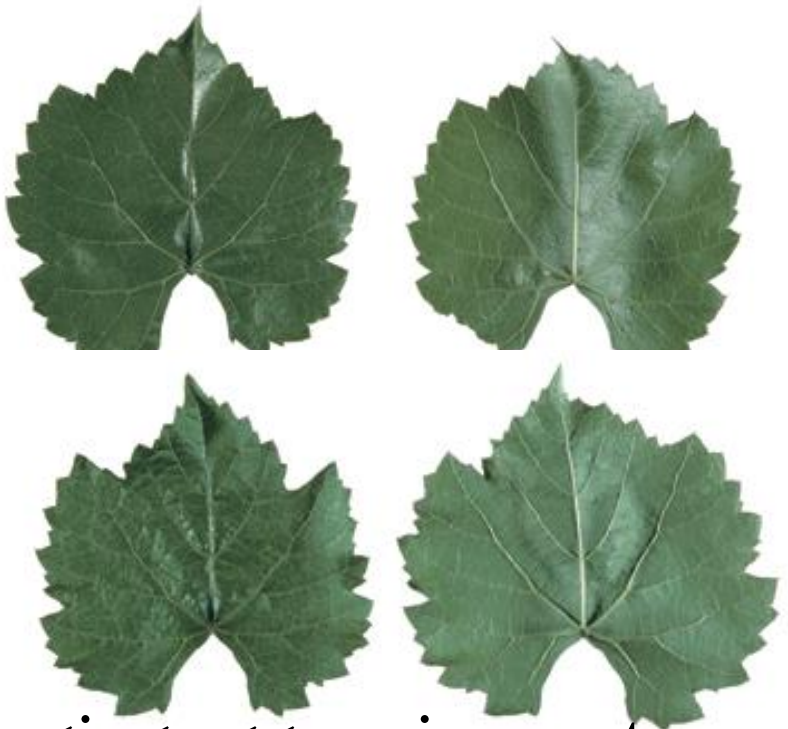
V. champinii - Based Rootstocks

- A natural hybrid of *V. candicans* x *V. rupestris*
- “champinioid”
- Very vigorous
- Drought tolerant due to deep root system
- Broad nematode resistance; does not tolerate fanleaf degeneration
- Often more difficult to propagate

Ramsey (Salt Creek)

- Selected by T.V. Munson.
  Salt Creek is *V. doaniana*.
- Very good nematode, moderate phylloxera resistance, induces very high vigor in scions
- Good for sandy low vigor soils; rotate to other nematode resistant rootstocks
- Good salt tolerance, widely used in droughty, saline, shallow soils in Australia
- Dog Ridge is more vigorous (*V. candicans* x *V. berlandieri*?)

Freedom & Harmony



- Freedom has greater vigor and easily propagated, high K uptake
- Not phylloxera resistant - have *vinifera* in their parentage; damaging aggressive root-knot nematode strains have been selected
- Good for sandy low vigor soils; rotate to other nematode resistant rootstocks
- Freedom is very intolerant of viruses that induce graft failure

VR O39-16 & O43-43

- *V. vinifera* x *M. rotundifolia* siblings
- Only sources of tolerance to fanleaf degeneration
- O43-43 susceptible to phylloxera, O39-16 susceptible to root-knot nematodes
- May act as natural nematicides
- High vigor, respond well to deficit irrigation and cover crops; poor growth on limestone soils
- Hard to propagate

Grower Practices

- Plant vines early in the season
- Dormants might be more reliable
- Do not ”push” first year vines – establish roots and then a trunk
- First and second year vines mature shoots slowly… do not overgrow shoots at the expense of roots, trunks and cordons
- Hard frosts in late November and early December can be very damaging


THANKS!