

# Under-vine vegetation in vineyards: above and belowground effects and implications

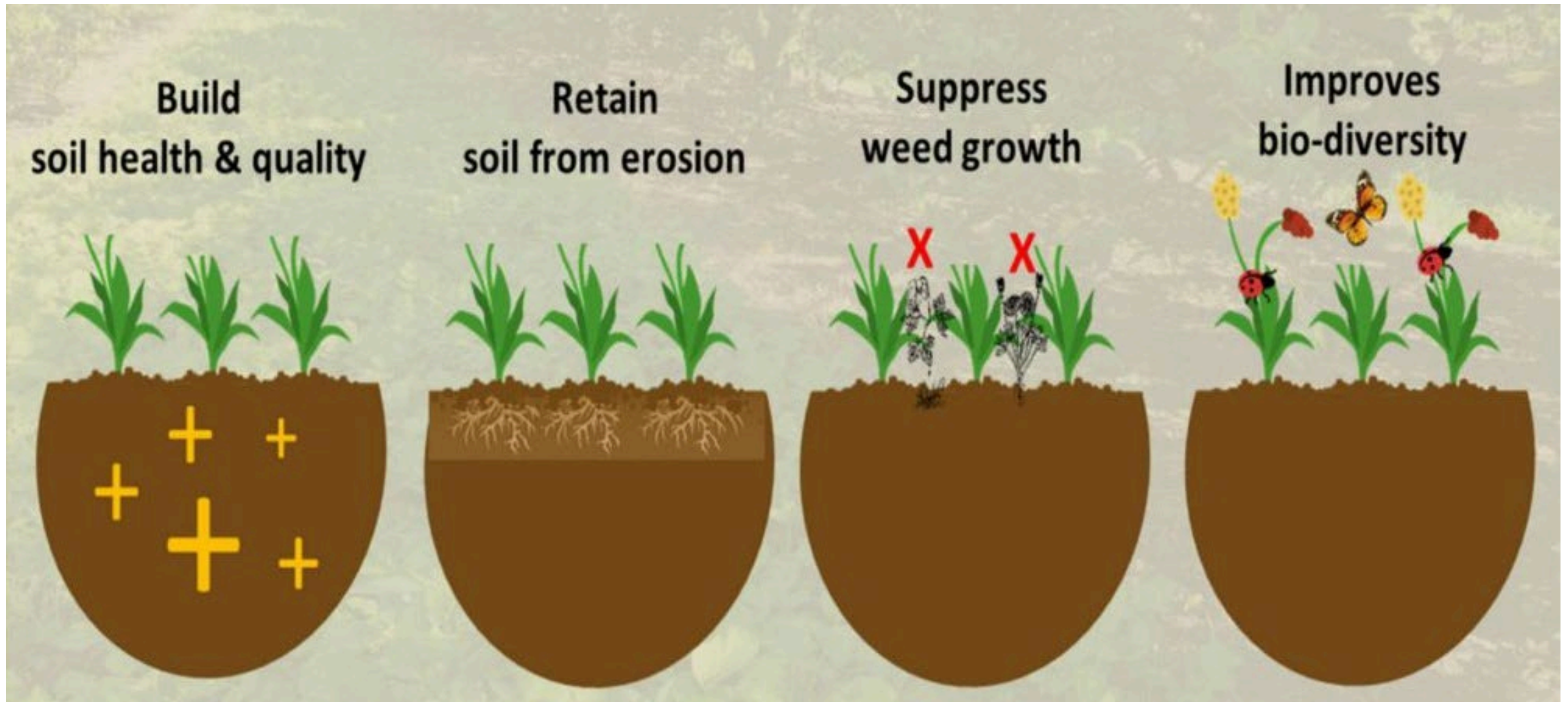
Michela Centinari

Associate Professor of Viticulture

Penn State University



# Cover crops: soil health building practice

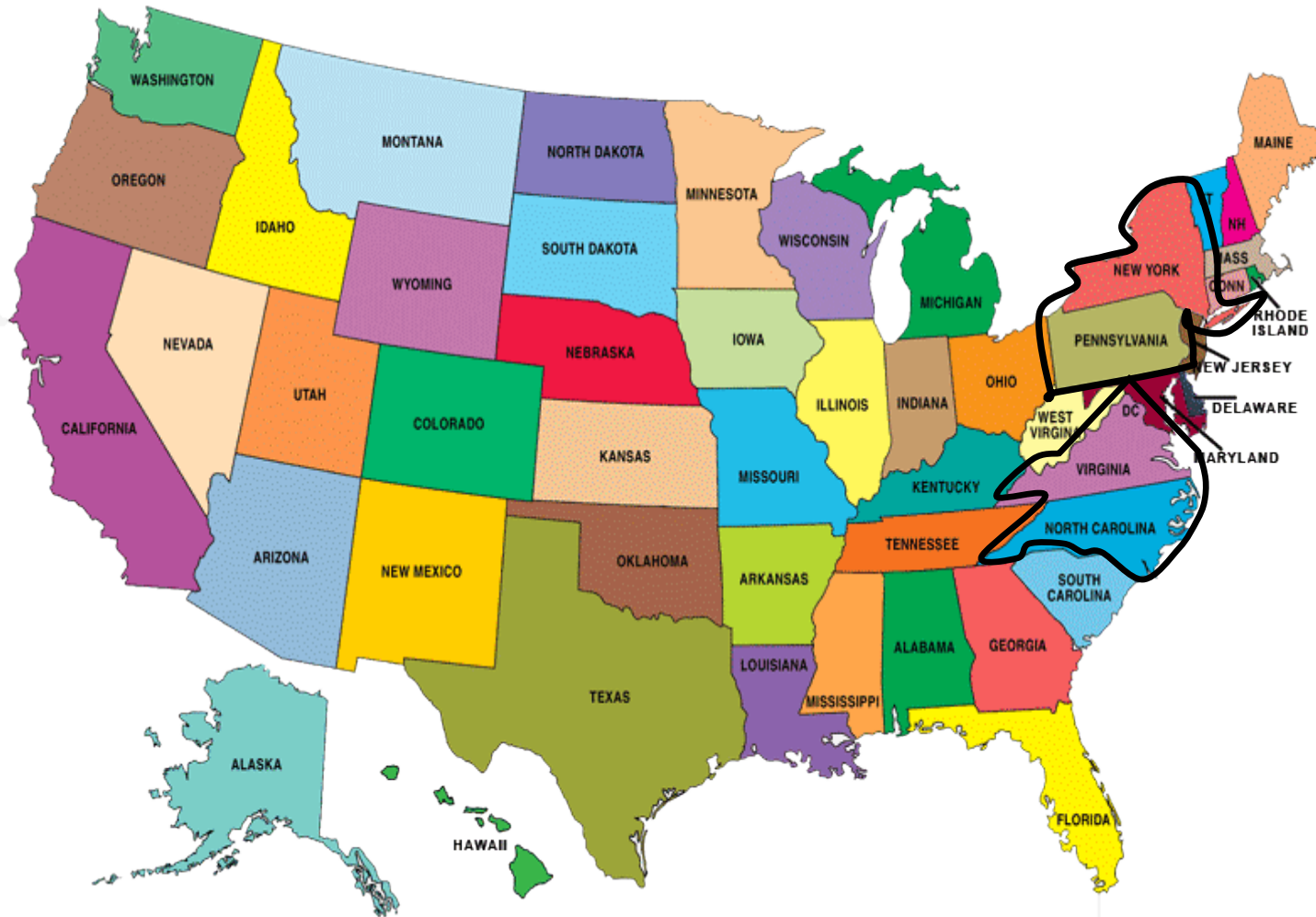


# Increasing vineyard sustainability using cover crops



Under-vine (trellis) cover crops

# Research on under-vine vegetation in vineyards



Canada

Australia and New Zealand

South America (Uruguay)

Europe (France, Spain)

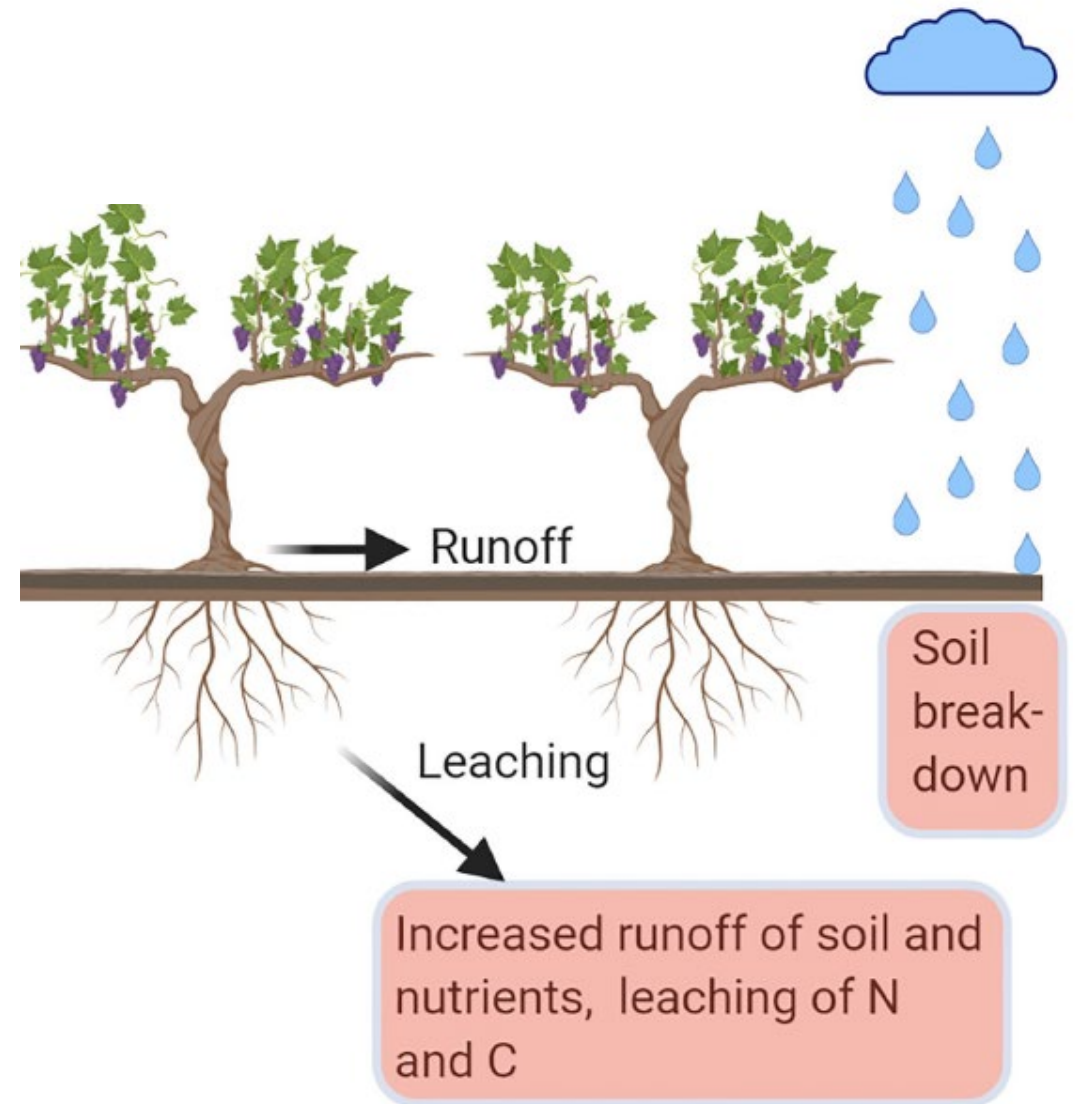
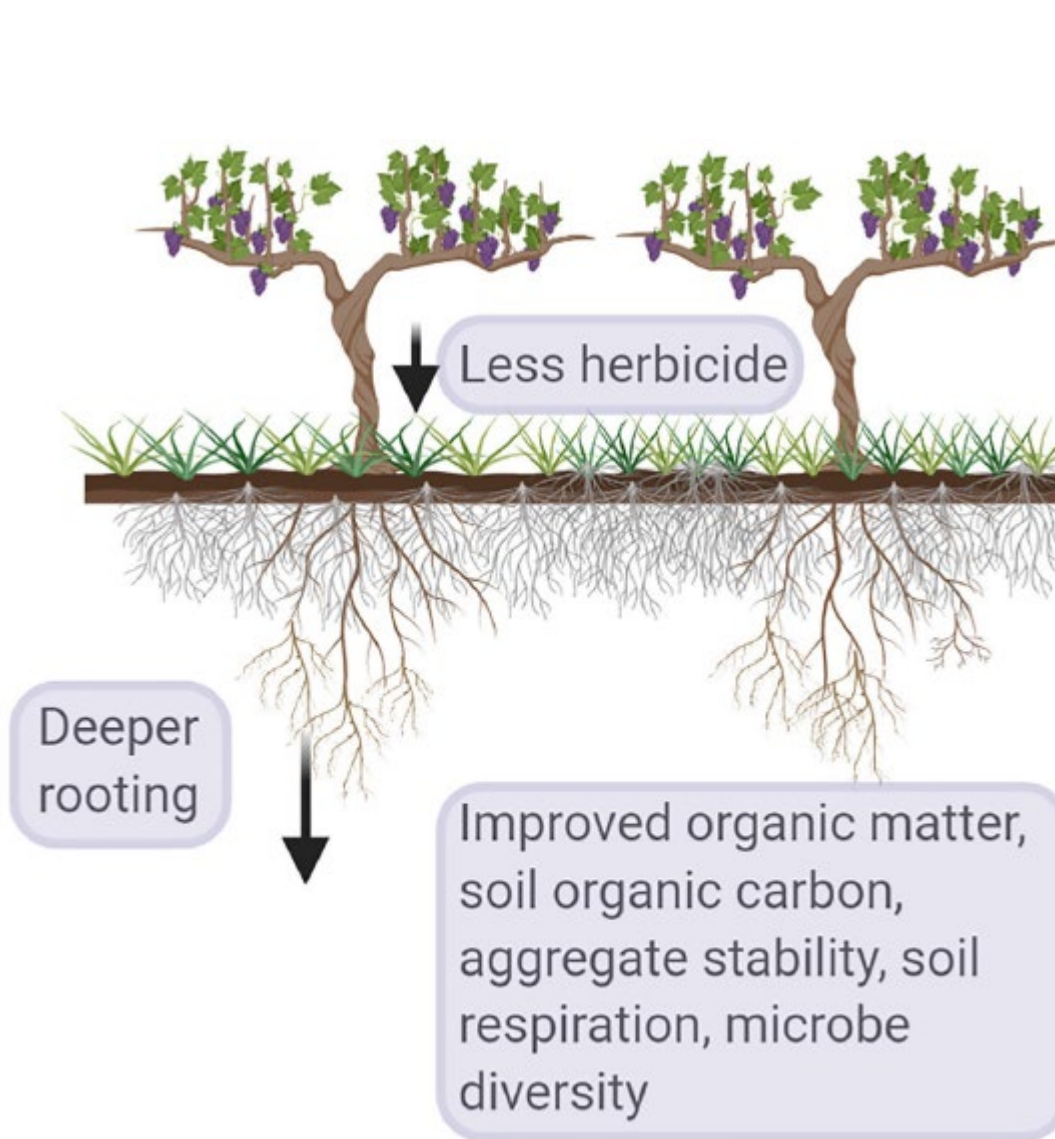
# Research on under-vine vegetation in vineyards



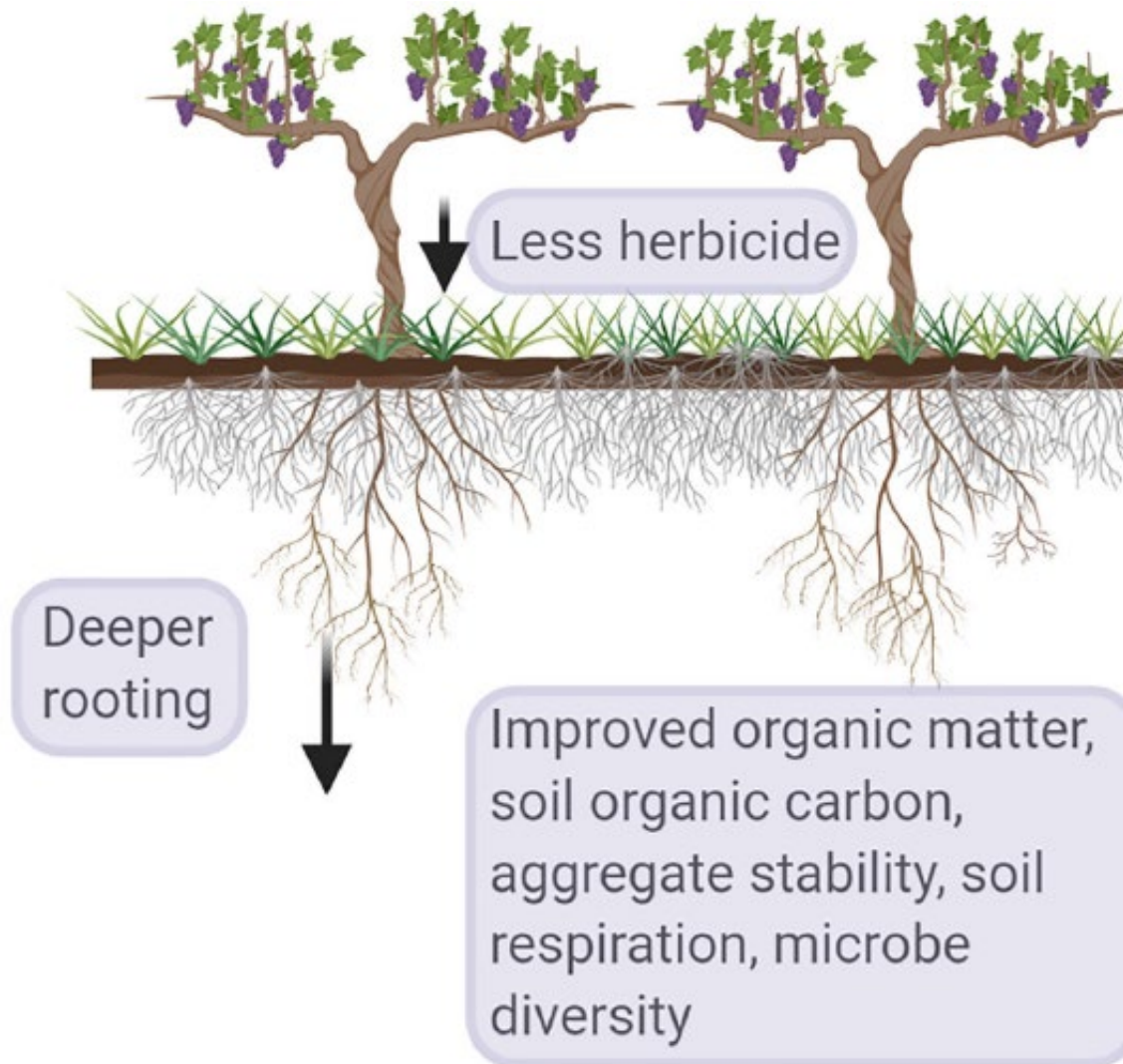
## **Under-Vine Vegetation Mitigates the Impacts of Excessive Precipitation in Vineyards**

*Justine Vanden Heuvel<sup>1</sup> and Michela Centinari<sup>2\*</sup>*

# Summary of the major belowground benefits



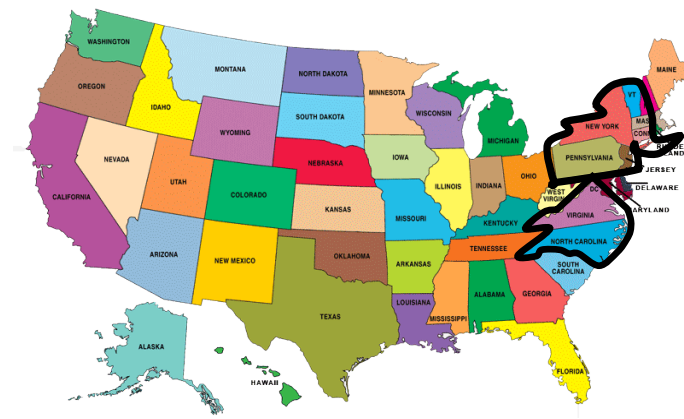
# Benefits and potential drawbacks of cover crops



## Potential drawbacks

- **Decrease soil resources**
- **Yield reduction**
- **Cover crop management costs**
- **Pest habitat**

# Under-vine cover crop options



## Perennial species



Creeping red fescue



Grass mix



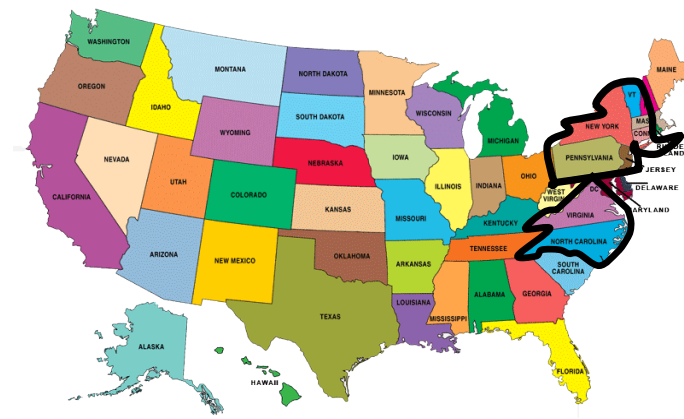
Chicory



White clover



# Under-vine cover crop options



## Annual species



Annual ryegrass



Buckwheat



Crimson clover and red clover

# Under-vine cover crops in other countries



*Trifolium fragiferum* (strawberry clover) sown under Merlot vines in Navarra, Spain



Grass cover crops (Safeguard ryegrass, in the photo) and annual pasture legume in South Australian regions

# Under-vine cover crops in other countries



Cresando Latino white clover in Okanagan Valley, British Columbia, Canada (Photo credit, Sharifi)

Spring lentils

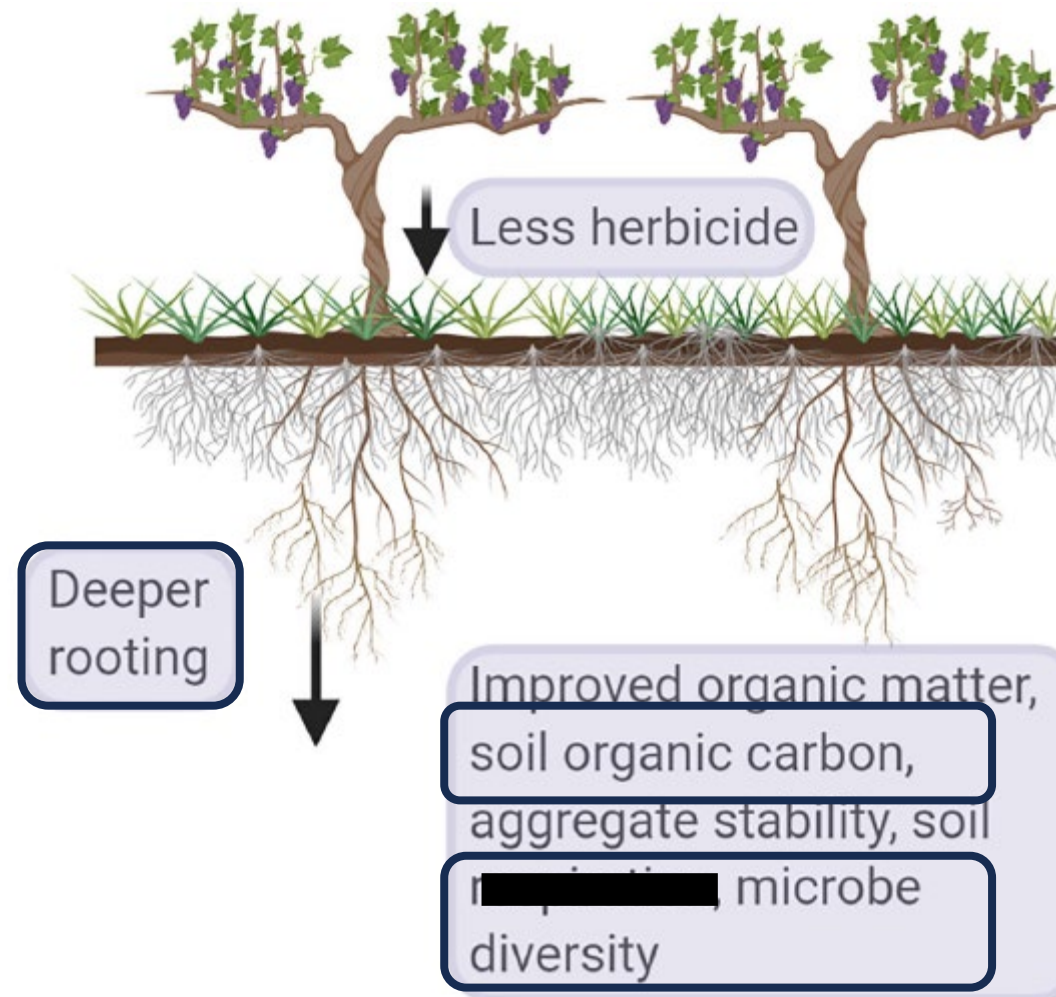
Ryegrass & Birdsfoot

## Criteria for cover crop selection:

- Rapid establishment, good competitiveness with weeds
- Low maintenance
- Low growing (minimize interference with fruit-zone)
- Shade tolerance



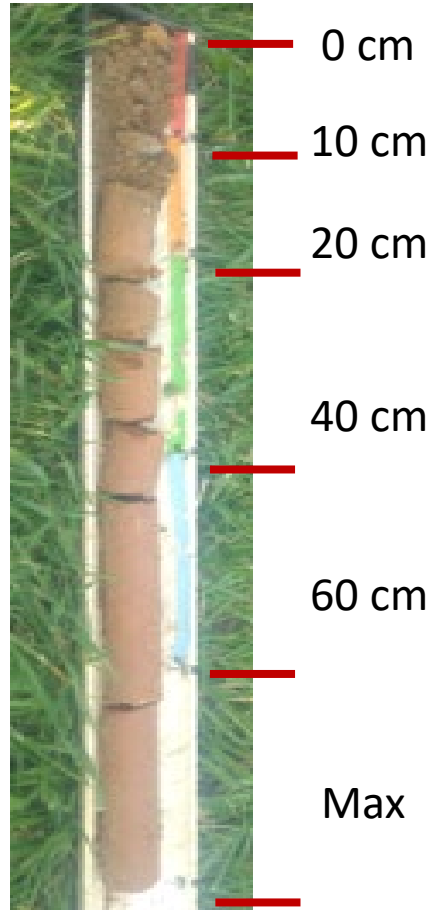
# Summary of the major belowground effects



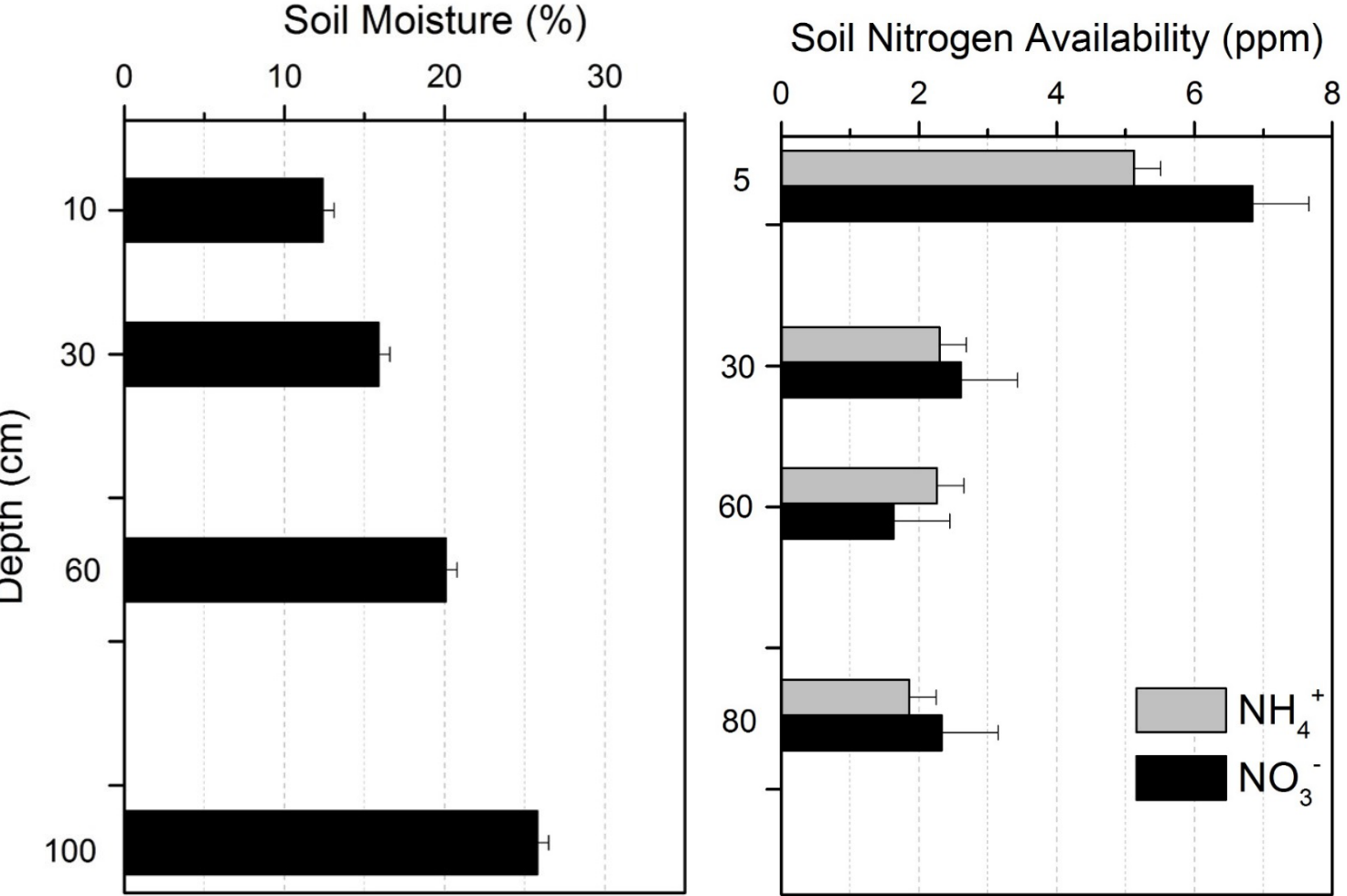
# How to sample roots and soil across depths



# How to sample roots and soil across depths



# Soil moisture and mineral nitrogen available change with depth

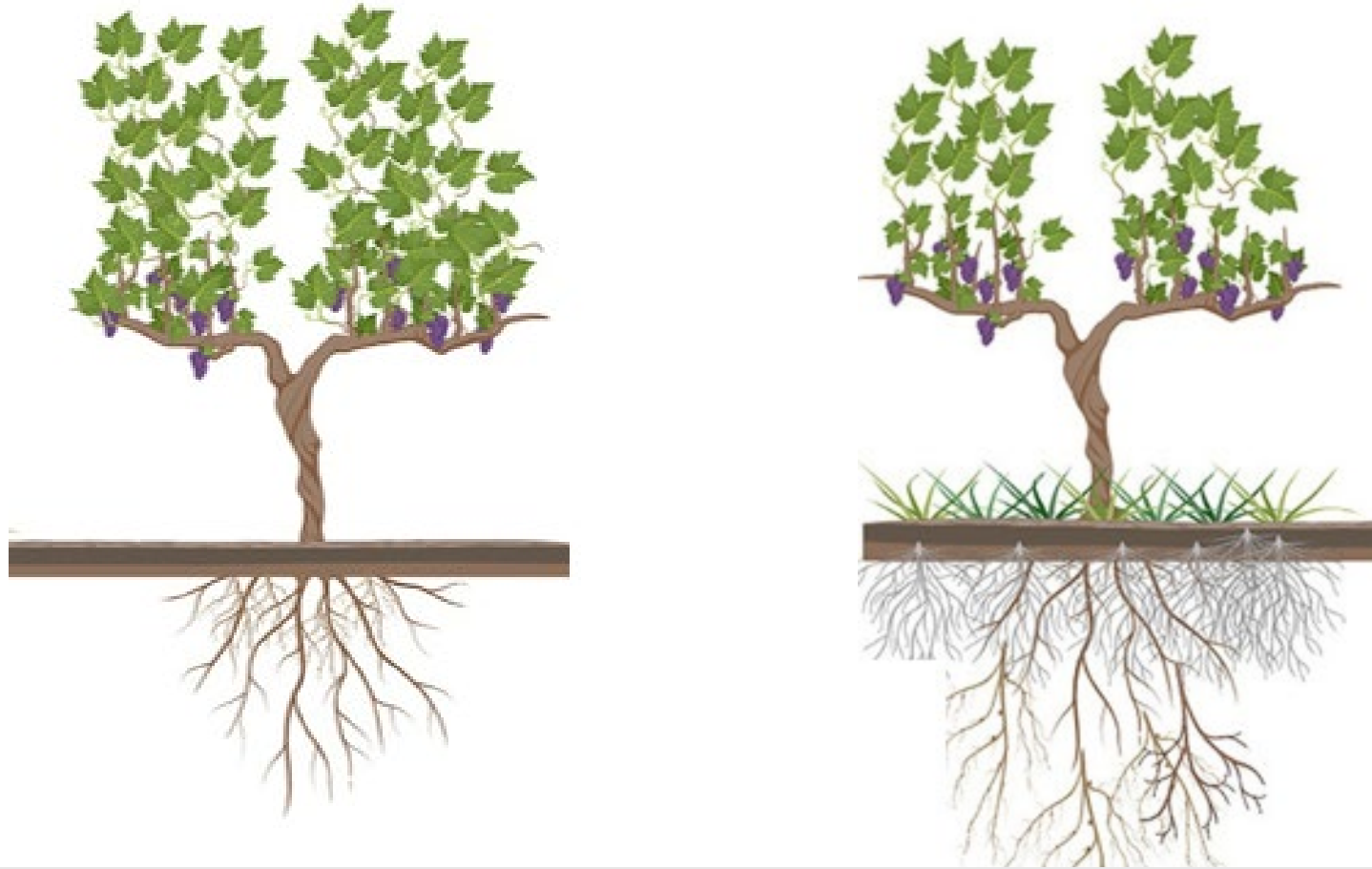


Other soil properties that change with depth:

- Carbon content ↓
- Microbial biomass & diversity ↓

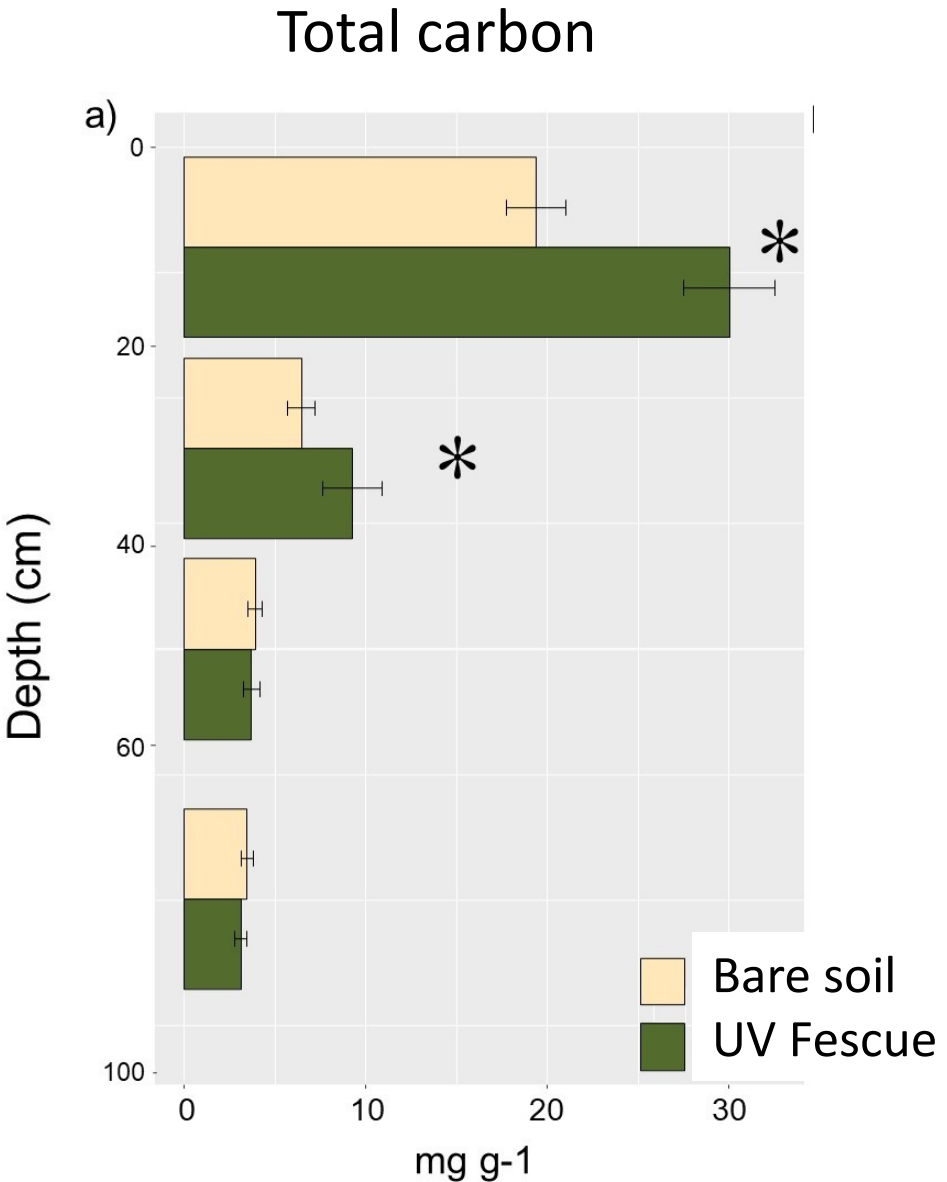


# Grapevines shift roots deeper in response to cover crops



Grapevine roots are experiencing a drastically different soil environment

# Do under-vine cover crops increase soil carbon at depth?

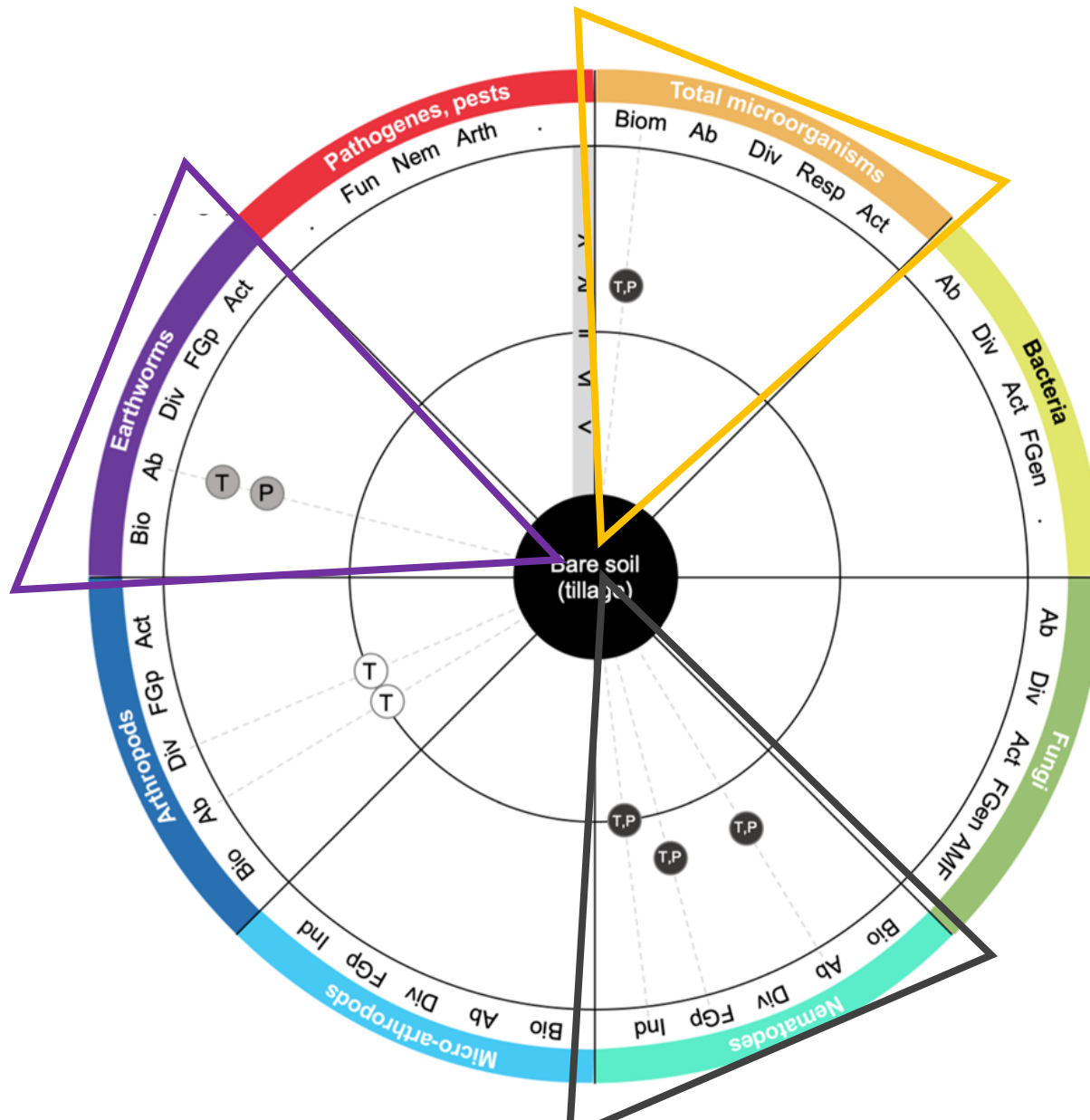


Total carbon increased  
~50% from 0-16 inches

Fleishman et al., 2021; Agri. Eco. Env.

- Increases in total C and N did not extend beyond the fescue rooting zone
- At least in the early stages (3 years after UV fescue planting), the cover crop did not influence deep total carbon

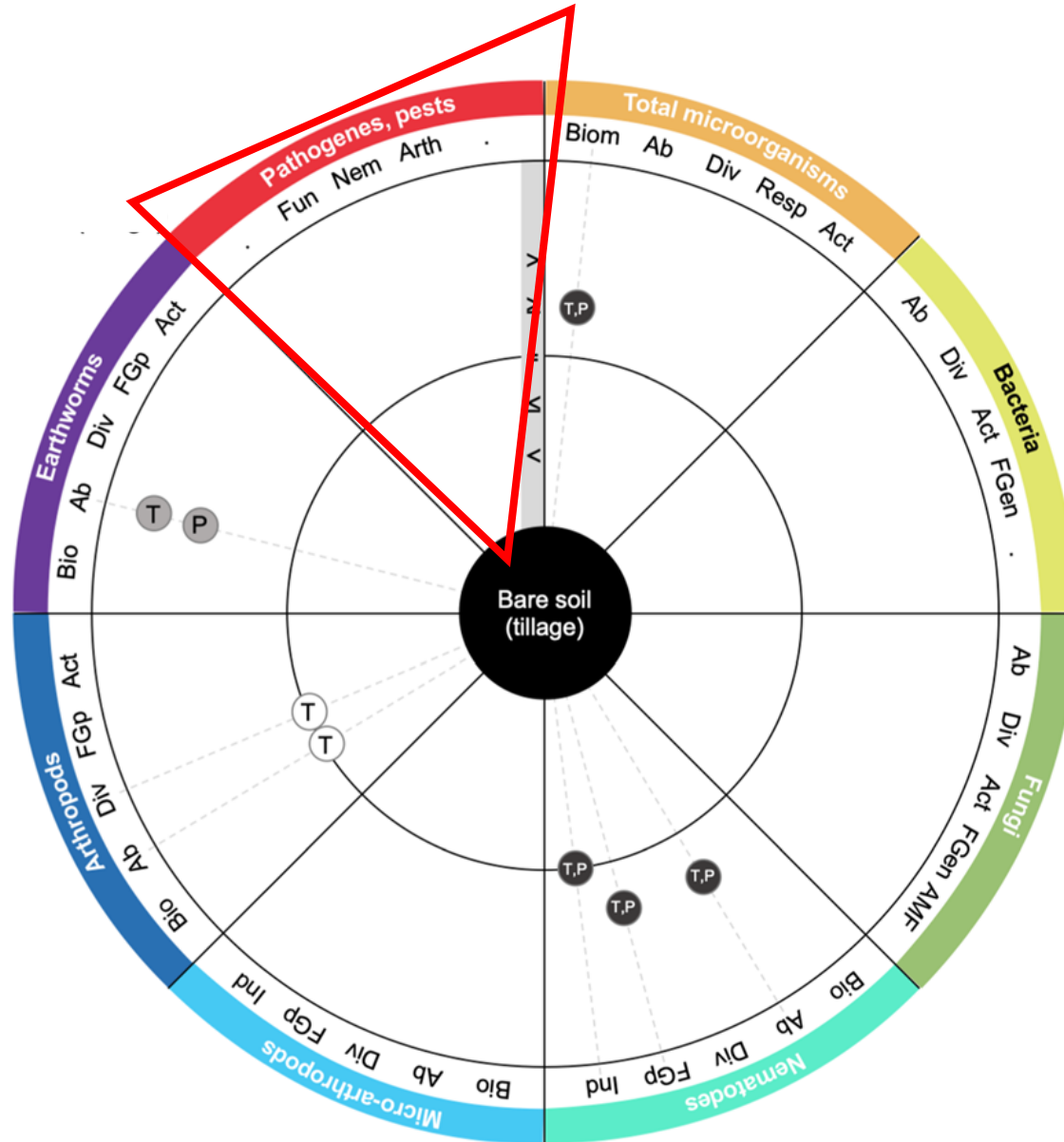
# Impact of cover crops on soil biological quality



The presence of plant cover has a **positive** or **neutral** effect on soil biology

No difference in impact was found between **temporary (T)** and **permanent (P)** cover crops

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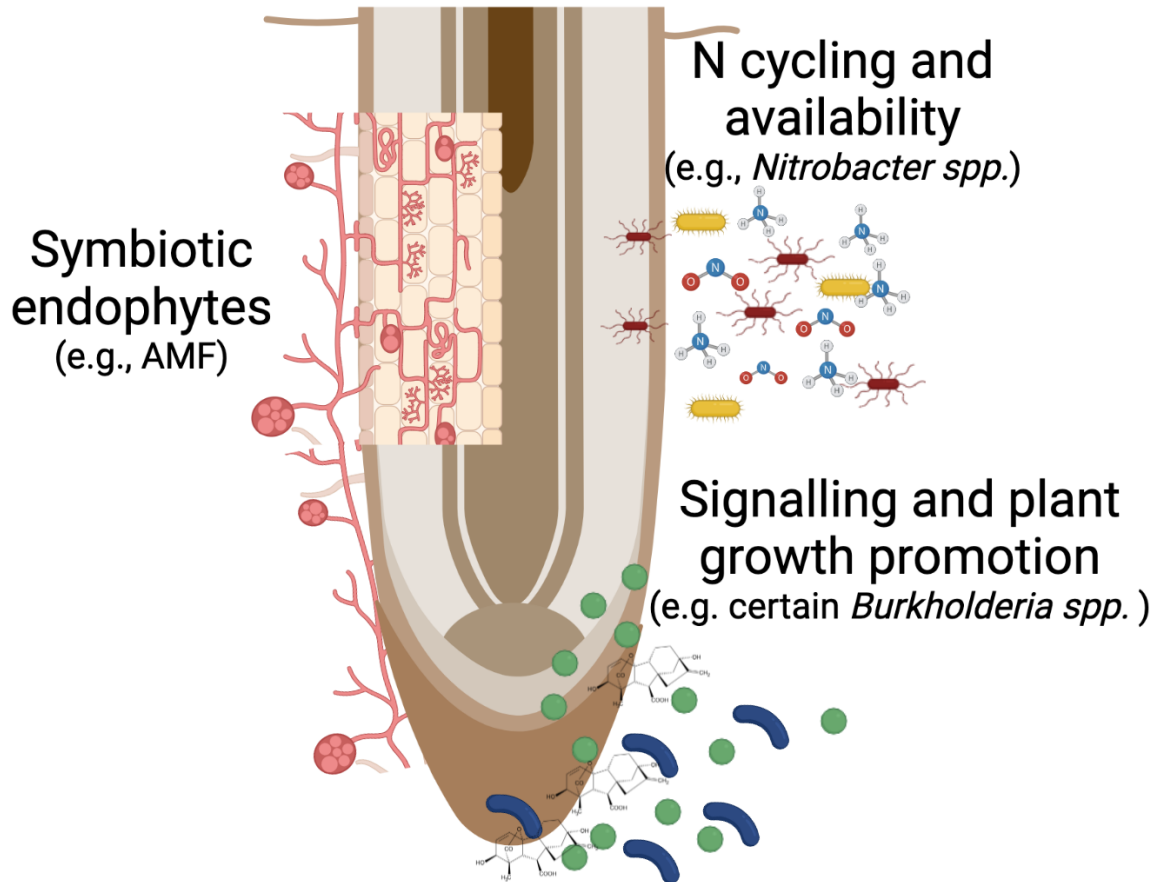
# Does under-vine fescue shift grapevine rhizosphere bacteria and fungi?



Suzanne Fleishman

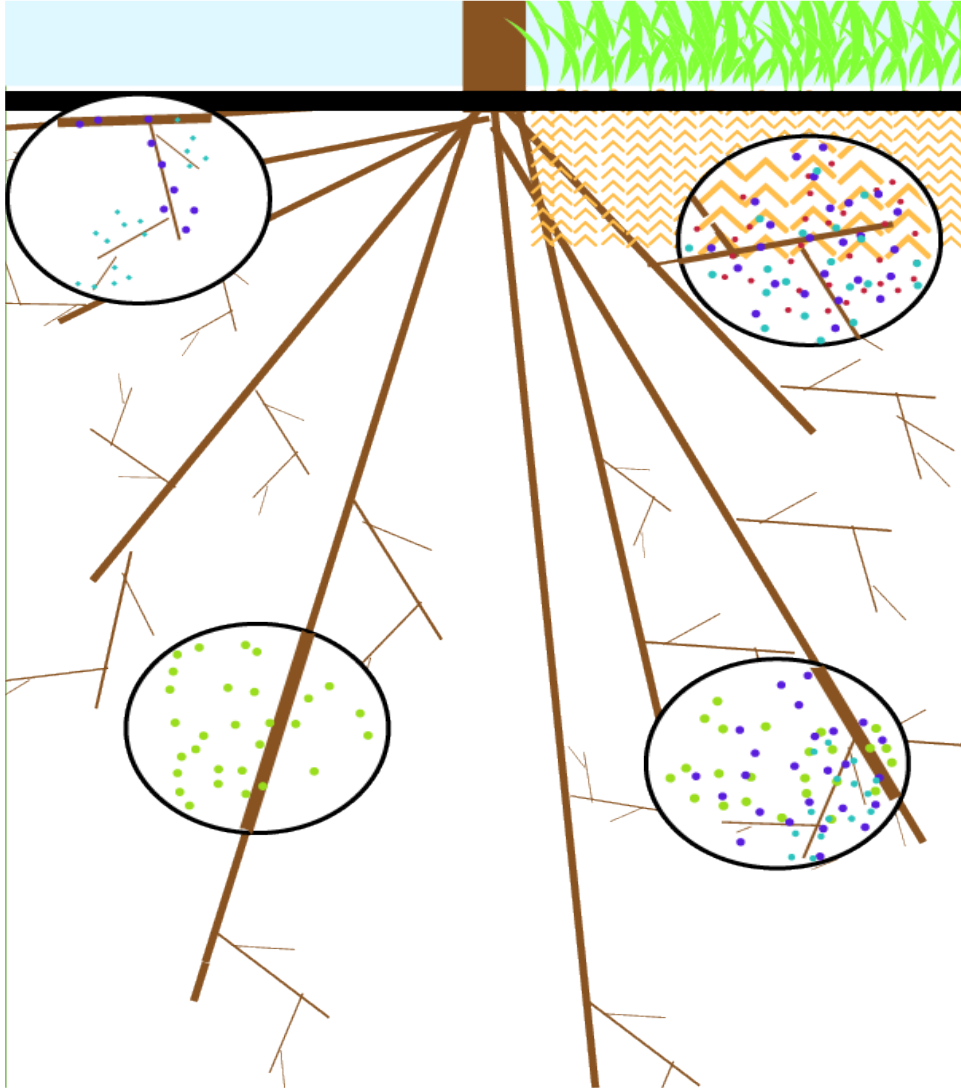


Terry Bell



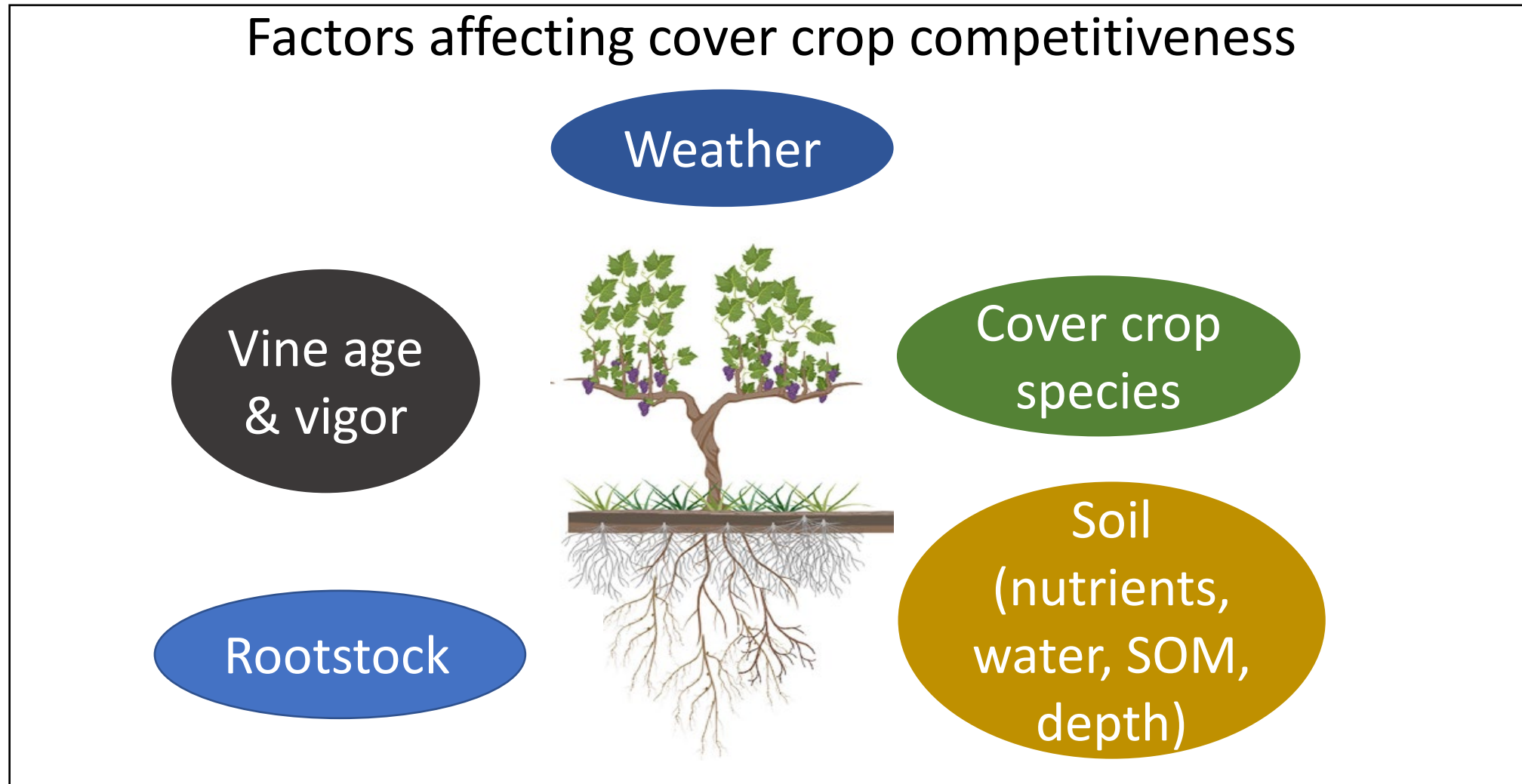
- Certain bacteria and fungi can beneficially impact vine nutrition
- Increasing plant diversity can increase soil microbial diversity and vine resiliency to abiotic stress (water stress, nutritional, heat stress)

# Summary

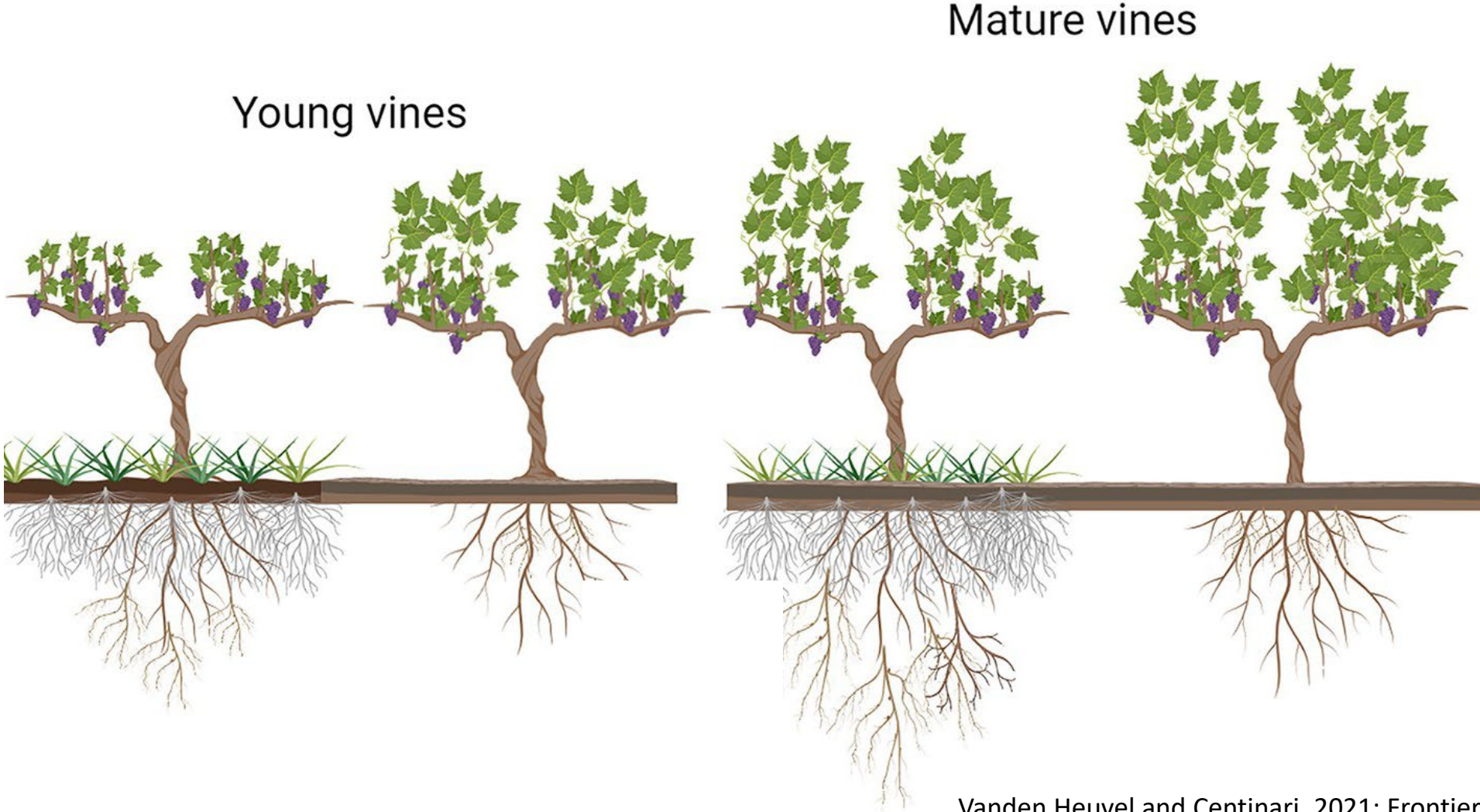


- Under-vine fescue increased diversity of rhizosphere bacteria across depths but not fungi
- Variability year-to-year due to abiotic factors

# Impacts of under-vine cover crops on vine growth is variable



Reductions in vegetative growth induced by under-vine cover crops are greater in younger vines than in older and more established vines



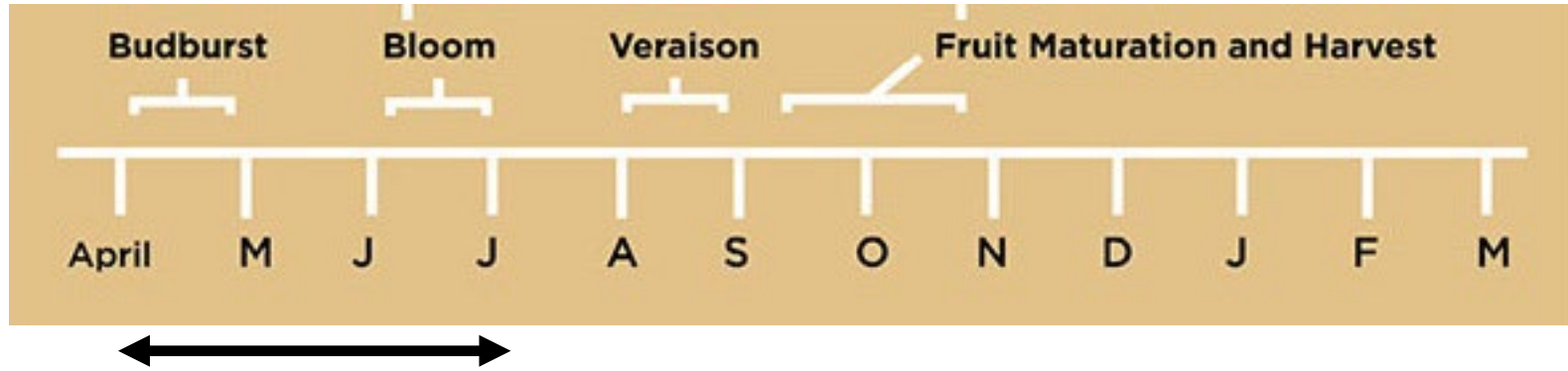


# No good examples of under-vine vegetation

Minimizing weed competition under the vines is particularly critical on newly-planted vines



# Timing and degree of competition



## Perennial grasses

- Can reduce vine growth
- No significant effect on vine water status (in our region)

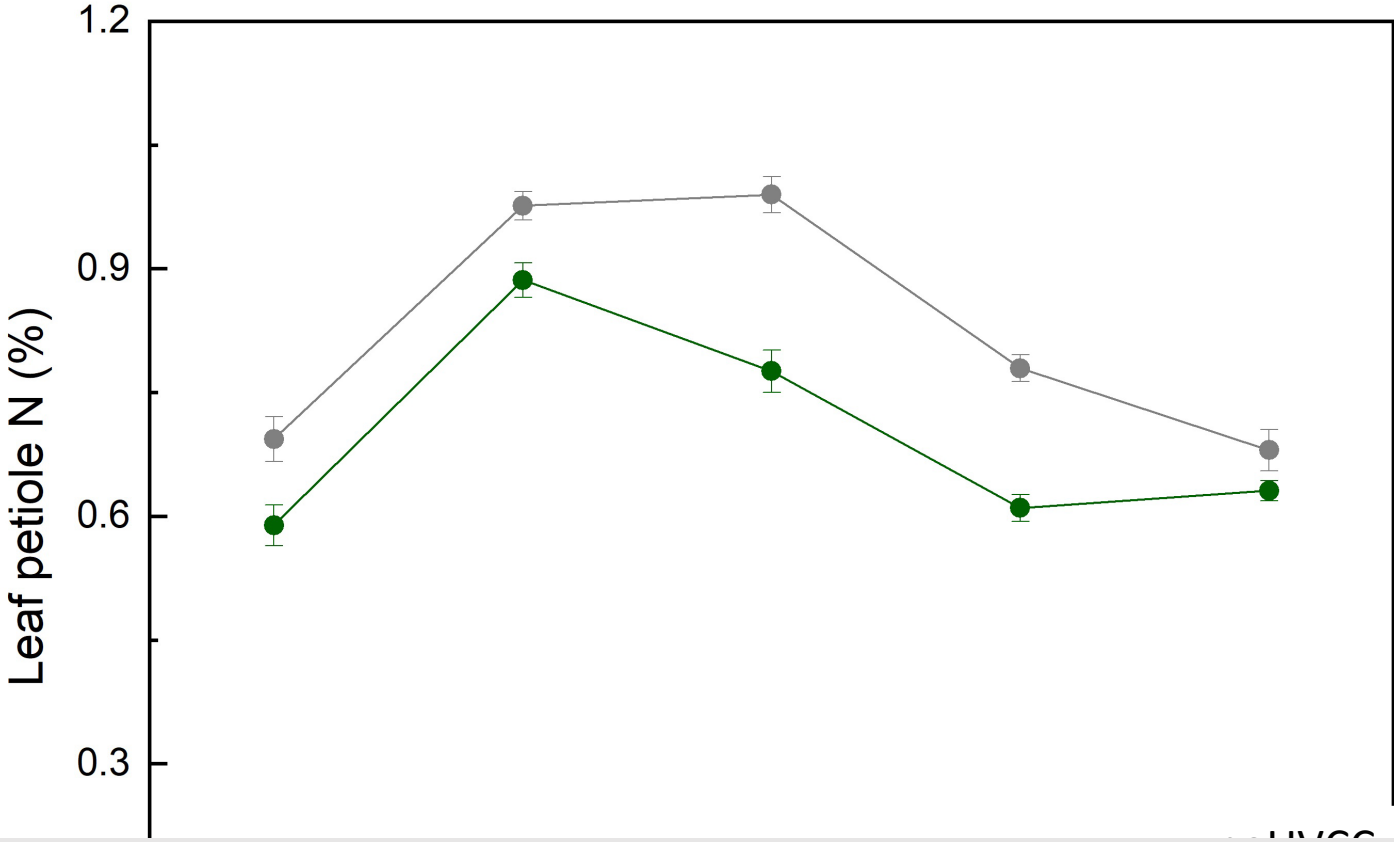
Creeping red fescue (*Festuca rubra*)



Clean and Green  
(80% tall fescue, 20% annual ryegrass)

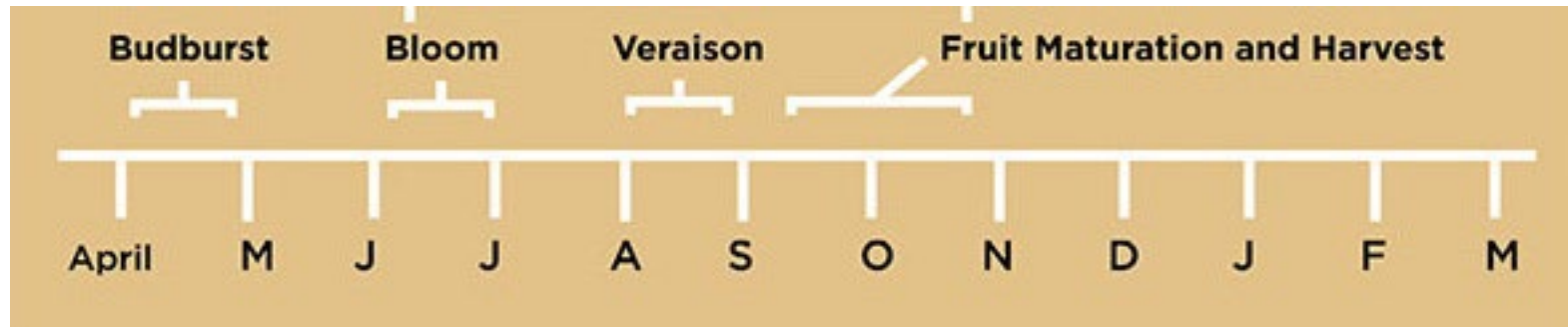


# Clear evidence of nitrogen competition over 5 years



Careful monitoring is required to ensure vines have adequate nutrition

# Timing and degree of competition

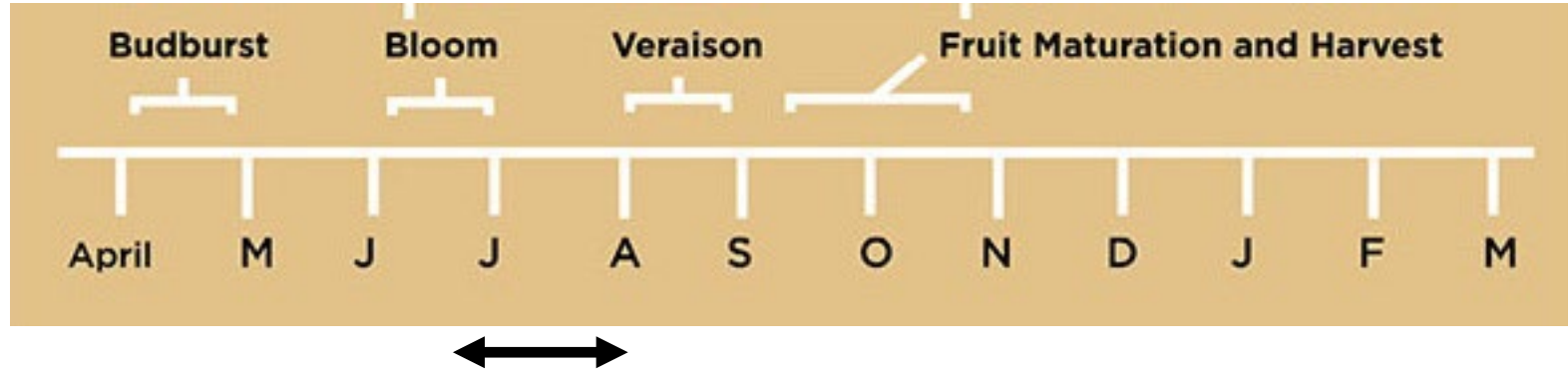


Natural vegetation  
(i.e., managed weed growth):

- Can provide almost season-long competition
- Species that comprise the stand will change by site and year



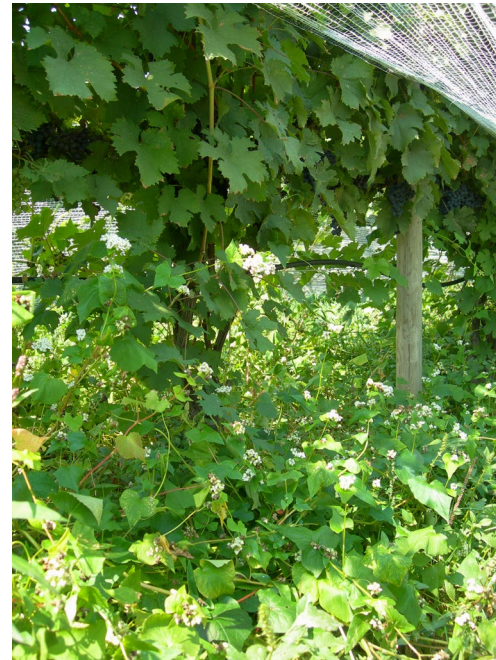
# Timing and degree of competition



## Buckwheat

(*Fagopyrum esculentum*)

- Easily out-competing weeds
- Provides little competition for water and nutrients



# Other options

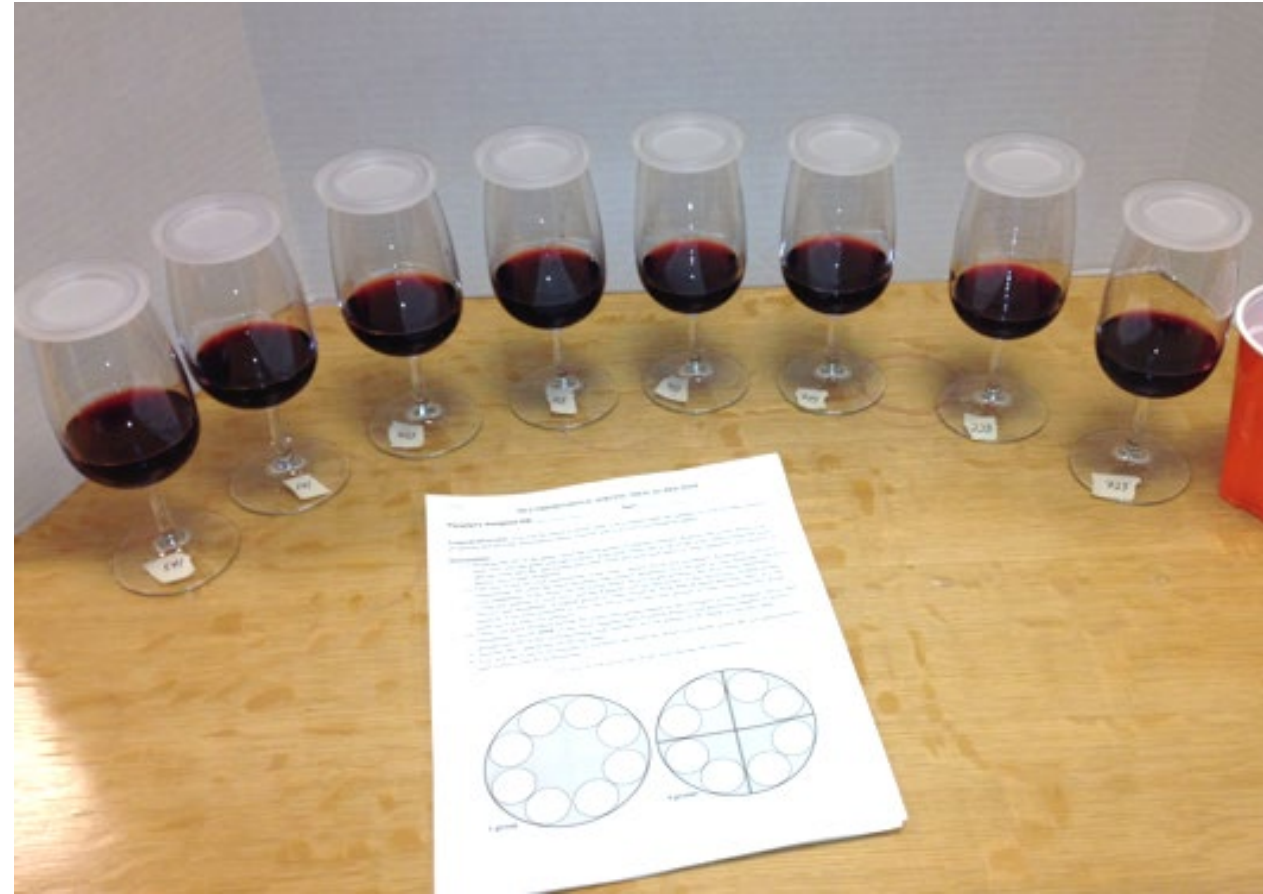
## Potential good options (low competition)

- Spring lentils  
(*Lens culinaris*)
- Clover  
(depends on species and sites)

## Unsuccessful options (harbor pests)

- Turnip -> wireworms  
(*Brassica rapa*)
- Winfred brassica -> aphids/ mites  
(*Brassica napus*)

In general, yield reduction is less pronounced than reduction in vegetative growth



# Cost of adoption

*Potential costs:* site preparation, seed, planting, mowing, and additional irrigation and fertilization

*Potential savings:* elimination of herbicide application and/or cultivation and perhaps reduced need for canopy management

Modified rotary spreader



Cornell Cooperative Extension





# Partial budget analysis of under-vine groundcover management in Noiret

Under-vine scenario	Yield (t/acre)	Crop value/acre	Under-vine management costs	Crop value minus under-vine costs	Difference to base scenario (herbicide)
<b>2017</b>					
Herbicide	4.22	\$ 2,445	\$ 43	\$ 2,402	\$ -
Fescue	3.40	\$ 1,970	\$ 412	\$ 1,558	-\$ 844

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<b>2018</b>					
Herbicide	4.33	\$ 3,000	\$ 99	\$ 2,901	\$ -
Fescue	4.89	\$ 3,387	\$ -	\$ 3,387	\$ 486

# Summary

- Documented substantial environmental benefits (reduce herbicide, improvement of soil health) and few drawbacks (yield reduction?!)
- Competition imposed by cover crop will differ based on water and nutrient availability, weather conditions, vine age, cover crop species

## ***Open questions - Do under-vine cover crops:***

- ***Influence the presence of insect pests and their level of infestation?***
- ***Affect the microbiome of the fruit and wine quality?***

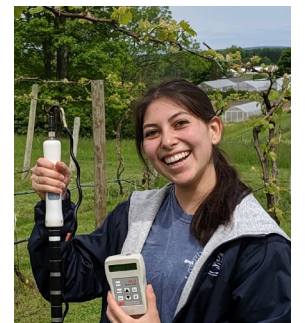
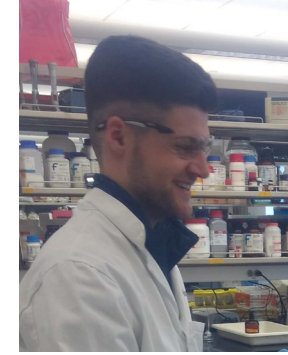
# Acknowledgements

## Graduate and undergrad students

Annie Klodd, Suzanne Fleishman, Jing Guo,  
Hayden Bock, Grant Hoffer, Erica Laveaga

## Collaborators:

Don Smith, Justine Vanden Heuvel, Terry Bell,  
Tony Wolf, Dave Eissenstat, Kathy Kelley, Taryn Bauerle,  
Steve Lerch



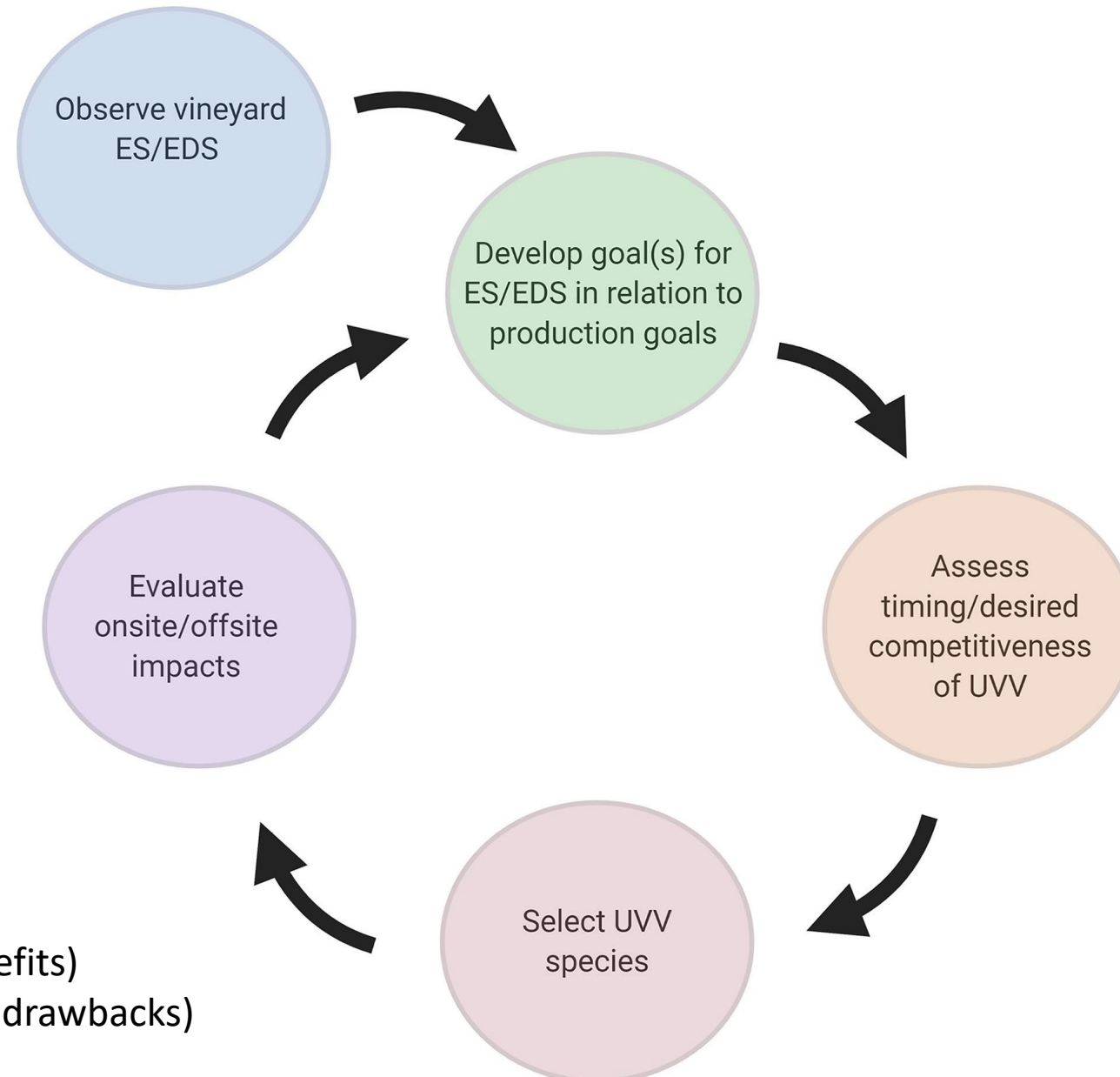


Thank You

Questions?

Michela Centinari  
email: [mzc22@psu.edu](mailto:mzc22@psu.edu)

# Iterative framework for adoption of under-vine vegetation (UVV)



ES: ecosystem services (benefits)

EDS: ecosystem disservices (drawbacks)

# Cover Cropping



## Decision Support Tool

This tool is designed to aid the selection of cover crops suitable for use in Australian vineyards.

To use the tool, please select your criteria for a cover crop from the options below and press submit. You will then be presented with a list of crops which match your criteria.

Further information about cover cropping is available from the [Wine Australia website](#) or by emailing [research@wineaustralia.com](mailto:research@wineaustralia.com).

**Note:** Not all search criteria will give a result. If you find no results, try reducing the criteria to find alternatives which may suit your circumstances.

Minimum rainfall:

Perennial/annual:

Purpose for Cover Crop

- Green manure
- Weed suppression
- Permanent cover
- Biological nitrogen
- Insectary / habitat
- Native species
- Grazing
- Nematode non-host
- Devigouring vines
- Undervine cover crop

## Results

The following crops match your search criteria. To see more information about a specific crop (such as seed rate, cost, weed competitiveness etc), click on its name.

- [Annual ryegrass \(\*Lolium rigidum\*\)](#)

## Links



Cover Crops - chapter reproduced from *Soil, Irrigation and Nutrition*.

## Sponsors



Wine Australia for Australian Wine

# UVV Planting and Management

Hand seeding for small areas (research plots)



How can we mechanically apply cover crop seed to the area under the trellis?



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<b>...2020 (*frost)</b>					
Herbicide	2.68	\$ 1,843	\$ 86	\$ 1,757	\$ -
Fescue	2.61	\$ 1,793	\$ -	\$ 1,793	\$ 36
<b>2021</b>					
Herbicide	8.08	\$ 5,696	\$ 143	\$ 5,553	\$ -
Fescue	7.30	\$ 5,146	\$ -	\$ 5,146	\$ (407)

# UVV Planting and Management

Mechanical methods for seeding (H. Walter-Peterson and A. Wise; Cornell Cooperative Extension)

Vicon spreader with banding spout attachment



Photos credit: H. Walter Peterson

Modified rotary spreader



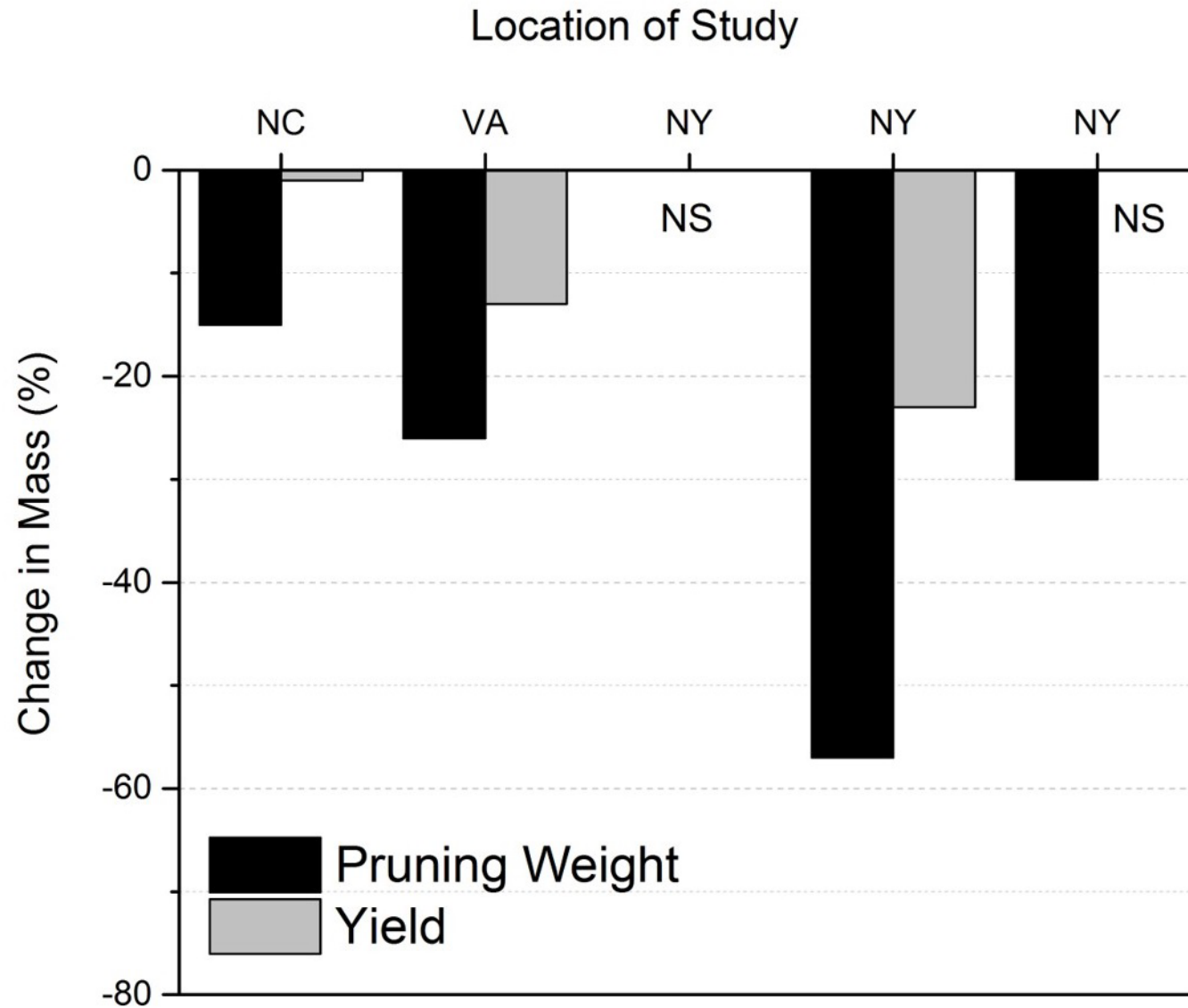
More detail on the calibration and set up of these systems can be found here:

<https://www.youtube.com/watch?v=q71MzX8e4dl>





# Growth reduction is context dependent



## Variables

- Seasonal resource availability
- Grapevine age
- Cover crop species
- Soil properties
- Rootstock genotype

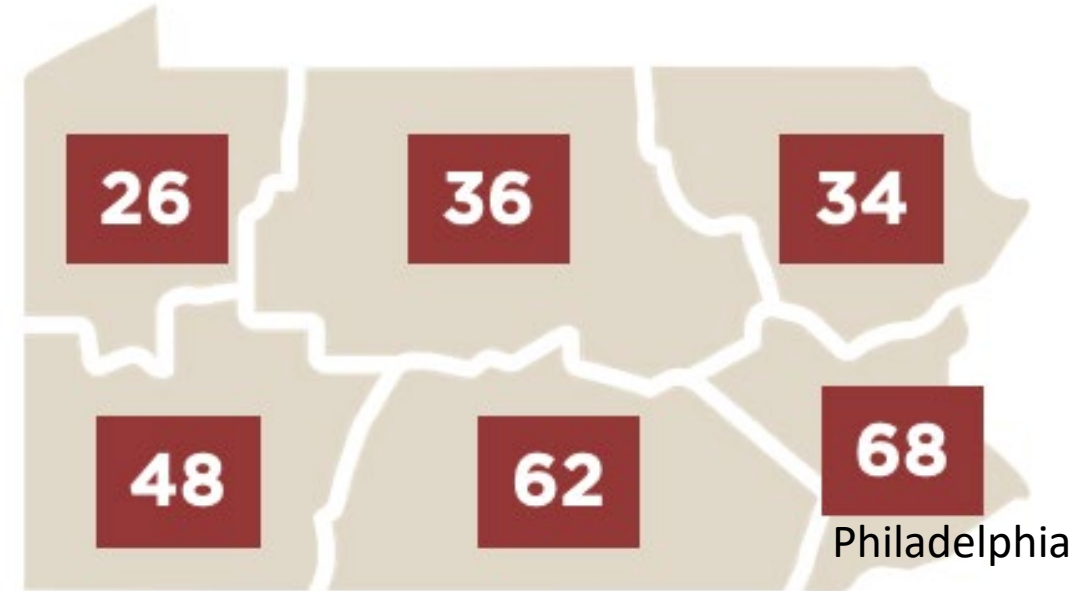
NS = non significant

# Pennsylvania Wine Industry

14,000 acres of grapes



Over 300 wineries



<https://pennsylvaniawine.com/find-wineries/>

# Penn State Wine and Grape Team

## Team Members

