How to Choose Rootstocks for Foothill Vineyards, and Why Phylloxera Matter

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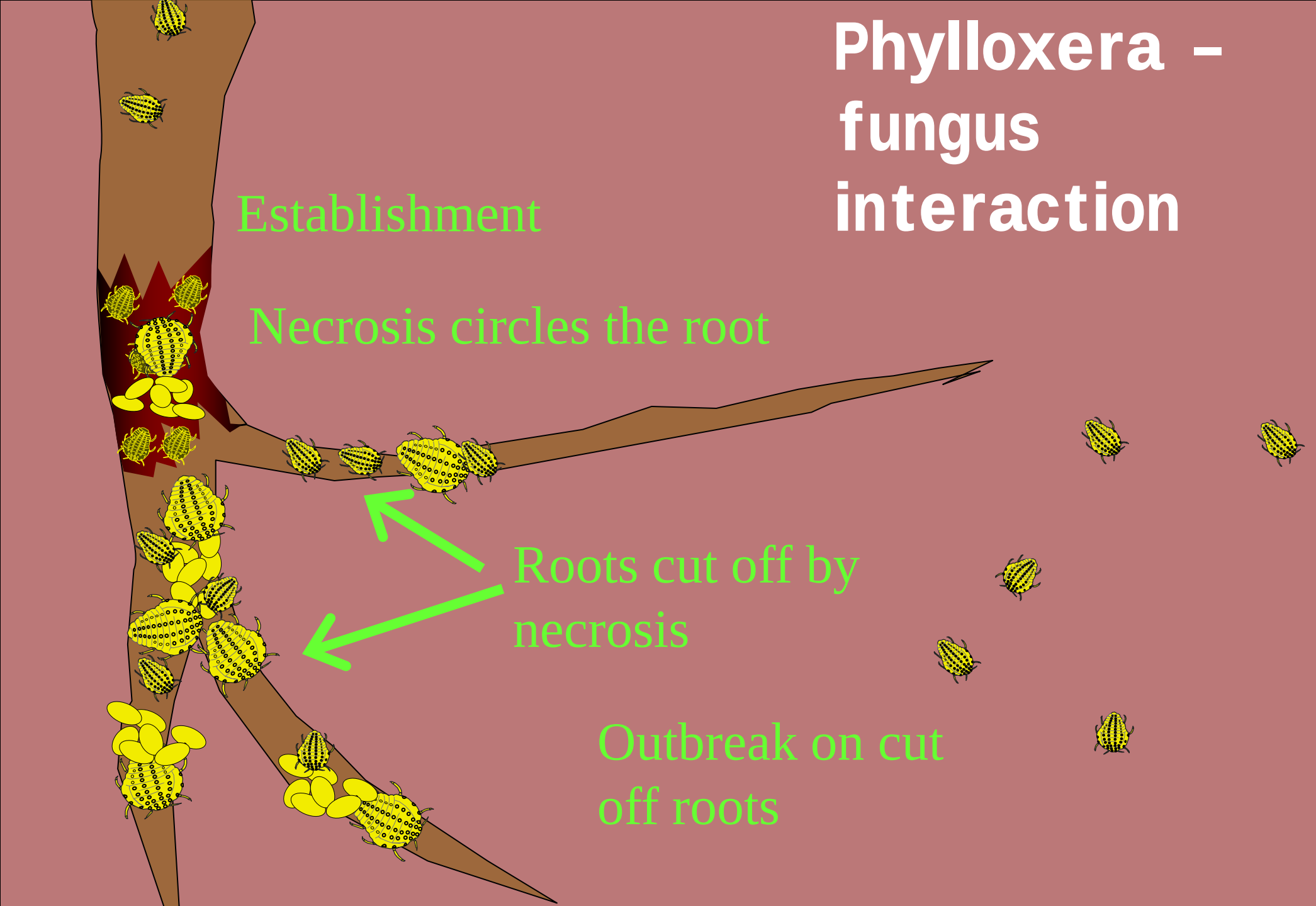
Grape Breeding

- Grape rootstock breeding began in response to the destruction of the European wine industry by the North American grape root aphid – phylloxera

Phylloxera – fungus interaction



Grape Breeding

- Rootstocks were bred in France, Italy, Hungary and Germany from resistant American species, but –
- first carbon bisulfide,
- then French Hybrids,
- and finally rootstocks

Origin of rootstocks

- French came to the US and visited T. Volney Munson, “the father of American viticulture”
- Of the 30 or so *Vitis* species only two root as well as *vinifera* – *riparia* and *rupestris*
- Both grow well on limestone based soils, but they fail as rootstocks because they do not take up enough iron for *vinifera* scions

Origin of rootstocks

- Back they went to Munson and the Edwards Plateau in Texas
- *berlandieri* was imported, but had to be hybridized with *riparia* and *rupestris* because it rooted so poorly from dormant cuttings
- The progeny rootstocks (*berlandieri* x *riparia*, *berlandieri* x *rupestris*) provided lime tolerance
- *champinii* and *monticola* also tolerate lime

V. riparia

V. rupestris

Jack Fork River, MO

V. berlandieri

History of rootstock use in California

- Most vineyards dry-farmed or with limited irrigation
- *vinifera* x *rupestris* rootstocks thrived – AXR#1, 1202C, 93-5C
- St. George did well too

Why not just use St. George?

- Easy to propagate
- Expansive roots – somewhat drought tolerant
- Roots exclude salt from getting to shoots
- Tolerates virus – diminishes expression
- But … very susceptible to most nematodes; supports high phylloxera numbers on root tips (nodosities); no lime tolerance

Which rootstock to choose?

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

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

V. riparia x *V. rupestris*

- 101-14 Mgt, Schwarzmann, 3309C
- Both relatively shallow roots, induce low to moderate vigor
- 101-14 Mgt poorly adapted to cracking clay soils
- 3309C relatively low vigor
- Neither would be classified as drought adapted

1616C

- *V. solonis* x *V. riparia*
- Good phylloxera resistance, good nematode resistance
- Relatively shallow rooted, induces low to moderate vigor in scions
- Tolerant of wet, water-logged soils

V. berlandieri x *V. riparia*

- Relatively shallow root systems, induce low to moderate vigor – 420A Mgt an exception
- 5BB, 5C = SO4, 420A Mgt, 161-49C
- 5C poorly adapted to drought, deficit irrigation, and cracking clay soils
- 420A very *V. berlandieri*-like – late season growth, hard to graft/propagate

V. berlandieri x *V. rupestris*

- 1103P and 110R
- Relatively deep root systems avoid drought
- Can induce excess vigor with high spring rainfall and deep soils
- 140Ru is higher vigor, excellent salt tolerance
- 1103P is reported to be moderately tolerant of saline soil, 110R less so

Vitis champinii

- Texas, Edwards Plateau, limestone soils
- Natural hybrid of *V. candicans* x *V. rupestris* (*V. monticola*, *V. berlandieri*)
- Deep roots, induces high vigor, resists nematodes, moderate phylloxera resistance, relatively difficult to propagate

V. champinii rootstocks

- Ramsey and Dog Ridge – Munson selections for fruiting varieties
- Deep roots, very high vigor —sandy, infertile soils
- Moderately difficult to propagate
- Moderate phylloxera resistance, strong nematode resistance
- Can delay maturity, reduce color, increase K in juice
- Harmony and Freedom for nematodes

VR O39-16

- *V. vinifera* x *M. rotundifolia*, bred by Olmo, and selected for fanleaf resistance by Lider and Goheen
- Good resistance to *Xiphinema index*, induces tolerance to fanleaf, poor resistance to root-knot nematodes
- Half *V. vinifera* so phylloxera resistance questionable – but survived 20 yrs
- Very deep roots, induces high vigor in scions, not strong on sandy soils… drought / root-knot?

New Rootstock Development

- Resistance from *V. champinii* (multiple forms), *V. rufotomentosa*, and *M. rotundifolia*
- Tested for resistance to three root-knot nematode strains (*Meloidogyne* spp. – 2 aggressive isolates)
- Against the dagger nematode (*Xiphinema index*)
- All of these nematodes in a combined inoculum and at high soil temperatures
- And then against: citrus (*Tylenchulus semipenetrans*), lesion (*Pratylenchus vulnus*) and ring (*Mesocriconema xenoplax*) nematodes

Rootstock 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

New 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

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

- Bred by David Ramming, selected by Mike McKenry; released in 2003 … in trials
- 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

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

Breeding Rootstocks to Tolerate Drought, and Control Growth and Phenology

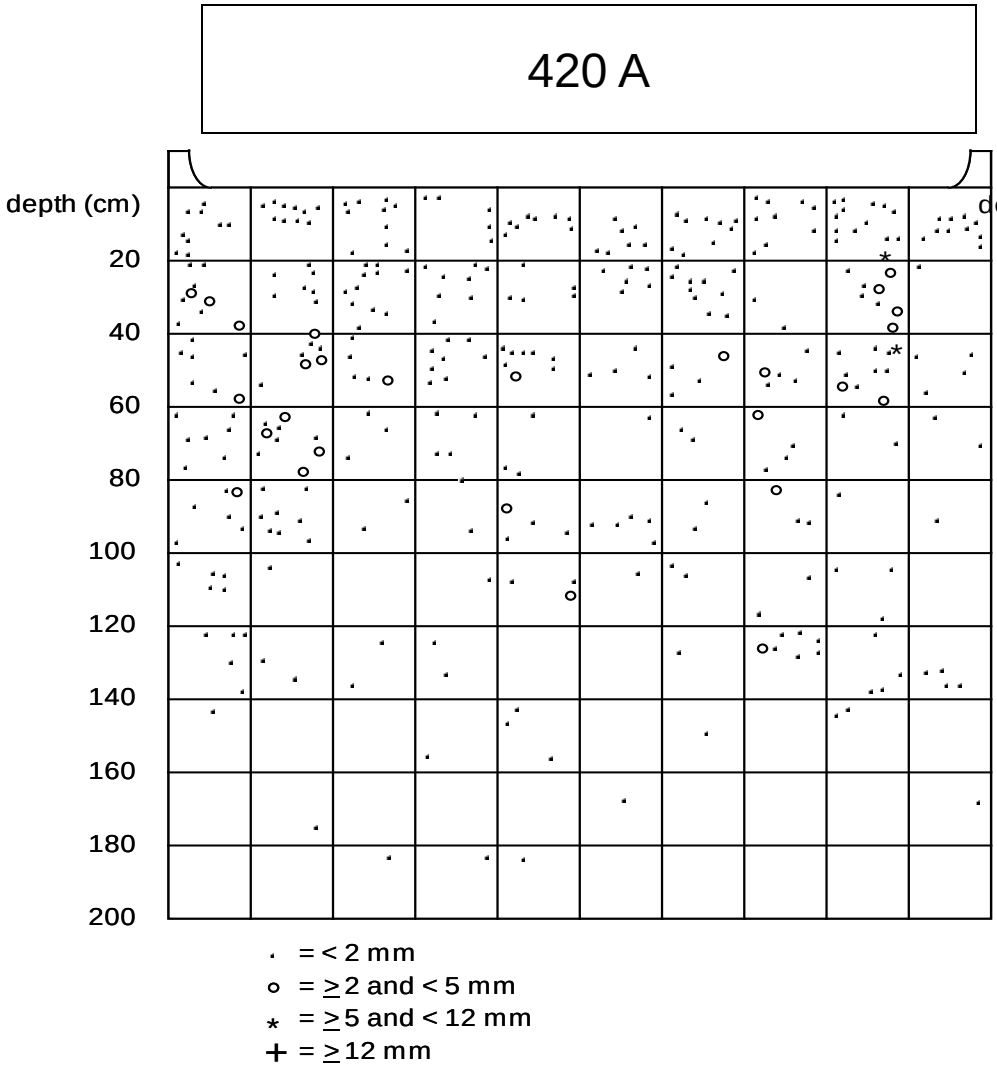
- In collaboration with Andrew McElrone
- Root architecture – shallow to deep rooting angles
- Root density – two tiered to even distributions
- Hydraulic lift
- Water use efficiency / productivity
  - Mike Anderson and Jim Wolpert's trials – associate characters with drought tolerance
- Control of vigor and leaf longevity

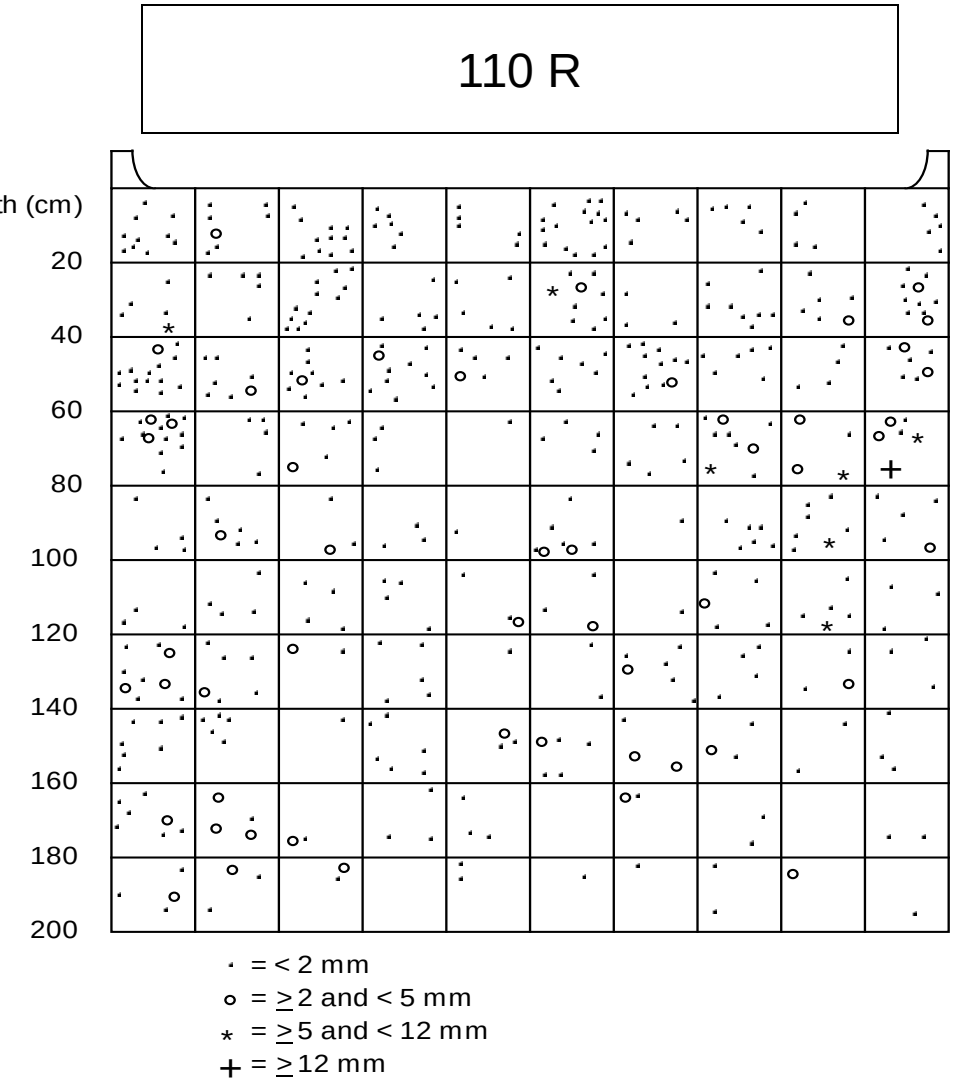
What is needed?

- Understanding drought adaption vs drought tolerance
- Can we uncouple rooting depth from drought adaptation/tolerance?
- What is the relationship of seasonality to rooting depth and rootstock parentage?

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

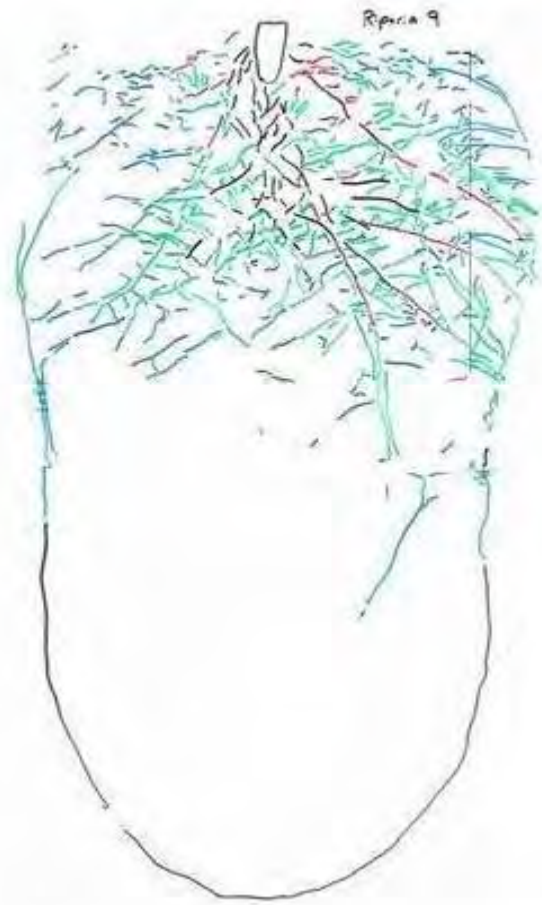

420 A
depth (cm)
20
40
60
80
100
120
140
160
180
200
= < 2 mm
= ≥ 2 and < 5 mm
= ≥ 5 and < 12 mm
= ≥ 12 mm


110 R
depth (cm)
20
40
60
80
100
120
140
160
180
200
= < 2 mm
= ≥ 2 and < 5 mm
= ≥ 5 and < 12 mm
= ≥ 12 mm

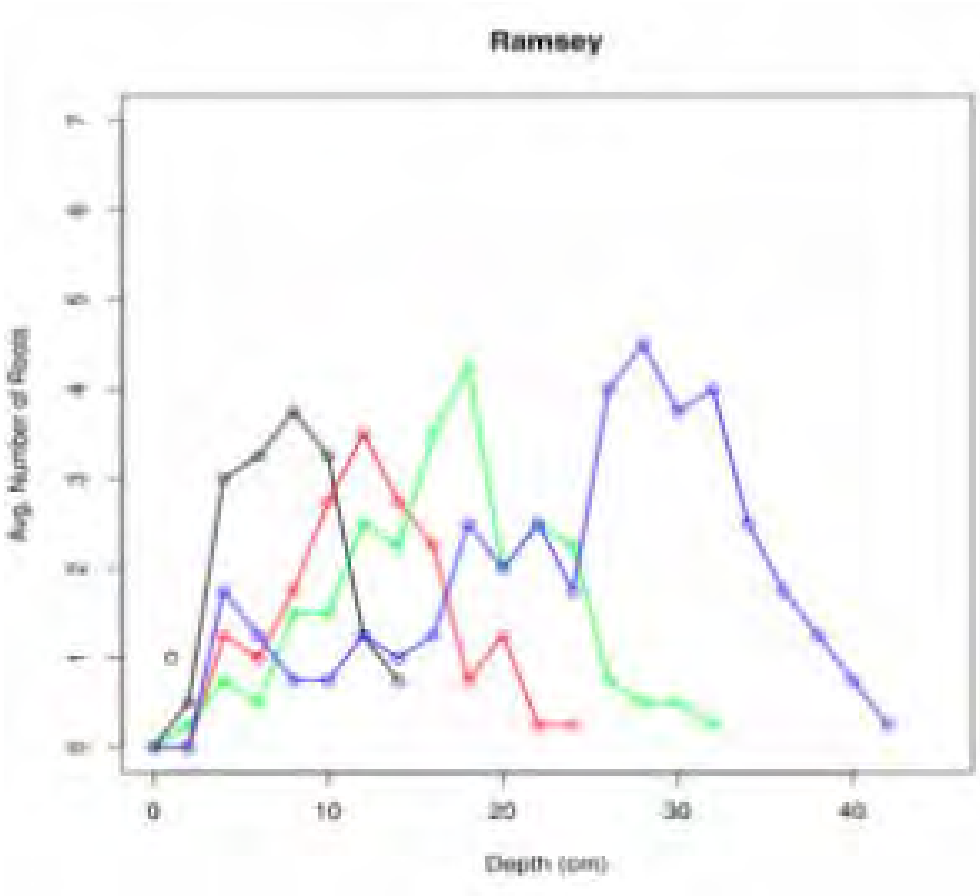
Rhizotrons:
Charting root development

Ramsey

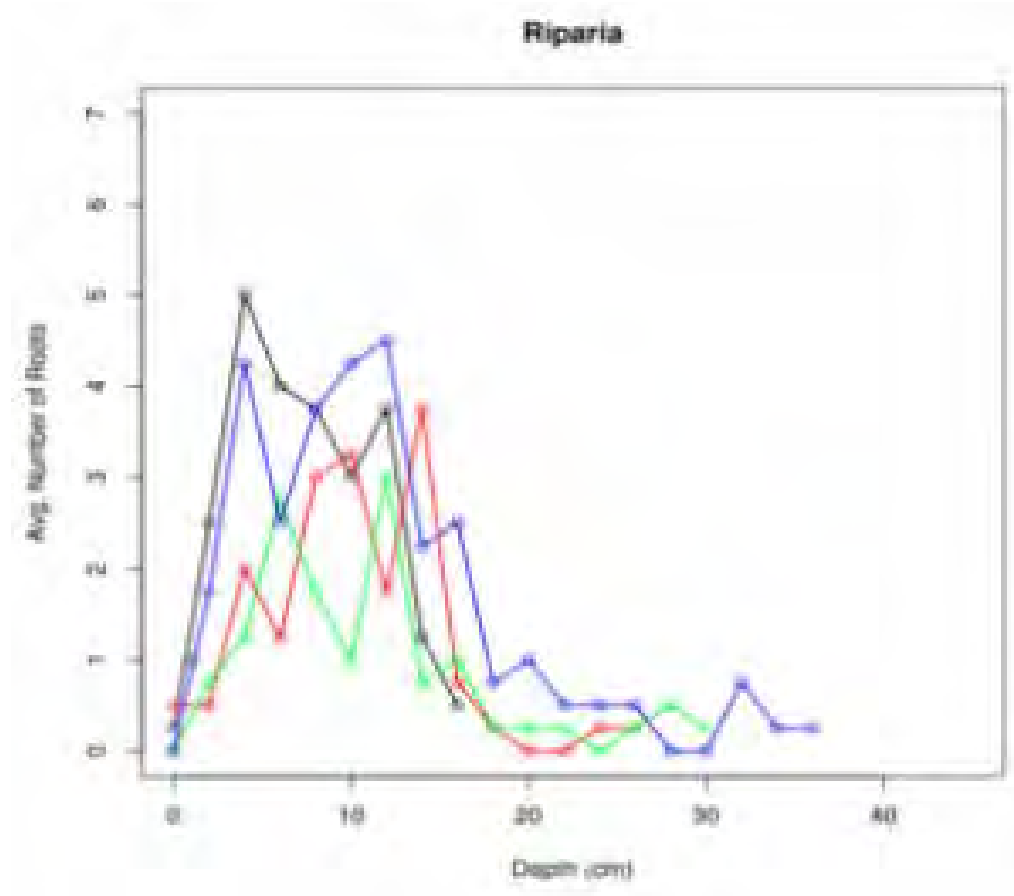
Riparia Gloire



Rhizotrons: root development over time



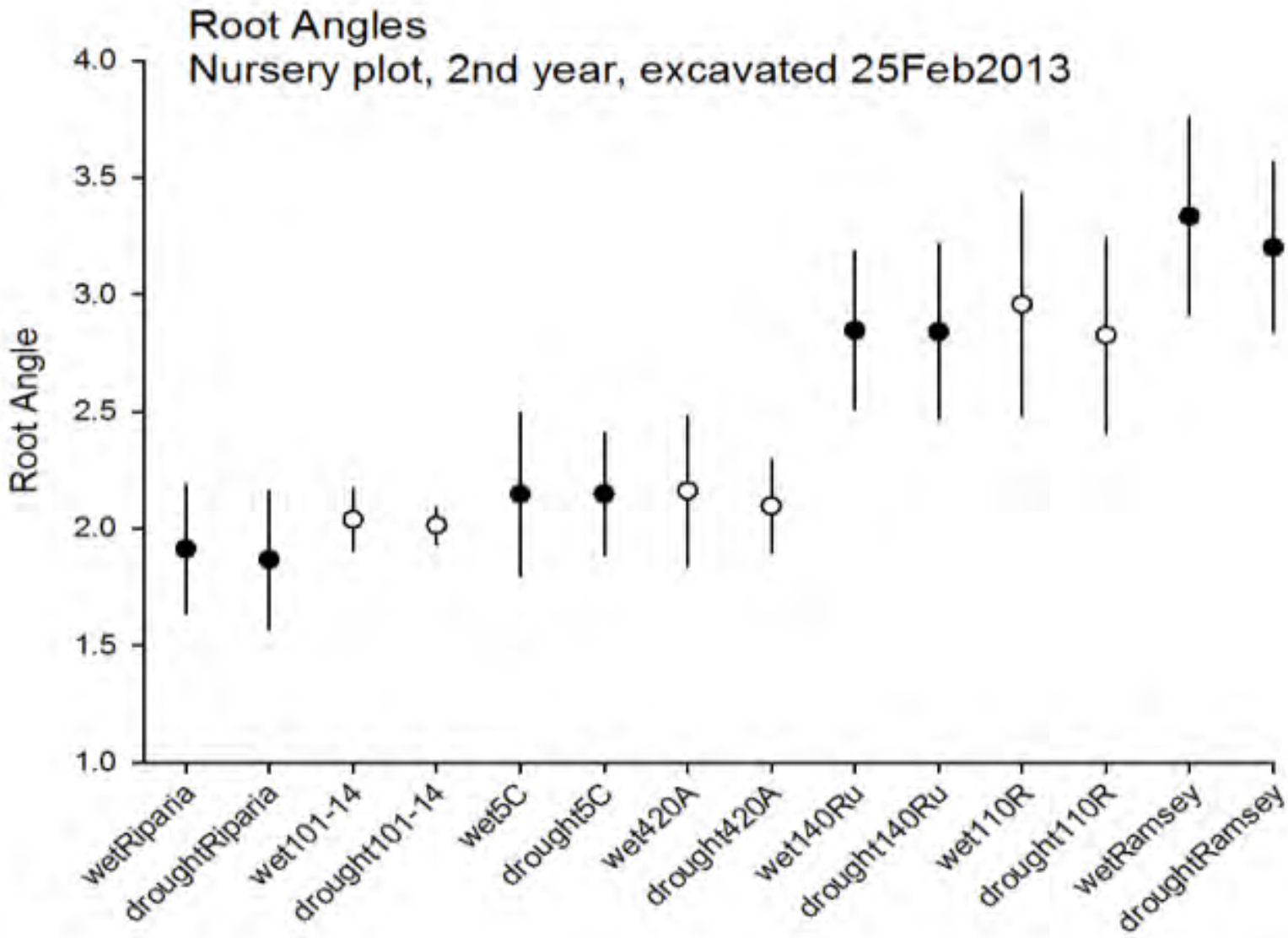
Ramsey



Riparia

Field-grown vines: 2 seasons of growth, dry-farmed vs. well-watered

Field-grown vines: Stable root architecture regardless of watering regime

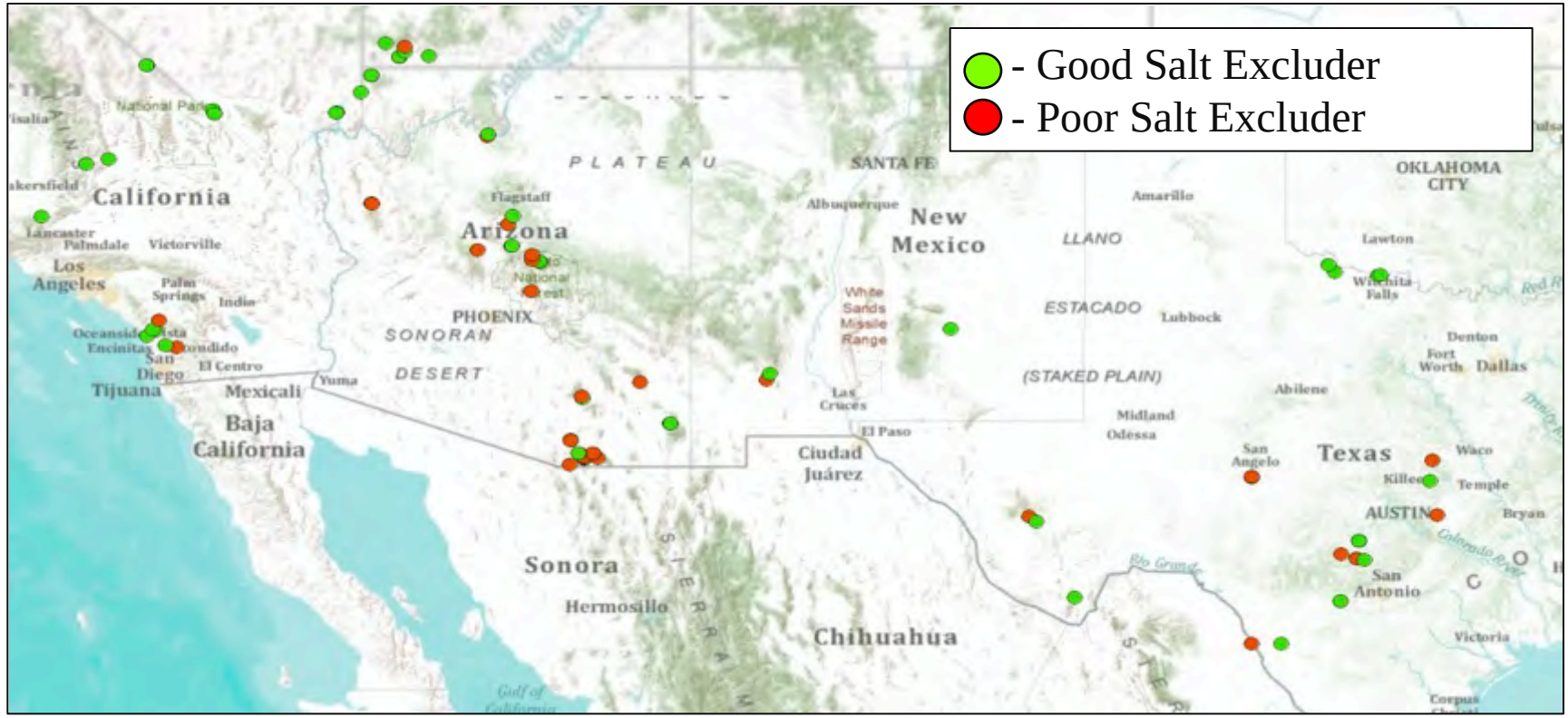


Drought Resistance –Osorio, McElrone

- What anatomical traits influence drought tolerance?
- Root angle
- Xylem diameter / distribution
- Storage capacity
- Stomatal distribution

Germplasm Discovery

- Genetic / Geographic Analyses



- Overall characterization of the population for targeted collection and effective germplasm selection

V. monticola

- Dry limestone, very limited water
- Weak vine with broad adaptability
- Roots poorly, may be good for breeding

V. californica

Salt flat near serpentine outcrop, Lake Co., CA

Butts Canyon, Lake Co., CA

V. girdiana

Grapevine Canyon,
InyoKern, CA

Scotty's Castle,
Death Valley, CA

V. girdiana and *V. arizonica*

Lake Mead, NV

Lake Mead, NV

101-14 Strains of Phylloxera

- Strains collected on 101-14 have better reproductive capacity on 101-14
- 101-14 Strains can:
  - Reproduce in less than 2 weeks
  - Adults can produce more than a dozen eggs a day
- Lead to extremely large populations on 101-14
- May lead to reduced fitness of 101-14 during heavy infestation
- But only on root tips – nodosities

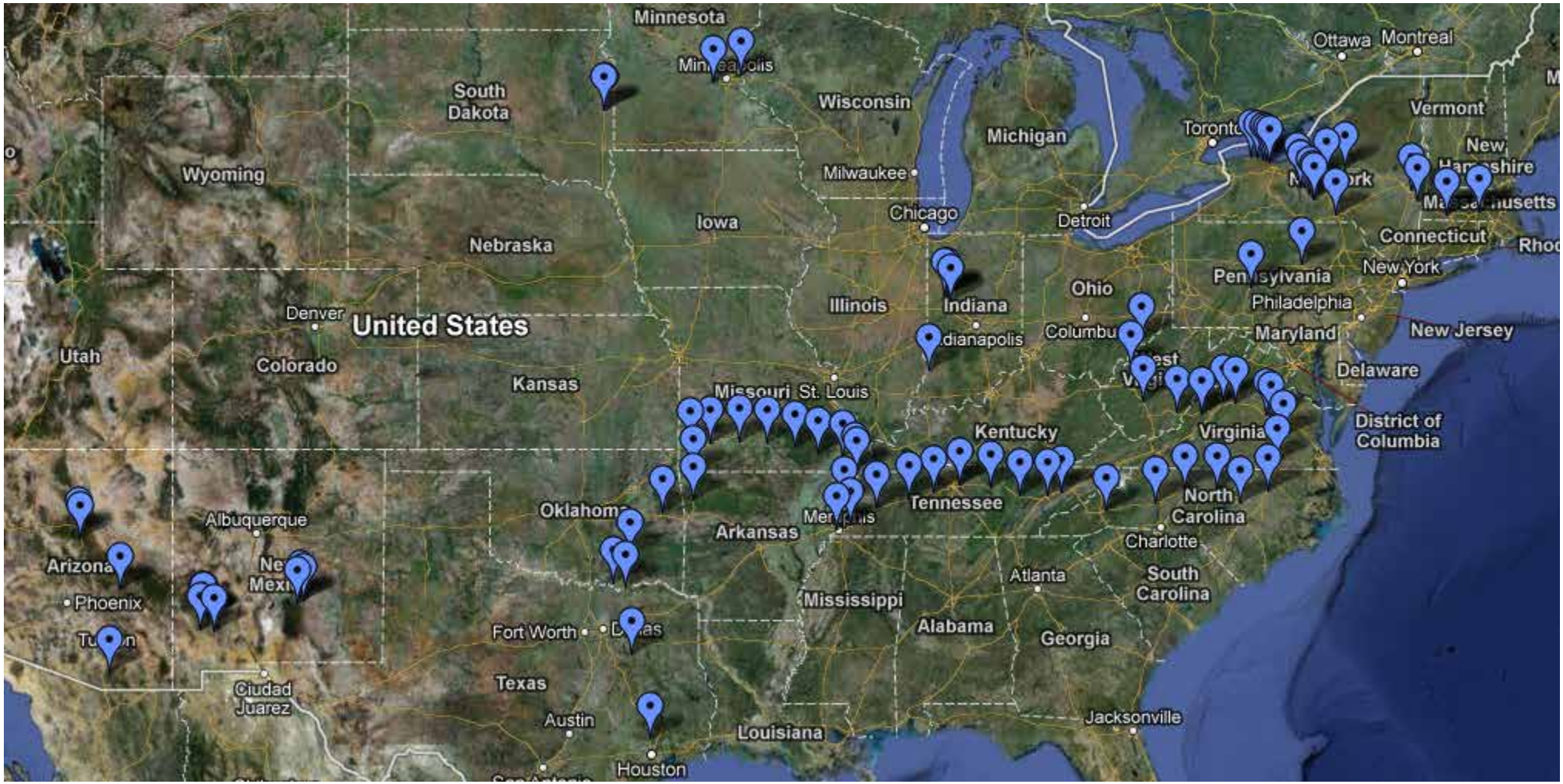
What is responsible for 101-14's decline?

- Heavy clay soils — too wet in the Spring and cracking in Summer
- 101-14's predominantly horizontal and thin roots
- Poor 1° root regeneration – not well adapted to deficit irrigation
- Better adapted phylloxera strains

1103P Phenotyping

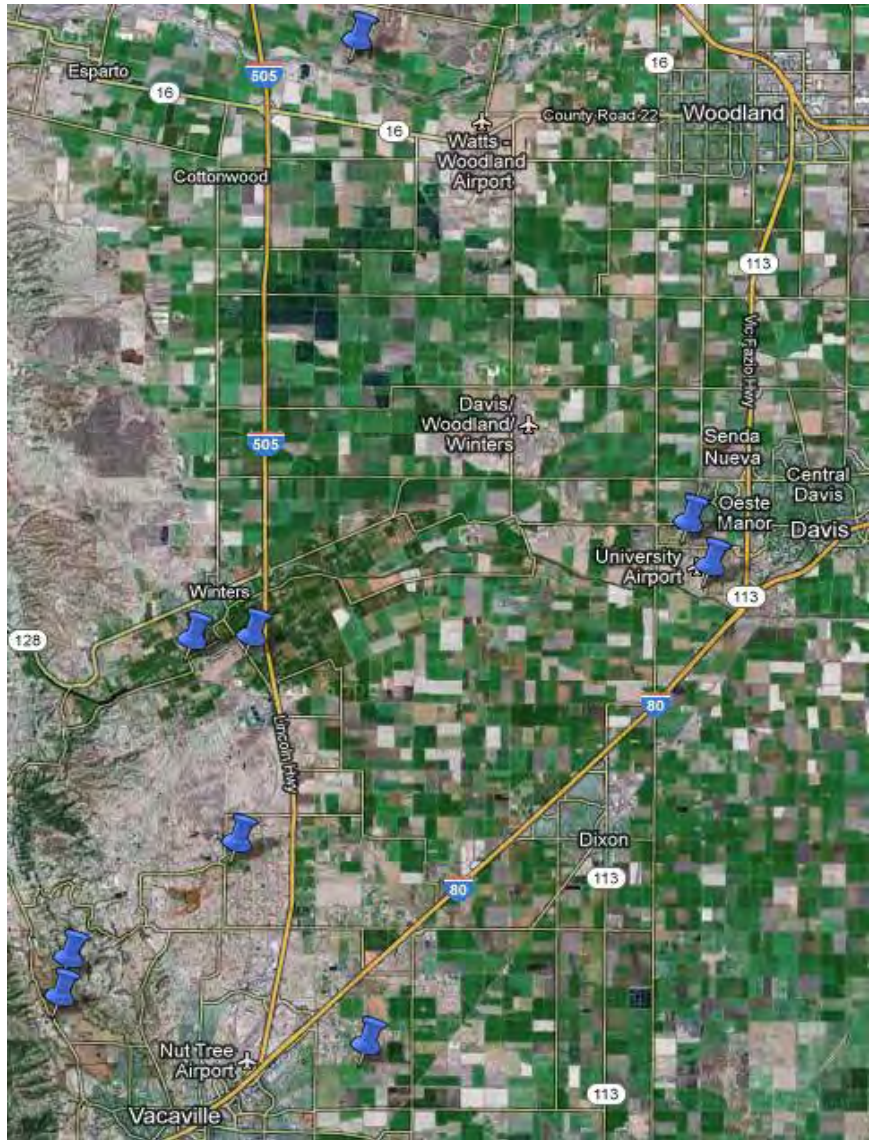
- All strains reproduce on 1103P
- VIN R1 and AXR R1 did poorly
- A few tuberosity like galls formed

National Samples



California Foliar Samples

- 4 Sites near Vacaville, CA
- 2 Sites near Winters, CA
- 1 Site near Woodland, CA
- 2 Sites on UC Davis campus

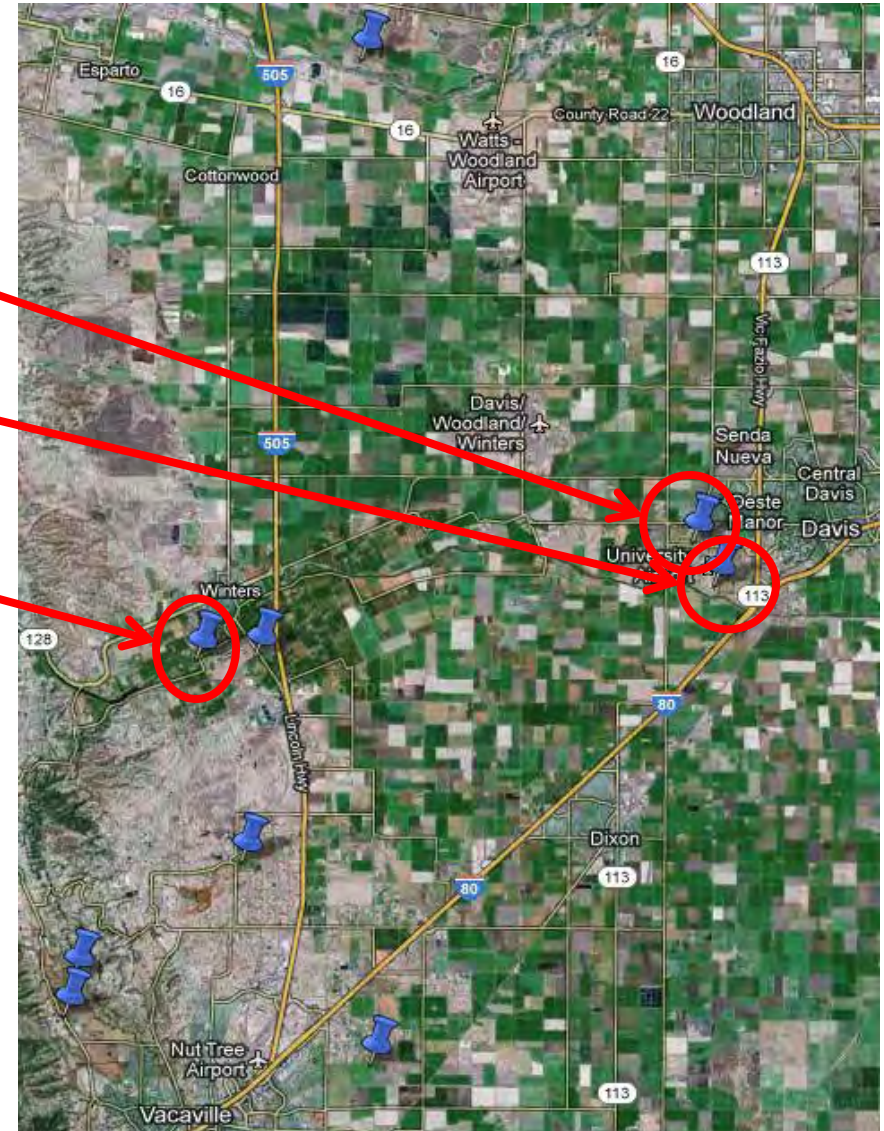


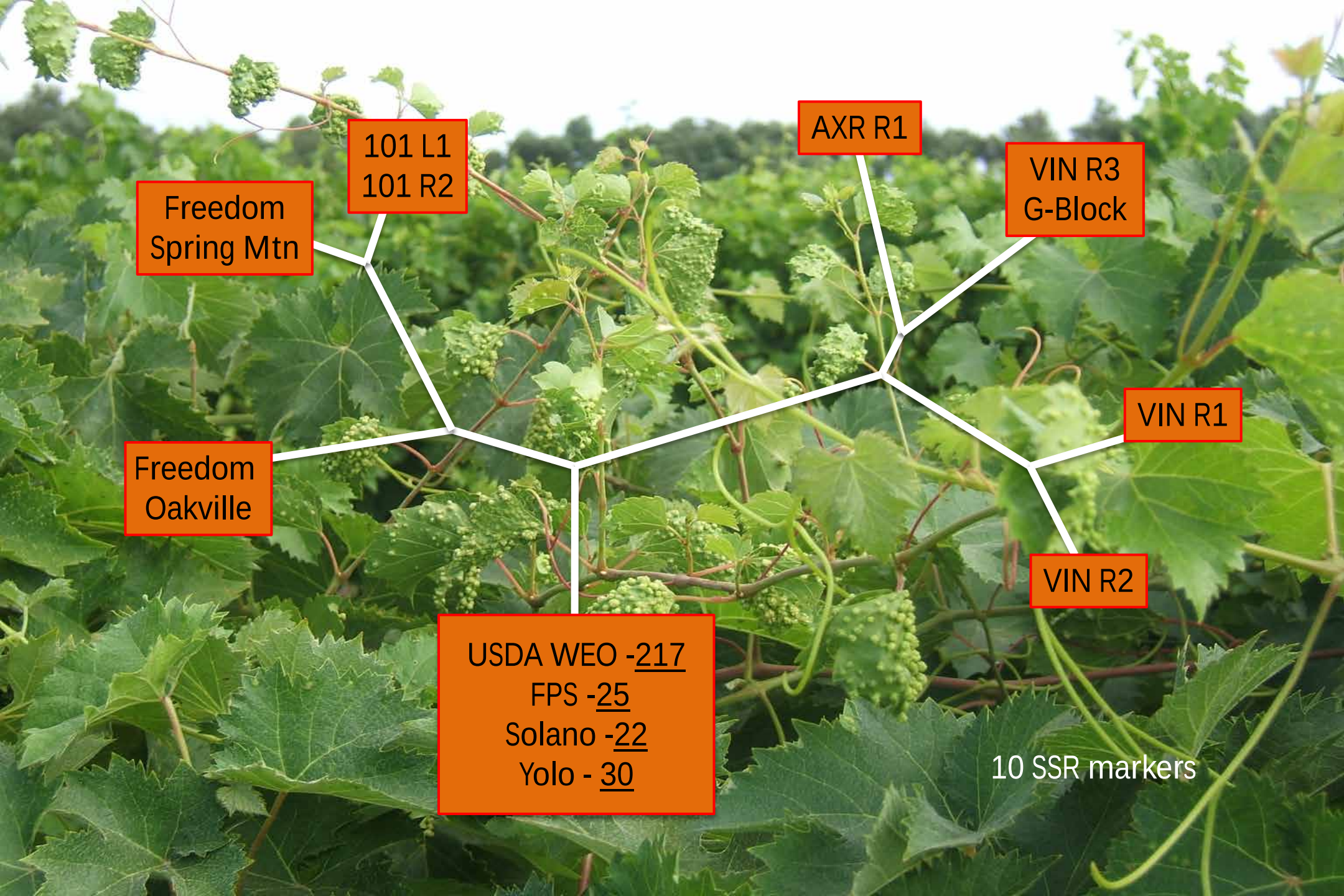
California Foliar Samples

FPS Indexing Blocks

FPS vineyard

Wolfskill Experimental Orchard




101 L1
101 R2
AXR R1
VIN R3
G-Block
Freedom
Spring Mtn
VIN R1
Freedom
Oakville
VIN R2
USDA WEO -217
FPS -25
Solano -22
Yolo - 30
10 SSR markers

Thanks!