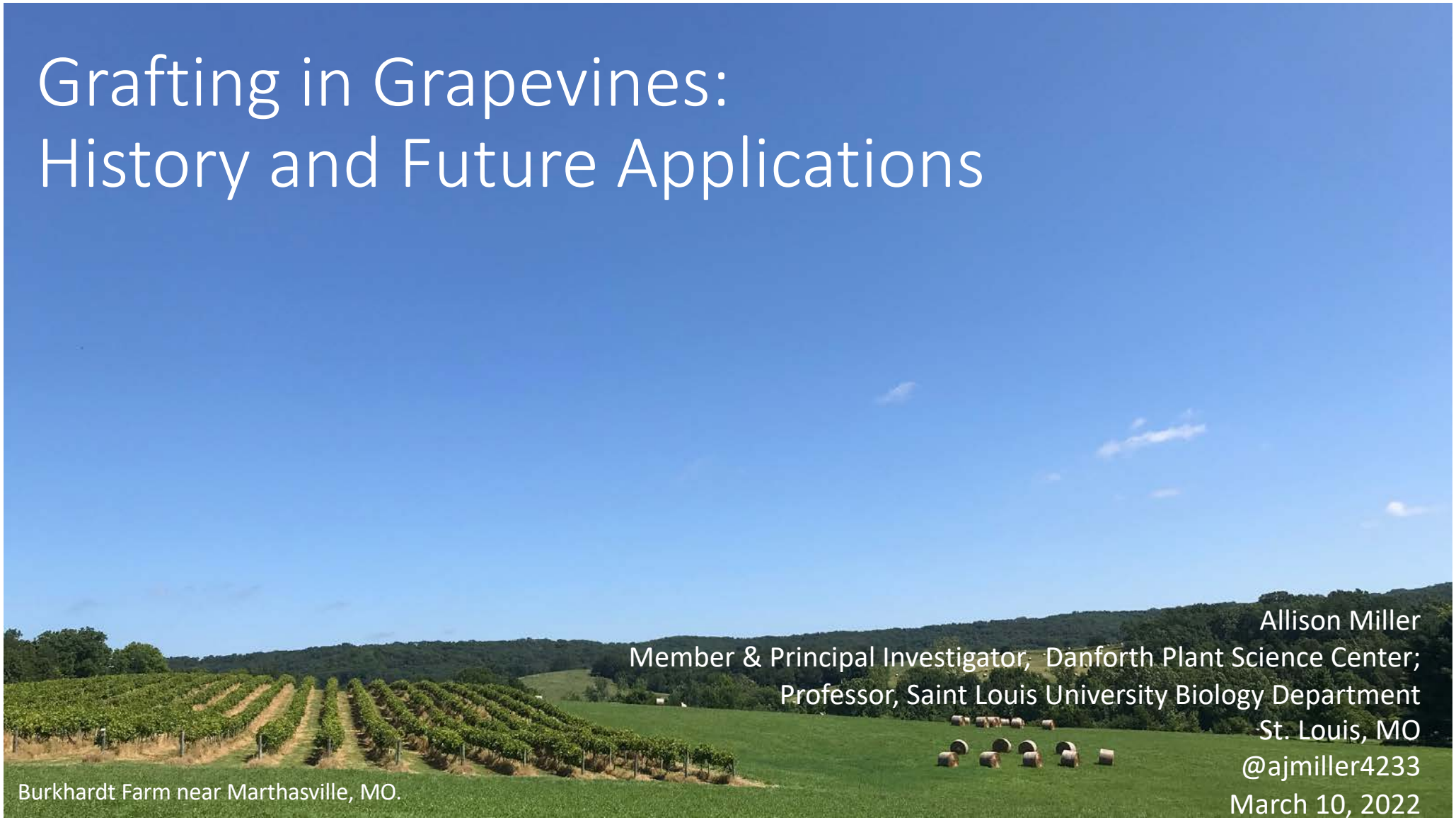
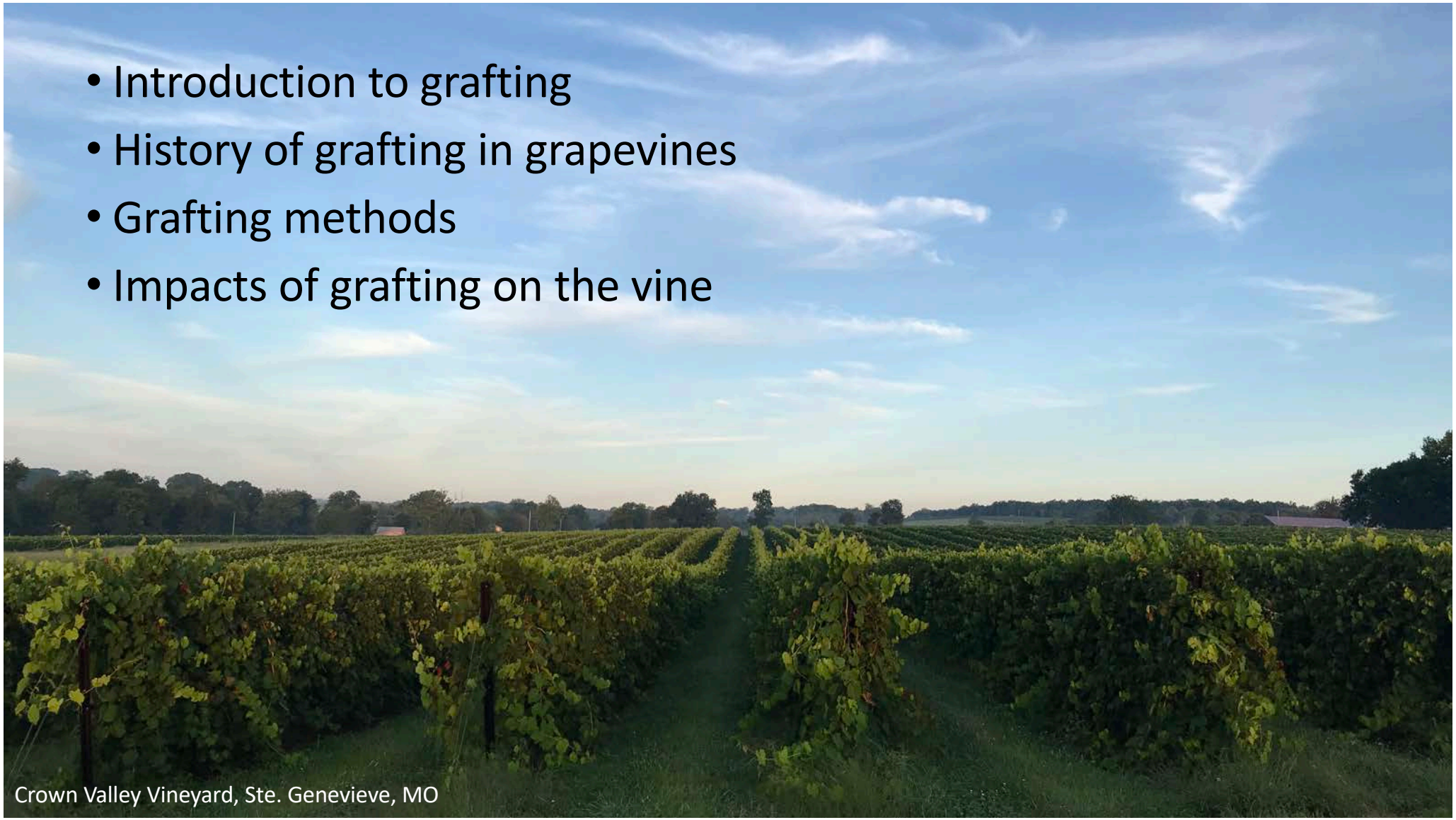
Grafting in Grapevines: History and Future Applications



Allison Miller
Member & Principal Investigator, Danforth Plant Science Center;
Professor, Saint Louis University Biology Department
St. Louis, MO
@ajmiller4233
March 10, 2022

Burkhardt Farm near Marthasville, MO.


• Introduction to grafting
• History of grafting in grapevines
• Grafting methods
• Impacts of grafting on the vine
Crown Valley Vineyard, Ste. Genevieve, MO

Grafting

Grafting typically joins two plant organs (root system and shoot) from different individuals that form vascular connections and survive in a unique symbiotic relationship as a genetic chimera [Mudge, K. et al. (2009) A history of grafting. Hortic. Rev. 35, 437–494].

Grafting occurs in nature

In nature, grafting can occur between stems or roots of the same individual or the same species or even between congeners or plants of different families

Bormann FH, Graham Jr. BF. 1959. The occurrence of natural root grafting in eastern White Pine *Pinus Strobus* L., and its ecological implications. *Ecology* 40(4): 677-691.

Fig. 9.3. Natural grafting. (A) Root grafting of yellow birch. (Photo by K. Mudge) (B) Root grafting of apple. (Photo by Janick 2005) (C) Natural root autografting of strangler fig on sable palm. (Photo by K. Mudge) (D) Shoot grafting of oak. (Photo by R. Uva).

Mudge et al. 2019

Snyder M. Self-grafting trees. Northern Woodlands. July 12, 2013.

Grafting is an ancient horticultural technique

Roman mosaic from St. Romain-en-Gal. 3rd century AD.

Grafting was mentioned by the Hippocratic treatise One the Nature of the Child (424 BCE) in Ancient Greece.

Indirect evidence suggests grafting was practiced in the first century BCE in China)

Grafting was practiced in the Mediterranean region by the 5th Century AD at least (Mudge 2009)

Grafting played a key role in the origins of woody perennial crops.

70% of perennial crops are propagated clonally; however, some of these do not root easily. Grafting to individuals or species that root well made it possible to clonally propagated many woody perennial crops (Mudge 2009)

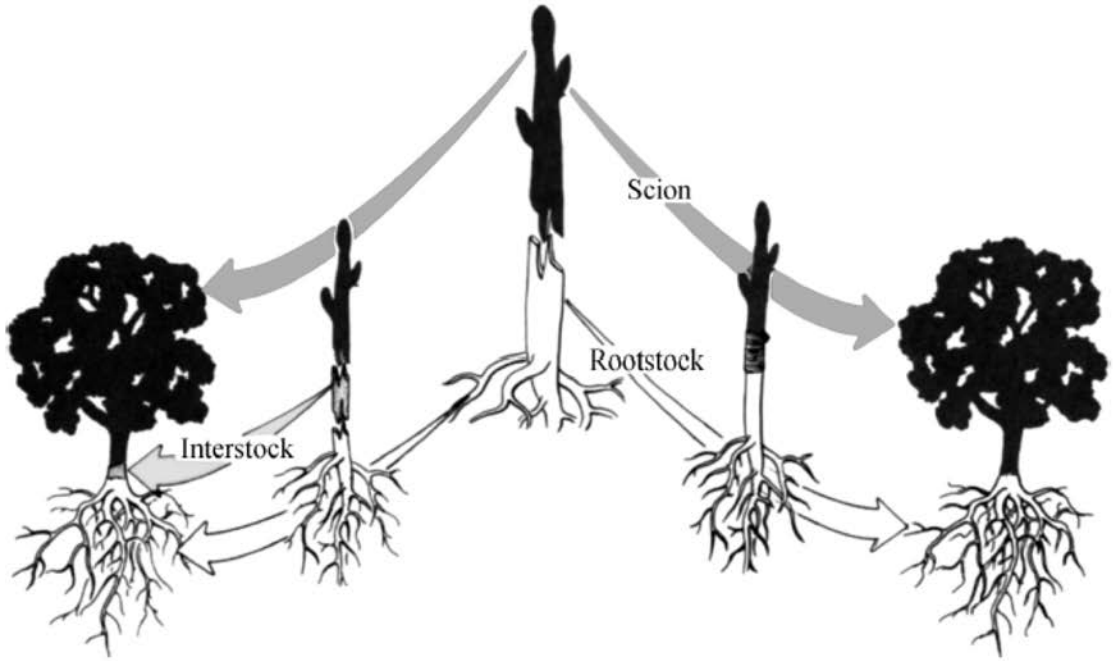


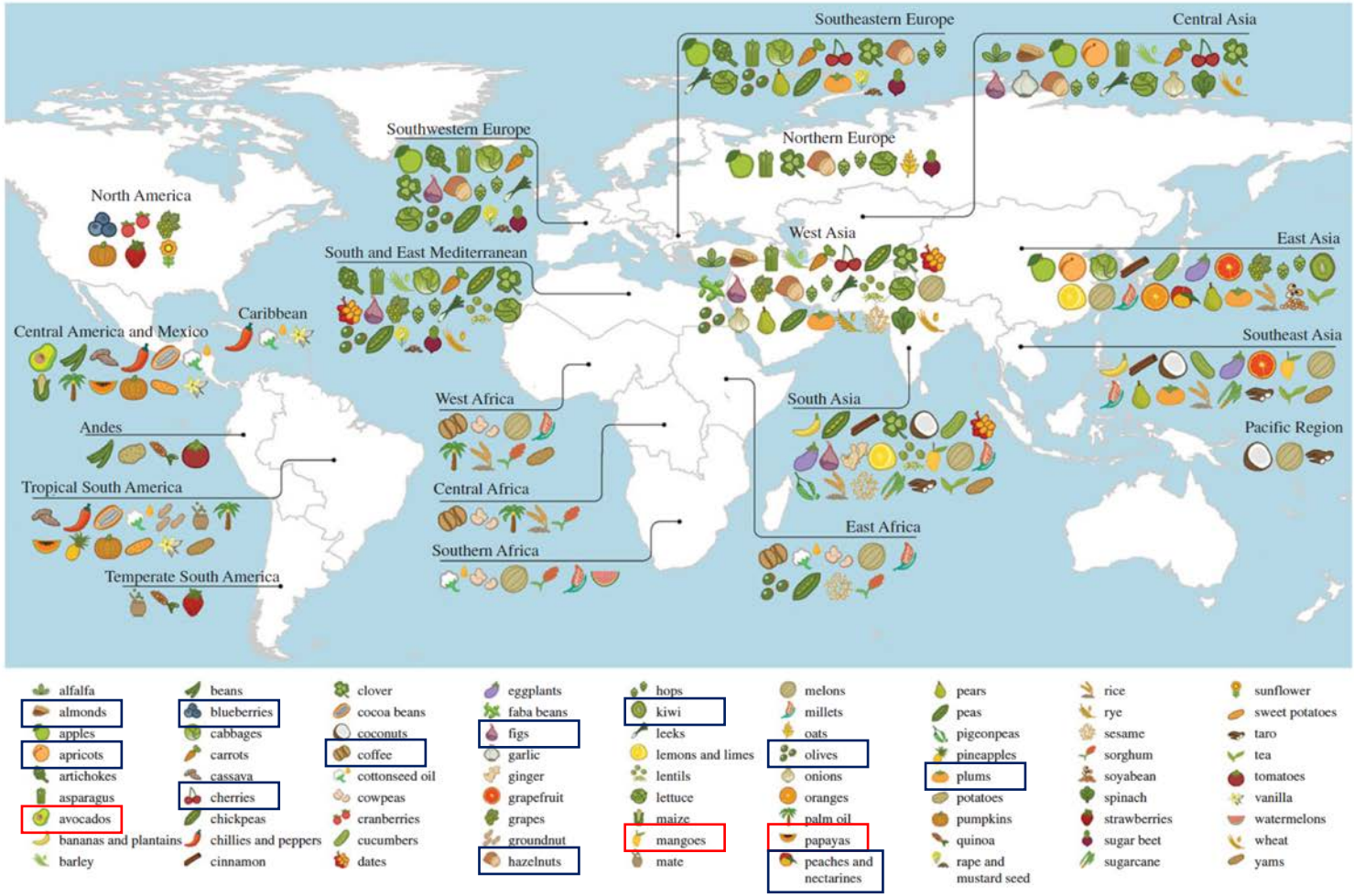
Fig. 9.1. Single-worked and double-worked grafts in fruit trees. (*Source*: Janick 1983).

More than 70 major perennial crops are grafted

Grafted crops

Almonds, apricots, avocados, blueberries, cherries, coffee figs, hazelnuts, kiwi, mangoes, olives, papayas, peaches and nectarines, plums, also…

Adansonia digitata
Anacardium occidentale
Artocarpus altilis
Casimiroa edulis
Disopyrus kaki
Psidium guajava
Sclerocarya birrea
Tamarindus indica
Ziziphus spp.



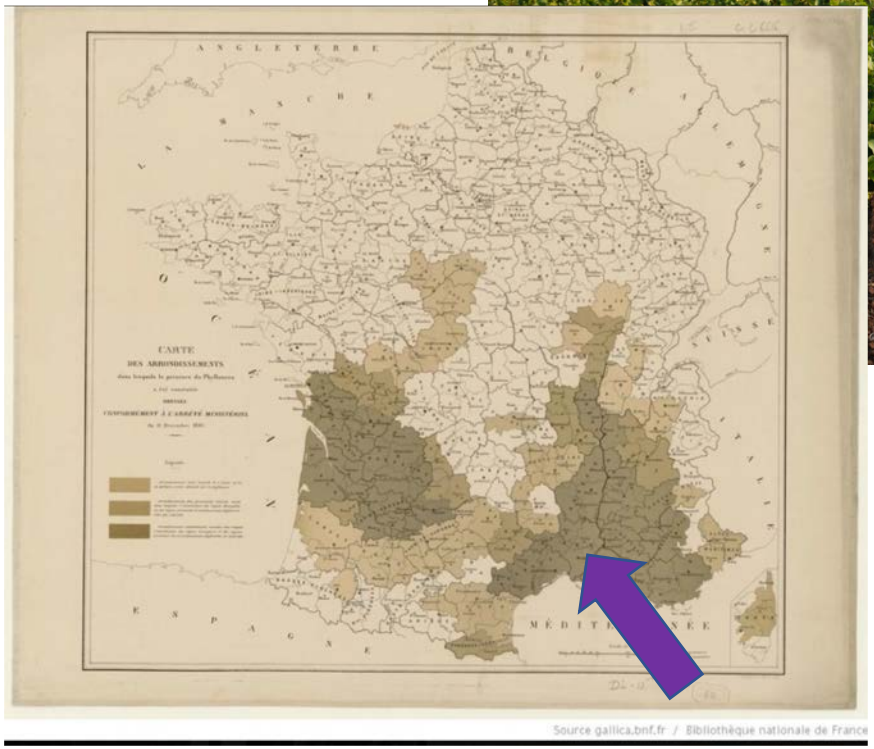
Khoury et al. 2016. *Proc. B. Roy. Soc*. Warschefsky et al. 2016. *Trends in Plant Science.*

History of grafting in grapevines

Grafting in grapevines started in earnest in the mid-1800s.

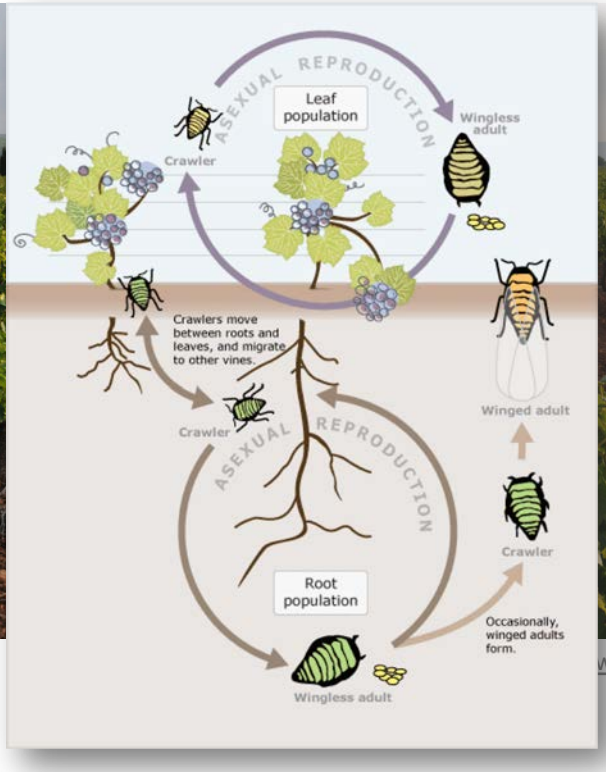
CAVE ARNAUD DE VILLENEUVE ET CHATEAU PEZILLA

https://www.tourism-mediterraneanpyrenees.com/



Source gallica.bnf.fr / Bibliothèque nationale de France

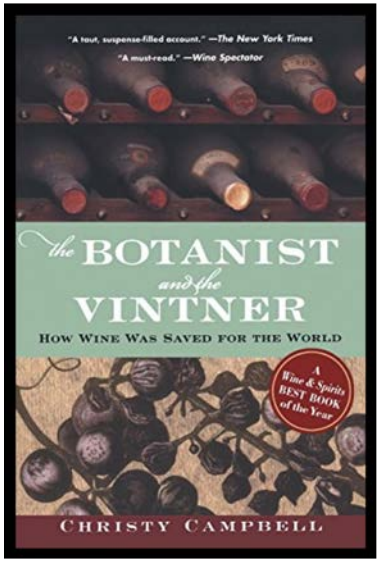
CAVE ARNAUD DE VILLENEUVE ET CHATEAU PEZILLA

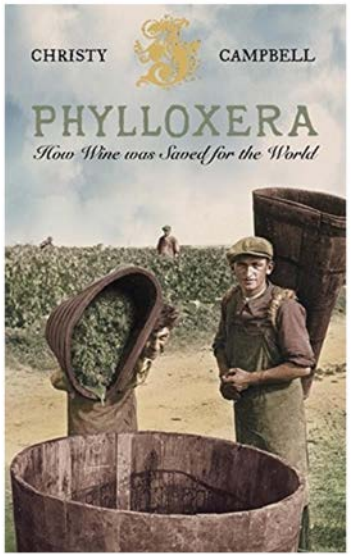


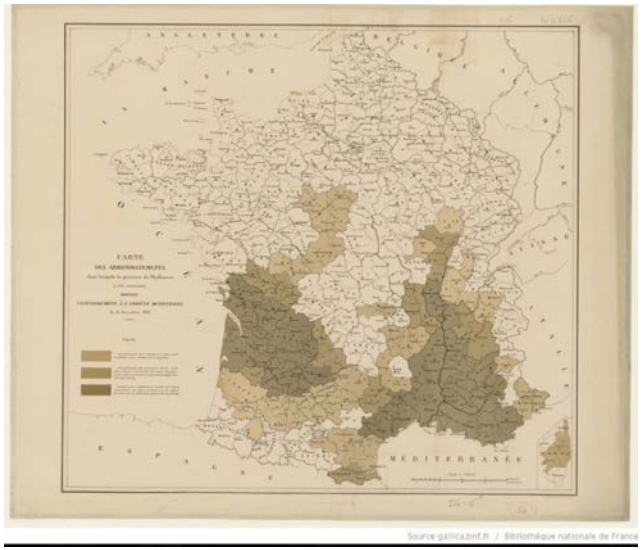
https://teara.govt.nz/

https://www.oregonlive.com/. *(Kevin Powell/Sugar Research Australia Limited)*

w.tourism-mediterraneanpyrenees.com/







Phylloxera dates

France 1863

Portugal 1871

Spain 1878

Spain (Rioja) 1901

Italy 1870

California 1873

Switzerland 1874

Germany 1875

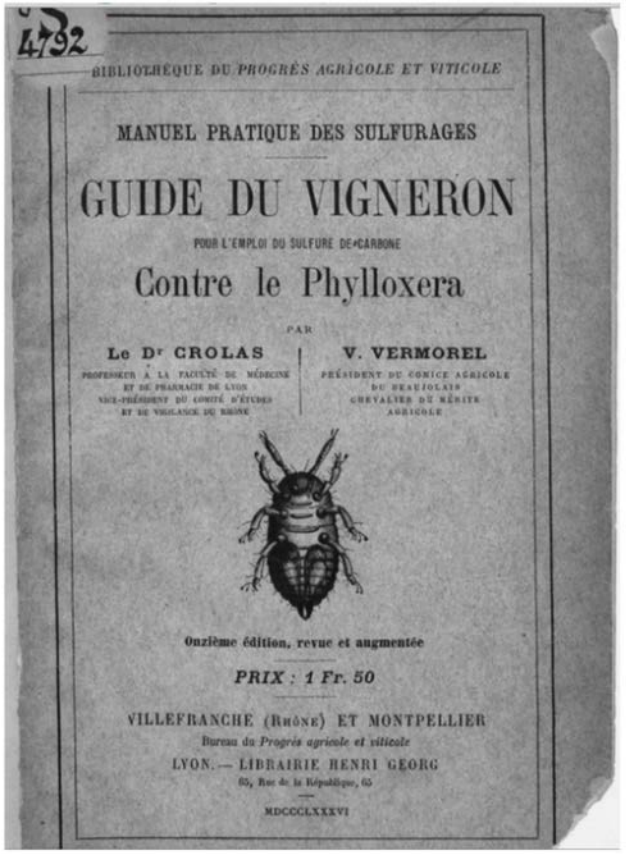
Australia 1877

New Zealand 1885

South Africa 1885

Peru 1888

Greece 1898



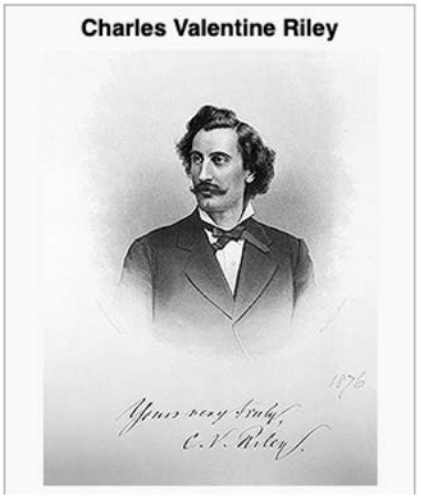
1880 French guide for grape growers on how to combat Phylloxera with sulphur.

http://www.tenzingws.com/

International response to Phylloxera introduction in Europe


Jules Émile Planchon

Julian Planchon was a French botanist who discovered that *Phylloxera* was the cause of the French vine blight in the mid 1800's



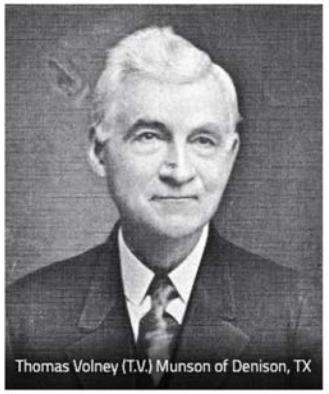
Charles Riley was a British born entomologist working in the US. He was the state botanist of Missouri and later served as an entomologist with the USDA.


GEORGE HUSMANN

George Hussmann of Hermann Missouri, and others sent hundreds of thousands of North American rootstocks to France. He later moved to California and helped found the CA wine industry.


Hermann Jaeger, c. 1880

Hermann Jaeger, born in Switzerland, was a grapevine breeder who also sent phylloxera resistant rootstock to France from MO. He lived and worked in Neosho, MO, in western MO.


Thomas Volney (T.V.) Munson of Denison, TX

T.V. Munson, born in IL and relocated to Denison TX. He was a grapevine breeder. He sent rootstocks from Texas to Europe, including *V. cinerea* ssp. *helleri*, which is adapted to chalky soils.

Phylloxera: How Missouri Saved the French Wine Industry. Feast Magazine. April 28, 2017.

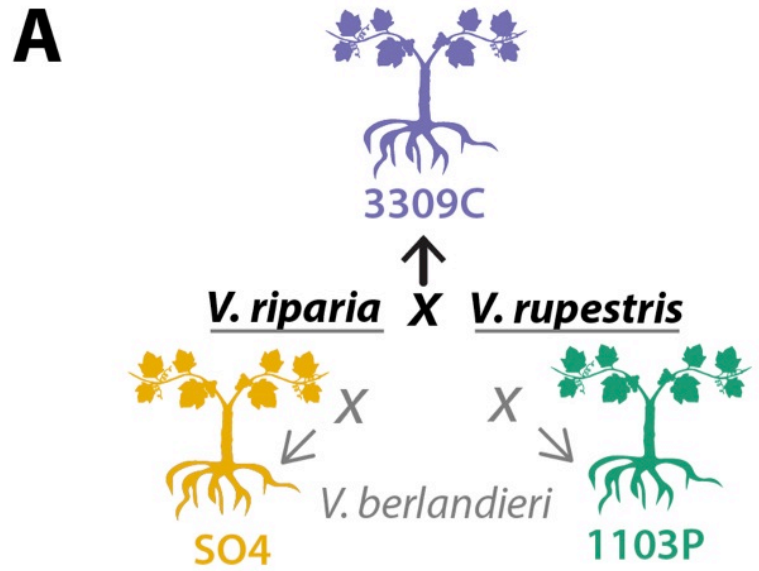

Dent County, Missouri


Dane County, Wisconsin

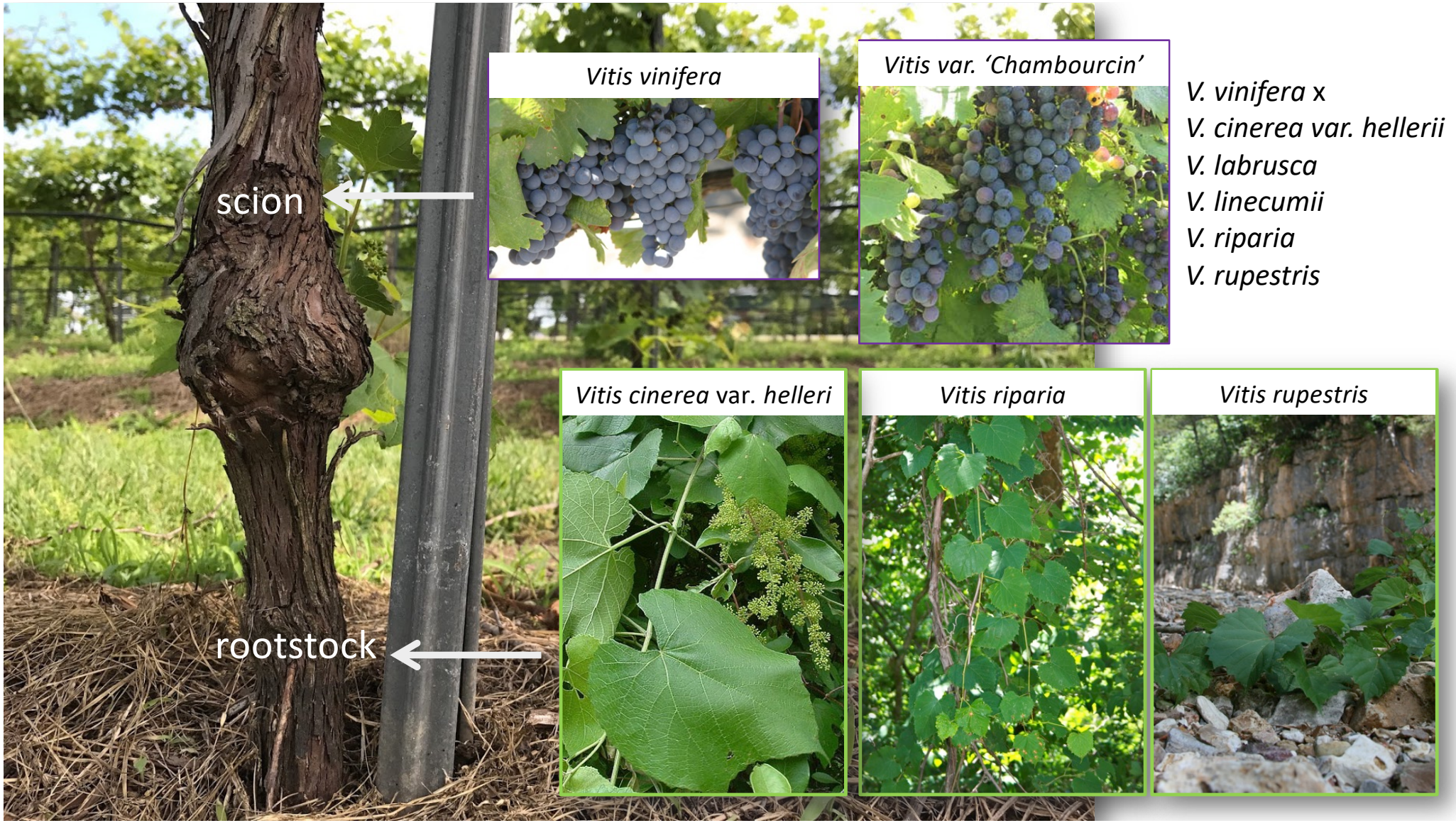

Maries County, Missouri

Rootstock varieties are derived from native North American grapevine species

- 3309C (*V. riparia* x V. *rupestris*) – phylloxera resistant
- 101-14 (*V. riparia* x *V. rupestris*) – phylloxera resistant
- 1103P – (*V. berlandieri x V. rupestris*) – phylloxera resistant, adapted to alkaline soils with pH > 7)
- 420A (*V. riparia* x *V. berlandieri*)
- Riparia gloire (*V. riparia*)



https://doubleavineyards.com/


scion
rootstock
Vitis vinifera
Vitis var. ‘Chambourcin’
V. vinifera x
V. cinerea var. hellerii
V. labrusca
V. linecumii
V. riparia
V. rupestris
Vitis cinerea var. helleri
Vitis riparia
Vitis rupestris

Grafting methods

Grafting can be done on vines already in the field as well as before vines are planted.

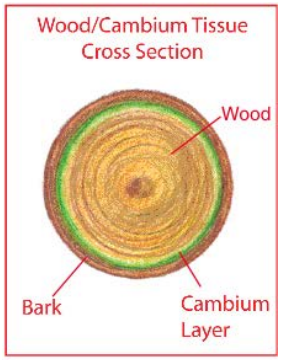
Grafting systems

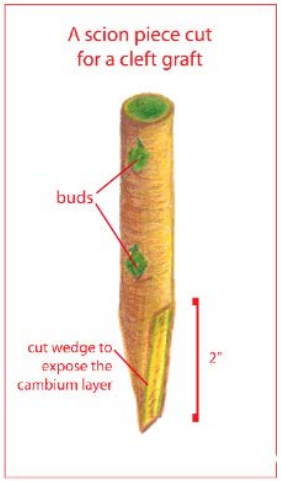
1. Field grafting
   - Pre-Grafting: The vine in the field is prepared for grafting. The site where the graft will happen is determined. The canopy is removed.
   - Grafting: Grafting takes place when the vines come out of dormancy. Graft cuts are made. Sap will run when the vine is cut.
   - Follow-up.

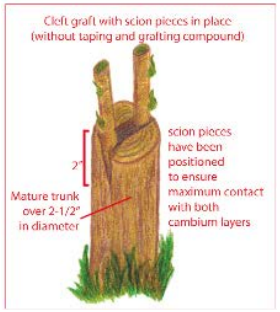
2. Bench grafting
   - Completed on young vines before they are planted in the field.
   - Scion and rootstock must be the same diameter, and at the correct physiological stage

Field-grafting: used in California but not much in other areas.

- Prepare the scion: cut mature cane at the base, once removed, it can be cut into multiple scions with two buds per scion.
- Prepare the trunk: cut the entire canopy from the trunk in the spring using pruning shears (if small) or a chain saw (if large). Make an incision into the cambium.
- Graft:
  - Cleft grafts: cut the trunk two inches down with an axe. Put two pre-shaped scions in the cut.
  - Whip grafts: used when the trunk is small.

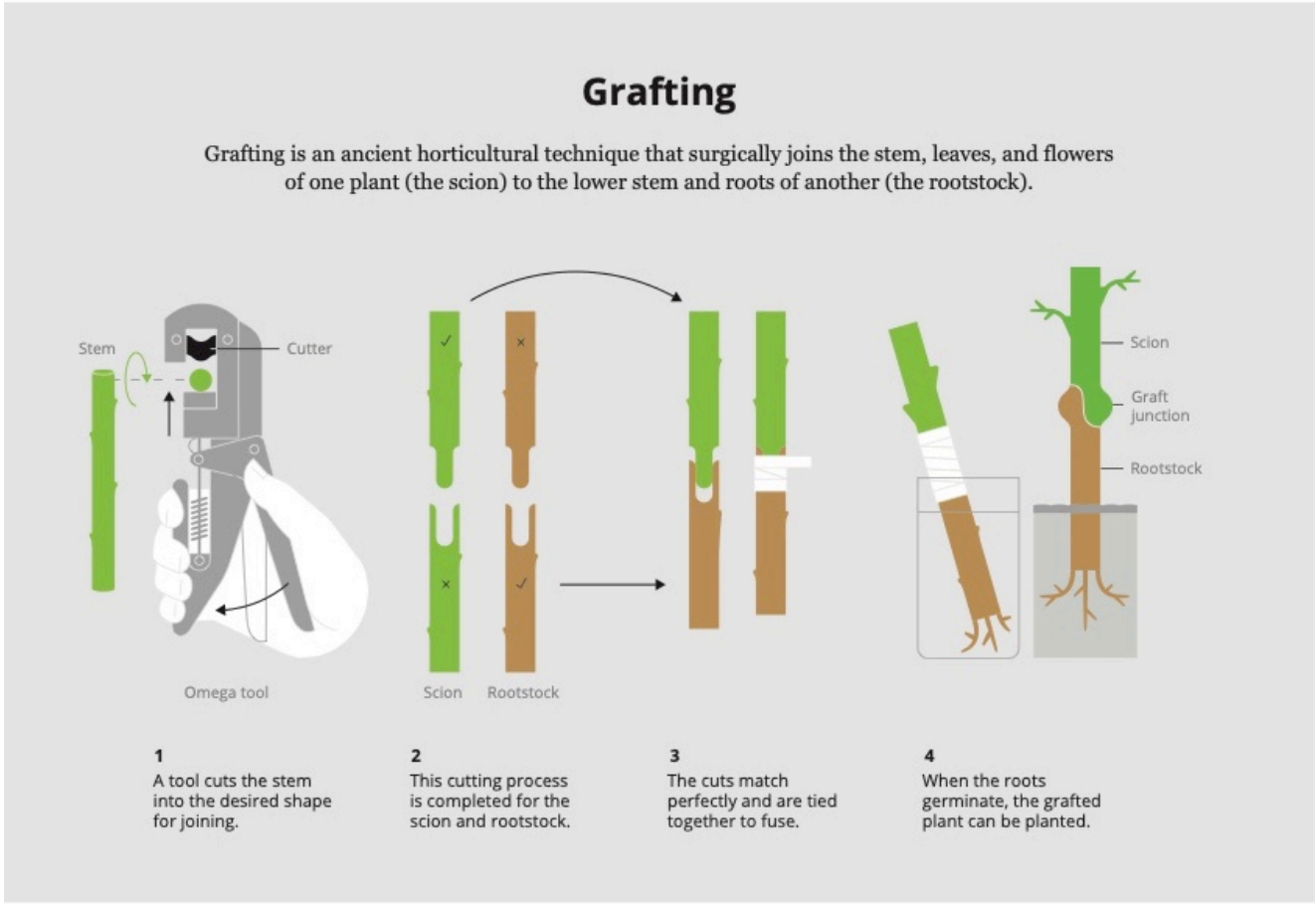






https://winemakermag.com/

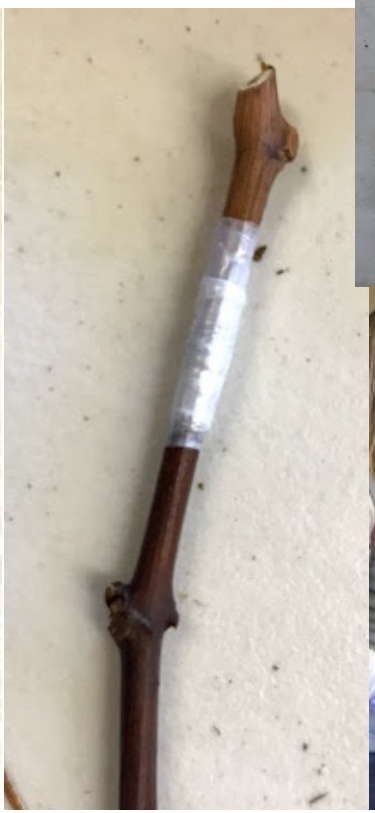
Bench grafting: a common form of grafting in viticulture



Khoury/Miller et al. 2019. *Communications Biology*.

Bench grafting






Types of grafts

Grafting with an omega tool

(a)

(b)

(c)

Whip and tongue grafting

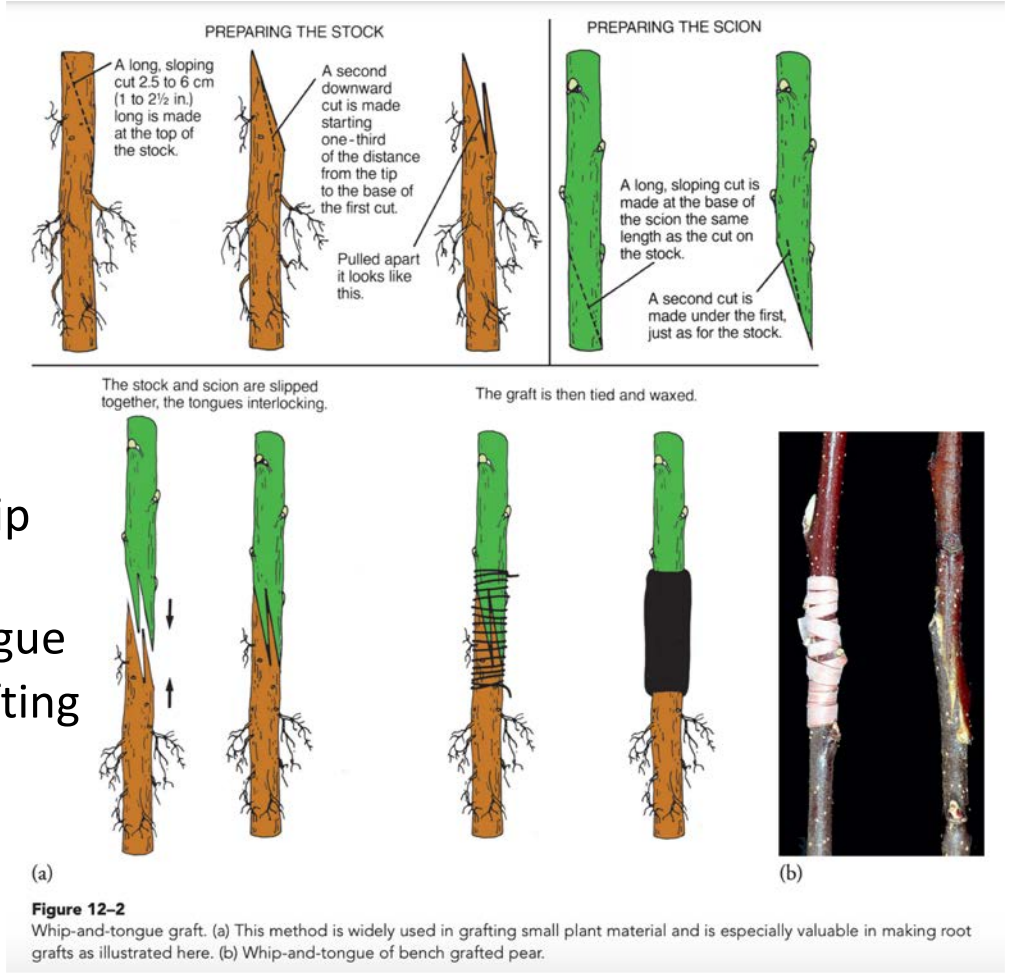


Figure 12–2
Whip-and-tongue graft. (a) This method is widely used in grafting small plant material and is especially valuable in making root grafts as illustrated here. (b) Whip-and-tongue of bench grafted pear.

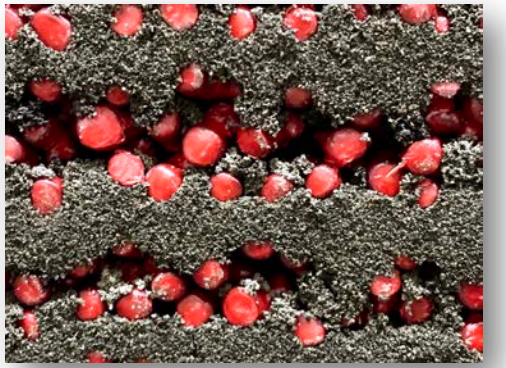
https://aggie-horticulture.tamu.edu/

Hermann Wiemer Vineyards, Dublin, NY

Est. 1979

Hermann J. Wiemer

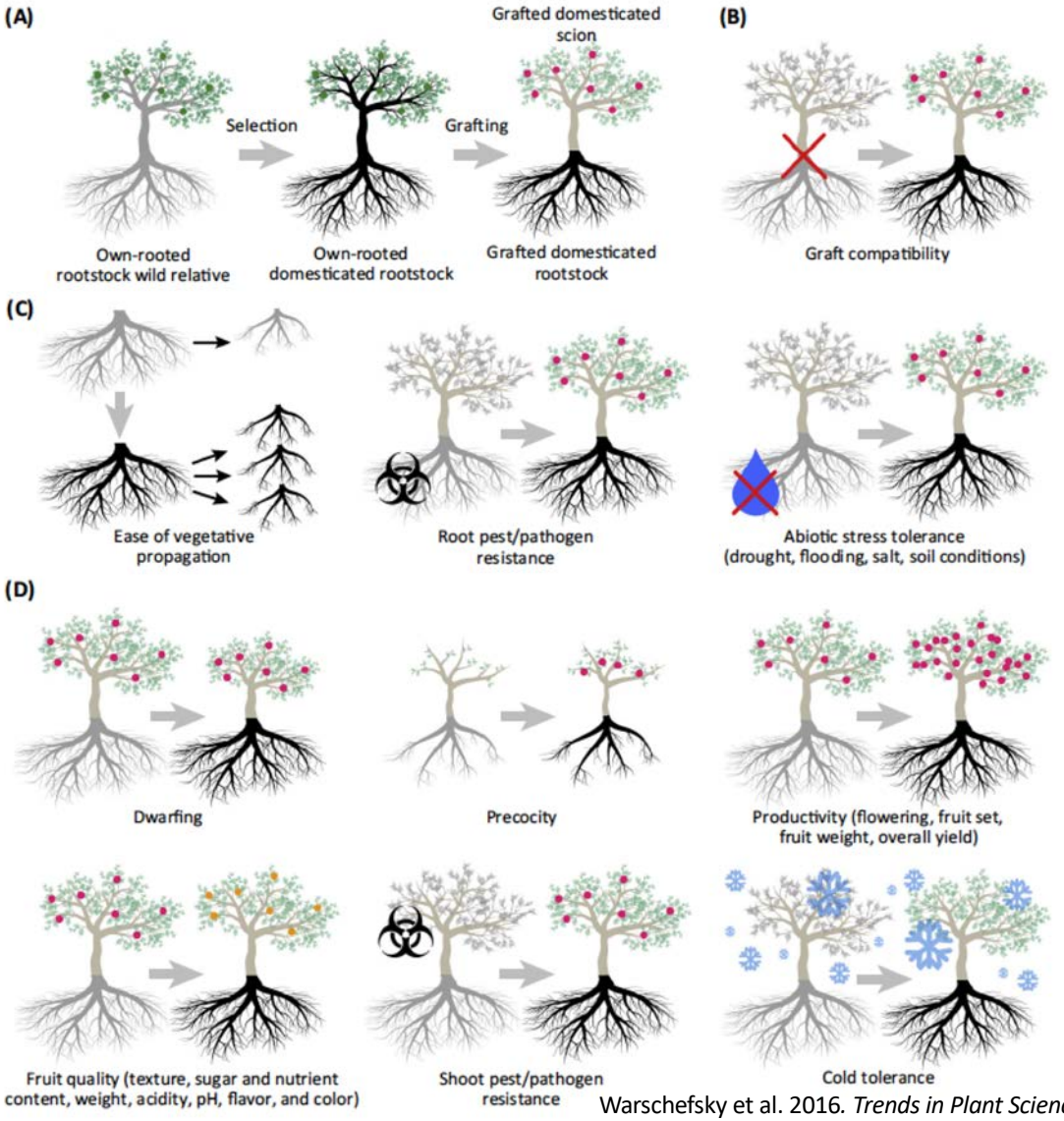
VINEYARD



https://www.tourism-mediterraneanpyrenees.com/

Why graft?

What motivates grafting, and what does grafting do to the vine?



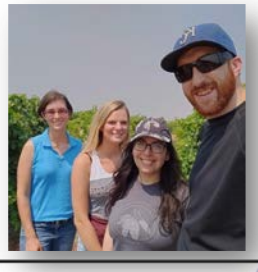
Warschefsky et al. 2016. *Trends in Plant Science.*

Grafting separates breeding for above-ground features of the scion
from breeding for below ground features of the root system.

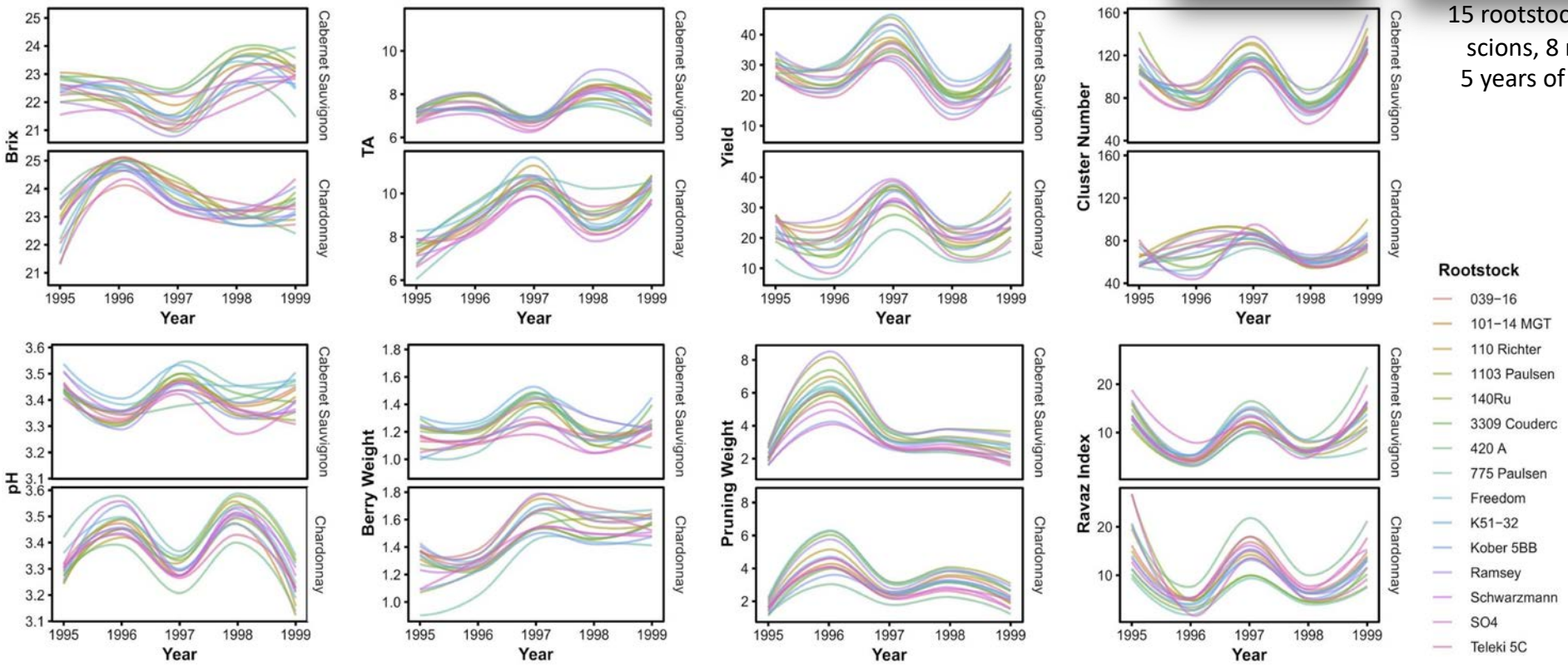
Does grafting affect the scion?

Rootstock impacts scion traits

Historical rootstock trial data



15 rootstocks, 2 scions, 8 reps; 5 years of data



Migicovsky et al. *in review.*

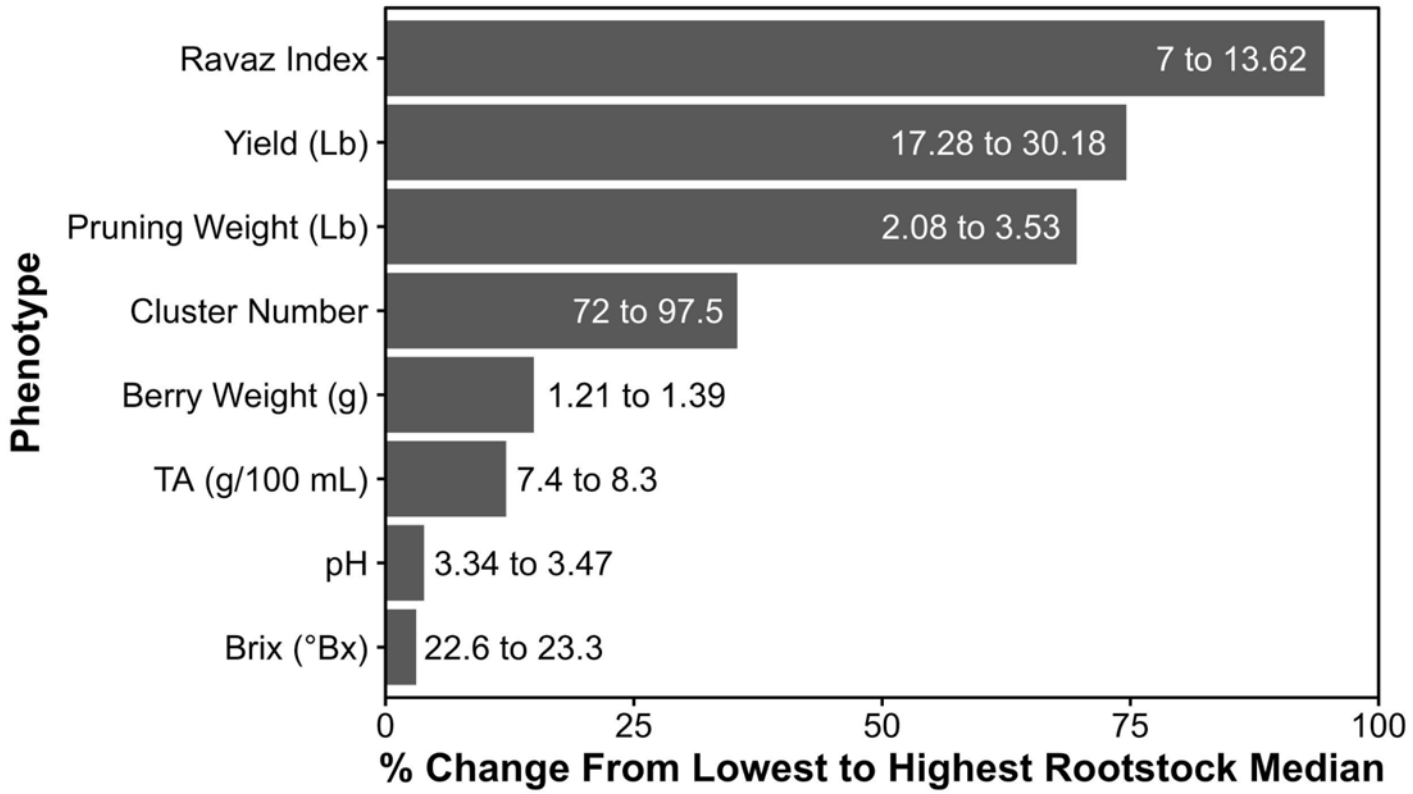
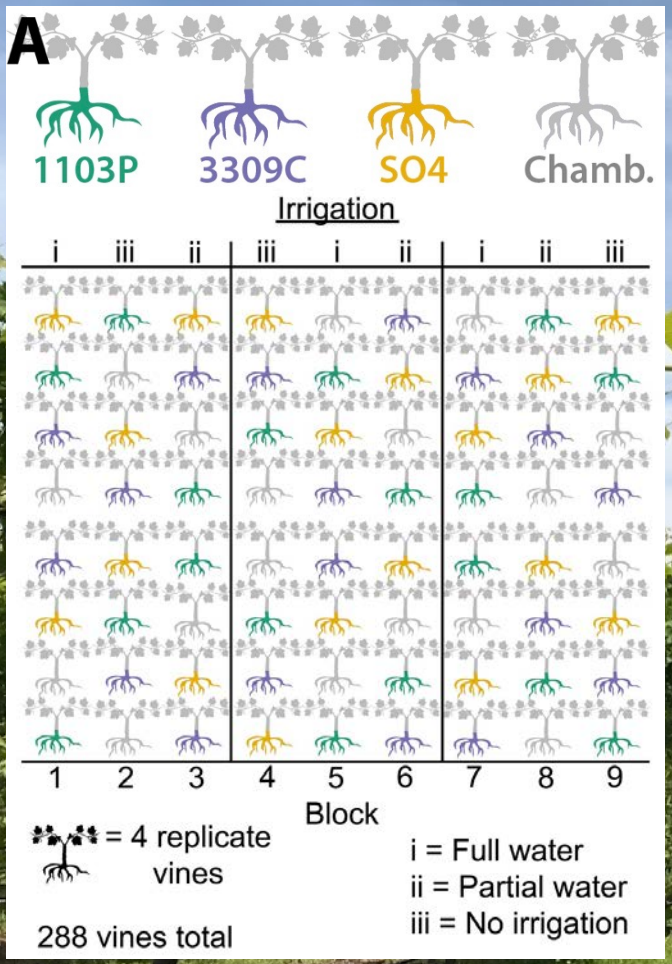


Figure 6. Percent change in each phenotype from rootstock with the lowest median to the rootstock with the highest median. Phenotypes are ordered from largest percent change to lowest percent change. Raw values are also listed.

Migicovsky et al. *in review.*

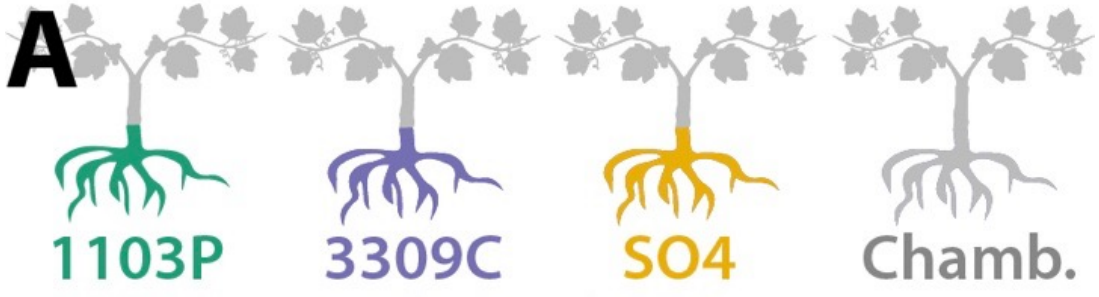
Inter-annual phenotypic variation in a common scion (‘Chambourcin’) ungrafted and grafted to three rootstocks.



University of Missouri Southwest Research Farm, Mount Vernon, Missouri

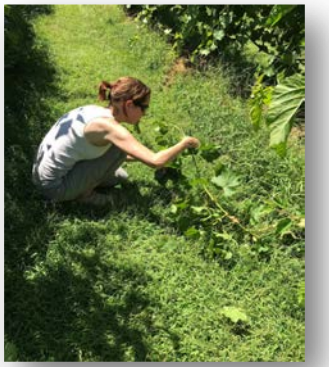
University of Missouri Southwest Research Station, Mount Vernon, MO

Three rootstocks, one ungrafted control; one scion (Chambourcin)



Three collection times per year;
Three years (2017, 2018, 2019)

anthesis
mid-May



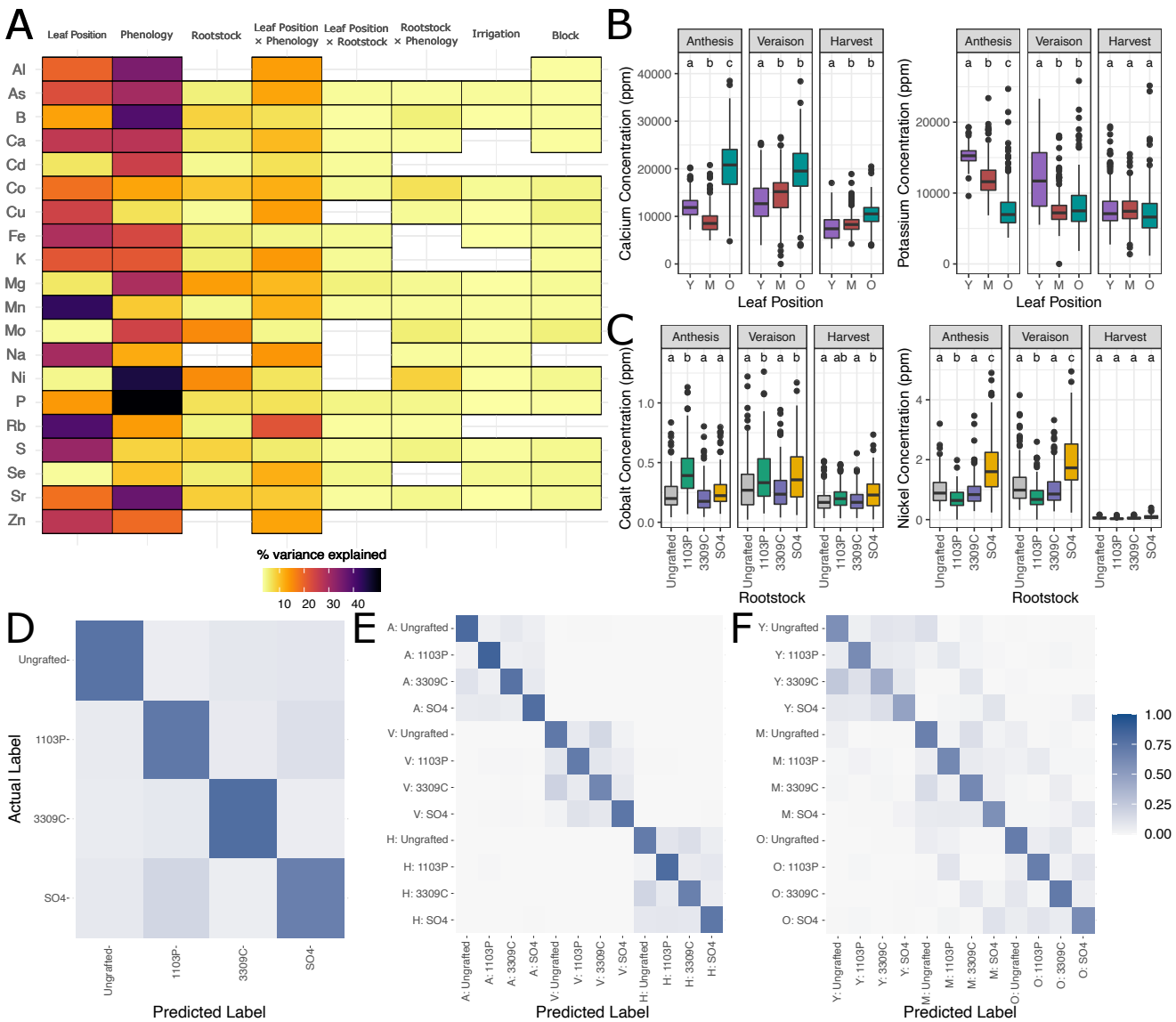
veraison
late July

harvest
mid-late September

Ion concentrations in leaves

Harris* ZA, Klein LL, Awale M, Swift J, Migicovsky Z, Bhakta N, Frawley E, Chitwood DH, Fennell A, Kovacs LG, Kwasniewski M, Londo JP, Ma Q and Miller AJ 2021.. **Root system influence on high dimensional leaf phenotypes over the grapevine growing season.** *Gigascience.*

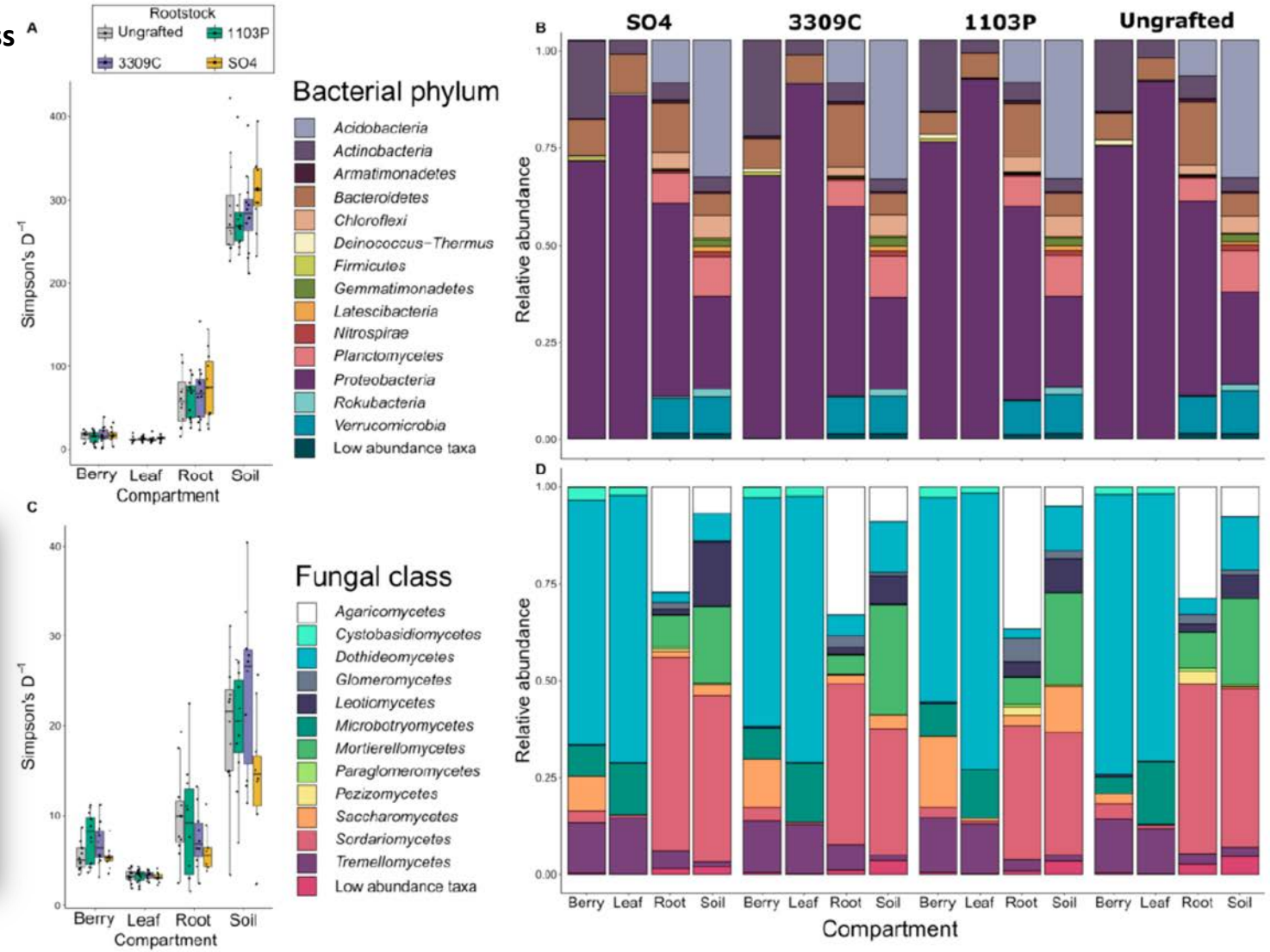
Zach Harris, SLU PhD Candidate
Danforth Center Fellow



Microbiome diversity across compartments

Swift* JF, Hall ME, Kwasniewski MT, Miller AJ. 2021. **Rootstock genotype impacts microbiome diversity and composition across the root and shoot system of grafted grapevines.** *Microorganisms* 9(1): 92.

Joel Swift, SLU PhD Candidate
NSF Graduate Research Fellow



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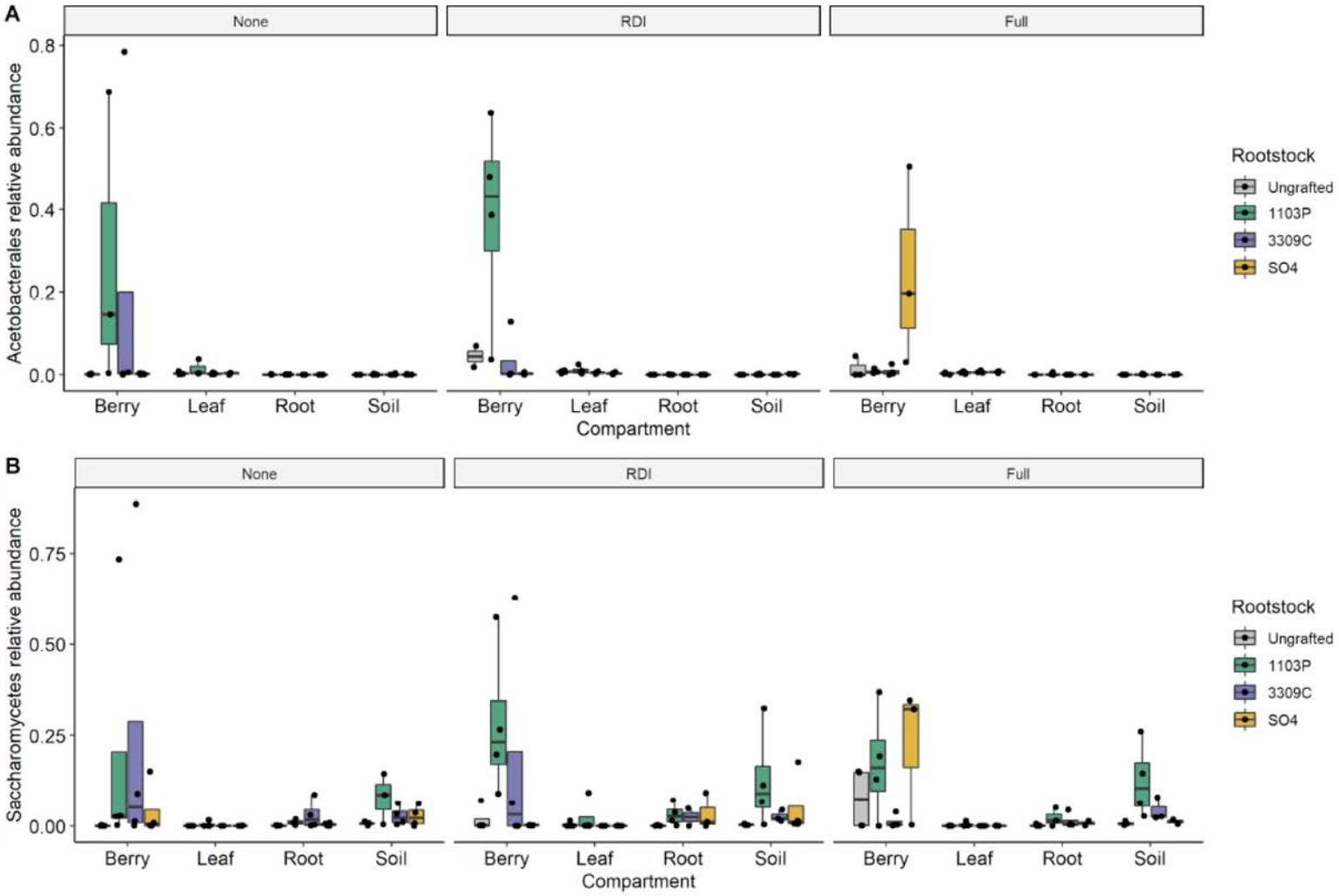


Grafting in grapevines: history and future applications

- Intro to grafting: grafting joins two genetically distinct organs.
- History of grafting in grapevines
- Grafting methods
- What impacts does grafting have on the scion?


• To what extent are growers grafting grapevines in Missouri?
• Why do people graft?
• Could grafting be expanded and improved to support viticulture in Missouri, in the Midwest, and beyond?
Crown Valley Vineyard, Ste. Genevieve, MO

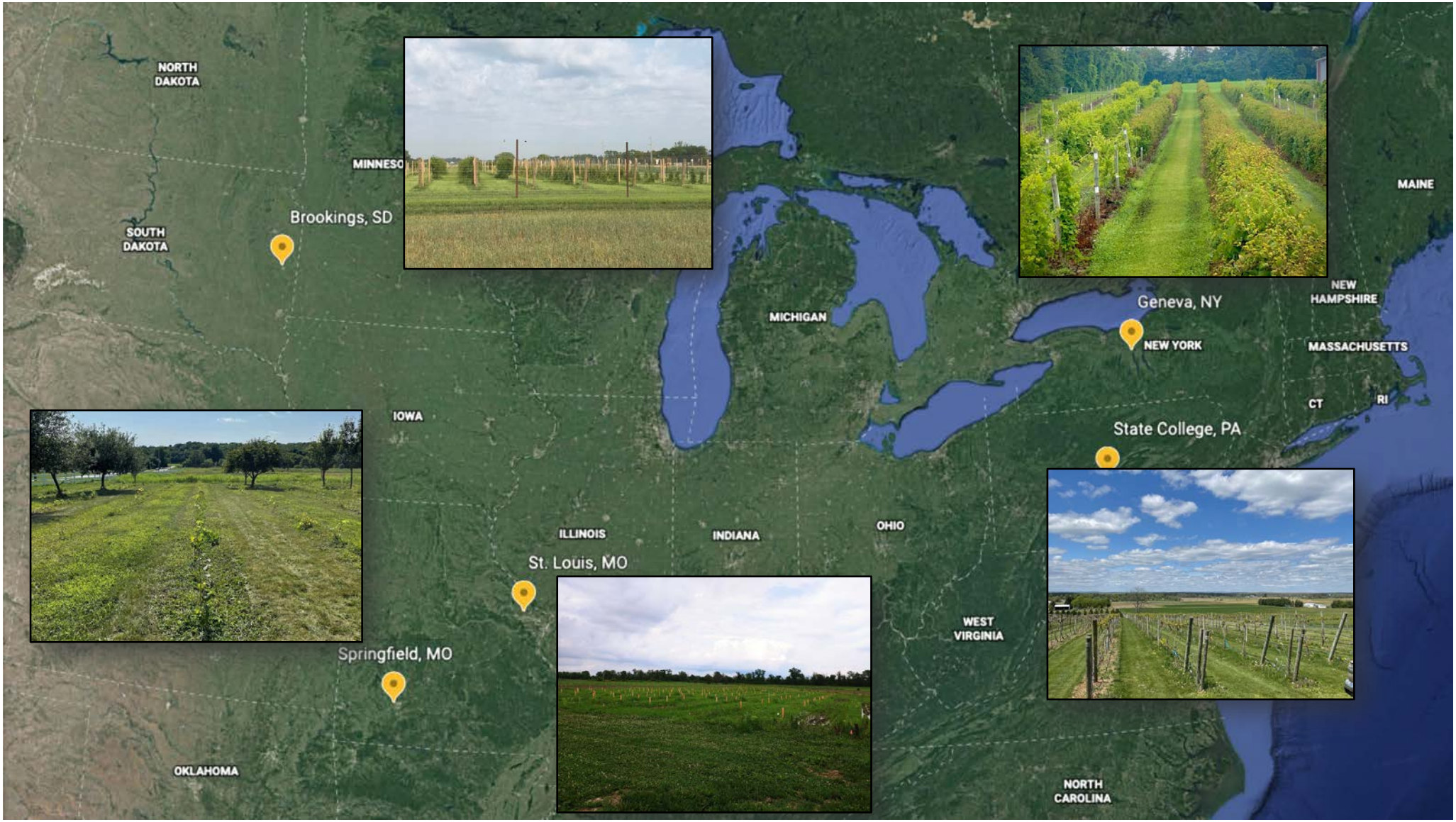
Ongoing work here in Missouri

1. Characterize rootstock effects on scion traits in commercial grapevines growing in three different regions of Missouri

2. Investigate how variation in a diverse rootstock population affects features of the dry red cultivar ‘Marquette’ across three contrasting sites in Missouri.

Replicated rootstock mapping population, grafted and ungrafted, with commercial controls, now planted in five sites.

Danforth Plant Science Center Field Research Site at Planthaven Farms


NORTH DAKOTA
MINNESO
SOUTH DAKOTA
Brookings, SD
MICHIGAN
Geneva, NY
NEW YORK
NEW HAMPSHIRE
MAINE
MASSACHUSETTS
CT
RI
IOWA
State College, PA
ILLINOIS
INDIANA
OHIO
St. Louis, MO
WEST VIRGINIA
Springfield, MO
OKLAHOMA
NORTH CAROLINA

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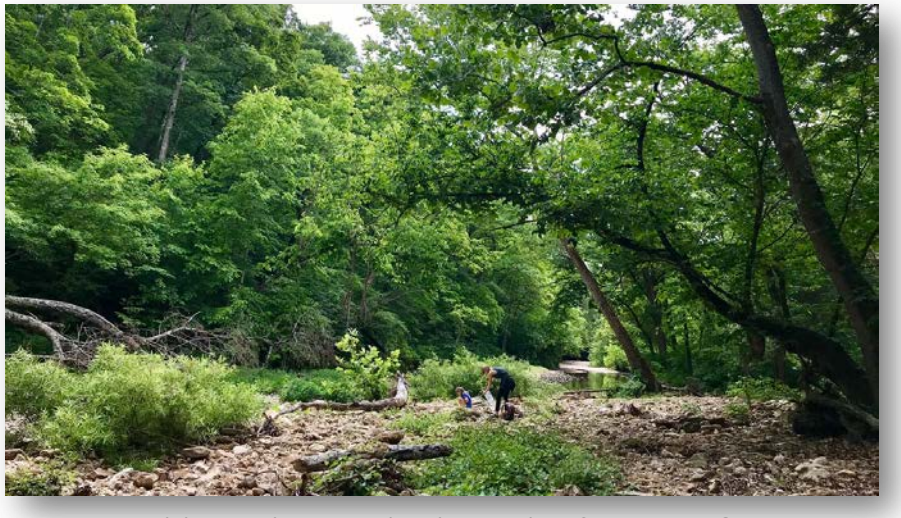
@vitisroots

NSF

National Geographic Society Incorporated A.D. 1888

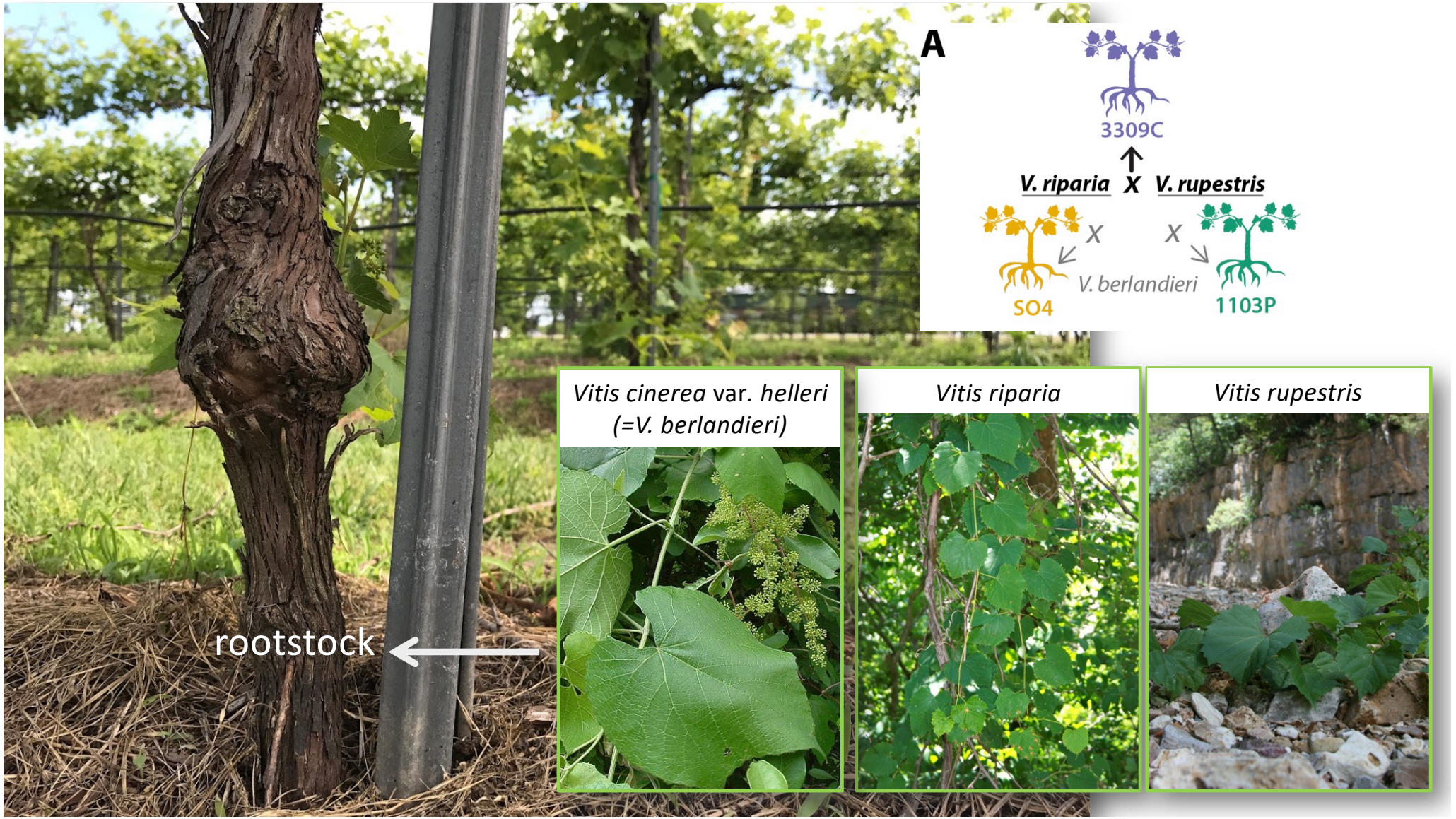
Grape and Wine Institute
College of Agriculture, Food and Natural Resources

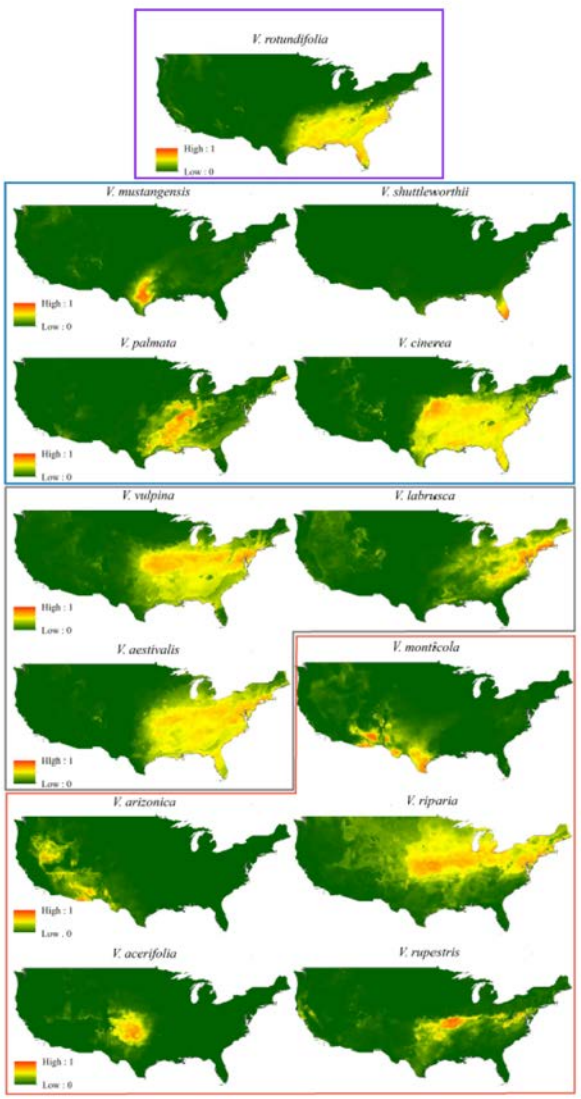


Vitis species growing in Maries County, MO

Rootstock diversity

The lesser known half of the perennial crop equation: diversity, domestication, and rootstock impacts on shoot system phenotypes in grafted grapevines

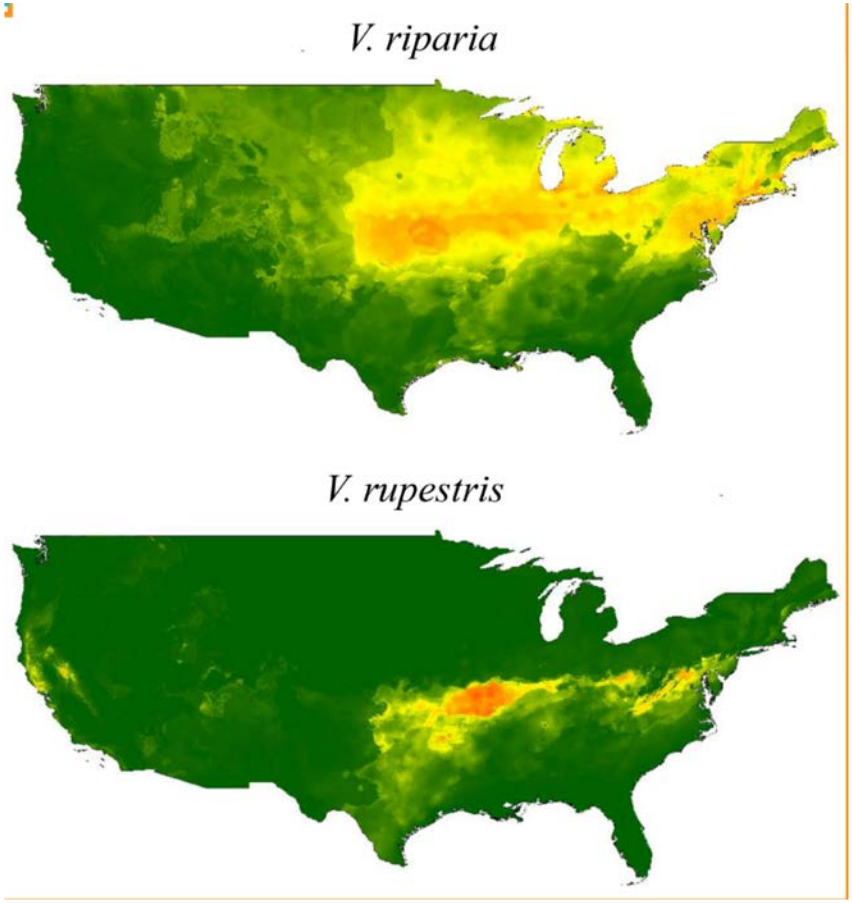

rootstock
A
3309C
V. riparia X V. rupestris
X
X
V. berlandieri
SO4
1103P
Vitis cinerea var. helleri
(=V. berlandieri)
Vitis riparia
Vitis rupestris



Vitis riparia

Vitis rupestris

Environmental niches of North American *Vitis* species



Callen, Klein, and Miller. 2016. *AJEV.*