RESILIENCE CAP Grant:
Research/Education/Extension at the University of Maryland

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

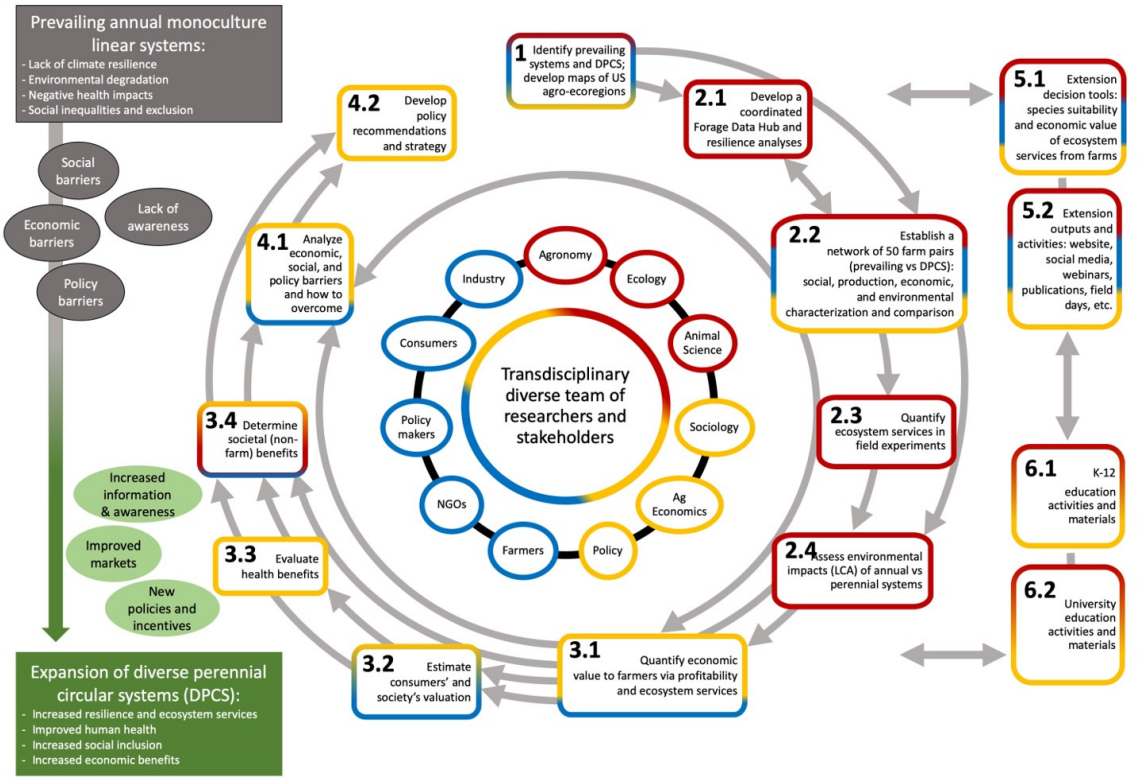
This 5-year project is supported by AFRI Sustainable Agricultural Systems Coordinated Agricultural Program (SAS-CAP) grant no. 2021-68012-35917 from USDA NIFA, led by Dr. Valentin Picasso, University of Wisconsin.

Abstract. Food production is dominated by annual crops which are associated with several environmental and socioeconomic problems. Transforming agricultural landscapes towards more diverse systems with perennial forages can solve most of those problems. However serious policy, economic, and social barriers impede this transformation. Our vision is to transform the current agricultural landscape through a process of engaging a diverse network of stakeholders and researchers to promote the adoption of diverse perennial circular forage systems.

Our transdisciplinary team will foster climate resilience, ecosystem services, profitability, social inclusion, and human health by identifying appropriate examples of diverse perennial forage systems for major US agro-ecoregions, quantifying their environmental and socioeconomic benefits, and incentivizing and promoting them via extension, education, and policy recommendations. We will quantify resilience to climate change by compiling and analyzing historic data in a forage data hub. We will measure soil and biodiversity ecosystem services from field experiments and farms. We will assess environmental impacts and benefits using a life cycle assessment. We will evaluate human health impacts, economic and social value of expanding diverse perennial forage systems. A national network of 50 pairs of farmers across the US will be established for research and extension activities including underrepresented groups. We will analyze economic conditions, social structures, and public policies that prevent wider adoption of these systems and develop policy recommendations to overcome these constraints. We will develop on-line decision tools and maps, communicate results to farmers, consumers, lenders, and policy makers, and develop and deliver coordinated educational materials to K-12 and university students.

Objectives and approach. Increasing crop diversity, perennial cover, and integration of crops, forages, and livestock in circular agricultural systems has the potential to increase resilience to climate change, provide ecosystem services, and improve human health, while fostering social and economic inclusion throughout the food system. Despite scientific evidence of the long-term

benefits of crop diversity and perenniality substantial policy, economic, and social barriers to adoption remain.



Proposed transformation from prevailing systems (top left) to diverse perennial circular systems (DPCS, bottom left) by engaging a team of natural (red) and social (orange) scientists with diverse stakeholders (blue) on six interconnected integrated objectives and activities.

Farm subsidies, credit, and insurance programs encourage high-input, low-diversity annual cropping systems. The linear economy results in negative externalities, market failures, and missing markets. Other social barriers to adoption include farm labor structure; scale of production; access to information; and farmer and consumer values and attitudes. Our transdisciplinary team proposes to foster climate resilience, ecosystem services, profitability, social inclusion, and human health by identifying, assessing, promoting, and incentivizing **diverse perennial circular systems (DPCS)** across agroecoregions in the US. These DPCS increase diversity and perennial cover, produce forage for livestock, recycle nutrients. Examples are: crop rotations that integrate perennial forages, living mulches and intercropping, service crop mixtures, or grass-legume pastures.

Our objectives are:

Objective 1. Identify and characterize prevailing and diverse perennial circular systems in major US agro-ecoregions. We will define agro-ecoregions across the US, and will identify and characterize systems and farmers associated with each system in major regions.

Objective 2. Assess and compare the resilience and ecosystem services of dominant and diverse perennial circular systems. Existing data on crop yields from perennial forages

variety trials and long-term grazing systems from across the US will be compiled in a *Forage Data Hub* and analyzed to determine resilience and stability (Obj. 2.1). Crop yields, soil samples, inputs, and information on production practices will be collected and analyzed for soil health and economic viability using a nationwide network of farms (Obj. 2.2). New data will be collected from long-term experiments that compare annual crops and diverse perennial systems for soil health and insect biodiversity (Obj. 2.3). Through soil modelling and life cycle assessment C, N, P cycles and erosion, including nutrient loading to water sources, will be examined for a selected subset of cropping systems, both annual and perennial. (Obj. 2.4).

Objective 3: Assess and analyze the direct and indirect economic, health, and social implications of increased adoption of diverse perennial circular systems. Building on the situational analyses in Obj. 1 and the agronomic and ecological analyses in Obj. 2, the research activities in Obj. 3 will focus on **assessing the value** of diverse perennial circular systems to society. Drawing from multiple social science disciplines, we will analyze the on-farm economic value of diverse perennial systems, society's valuation of products generated from them, and the un-priced health and social benefits they provide. These individual efforts will contribute to an iterative collaborative process that evaluates a comprehensive set of societal (non-farm) benefits provided by diverse perennial systems. This work, in turn, will inform the activities in Obj. 4 focused on the policy environment affecting the adoption of diverse perennial systems.

Objective 4: Analyze the economic conditions, social structures, and public policies that prevent wider adoption of diverse perennial circular systems and develop strategies to overcome these constraints. A guiding hypothesis of this project is that there are societal constraints preventing producers from more fully adopting diverse perennial systems. Building upon the analyses in Obj. 1.3 and 3 we will explore different impediments to wider adoption. We will explicitly assess economic constraints (supply chain issues, missing markets, market failures, etc.), social structures (producer demographics, rural support networks, etc.) and public policies (crop insurance, agricultural lending, farm bill programs, etc.) that we expect to affect producers' adoption decisions. This work will culminate in policy recommendations and a strategy for stakeholder engagement that will synergize with the activities in Obj. 5 and 6.

Objective 5. Develop extension media, activities, and actionable decision tools to communicate concepts about the benefits of diverse perennial circular systems to farmers, consumers, lenders, and policy makers. Our overall Extension learning objective is to educate the public, including farmers, consumers, lenders and policy makers, in a way that raises awareness across audiences about the benefits of diverse perennial systems. At the national level, efforts will center on consumers, lenders and policy makers. On regional and state levels, we will provide learning materials and tools to assist local Extension Services in encouraging adoption of farming practices that are appropriate for the location.

Objective 6. Develop and incorporate instructional content for K-12, undergraduate, and graduate courses on design and assessment of diverse perennial circular systems, resilience, ecosystem services, and economic value. Our vision of diverse perennial systems will form the framework of our educational programs, working in tandem with our research. Our programs will shape the training of the next generations of agricultural scientists, and to prepare them to lead in the face of climate and social change. In addition, our

project is deeply seated in a common land grant mission: "To advance innovative, profitable, and sustainable agricultural production systems." Our milestones will be reviewed annually, supervised by the Universities of Maryland, Wyoming, and Cornell. Participants' learning will be assessed via surveys and interviews. Additionally, we will track the accomplishments of students/teachers in our program. Outcomes from work with teachers will be shared throughout the project and project accomplishments (e.g., photos and videos) will be posted to the project website.

Overview of Maryland activities. The Lamp Lab will be coordinating the education efforts for the grant (Objective 6), and Bill is part of the coordinating committee. Educational efforts are broadly directed to K-12 education, as well as to undergraduate and graduate students. Research efforts will include coordination of sampling of beneficial arthropods in paired farms across the country (see details in next paragraph). We have a collaborator at the University of Maryland, Dr. Amanda Grev, who will be doing extension work as part of the grant. She is an Extension Specialist, Forage and Pasture, in the AGNR Department of Extension and based at Western Maryland Research and Education Center.

We hypothesize that DPCS agriculture leads to increased levels of beneficial biodiversity, such as pollinators and natural enemies, on farms. Using experimental sites described under Objective 2, we will quantify and compare the composition and functional diversity (including consumers, predators and parasites, pollinators, and decomposers) of foliar arthropods on the pairs of DPCS and conventional farm sites. We will collect sweep net and sticky card samples from four locations within the major crop on both farms in a pair (e.g., corn, wheat, soybeans). On three dates during the growing season, samples will be collected following standard crop monitoring procedures. Sticky traps will be deployed over one week at a time, while the number of sweeps per sample will be determined with the goal of collecting a minimum of 200 insects in the four sweep samples. This goal provides a robust estimate of the assemblage of macroinvertebrates within a crop and date. In addition, to estimate contributions of biodiversity by perennial crops, fields on these farms will be sampled three times during the growing season as described above. All samples will be preprocessed in the lab for general characterization and to provide an educational experience for interns. The subsequent processing of the samples at the University of Maryland Department of Entomology will focus on both taxonomic unit (family level) and functional unit (e.g., pollinator, natural enemy, herbivore). University of Maryland will provide insect collecting equipment, instructions for collection and mailing, mailing costs, and post-sampling processing.

University of Maryland Press Release:
https://agnr.umd.edu/news/entomology-and-extension-faculty-join-national-team-study-and-support-diverse-perennial-forage

FAQs:

1. What is meant by a circular system and why should I care?

In simple terms a circular economy is an economic system that recycles nutrients instead of wasting and accumulating pollution. A farming system which applies excessive Nitrogen fertilizer into annual crops, and then loses much of that Nitrogen due to erosion and leaching to the water, is not a circular system. It loses nutrients and money. Farming systems that use

legumes to fix Nitrogen, and/or livestock to graze or harvest forages and recycle manure into the soil, are examples of circular systems, which recycle nutrients and save money.

2. What kinds of perennial crops (or cover) are included in your vision to diversify crops on my farm? I use cover crops in the winter; does that count?

Diverse, perennial, circular systems (DPCS) are defined relative to the dominant system in each agroecoregion. Greater diversity means more crop species. Greater perenniality means more time or area in perennial forages. Greater circularity means adding legumes to fix nitrogen or integrating livestock. We are considering DPCS to have at least two of the three dimensions: may have greater diversity, or/and greater perenniality, or/and greater circularity. For instance, if the dominant system is a wheat monoculture, a DPCS may be a crop rotation including wheat and alfalfa, which increases diversity, perenniality, and circularity. If the dominant system is a perennial grass pasture, a DPCS may be a mixed pasture with grasses and legumes, which increases diversity and circularity, with the same perenniality. If the system is annual grasses for livestock, DPCS may be perennial grass-legume mixtures, which increases diversity, perenniality, and circularity. "Just" adding a rye cover crop in a corn-soybean system, for instance, only increases diversity, but not perenniality or circularity. If those cover crops are grazed, or fix nitrogen, they add circularity in addition to diversity, and we can consider them DPCS.

3. Are you talking about diversity within crops, like growing legumes and grasses together?

We are interested in adding diversity of crops in the farming system; it does not necessarily have to be in the same field. It can be diversity in space, like crop rotations. But intercropping, or forage mixtures, are excellent examples of DPCS.

4. Are you talking about adding a perennial crop to my rotation?

We are interested in increasing perenniality, via adding perennial forages in the rotation. However, as described above, adding diversity and circularity without adding perennial species is also a possibility. And adding diversity to already perennial systems is also another possibility.

5. What is meant by resilience, and why should I care? How will it affect me on my farm?

Resilience is the ability of a crop or a farming system to withstand a climatic crisis like a drought of flood, and remain productive. Diverse crop rotations have greater resilience because they can distribute risk among different crops, e.g., if a drought affects the corn, there are other crops that are more tolerant and remain productive. Perennial forages have root systems that allow them to tolerate drought better than annual crops. Diverse, perennial systems also build soil organic matter and soil health, providing for better water infiltration which reduces flooding. Resilient systems produce more in a bad year.

6. I don't believe in "climate change" but I do see greater extremes in the weather. How will DPCS help me?

We can agree that weather extremes are becoming more frequent. And droughts are being followed by floods, and heat waves followed by cold spells. Adding diversity and perennials to your farm will allow you to spread the risk in multiple crops, improve the soil structure and health, and be better prepared for those extreme events, as explained earlier. Increasing production in the more frequent bad years will benefit both farmers and consumers in the long-term.

7. What are ecosystem services, and why should I care?

Ecosystem services are the benefits that people obtain from ecosystems, regardless of their economic market value. Crops and livestock provide us with food, which is an ecosystem service with direct market value. Perennial forages protect the soil from erosion, fix carbon, and keep

nutrients in the farm instead of leaching them to the ground water, which are examples of ecosystem services that do not have direct market value. The beauty of a farming or ranching landscape, the recreational value of a lake, are examples of ecosystem services too. If we are able to quantify the ecosystem services, then we can estimate the value for society of those services. Economists can then develop markets for some of these services, like carbon markets. Policy makers can design policies to incentivize the provision of ecosystem services, and pay farmers for the benefits they are producing. Some studies suggest that the value of ecosystem services is many times larger than the direct market value of the food produced.

8. I used to have livestock, but the meat packing industry has left the area. I don't have anywhere to take animals now. I sold off my equipment to grow alfalfa. How will I pay for new equipment now?

We acknowledge there are constraints to diversify and integrate more forages in each farm. That is why we are working with economists, lenders, and policy makers. We want to identify those constraints, and help develop markets, lending programs, and policy incentives to help farmers to adopt more DPCS.