

Insects of Wheat, Legumes, and Canola Crops

Cereal Aphids



English Grain Aphids



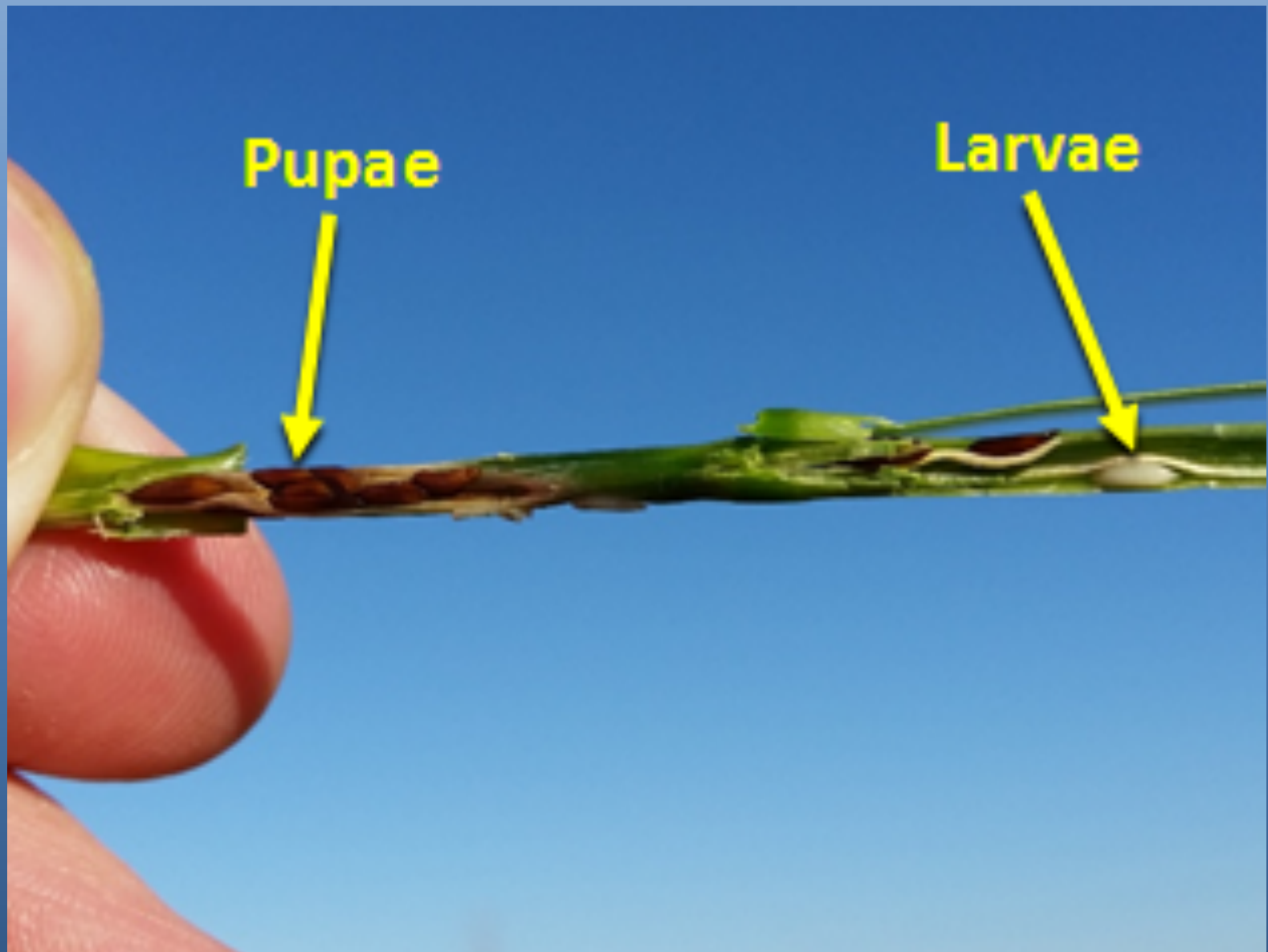
Bird-cherry oat aphid



Hessian Fly



Hessian Fly



Hessian Fly Injury

- Fall Damage

- Infested plants are stunted, with thickened leaves that are often darker green.
- Infested tillers often die,
- a fall infestation may thin stands and make plants more susceptible to winter kill.
- Surviving tillers will yield less grain.

- Spring damage

- Larvae feed near first node, weakening the stem so it is susceptible to lodging and poor seed fill
- Lower yield due to harvest and physiological yield losses



Wheat Head Armyworm



Cereal Leaf Beetle



Cereal Leaf Beetle



Wheat Stem Sawfly



Lygus Bugs



Pea Leaf Weevil



Cabbage Seedpod weevil



Cabbage Aphid



Convergent Lady Beetle



Damsel Bugs



Big Eyed Bugs



Carabids



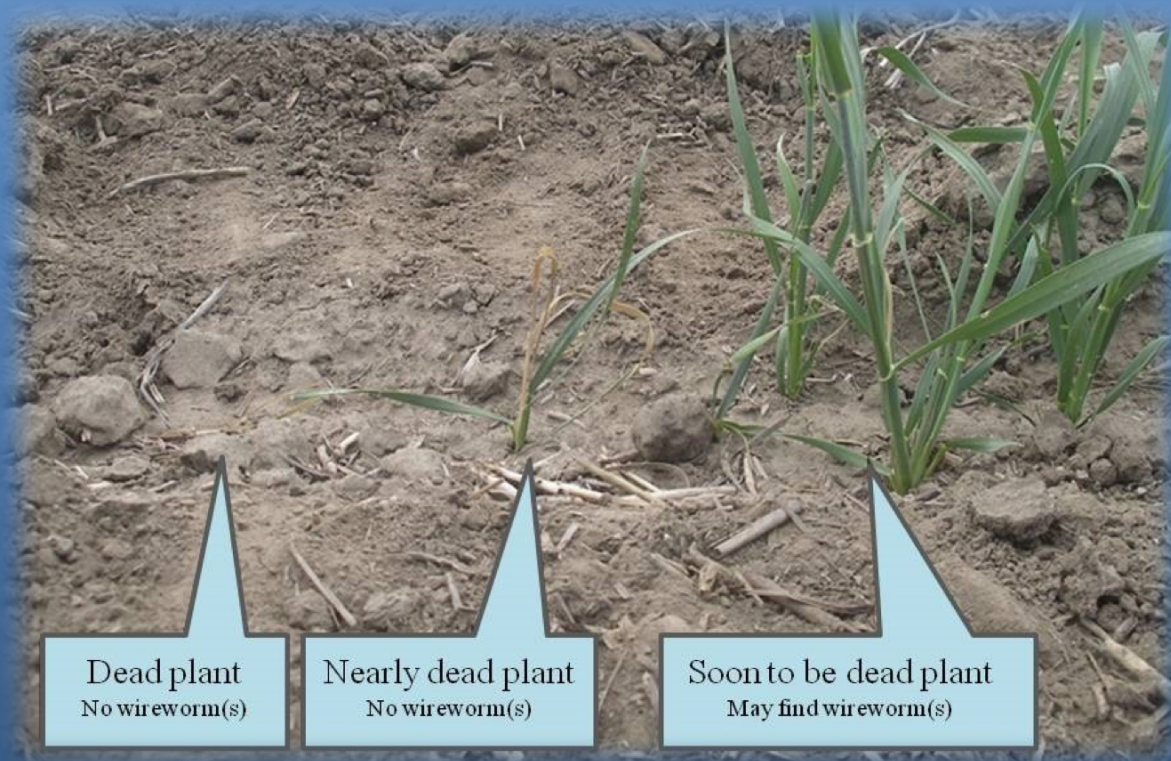
Parasitoids



Wireworms



Wireworm damage to wheat



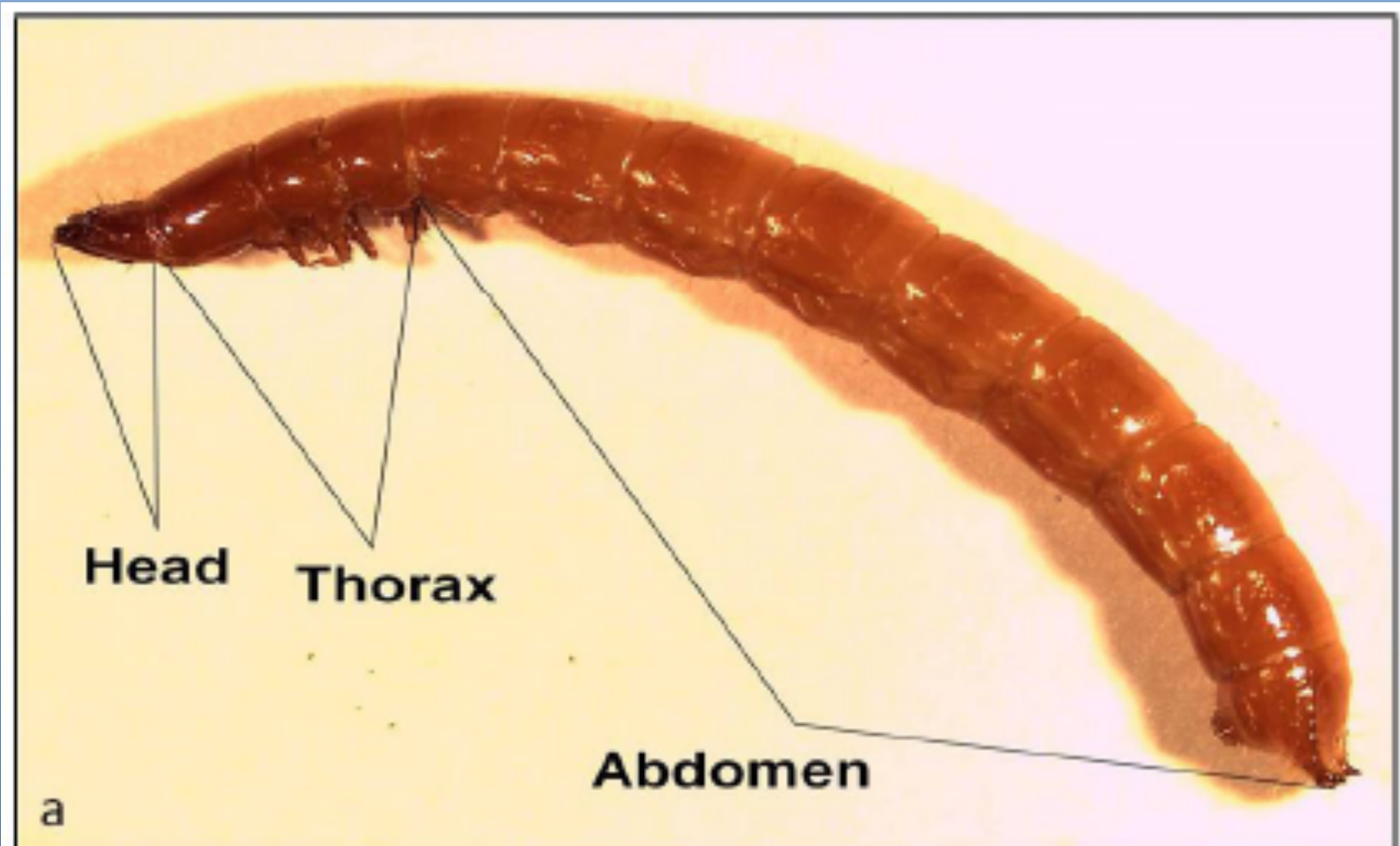
Dead plant
No wireworm(s)

Nearly dead plant
No wireworm(s)

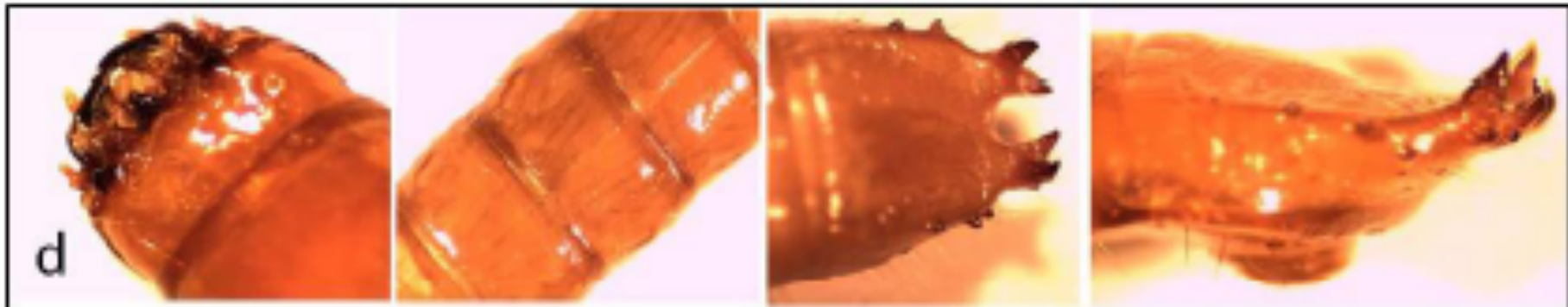
Soon to be dead plant
May find wireworm(s)



Wireworm Species



Wireworm Species



Oats and Wheat – No Gaucho



Wheat - Gaucho



Wireworm damage to wheat



The problem

- Soil-borne insects pose some of the most challenging problems in the agricultural ecosystems
- Live in cryptic habitats; appear irregularly in both time and space
- Damage is hard to anticipate
- Sudden appearance requires rapid, curative treatments

Neonicotinoid insecticides



Neonicotinoid insecticides vs. IPM

“By 2010, neonicotinoids accounted for 27 % of the world’s total insecticide use (Casida and Durkin 2013), and their application to pest management in maize is among the highest use of the insecticides in agriculture.”

-Furlan & Kreutzweiser 2015

“Long-term data suggest that the majority of maize farmland in Italy does not need to be protected with insecticides at sowing.”

-Furlan & Kreutzweiser 2015

“For the long-term sustainability of arable production, the research priorities should be directed toward reducing reliance on pesticides through the development of IPM.”

-Traugott et al. 2016

“An IPM approach considers all relevant and available information to make informed management decisions, providing pest control options based on actual need.”

-Furlan & Kreutzweiser 2015

“Whenever considered, any element of IPM strategies should be planned, taking into account the encountered wireworm species, because of the differences in biology, ecology and behavior that can occur between them.”

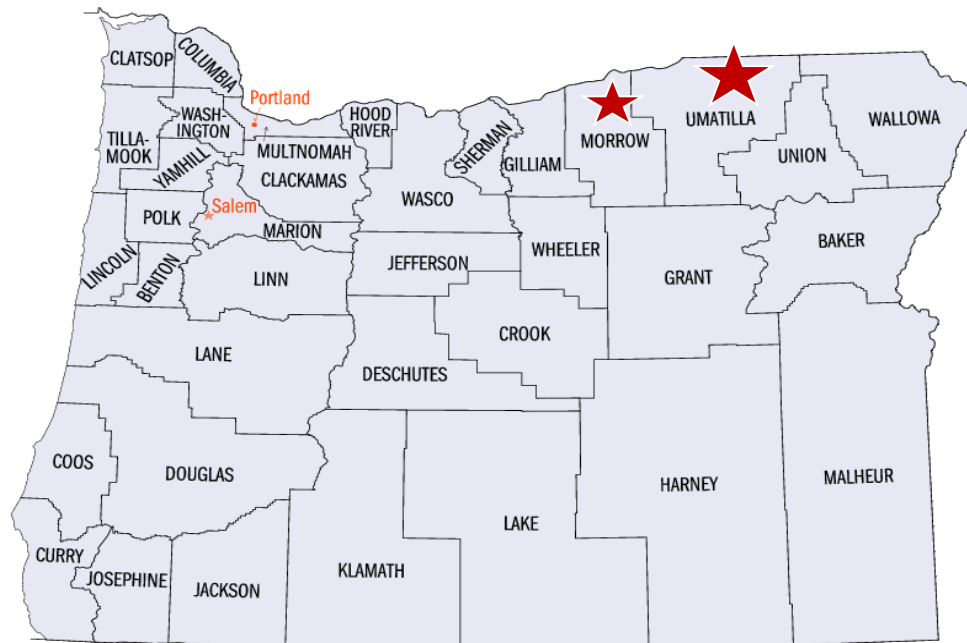
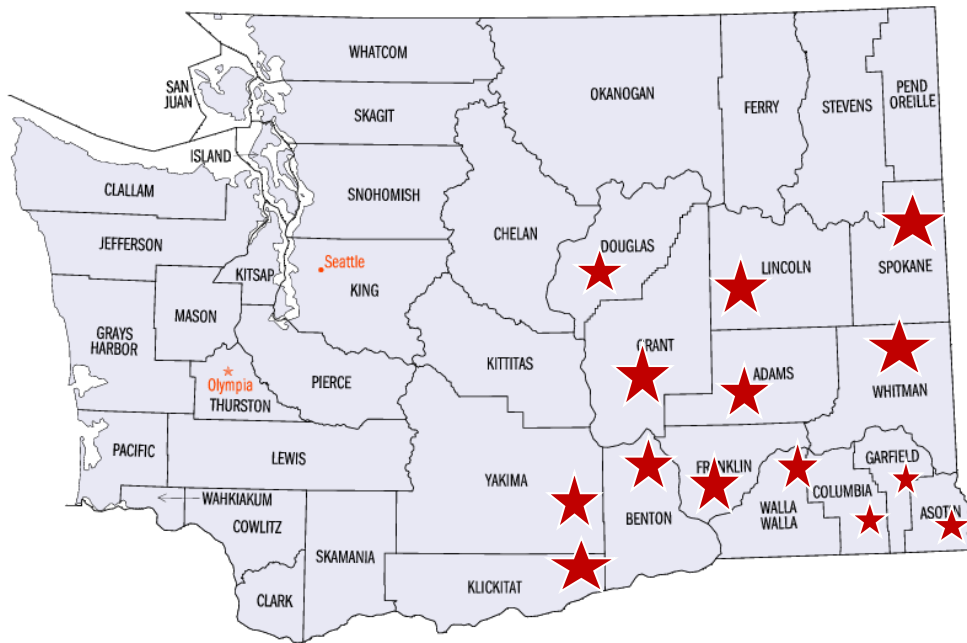
-Barsics et al. 2013

Objectives

- ✓ Determine pest species present and explore ecological factors associated with economically significant species
- ✓ Examine seasonal occurrence and vertical movement of economically significant species
- ✓ Investigate feeding ecology of economically significant species

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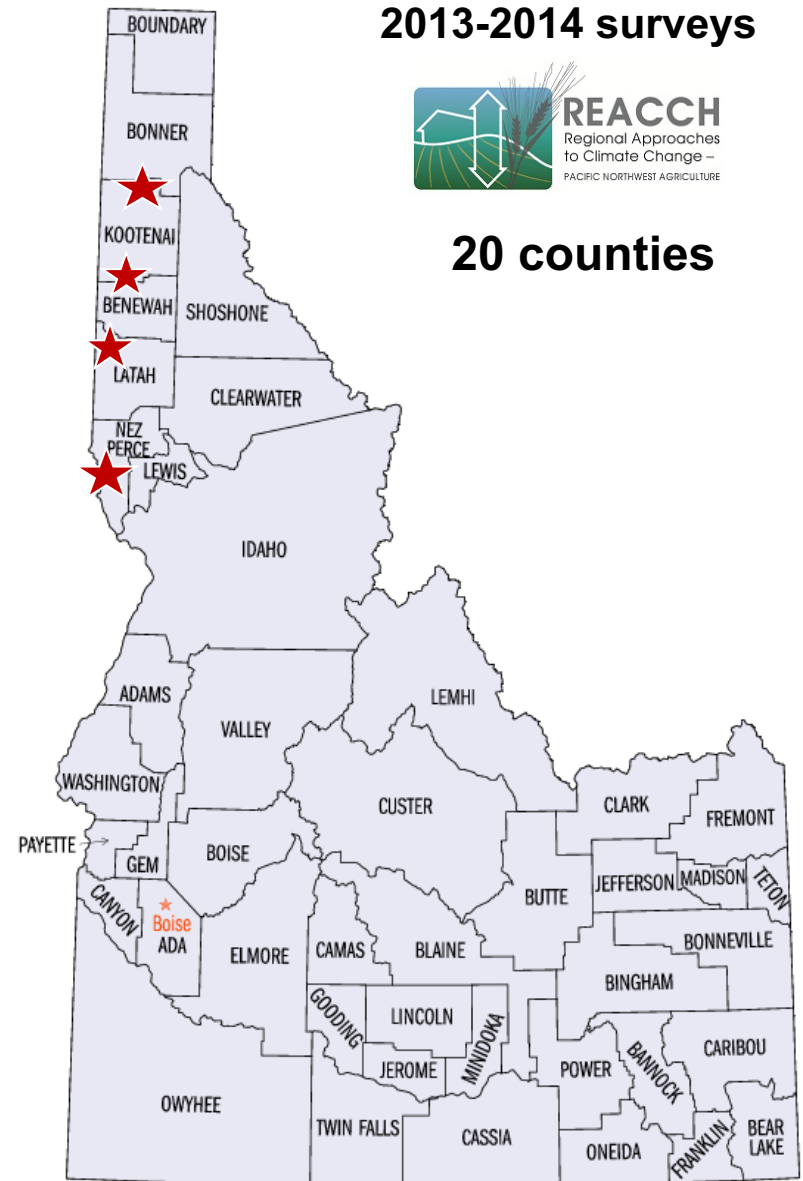
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2013-2014 surveys

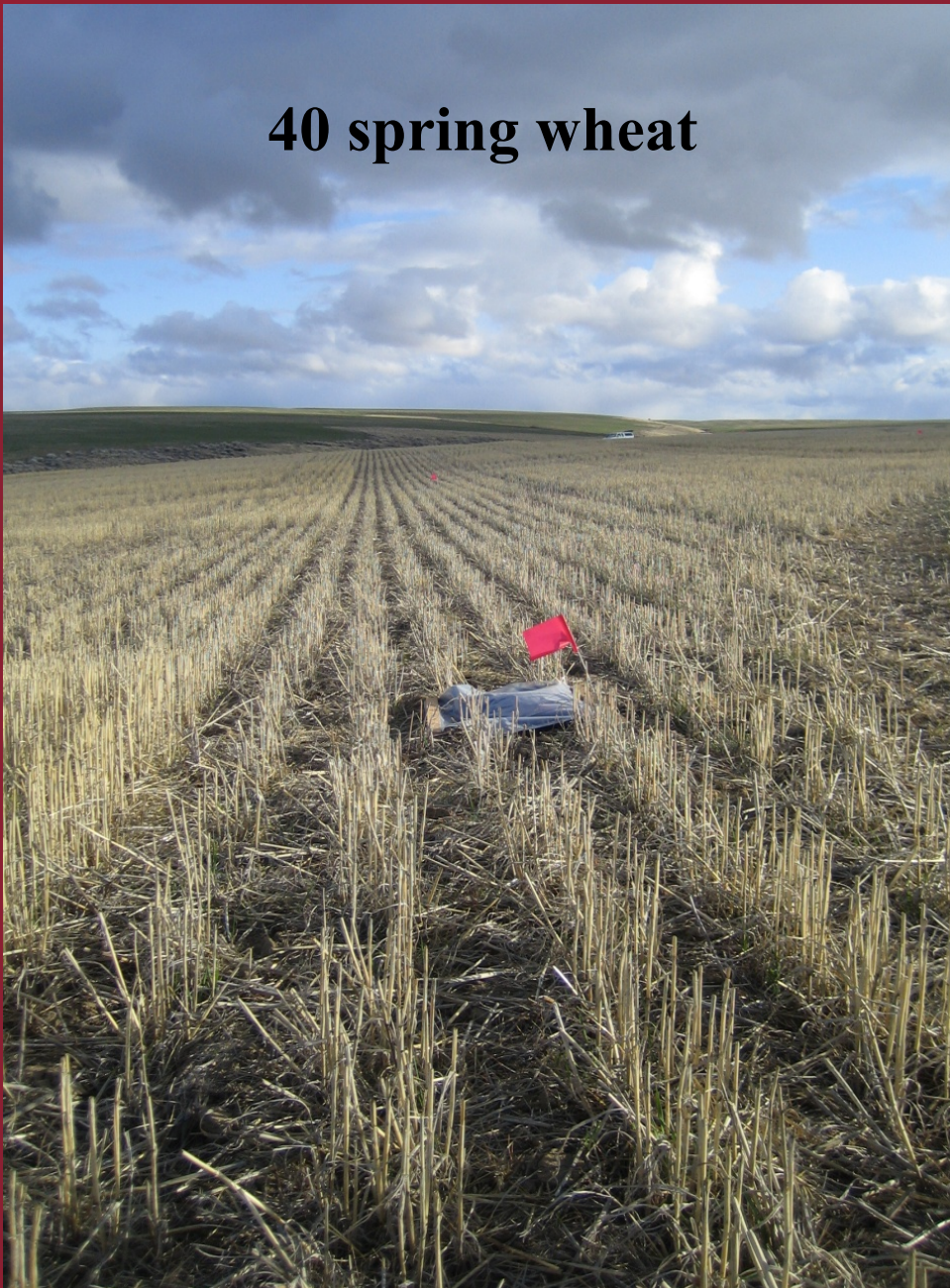


20 counties



Crop types

40 spring wheat



20 winter wheat



20 CRP



Sampling and Ecological factors associated with wireworms

Sampling

- Modified wireworm solar traps
- 10 Traps per field (zig-zag pattern)

Timing

- In the early spring
- When soil temperatures reached 6°C

Identification

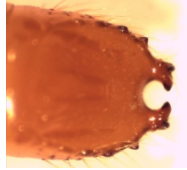
- Keys (Glen et al. 1943; Lanchester 1946)
- DNA verification (MSU) (Etzler et al. 2014)



Model parameters	Source
Rainfall 30 days prior to sampling	Weather stations, grower
Soil temperature	Soil thermometer
Crop type	On site
Slope	On site sampling
% sand	Soil samples
% clay	Soil samples
% silt	Soil samples
Soil pH	Soil samples
Soil moisture	Soil thermometer
Previous crop	Grower
Tillage	On site
Irrigation	On site

Community composition of wireworms

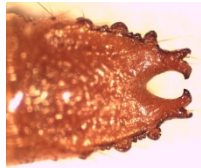
Limonius infuscatus



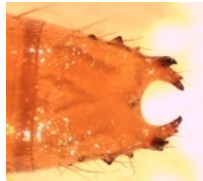
Limonius californicus



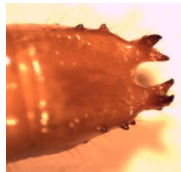
Hemicrepidius sp.



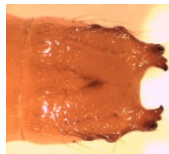
Hadromorphus glaucus



Selatosomus pruininus



Selatosomus aeripennis



Sylvanelater limoniiformis



Hypnoidus bicolor



Melanotus oregonensis



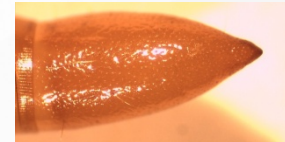
Dalopius asellus



Ampedus sp.



Agriotes sp.

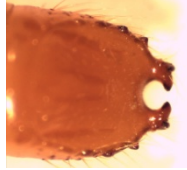


Aeolus mellillus



Community composition of wireworms

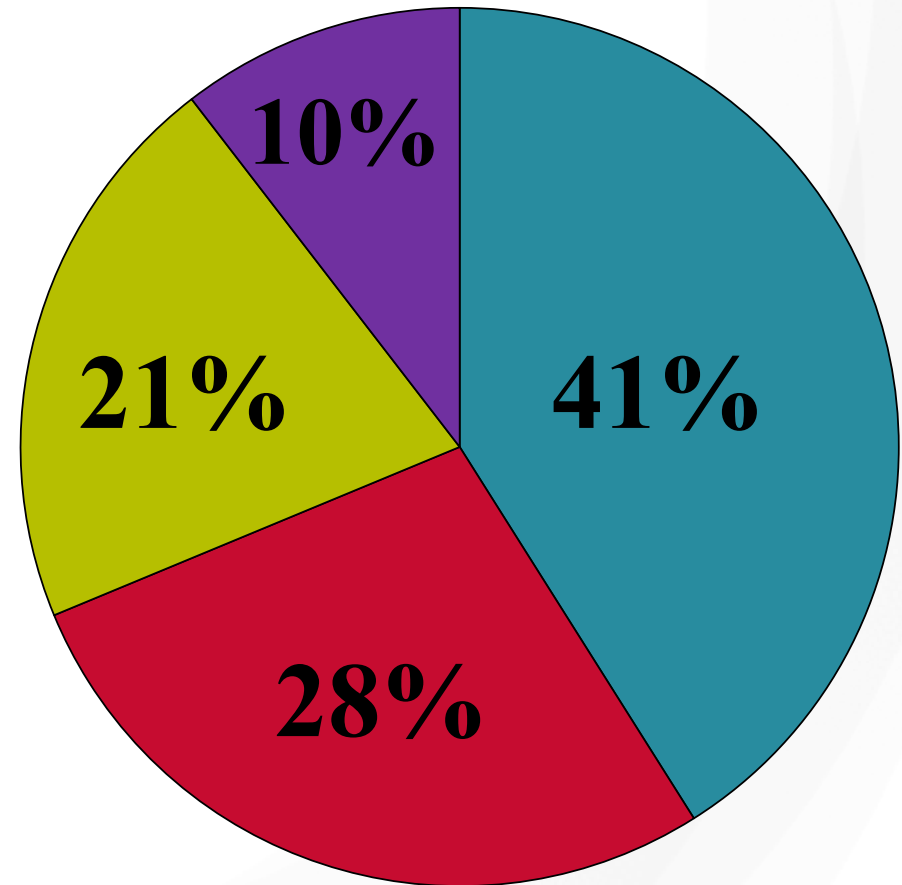
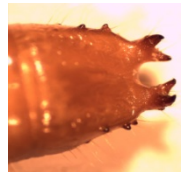
Limonius infuscatus







Limonius californicus



Selatosomus pruininus



-  *Limonius infuscatus*
-  *Limonius californicus*
-  *Selatosomus pruininus*
-  Other

Results – Wireworm abundance and species richness

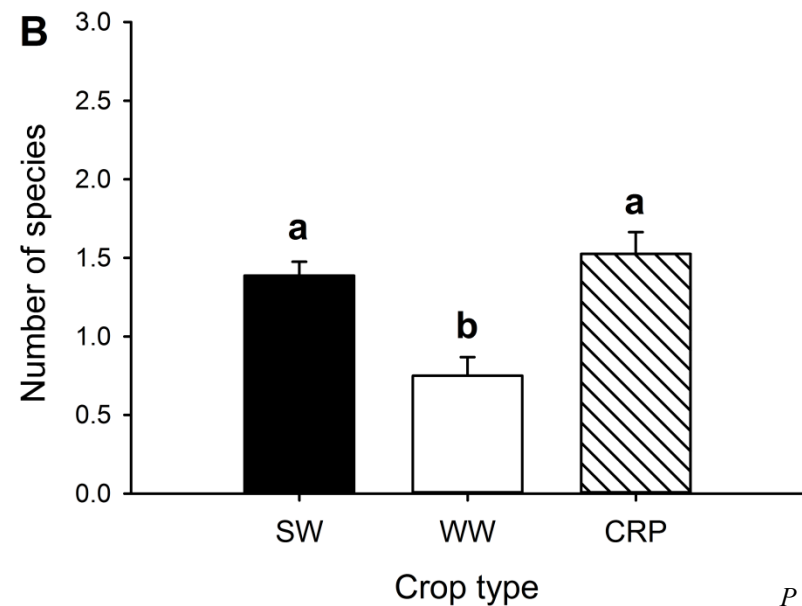
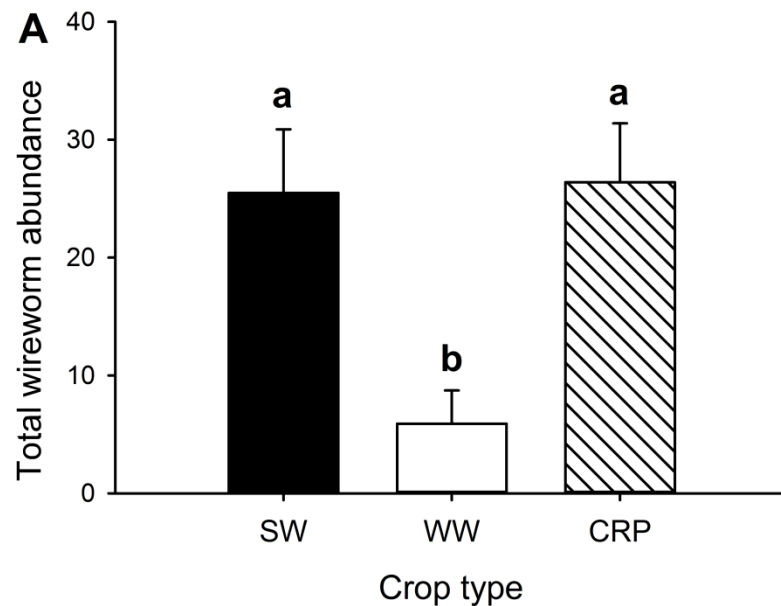
A Abundance	Estimate	SE	χ^2	<i>P</i>
Crop	N/A	N/A	23.65	< 0.0001***
Percentage of sand	-0.025	0.0076	9.80	0.0017***
Soil Temperature	0.29	0.086	11.14	0.0008***
B Species richness	Estimate	SE	<i>F</i>	<i>P</i>
Crop	N/A	N/A	12.82	< 0.0001***
Percentage of silt	0.0034	0.0022	2.46	0.12
Soil pH	0.21	0.10	5.72	0.018**

: $P < 0.05$; *: $P < 0.01$

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P < 0.05

Results – Abundance of major pest species

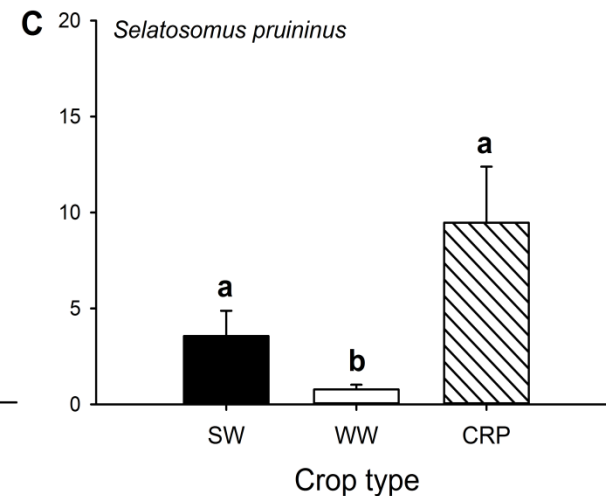
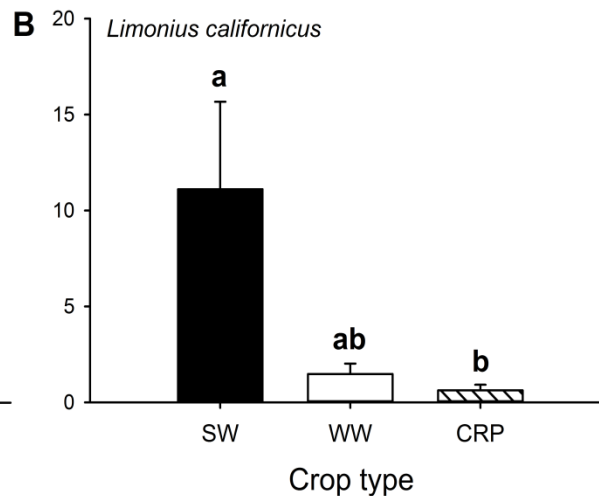
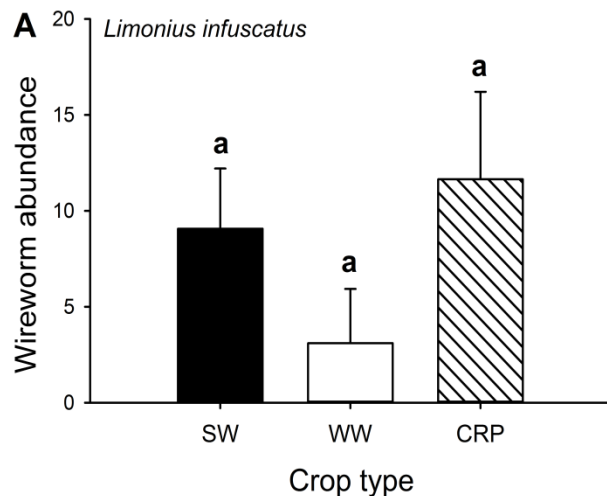
A <i>L. infuscatus</i>	Estimate	SE	χ^2	<i>P</i>
Crop	N/A	N/A	5.65	0.059*
Percentage of sand	-0.096	0.019	17.43	< 0.0001***
B <i>L. californicus</i>	Estimate	SE	χ^2	<i>P</i>
Crop	N/A	N/A	8.44	0.015**
Soil moisture	0.25	0.082	9.03	0.0027***
Soil pH	1.04	0.42	5.17	0.023**
C <i>S. pruininus</i>	Estimate	SE	χ^2	<i>P</i>
Crop	N/A	N/A	11.75	0.0028**
Percentage of silt	-0.013	0.0077	2.79	0.095*
Soil temperature	-0.39	0.18	5.02	0.025**
Soil moisture	-0.41	0.053	51.00	< 0.0001***

*: $P < 0.1$; **: $P < 0.05$; ***: $P < 0.01$

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$P < 0.05$

Results – Distribution map

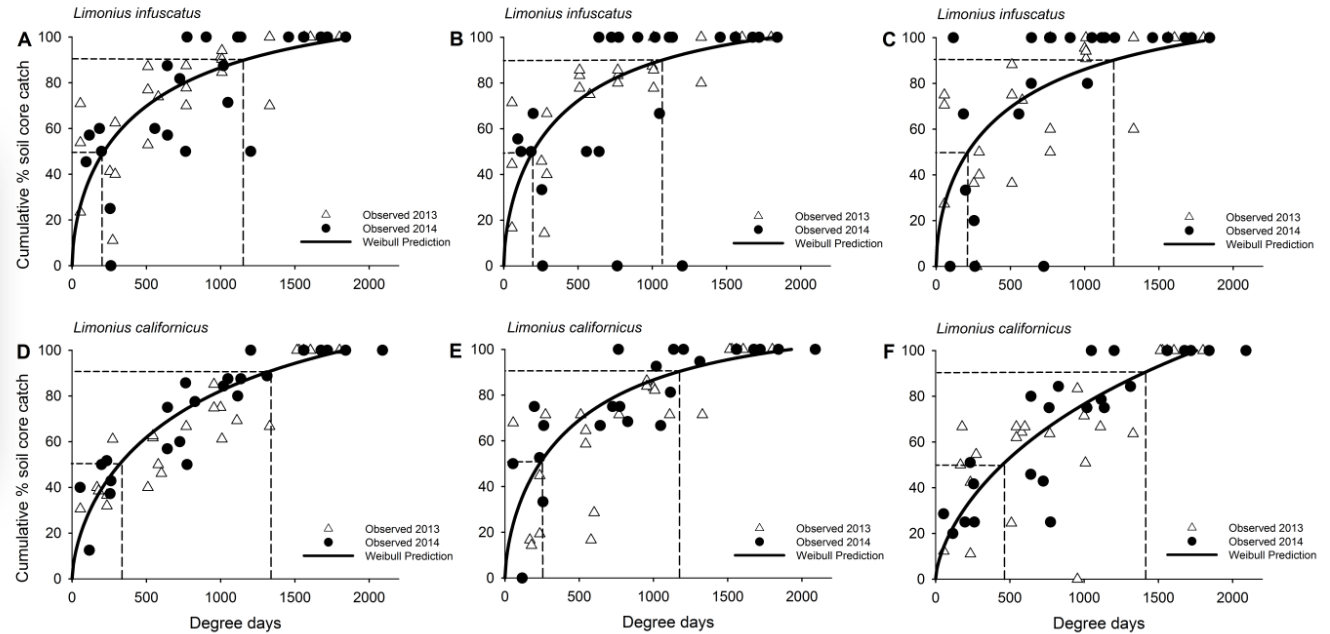


Objectives

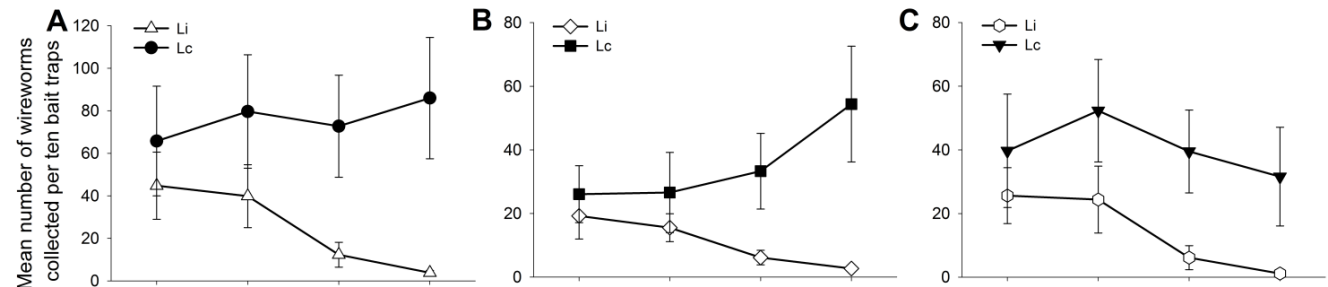
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Results

Population dynamics



Feeding activity

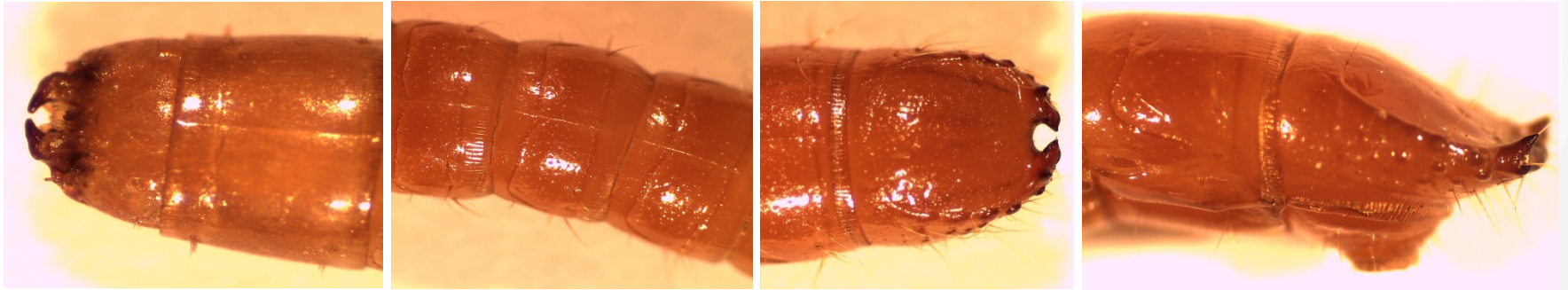


Objectives

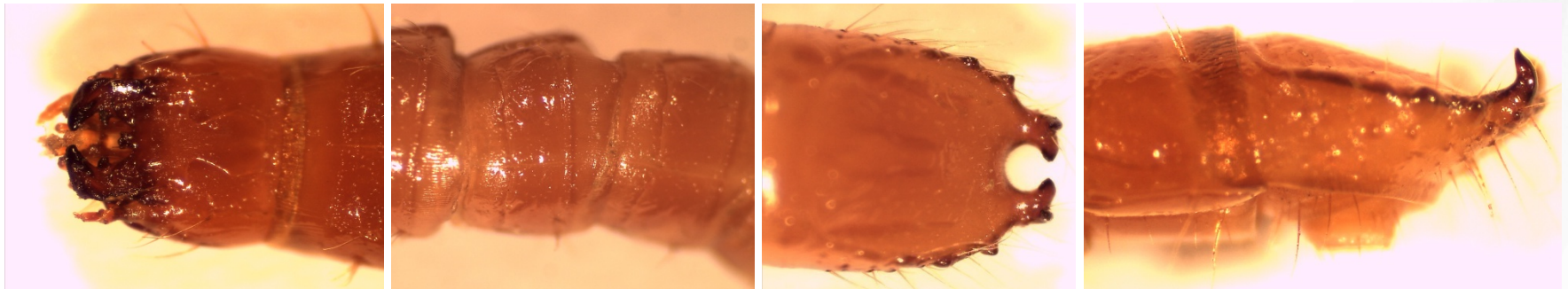
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Species damage potential

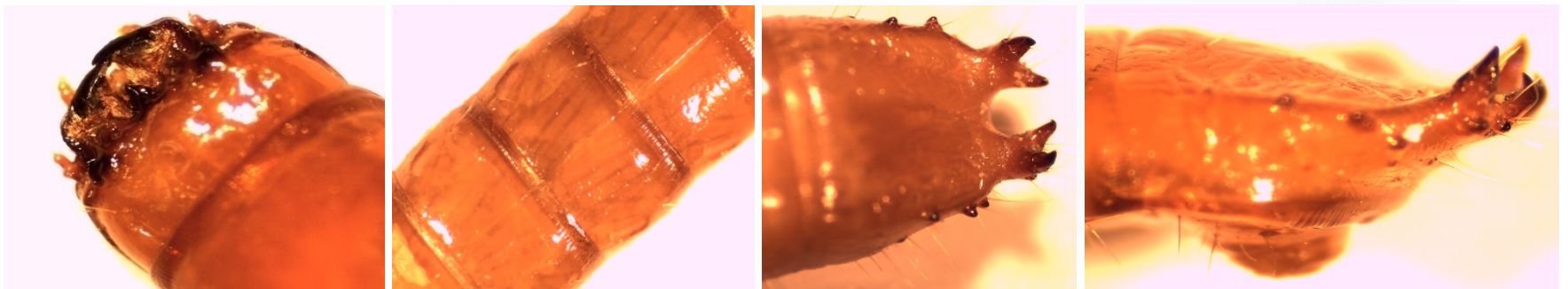
Sugarbeet wireworm, *Limonius californicus* (Mannerheim)



Western field wireworm, *Limonius infuscatus* Motschulsky



Great basin wireworm, *Selatosomus pruininus* (Horn)



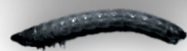
Materials and Methods

Preliminary data, 2013

Experiments, 2014:

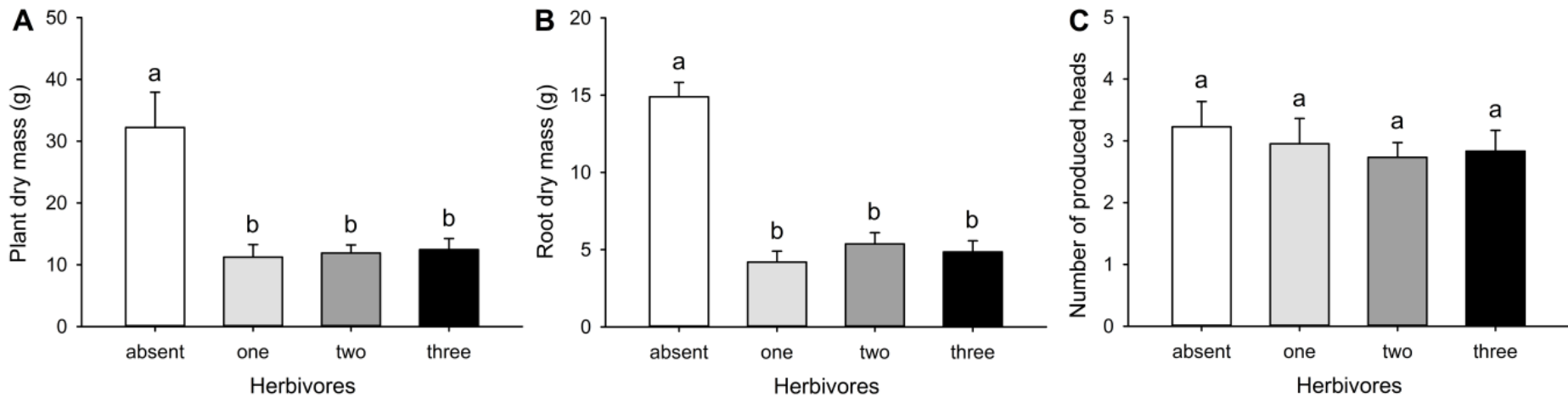
- ✓ Gray storage bins (70 l) – experimental units
- ✓ Wheat plants (10/unit)
- ✓ Wireworms (12/unit)
- ✓ Substitutive design





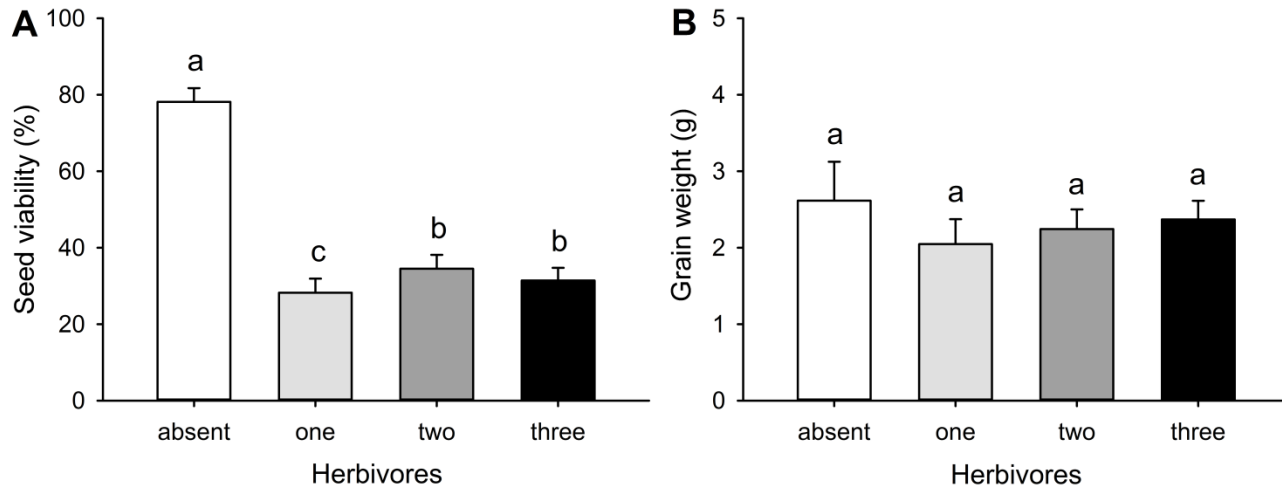
Results – Plant productivity / wireworm presence and species richness

Plant components



$\alpha = 0.05$

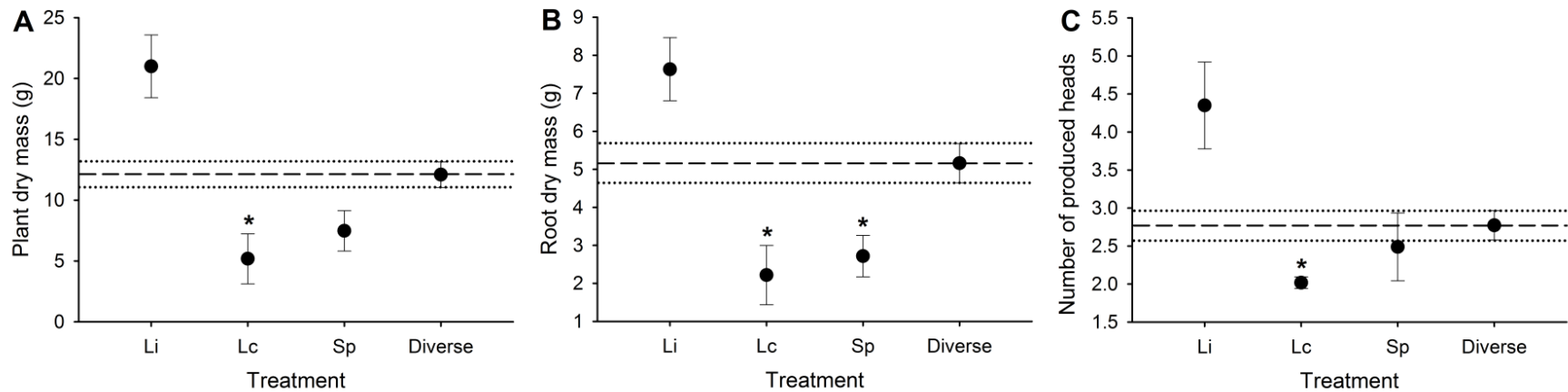
Seed components



$\alpha = 0.05$

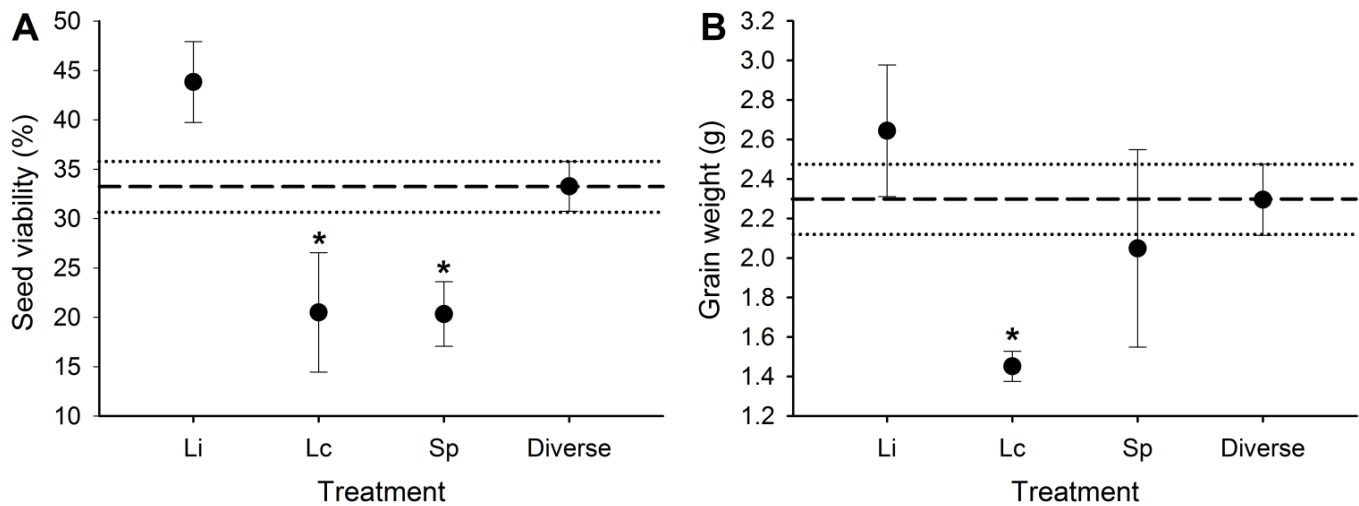
Results – Plant productivity / single species vs. diverse communities

Plant components



Seed components

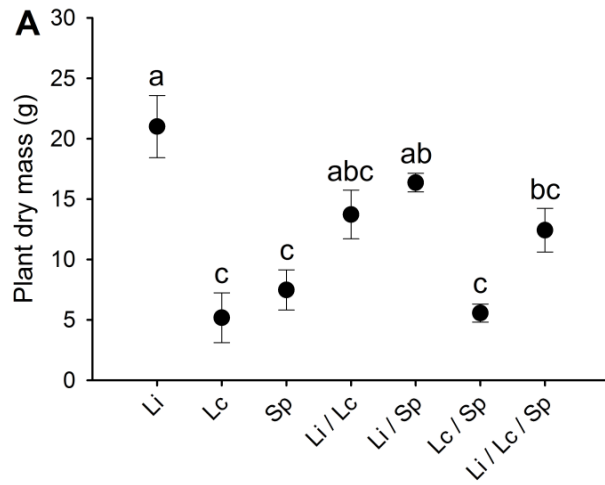
$\alpha = 0.05$



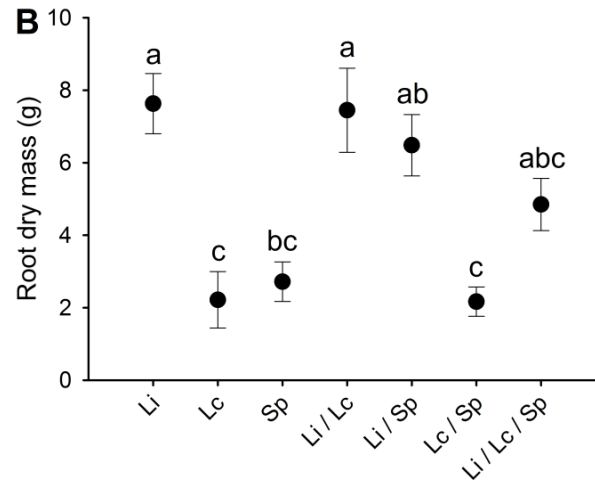
$\alpha = 0.05$

Results – Plant productivity / all treatments

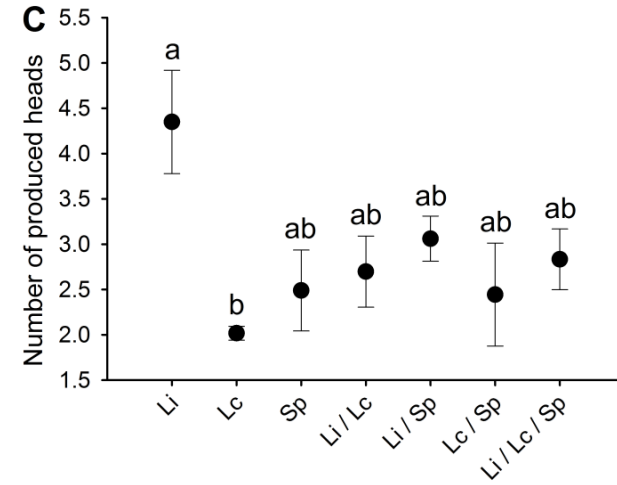
Plant components



Herbivores

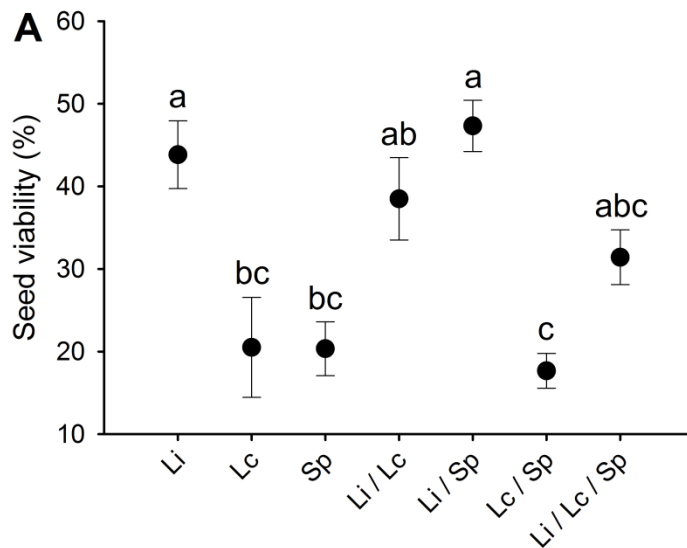


Herbivores

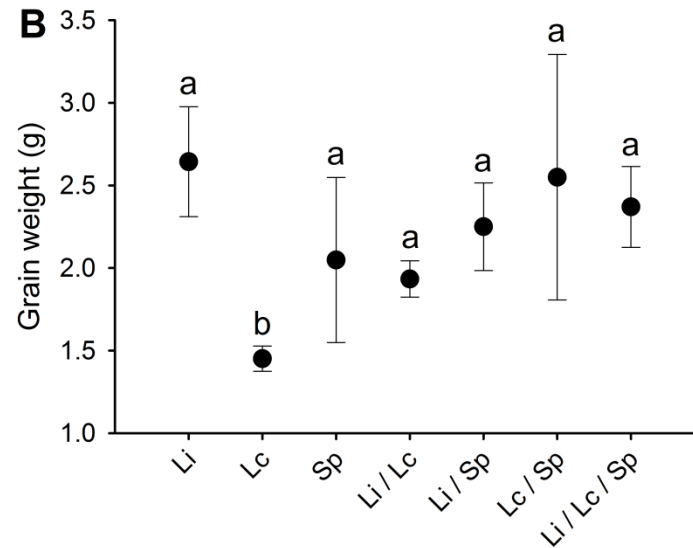


Herbivores

Seed components



Herbivores

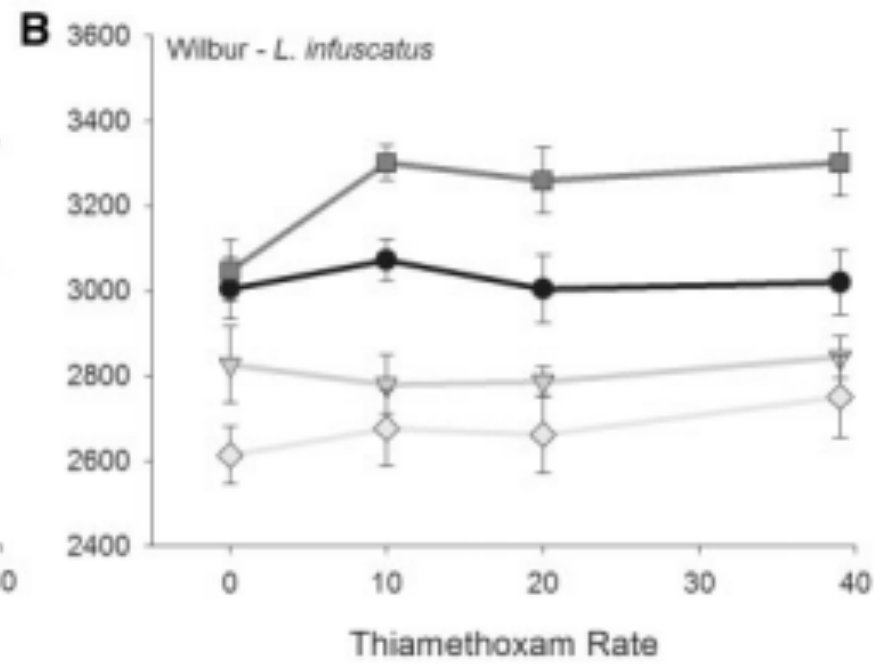
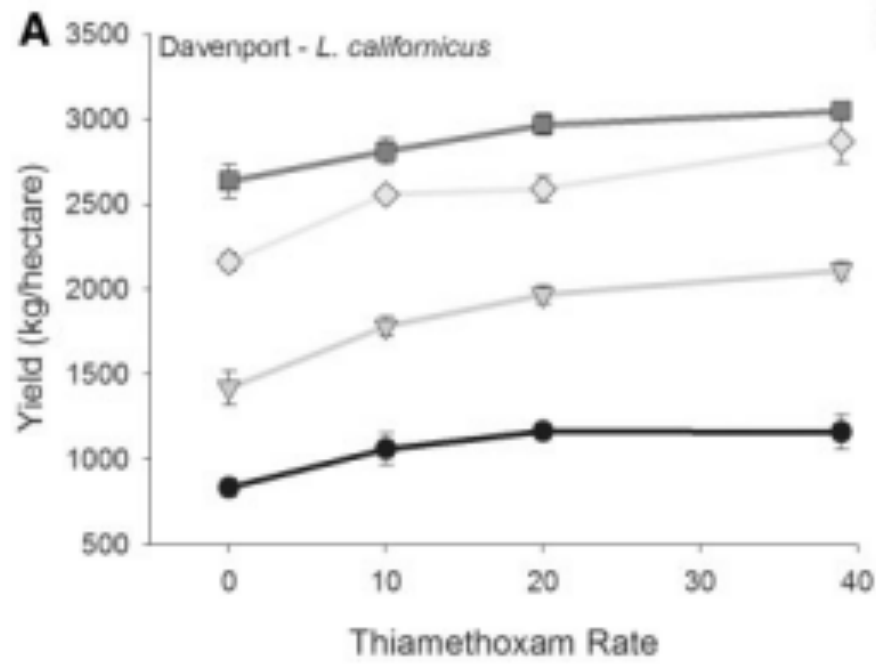


Herbivores

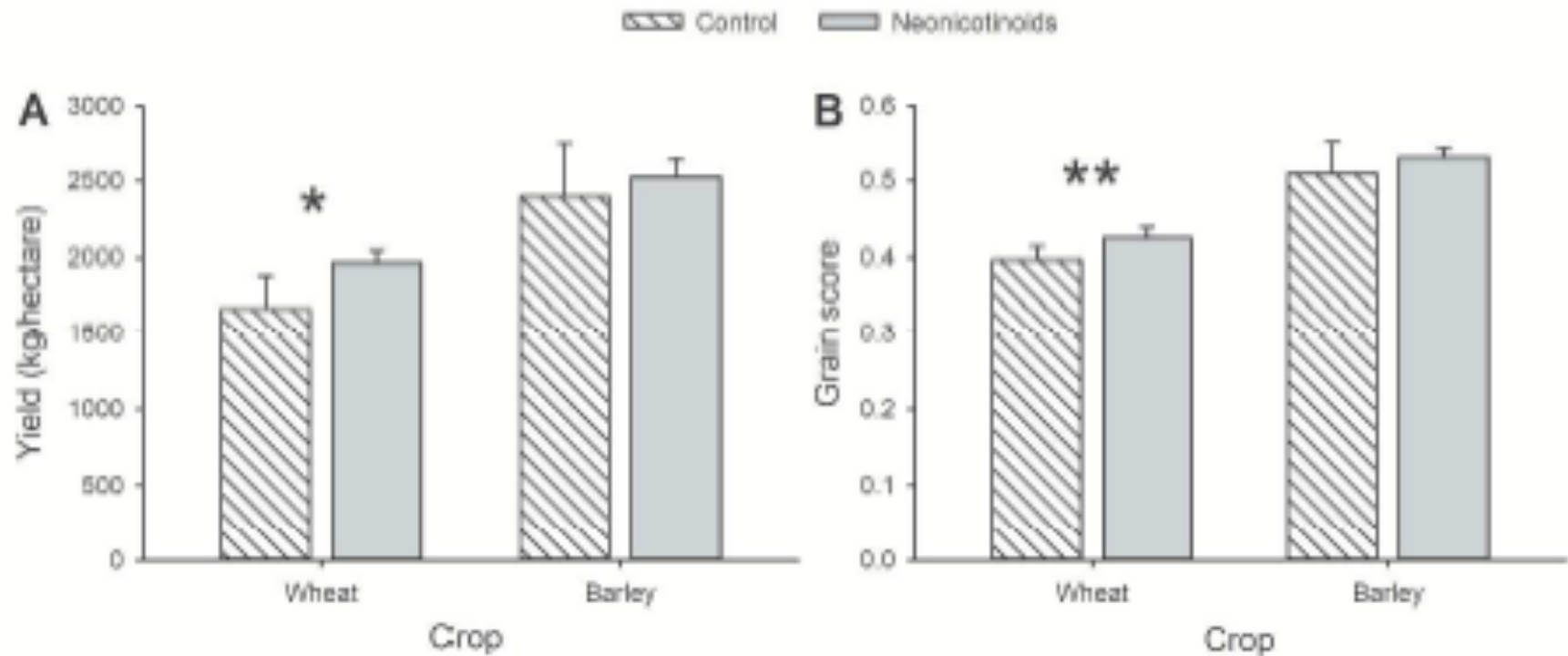
$\alpha = 0.05$

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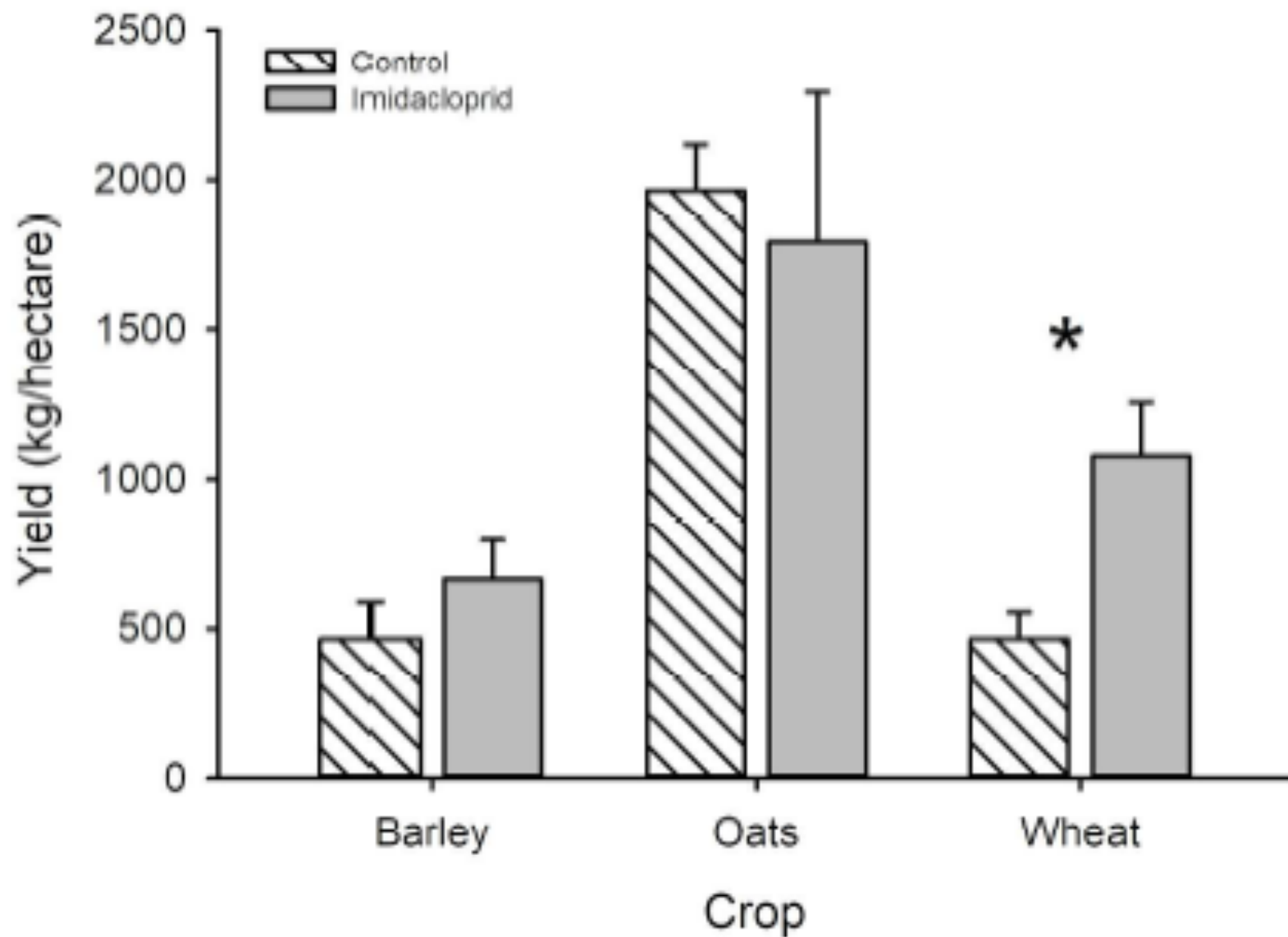
Field experiments done by Aaron Esser



Field experiments done by Aaron Esser



Field experiments done by Ivan Milosavljevic



Conclusions

- ✓ Major pest species in PNW wheat crops are identified
- ✓ First distribution data recorded for WA, OR, ID
- ✓ There is a difference in damage caused to wheat between wireworm species
- ✓ Solid foundation for IPM has been established

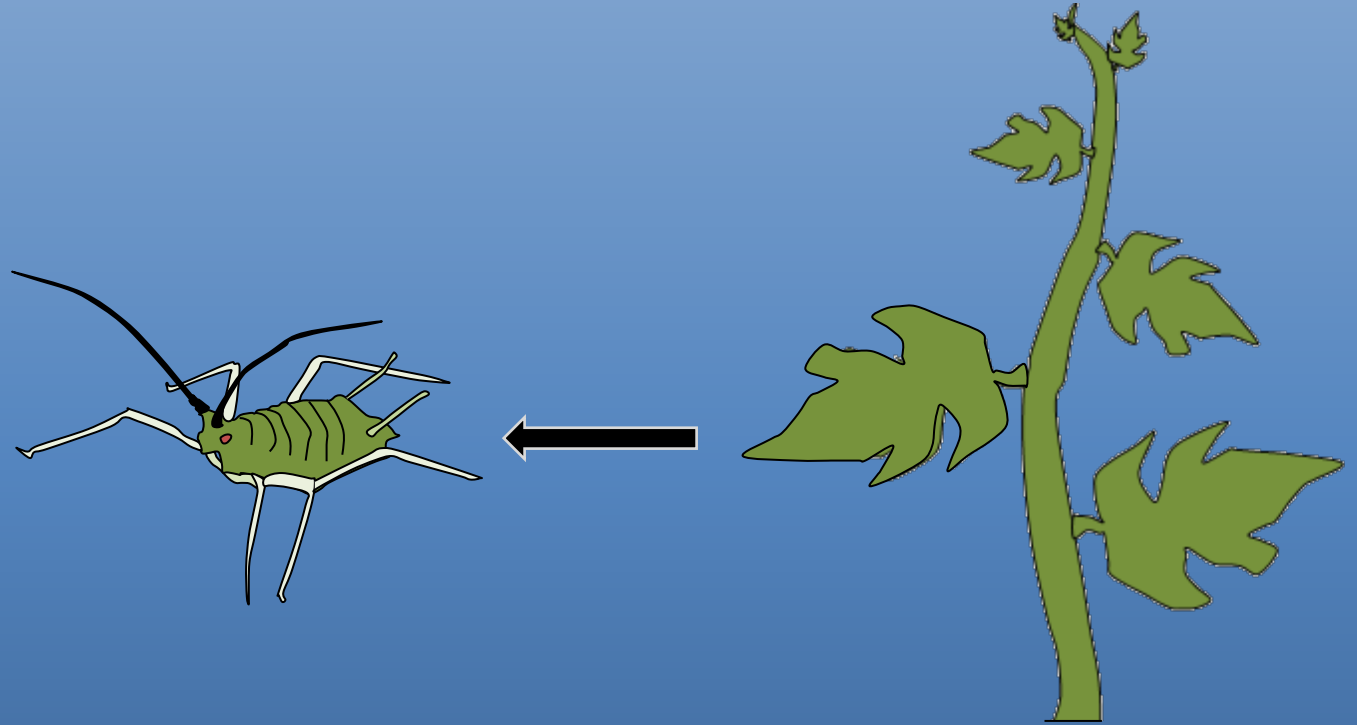


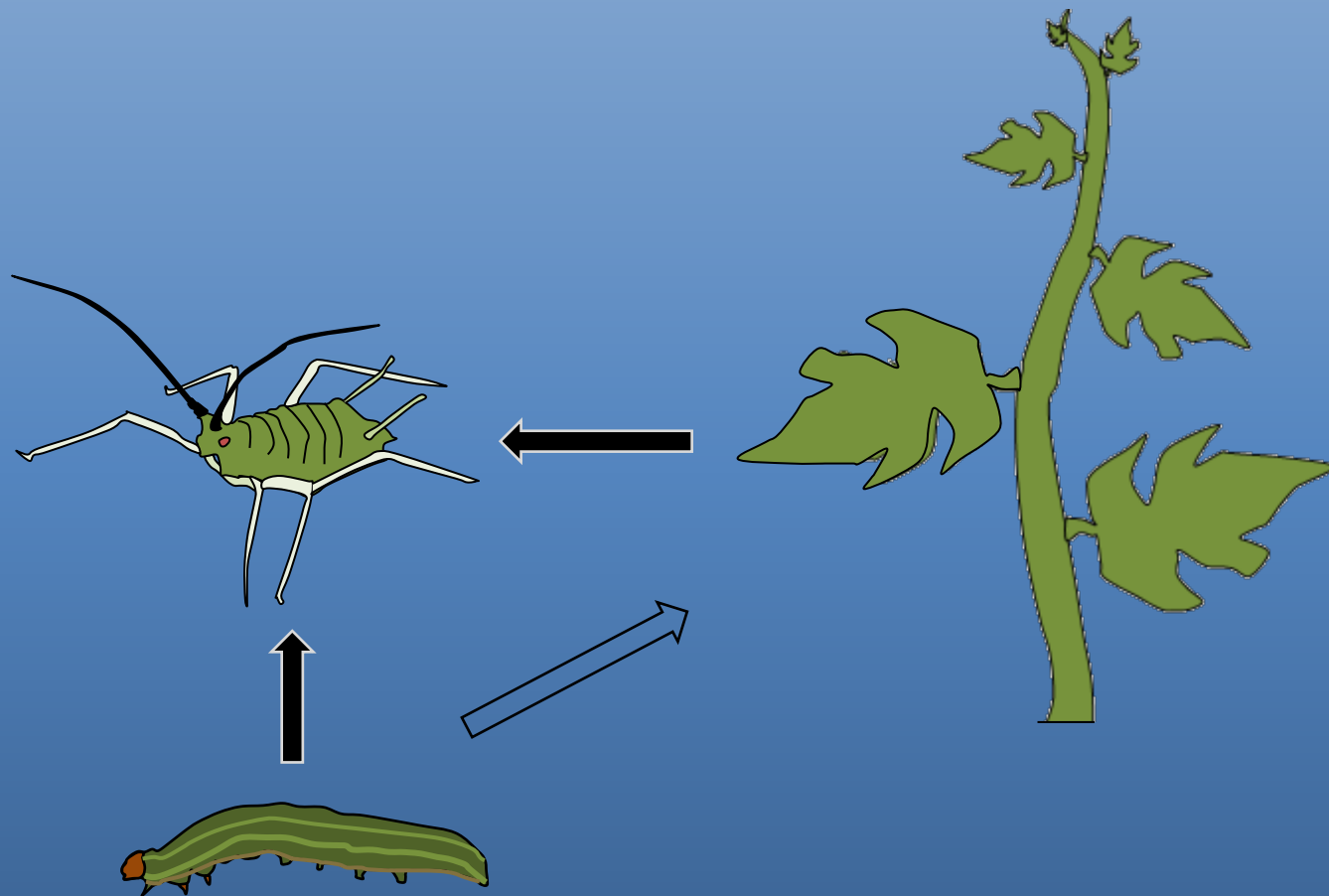
Viral Epidemics in Plants provide an example of complexity

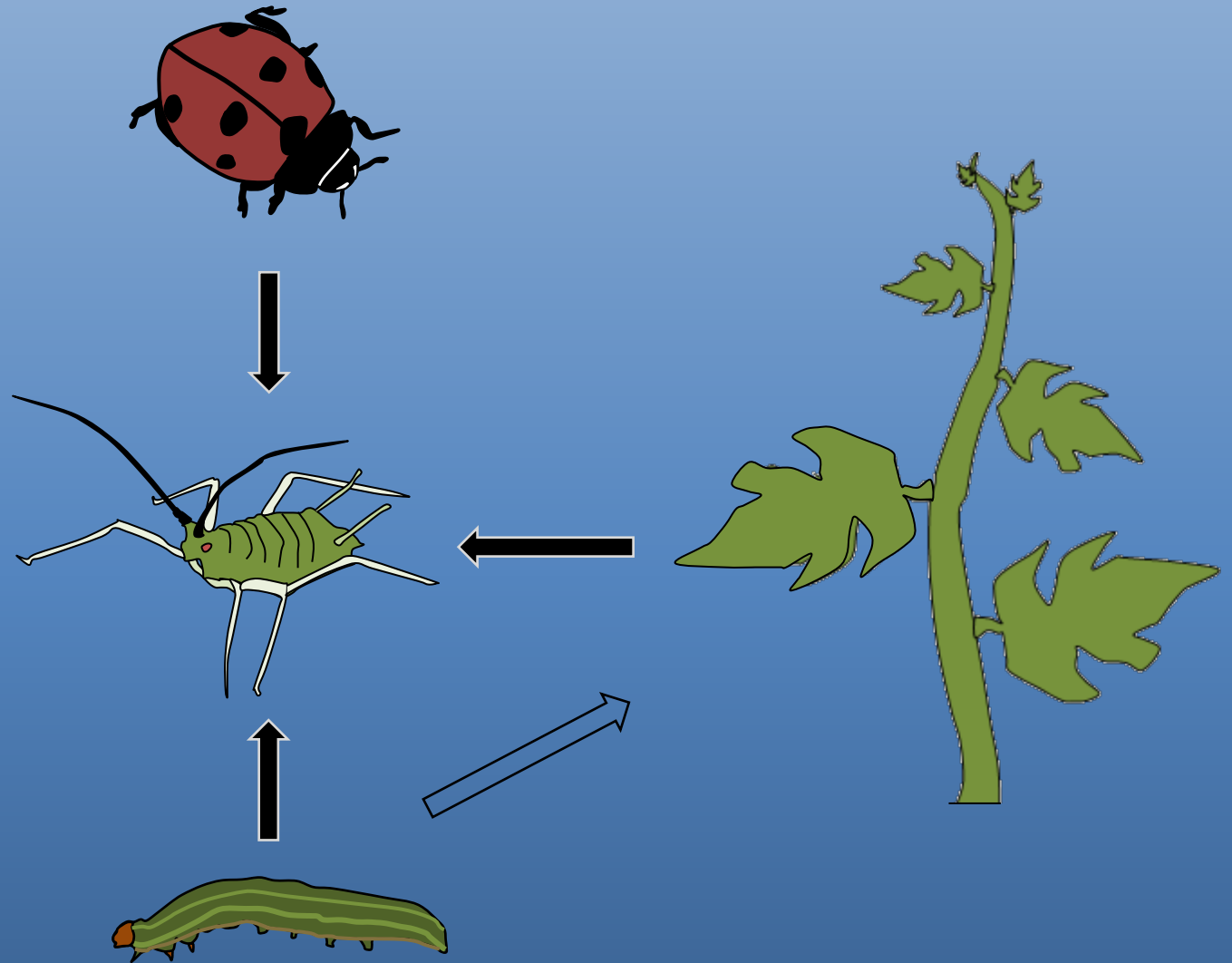
- Vector-borne
- Spatially patchy
- Temporally variable
- Difficult to predict

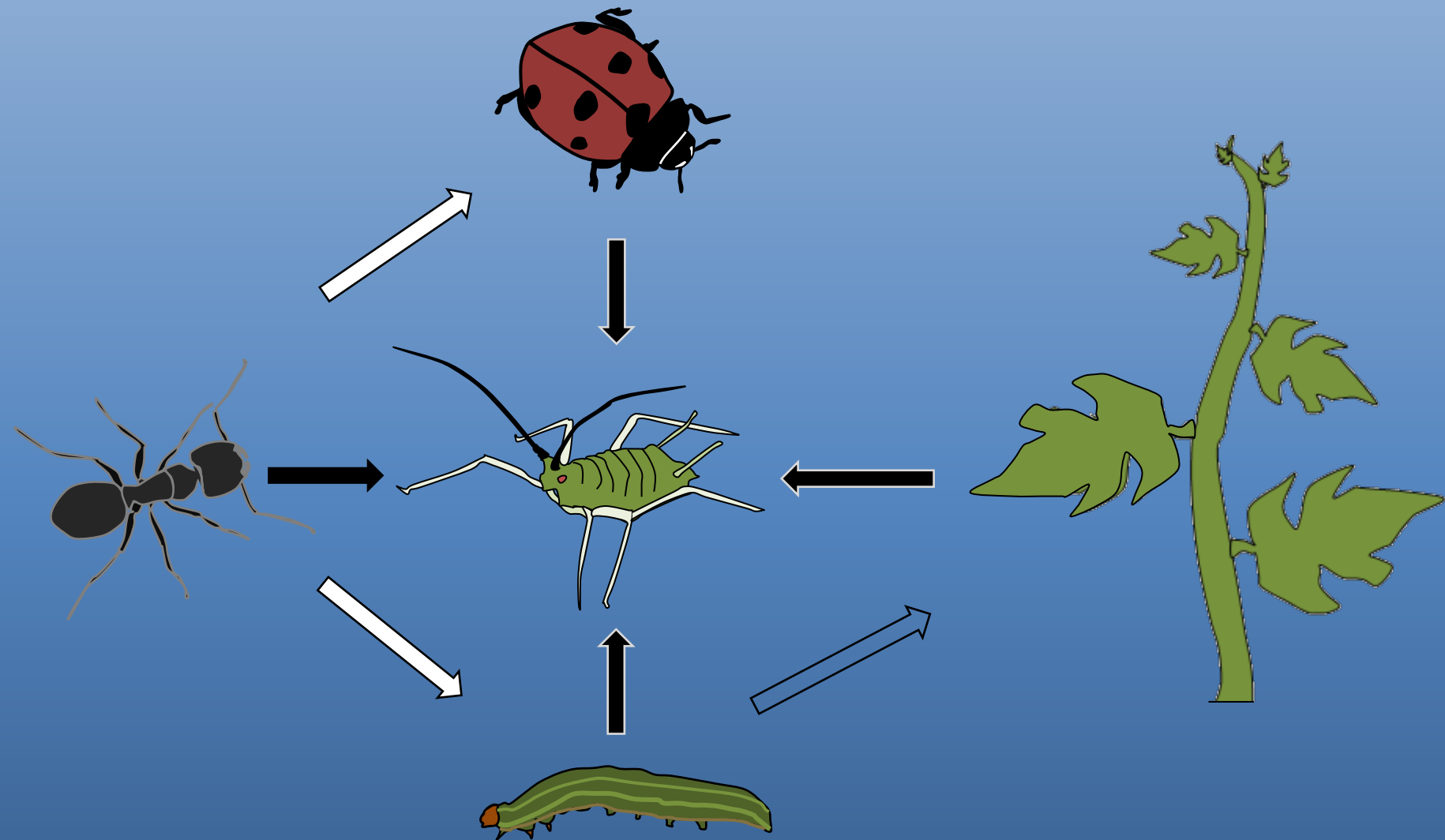


Fred Crowe, Oregon State University





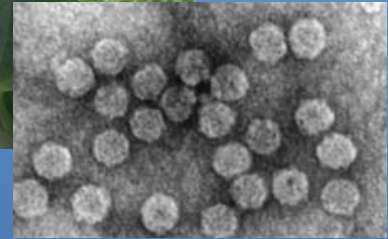
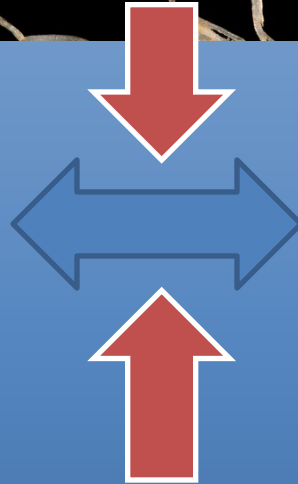
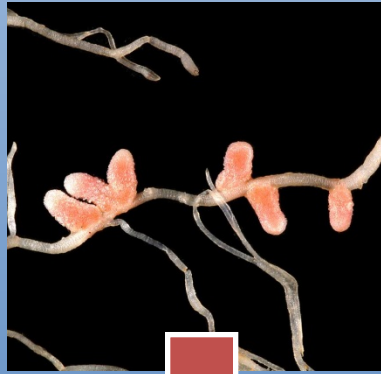




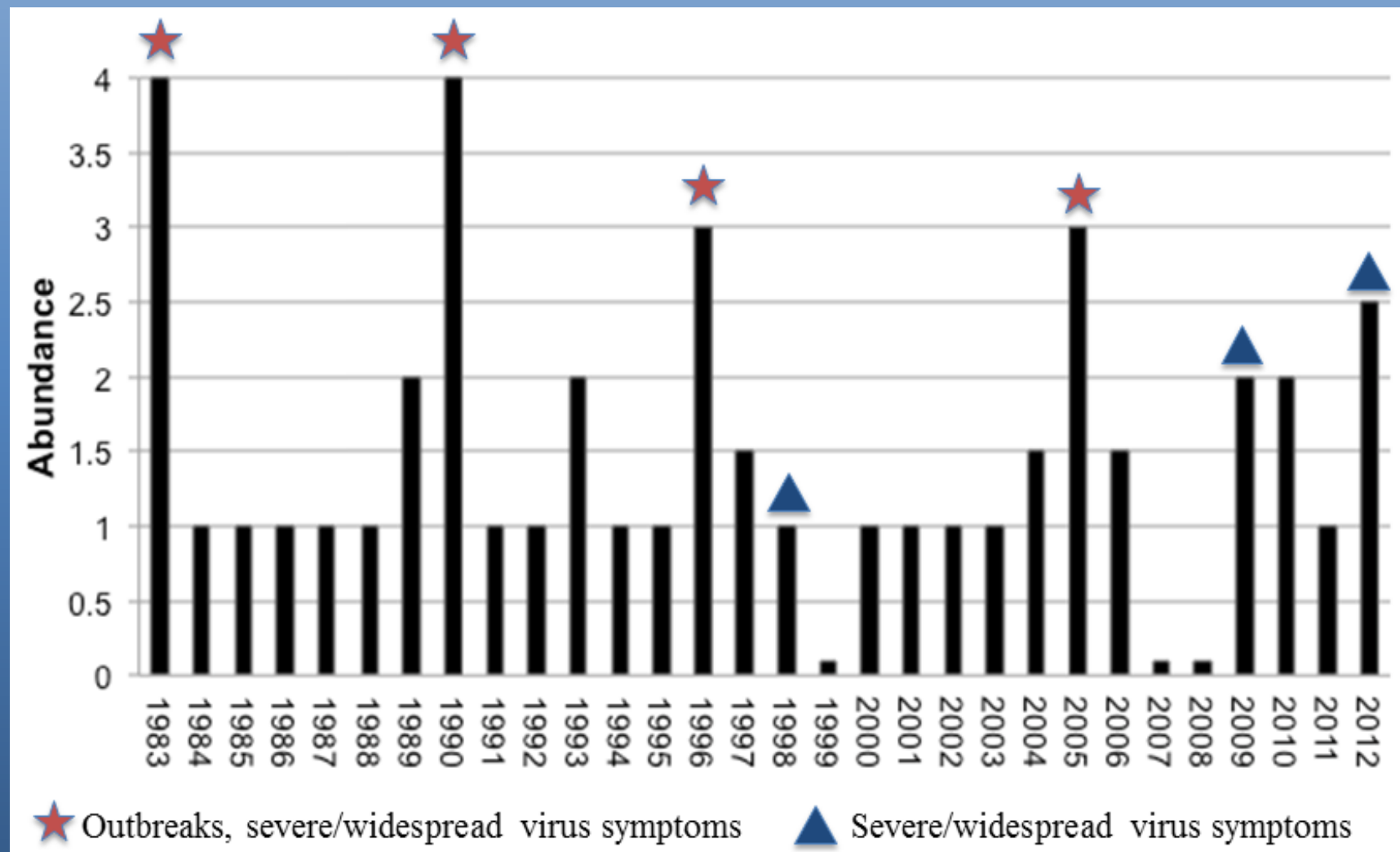
Study System

- Pea, *Pisum sativum*
- Pea aphid, *Acyrtosiphon pisum*
- Pea enation mosaic virus (PEMV)
- Pea leaf weevil, *Sitona lineatus*

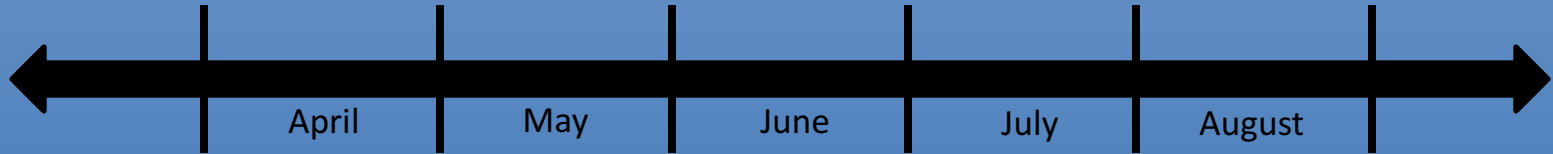




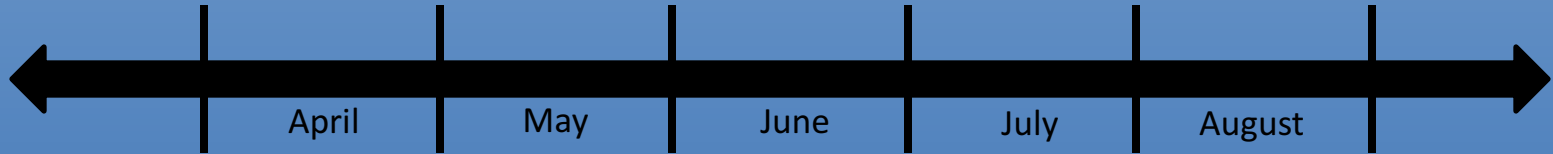
Unpredictable Outbreaks



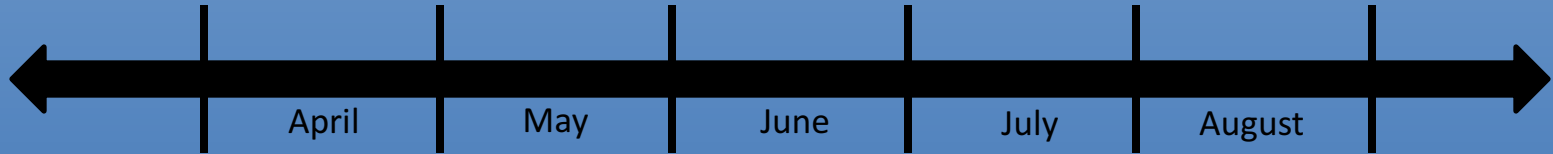
Timeline



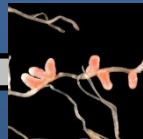
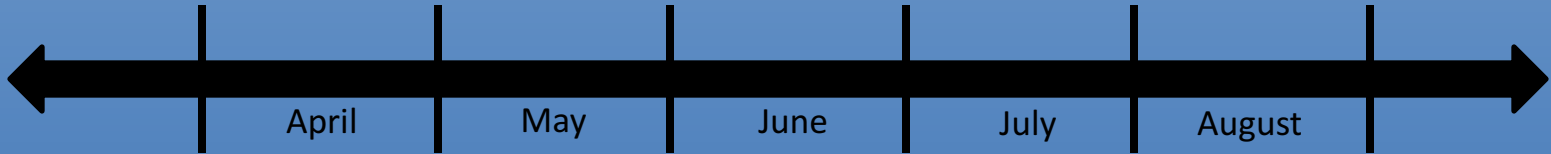
Timeline



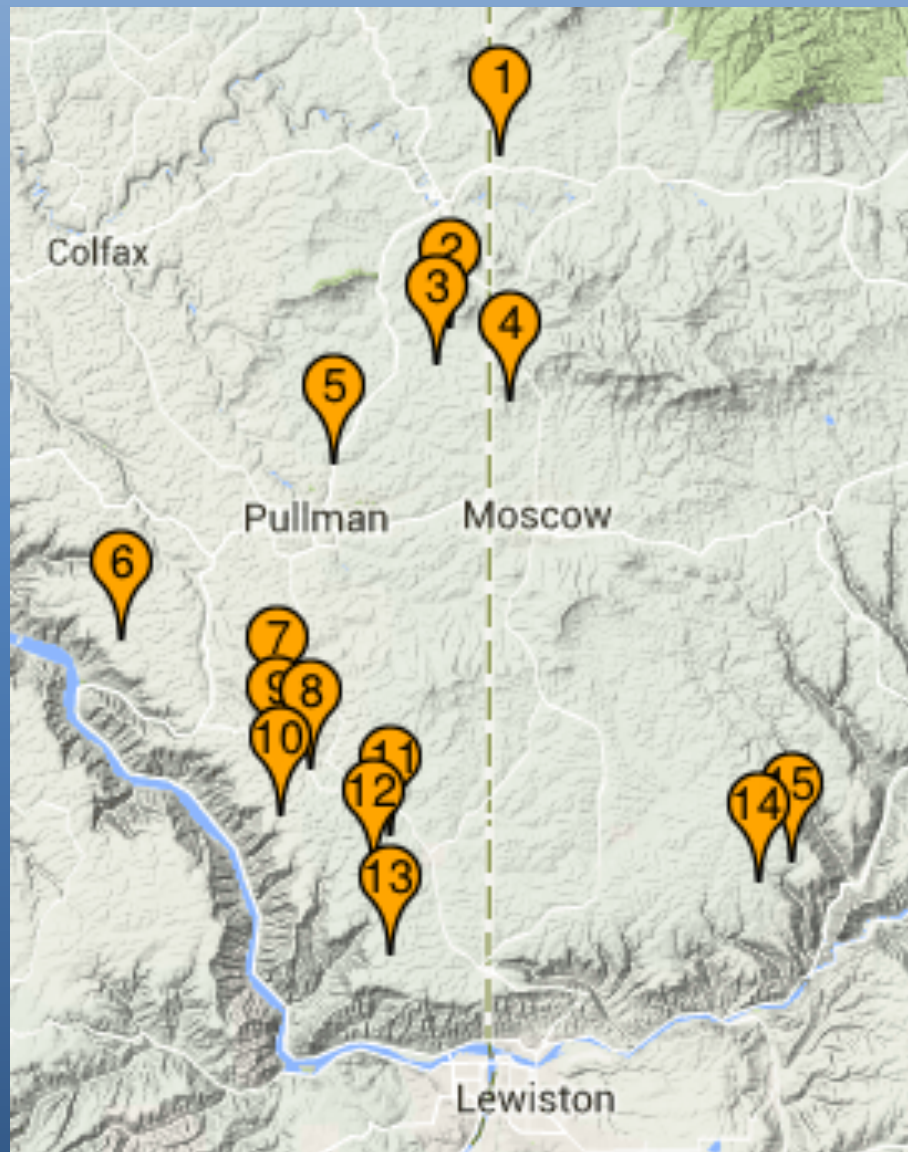
Timeline



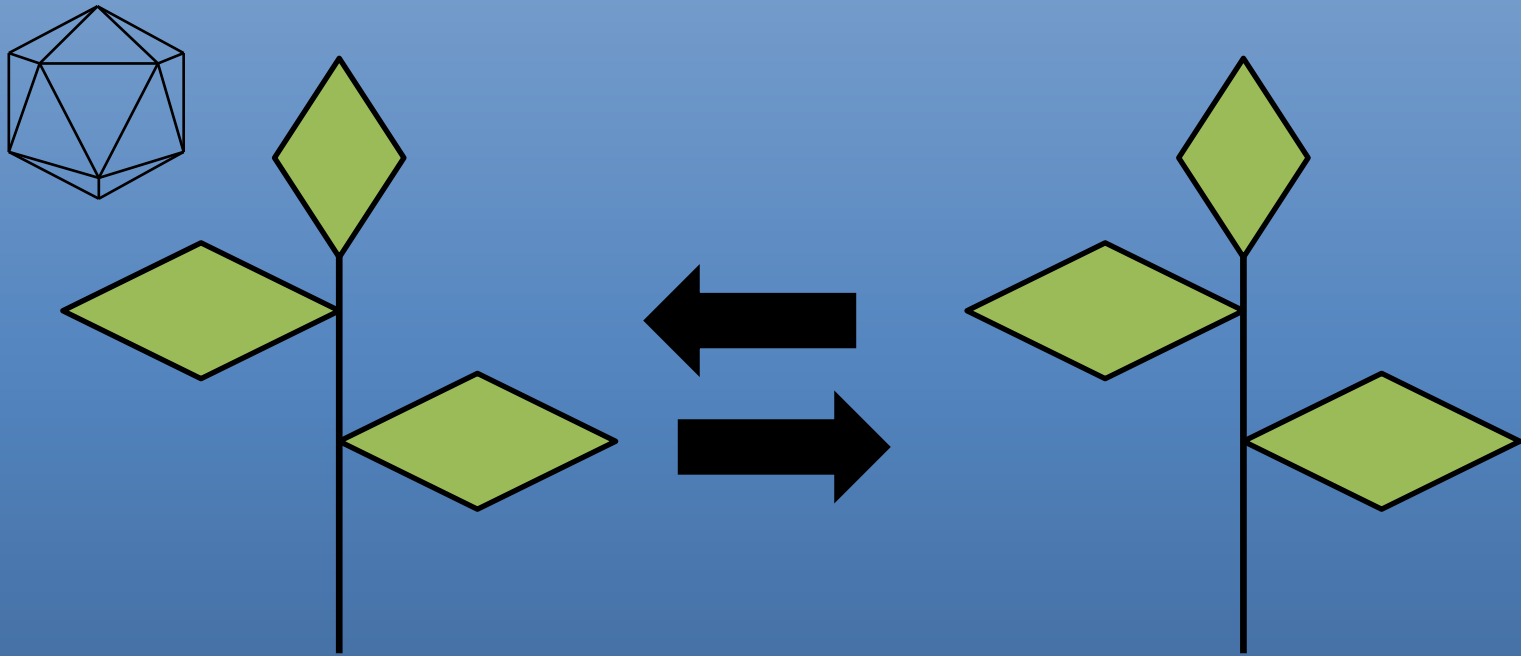
Timeline



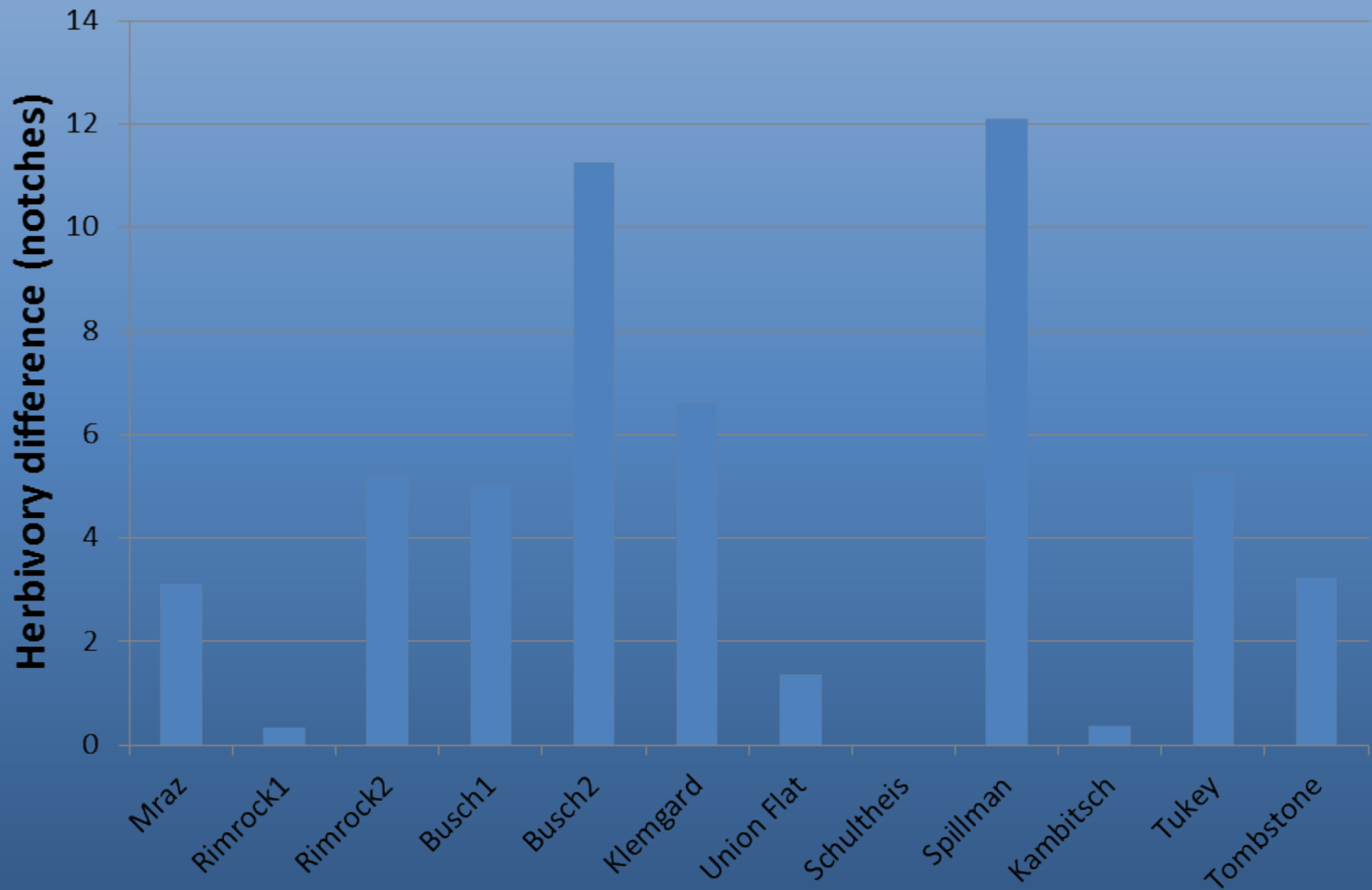
Unraveling the System



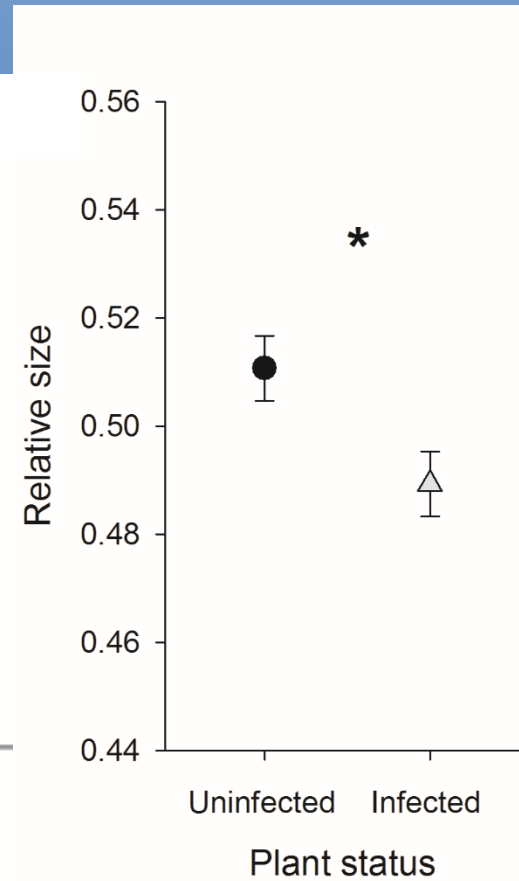
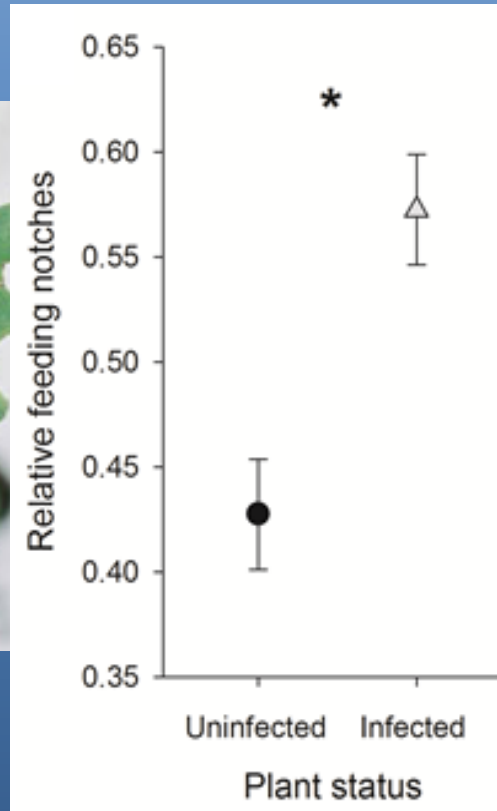
Do Communities differ on Infected Plants?



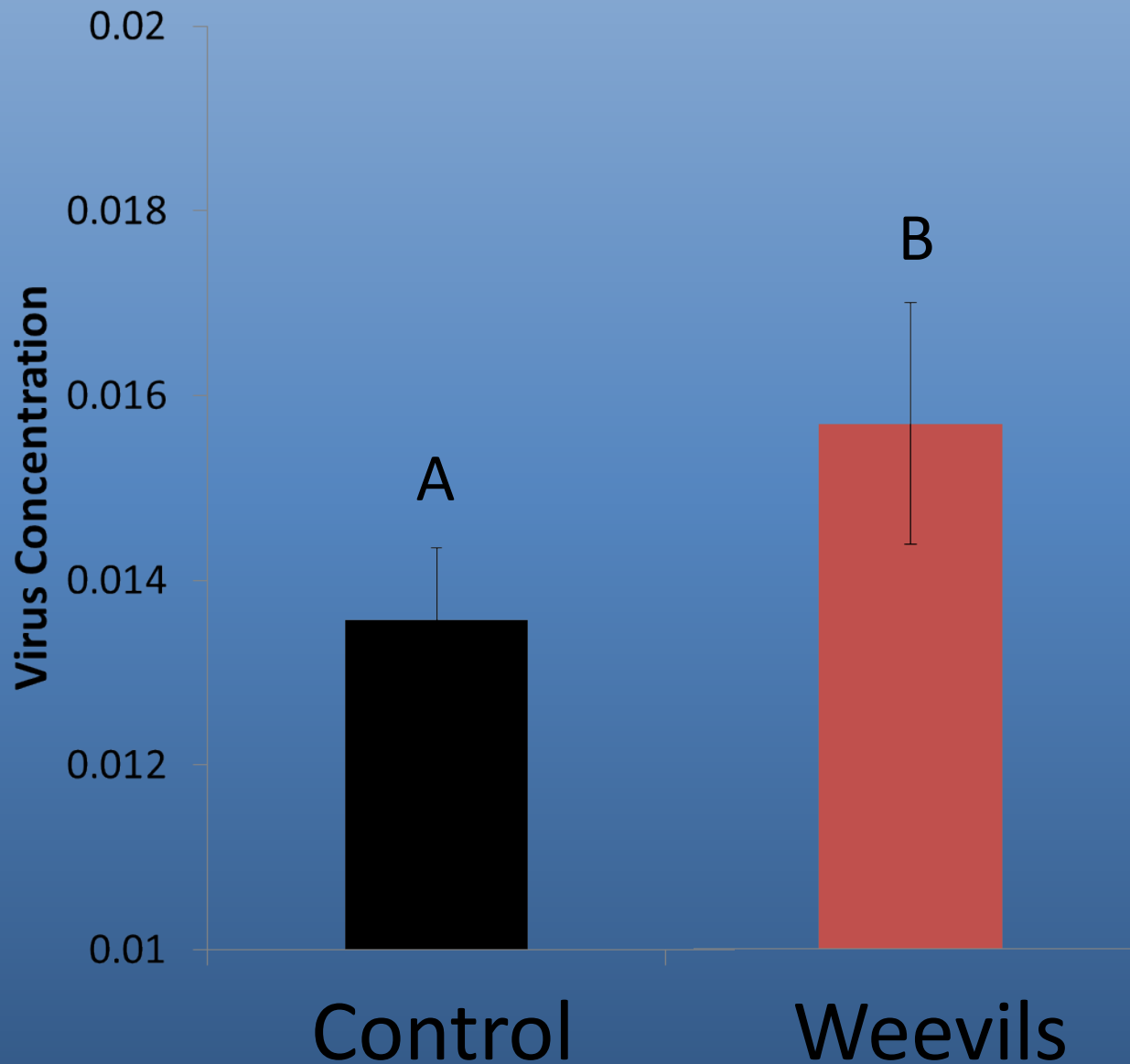
Weevils found on Infected Plants...



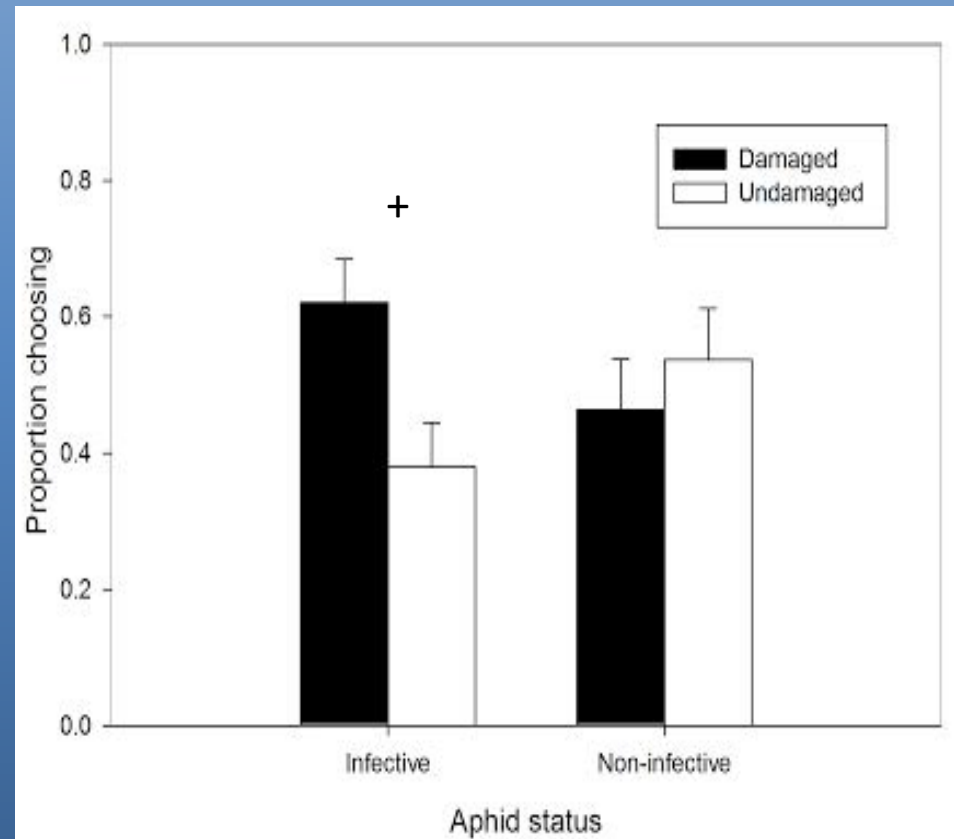
Infected plants receive more defoliation, despite being smaller



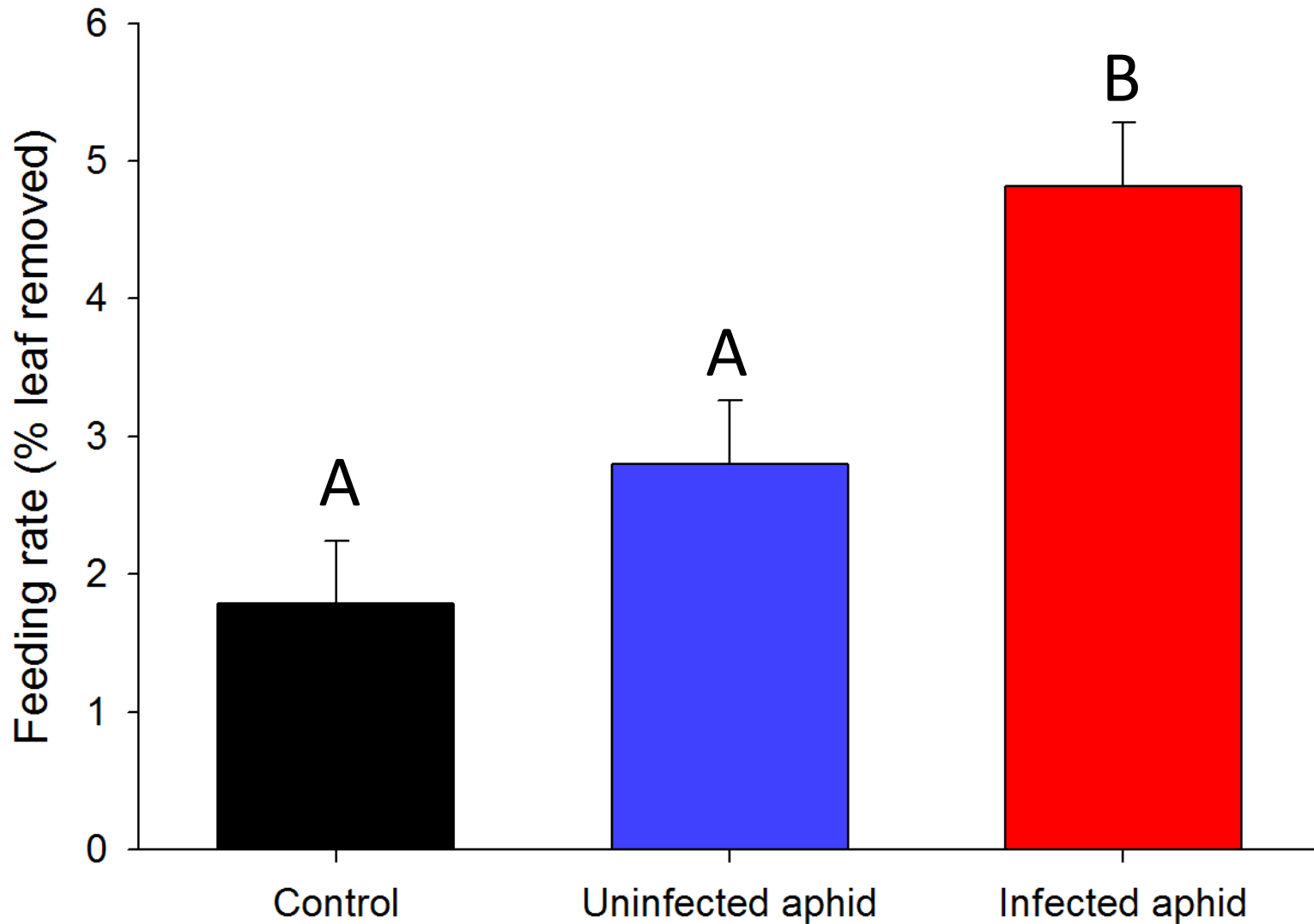
Weevil feeding increases PEMV



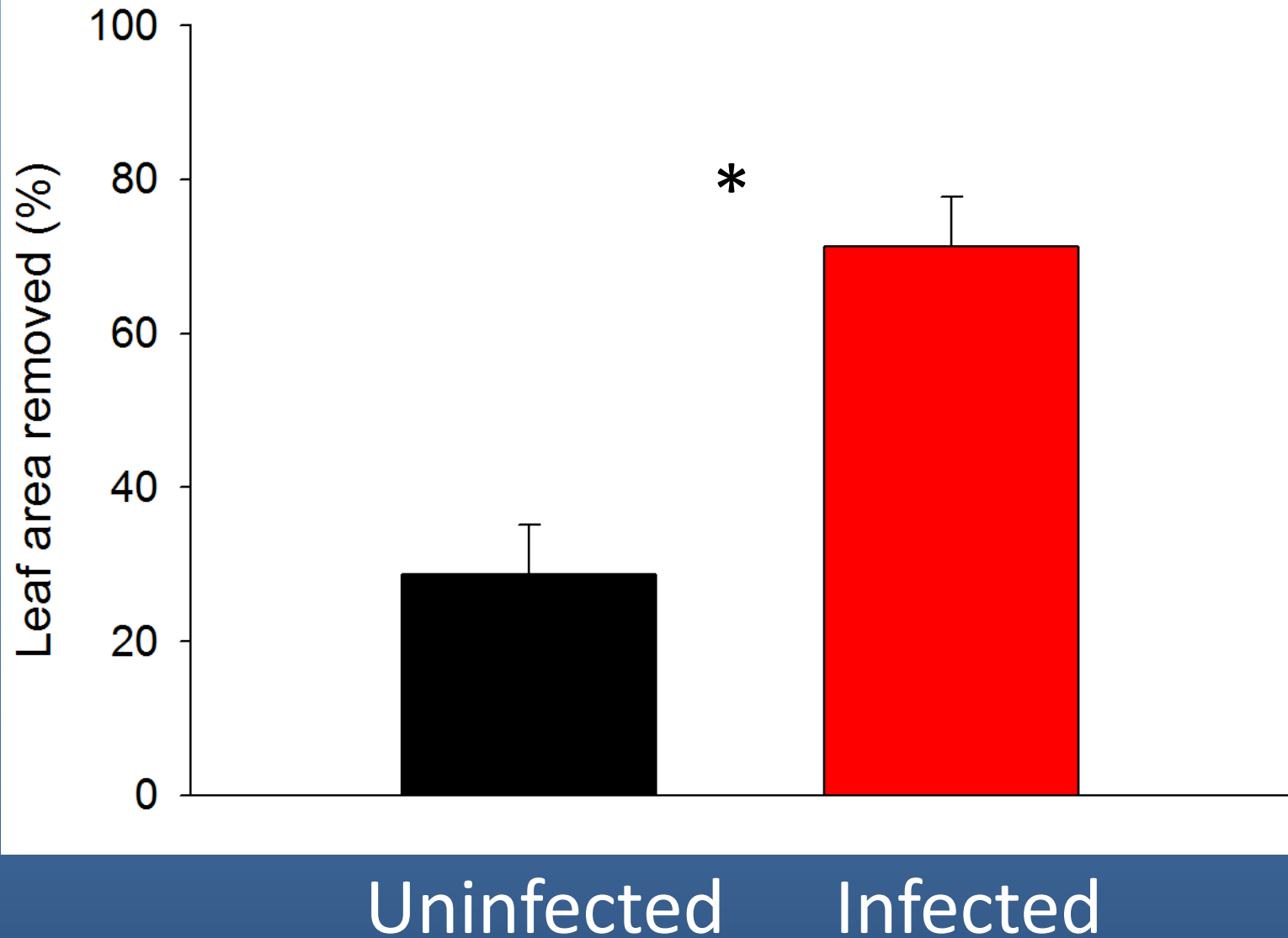
PEMV-infective aphids prefer weevil-damaged plants




PEMV Increases Weevil Feeding



Weevils prefer infected plants

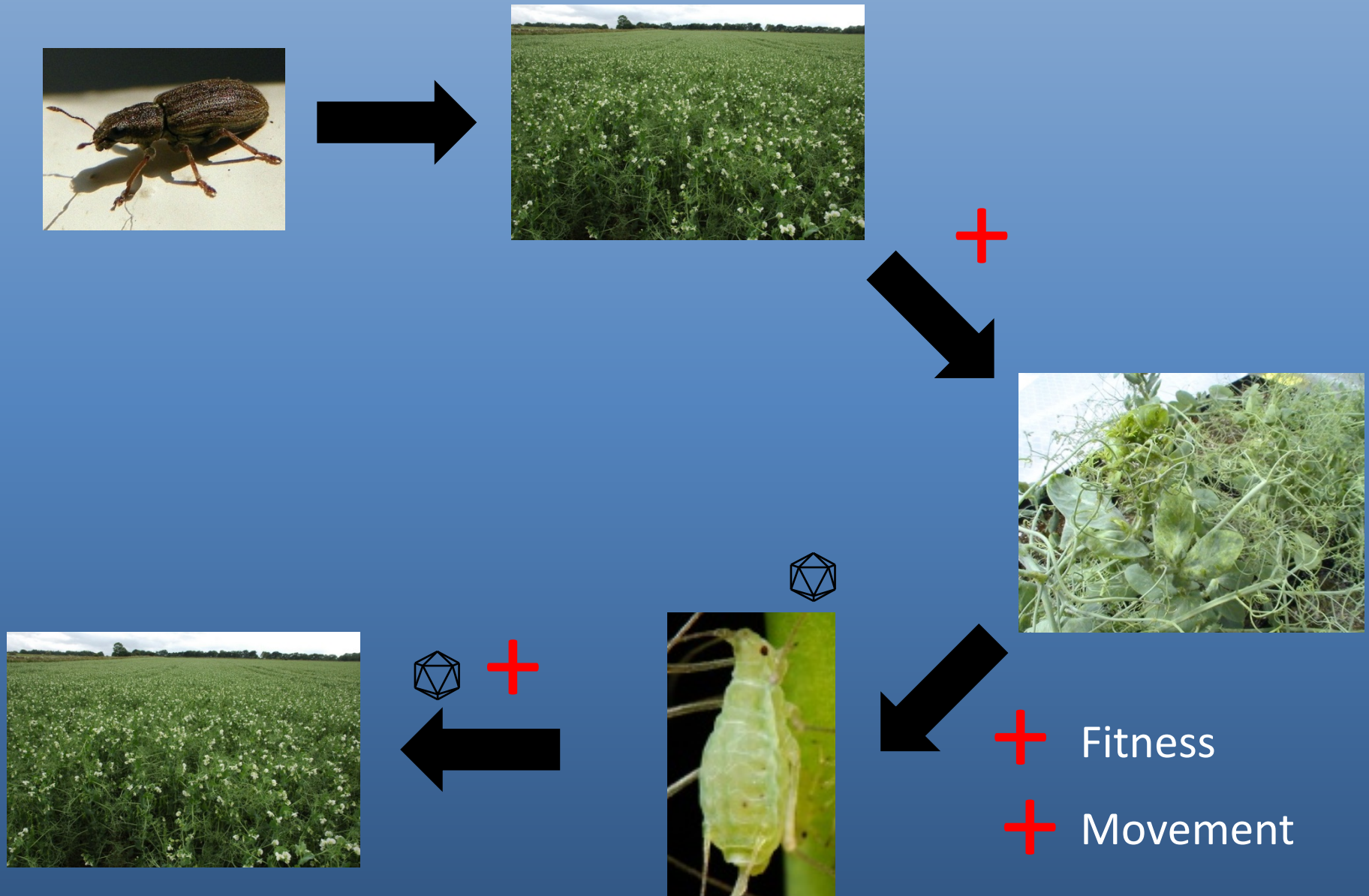




Virus attracts
weevils to plant

Weevils make plant
sicker

Complex Web of Interactions



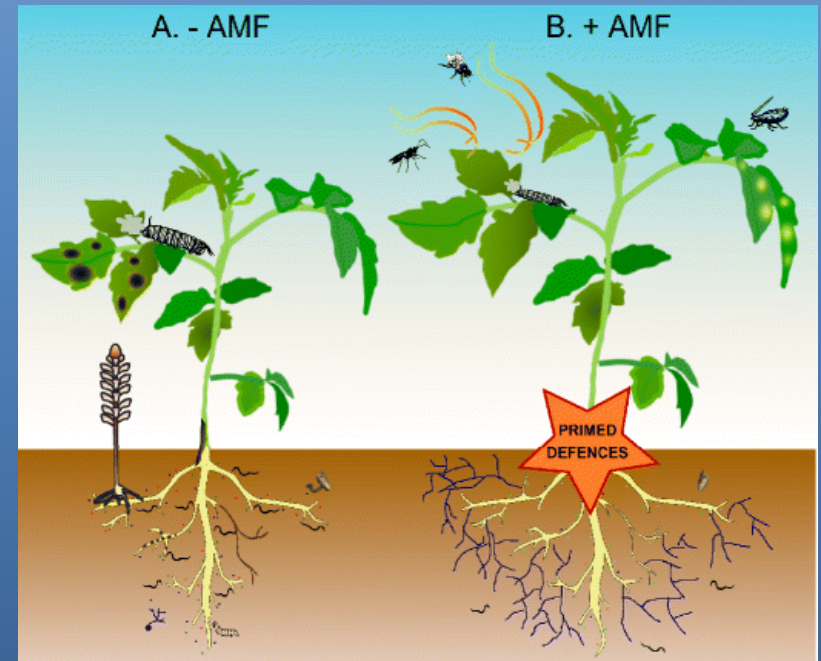
Shifting gears...what about soil?

How does soil health affect...

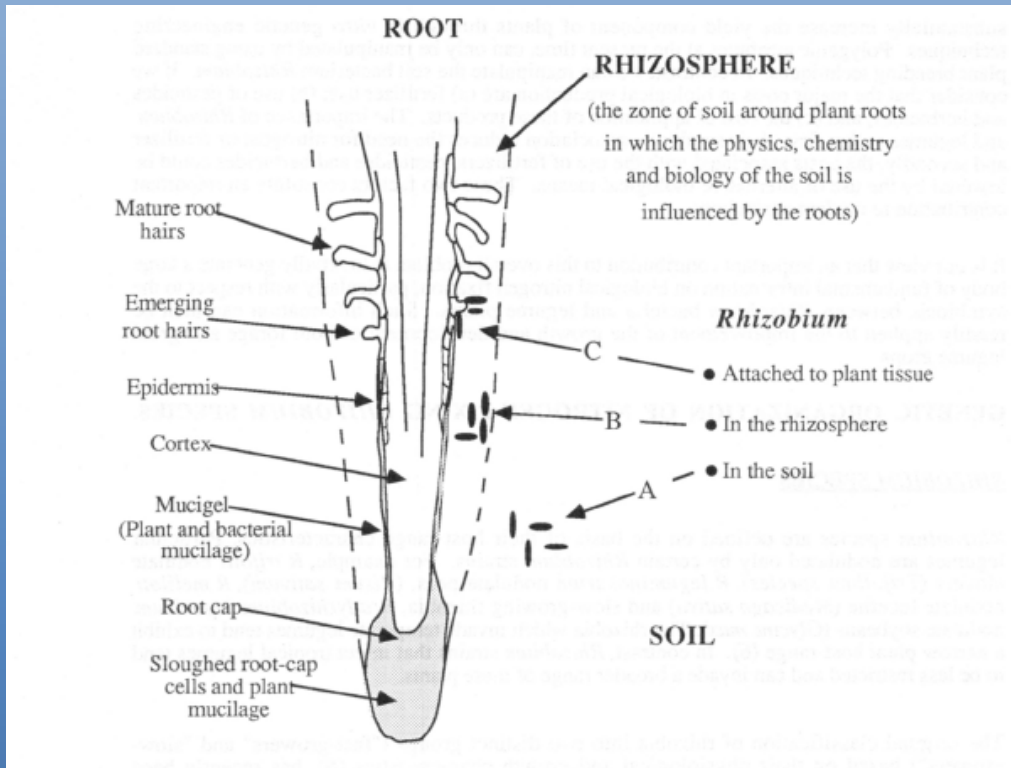
- 1) Pests?
- 2) Insect-transmitted disease?
- 3) Yield?

Soil communities impact plant health

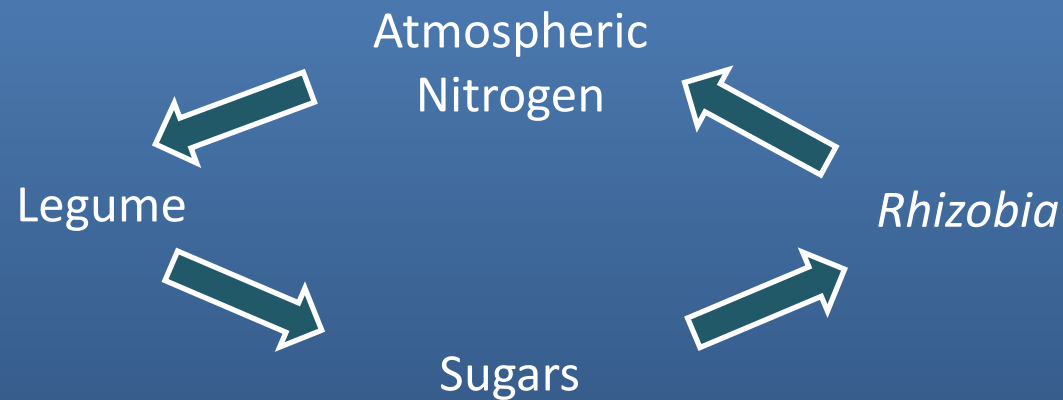
- Occupied niches prevent pathogen colonization
- Symbiotic relationships
- Entomopathogens
- Increased fertility



*Altieri & Nichols 2003, Phelan
et al. 1995, Jung et al. 2012,
Hoffmann et al. 2011*

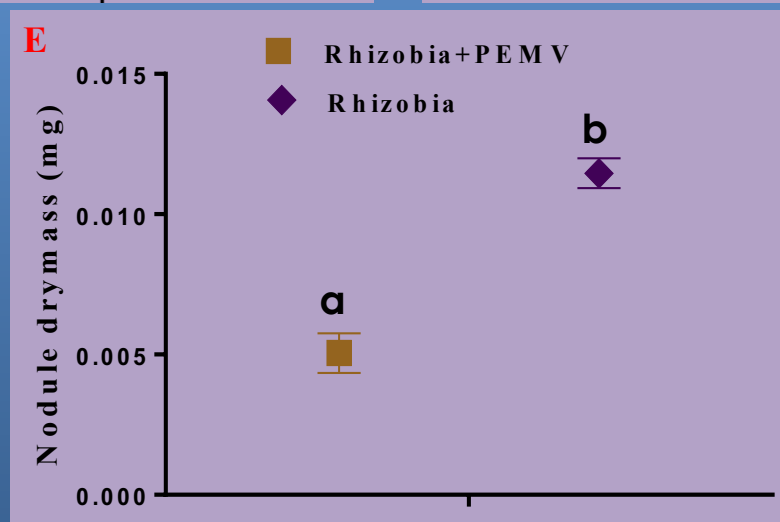
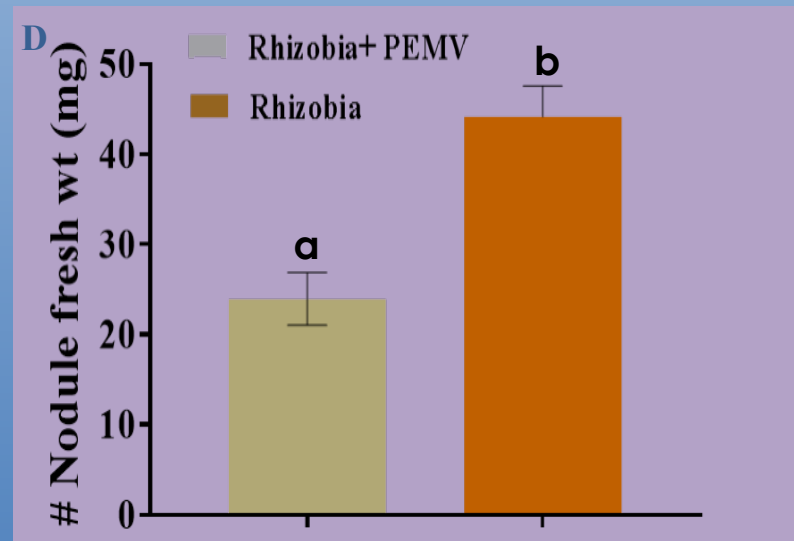
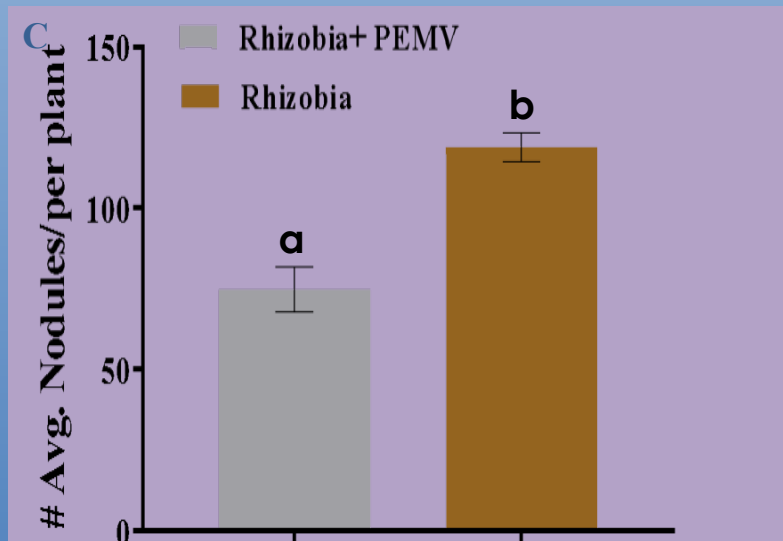


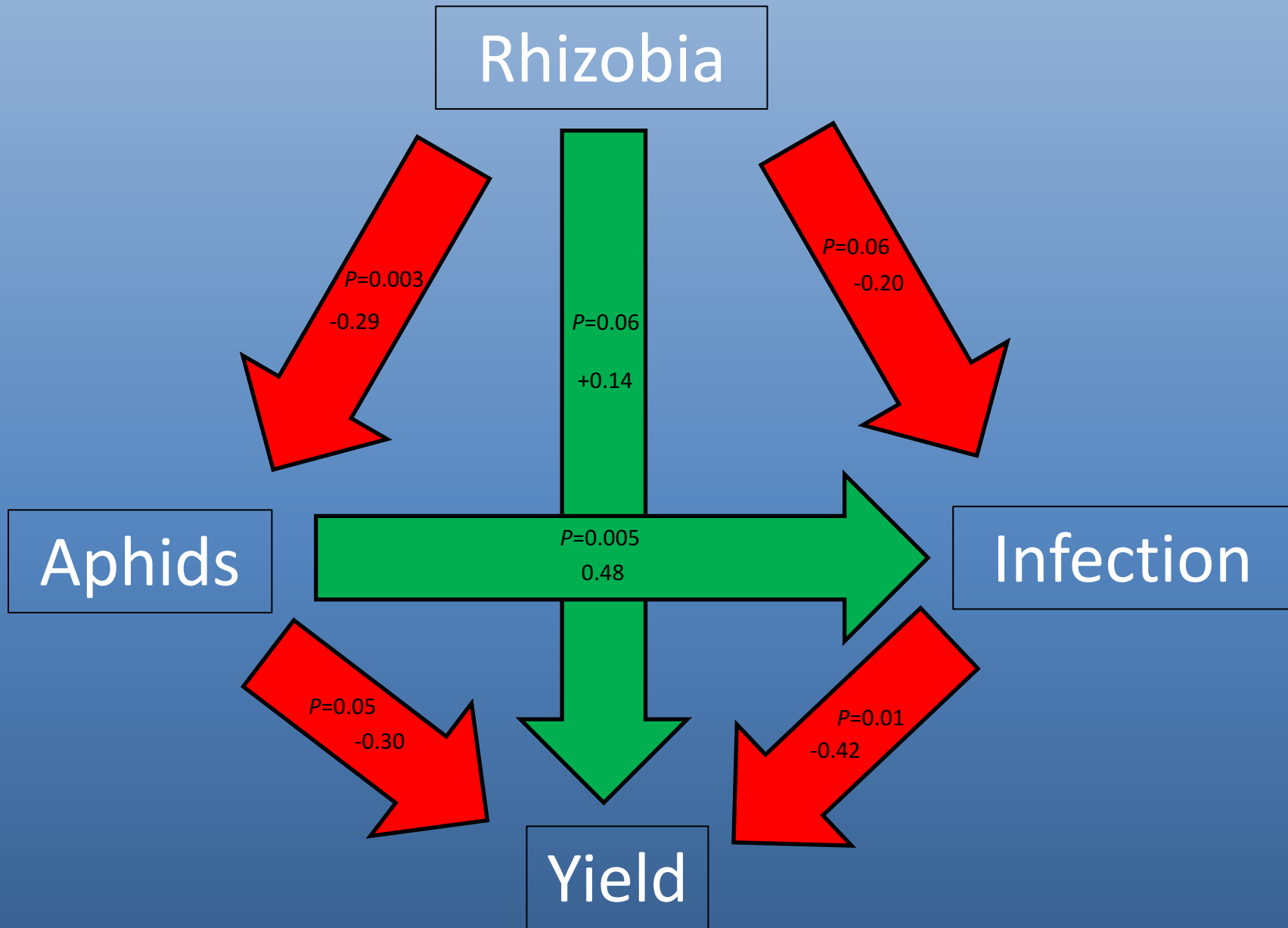
Harry Rose



Effect of PEMV infection on Nodule formation by Rhizobia in Peas







An aerial photograph of rolling green hills, likely in the Pacific Northwest, showing vibrant green fields and deep shadows. A small red barn and a church spire are visible in the distance. The word "Questions?" is overlaid in white text in the center of the image.

Questions?