

Does management of plant diversity enhance arthropod-mediated ecosystem services in agricultural landscapes?

ENTM 798K

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Agricultural
Resilience

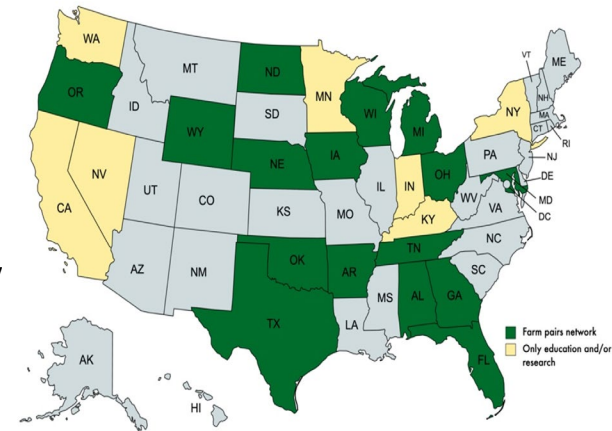


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Funding Source

Fostering Resilience and Ecosystem Services in Landscapes by Integrating Diverse Perennial Circular Systems (Resilience CAP)

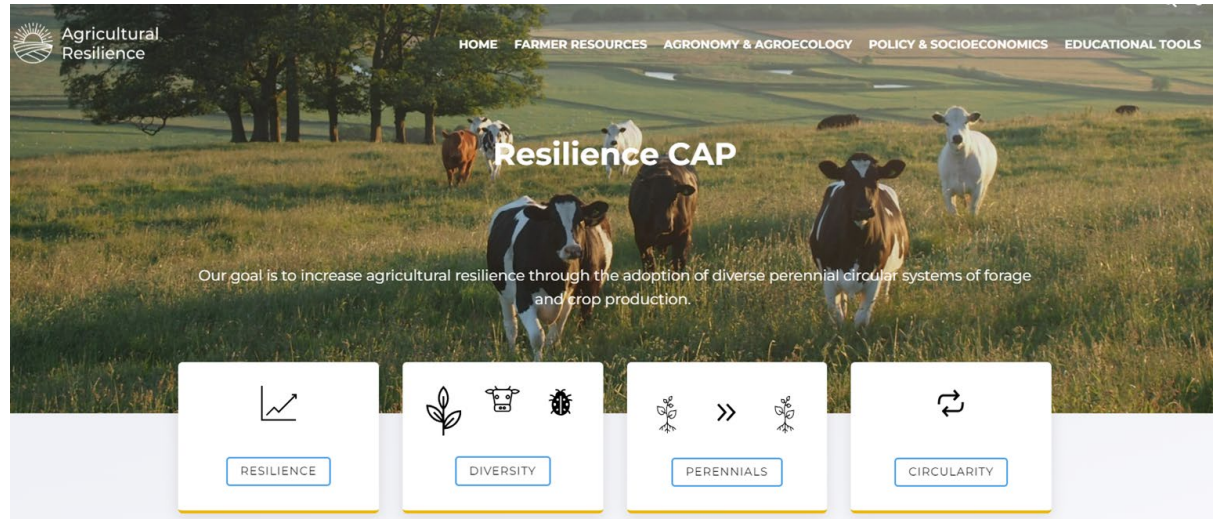
- **USDA-NIFA-Sustainable Agricultural Systems (SAS)
Coordinated Agricultural Projects (CAP)**
- **September 1, 2021– August 31, 2026**
- **\$10,000,000**
- **Transdisciplinary: plant, animal, soil sciences,
ecology, economics, sociology, public policy**



Resilience CAP

The Resilience CAP (RCAP) project is a nation-wide sustainability and forage grant looking at the application of **plant diversity**, **crop perenniality**, and **economic circularity** in agroecosystems.

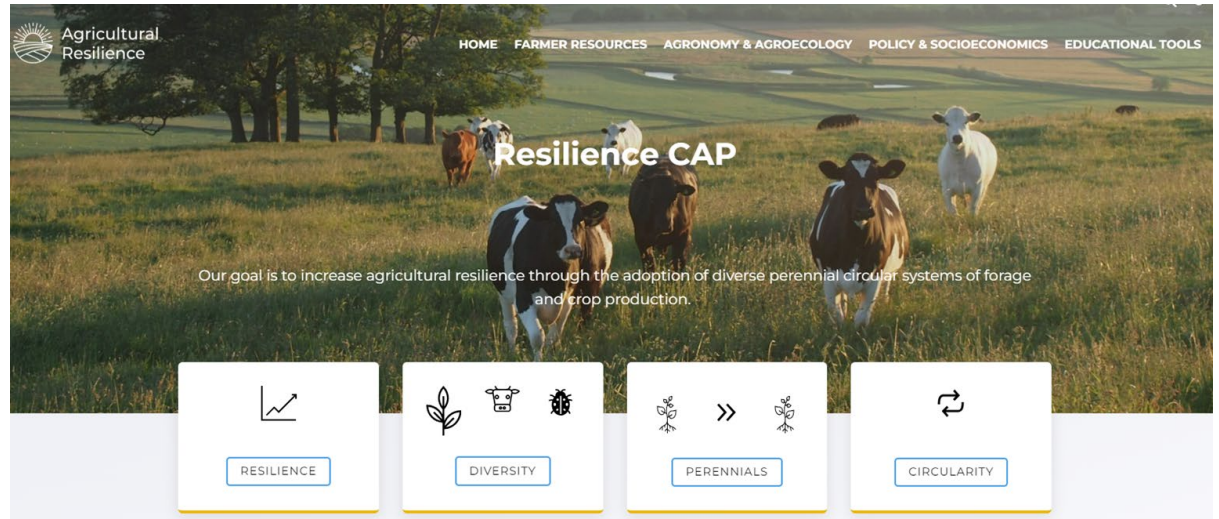
- New website



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Management of Plant Diversity

- Defined as multiple species of crops and other plants over time (crop rotations), space (intercropping or mixtures, growing more than one crop at the same time), or both.
- We broadly define plant diversity as including genetic diversity, crop plant diversity, and regional plant diversity.

***Examples of increasing
plant diversity***

Flower strip

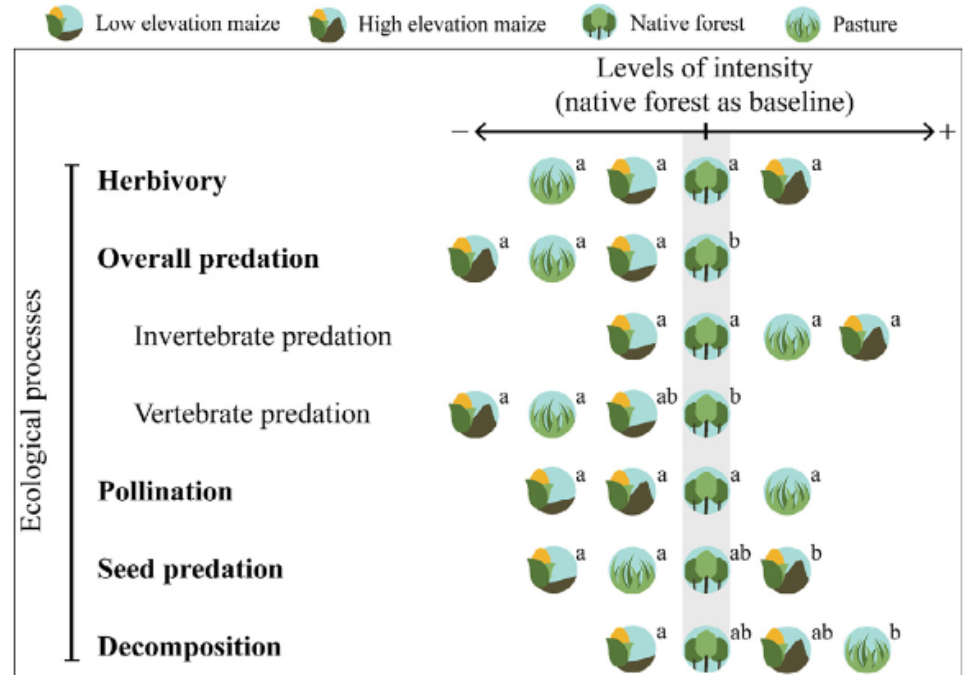


Intercropping



Ecosystem Services Provided by Arthropods

- **Biocontrol**
- **Pollination**
- **Nutrient Cycling**
 - **Decomposition**
 - **Bioturbation**
- **Disservices**
- ~~**Habitat Modification**~~



Ferrante et al. (2023)

Objectives

We hypothesize that farm management practices supporting plant diversity, as defined above, will enhance ecosystem services provided by arthropods.

Specifically, we examine the value of this effect in the context of four ecosystem services which may be measured using metrics that fall into one of three categories:

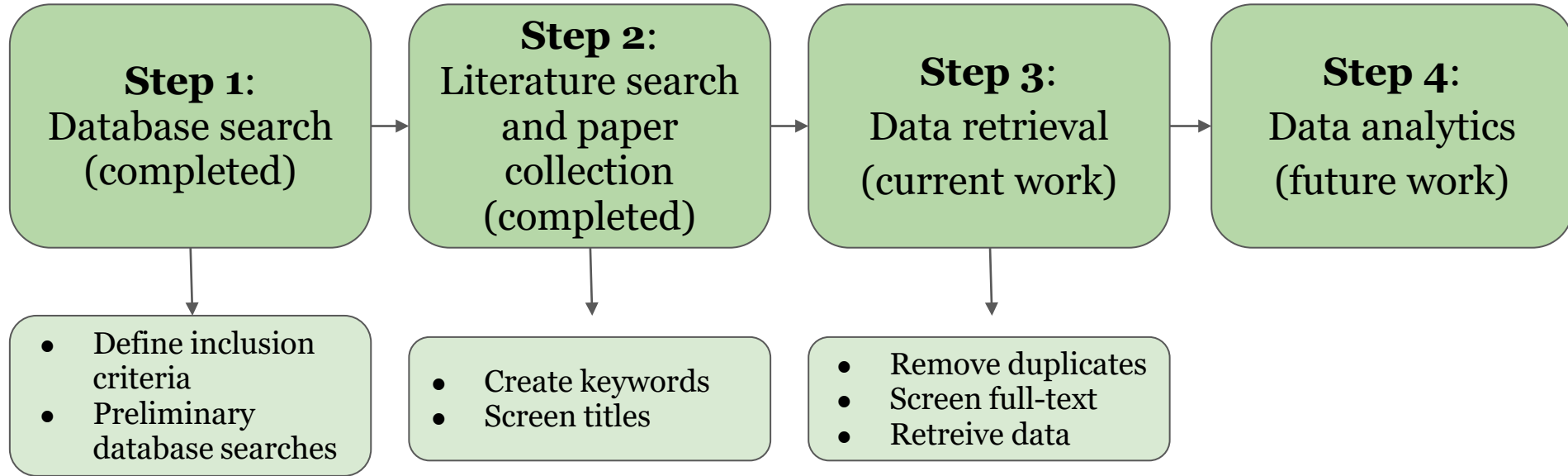
- (1) changes in the structure of the system**
- (2) changes in the processes & functions of the system**
- (3) changes in economic values associated with the system**



Measured value of plant diversity on arthropods

Value	Example
Structural	Insect abundance
Functional	Rate of ecosystem service provision
Economic	Crop yield

Approach



Approach cont.

Step 1: Database search (completed)

- Database: [ScienceDirect](#)
- Define inclusion criteria:
 - Research and review articles from the past 50 years
 - The title should indicate:
 - Structure, function, and/or economic value of a plant diversity management scheme.
 - Relationship between plant diversity and arthropods



Step 2: Literature search and paper collection (completed)

- Keywords in table to the right
- Screen titles
- Added screened titles to a shared Zotero folder



	Intercropping	Monoculture	time scale	spatial scale on farm	spatial scale in agroecosystem	
ES Keyword	Plant Diversity Keyword	Environmental Keyword(s)	Arthropod Keyword(s)	Science Direct with publication type, year (total number of titles retrieved)	Title screening (which titles pass the inclusion criteria)	
Biological Control	Plant diversity				128	50
	Intercropping				143	38
	diculture				5	5
	relay cropping				6	3
	living mulch				16	8
	polyculture				57	24
	plant genetic diversity				3	3
	Crop genetic diversity				5	3
	weeds	("agriculture" OR "agroecosystem" OR "farm" OR "farmscape" OR "agro-ecosystem" OR "crop")		("Insect" OR "arthropod" OR "Pollinator")	389	80
	cover crops				139	41
	crop rotation				166	15
	whole-farm landscape element diversity				0	0
	wildflower strip				30	14
	beetle banks				34	17
	wildflower banks				0	0
	farmscape heterogeneity OR farm heterogeneity				0	0
	semi natural habitat				153	39
landscape heterogeneity				68	17	

Example of data collection table for biocontrol outlining the keywords for search.

Approach cont.

Step 3: Data retrieval (current work)

- Filtered duplicates
- Secondary screening of inclusion criteria
- Scanning publications for data retrieval:
 - Ecosystem Service (BC=Biological control, P=pollination, D=decomposition, B=Bioturbation, H=habitat modification, DS=disservice)
 - Plant Diversity management scheme (I=Intercropping, M=monoculture, T=time scale, F= spatial scale on a farm, A= spatial scale in an agroecosystem)
 - Experimental settings (F=field, G=greenhouse, L=lab)
 - Value of plant diversity reported?
 - Measured value category of plant diversity scheme (S=structure, F=function, E=economic, O=other)
 - Discussion on the relationship between plant diversity and arthropods present?
 - Is the relationship between arthropods and plant diversity P=positive, N=negative, Or I=innocuous?



Step 4: Data analytics (future work)

Title Screening

- After search using keywords, title screening was used to narrow numbers of papers:

<u>Ecosystem Service</u>	<u>Literature search</u>	<u>Title screening</u>
Biocontrol	2590 papers	355 papers
Pollination	3818 papers	611 papers
Decomposition	934 papers	215 papers
Bioturbation	278 papers	187 papers
Disservices	252 papers	131 papers

Ecosystem Services - Biocontrol

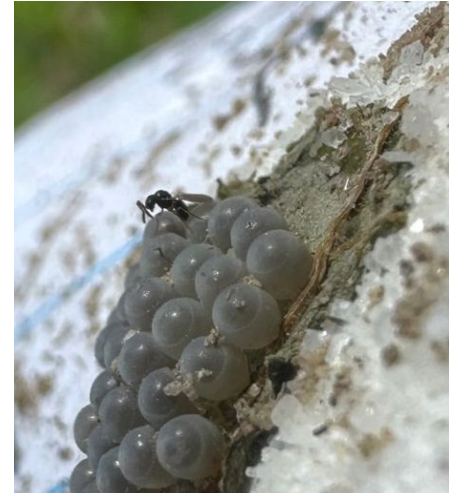
Definition: The use of natural enemies such as predators, parasites, parasitoids, and pathogens to regulate populations of pest organisms and minimize their impact on crops, ecosystems, or human activities



Leo M Kerner



Robert Salerno

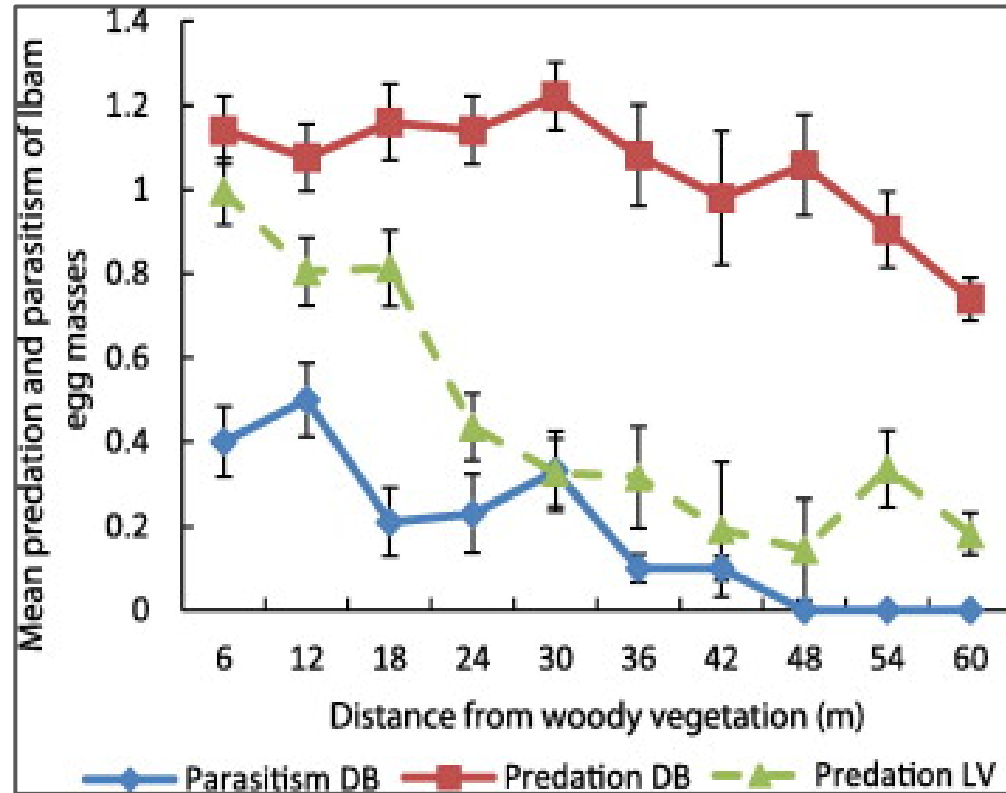


Examples of biocontrol agents

Ecosystem Services - Biocontrol

Example: Plant Diversity Within Farm

Fig. 1 Thomson and Hoffman 2013– (Mean parasitism and predation (DB + LV are study sites))



Ecosystem Services - Pollination

Definition: The transfer of pollen enabling plant fertilization and seed/fruit production



Helen Craig



Angela Saenz



Abuzar Bhatti



Katy C. Evans



Specialist pollinator *Peponapis pruinosa*, squash bee, in a pumpkin flower (PA); K C Evans



Generalist pollinator *Bombus impatiens* in a blueberry flower (PA); K C Evans

Ecosystem Services - Pollination

Example: Plant Diversity Within Farm

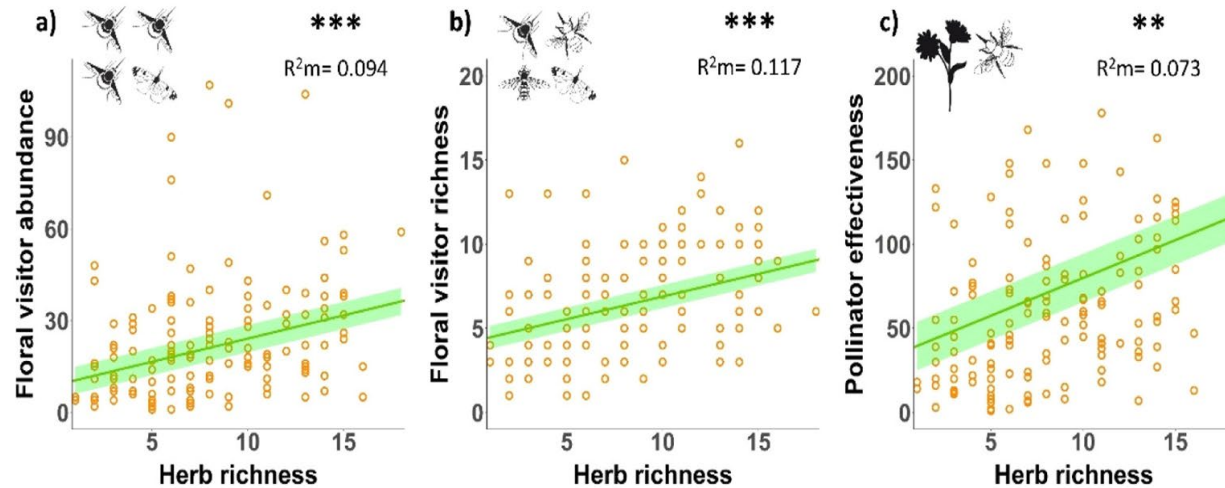


Fig. 1 Cano et al. 2022—Relationship between (a) floral visitor abundance, (b) floral visitor diversity, (c) pollinator effectiveness and herb richness per multi-floral sampling stands

Ecosystem Services - Nutrient Cycling

Definition: Movement and breakdown of organic matter and nutrients into bioavailable forms



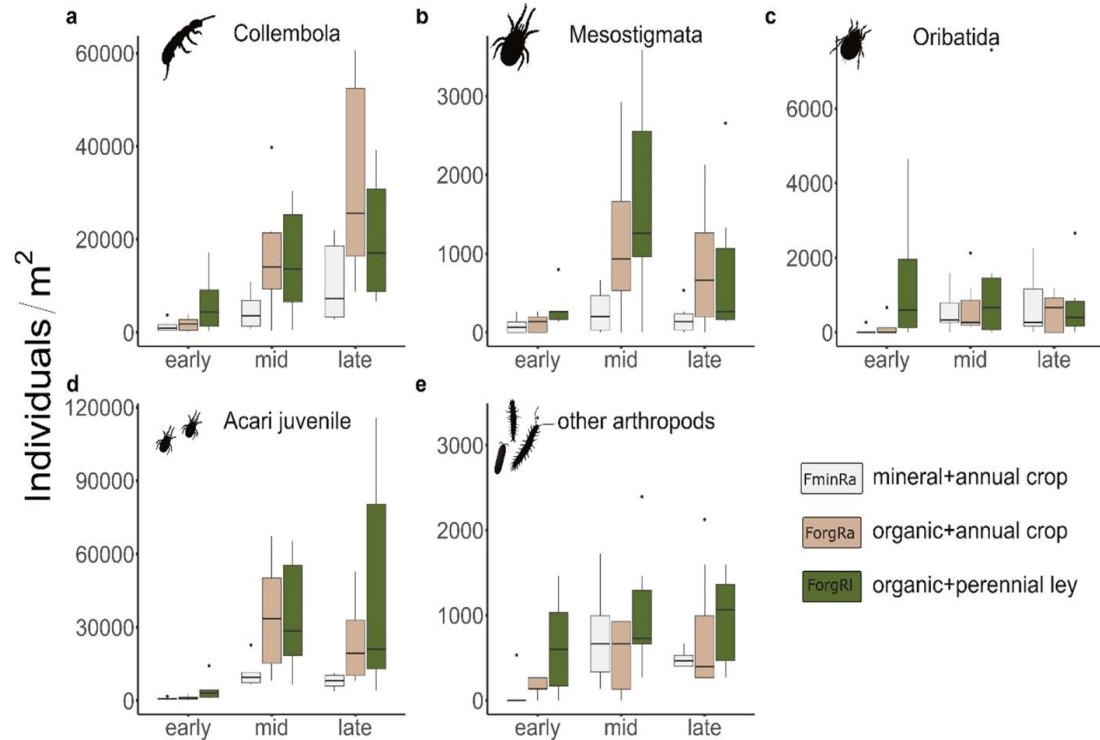
- Originally divided into decomposition and bioturbation
- Relatively few papers found
- High overlap between topics



Ecosystem Services - Nutrient Cycling

Example: Plant Diversity Within Field over Time

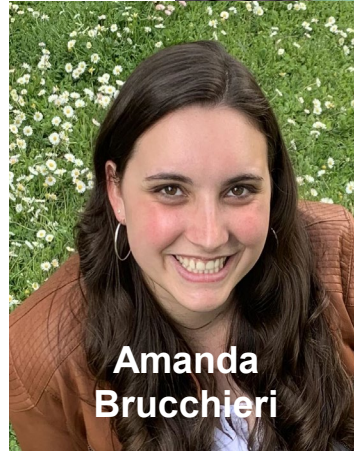
Heinen et al. 2023 – Legacy of
perennial crop rotation
resulted in the highest
abundances in most soil
mesofauna groups



Ecosystem Services - Disservices

Definition: Functions, processes and attributes of arthropods that result in perceived or actual negative effects to humans

Issue: Locating and determining the value of papers that focus on disservices as *separate* from aforementioned services.



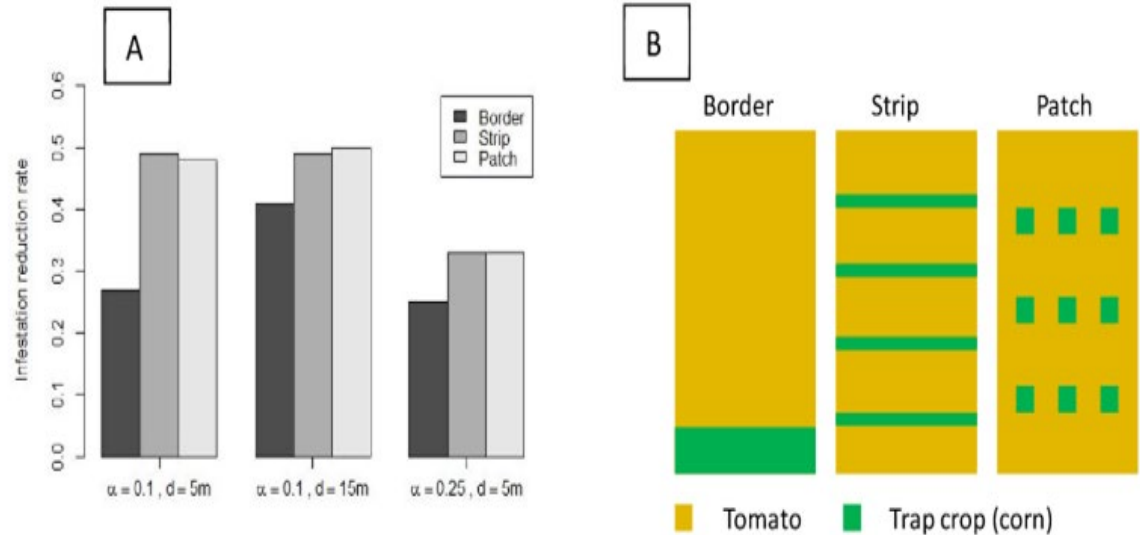
Amanda
Brucchieri



Tomato Fruitworm

Ecosystem Services - Disservices

Example: Plant diversity within crop



(A) Simulated rates of reduced infestation by tomato fruitworm according to trap-crop planting design (as shown in B), relative attractiveness of the commercial vs. trap-crop and insect perception distance. Ratnadass, et al. (2021)

Conclusions to Date



- We spent extensive time to define terms and objectives
- The protocol was difficult to standardize across ecosystem services
- Once the protocol was established, it was easy to follow
- Current results:
 - Effect of plant diversity management on arthropod ecosystem services:
 - 63% positive
 - 11% innocuous
 - 26% need greater attention to results
- We are currently completing data retrieval from literature, to be followed by analysis



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Questions?



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