APPENDIX A

Project Number: TBD

Project Title: Phosphorus dynamics in agroecosystems

Requested Project Duration: From October 1, 2025 to September 30, 2030

Non-Technical Summary: Phosphorus (P) is a primary nutrient source in agriculture. From the 40 Megatons of P per year which is mined for US agriculture, more than 70% of the useable material is used for production of fertilizers. Many efforts are underway to recover P from natural ecosystems and use as fertilizer input, often referred to a "bio-mining". **The goal of this Multistate project is to illuminate phosphorus dynamics and highlight opportunities in development of technologies for recovery and reuse of phosphorus in agricultural systems**. The research objectives for reaching this goal are:

- Develop database for technologies relevant to agricultural P management;
- Document current and emerging technologies for P monitoring;
- Increase understanding of P impacts on ecosystems; and
- Investigate the history of P management in the United States.

The target audience for this project is: growers, technology developers, resource managers, extension programs, and researchers working in areas relevant to natural resource management. The outcomes will be curated in our Multistate database, and are designed to benefit as follows:

- New database accessible to stakeholders and technology end-users;
- Increased research reproducibility via shared protocols on technology development;
- Information for clarifying fundamental concepts in P management;
- Information on challenges/opportunities related to P management such as recovery from non-traditional sources; and
- Information on natural resource management for use at public museums.

Our team is working with partners and other organizations to maximize the dissemination and sharing of the outputs/outcomes from this group. We have developed three sub-committee groups which will identify key activities and work to achieve the outcomes. Each year, we will host a meeting to facilitate convergence of the outcomes produced by sub-committees using best practices in team science.

Statement of the Issue(s) and Justification: Phosphorus (P) is a critical element for life on Earth. Although P is all around us (there are more than 1 million chemical/biochemical forms), a few major P compounds are the primary nutrient source in agricultural systems. Namely inorganic phosphates in the di-hydrogen and the mono-hydrogen form. Thus, P-based fertilizers are produced in various forms to provide this critical element. Addition of P-based fertilizers increases crop yield by 30-40% in some soils. P-based fertilizers are the primary mass flow of this critical resource in current agricultural/food systems across the planet (Cordell and White, 2014).

P is primarily obtained from traditional mining activities. Of the approximate 40 Megatons of P per year which is mined for US agriculture, approximately 18 Megatons per year is used in the agrochemical industry, most of which is for fertilizer. Over-application of P fertilizer leads to reduced plant health, wastes finite resources, and can be released to receiving ecosystems which causes environmental problems. Currently, there are no large-scale systems that recover P and reuse this critical resource as fertilizer, although large efforts are underway to develop such systems. This "Phosphorus Management Problem" is a major global issue and requires detailed knowledge of stakeholder views as well as investment in new technologies for P recovery.

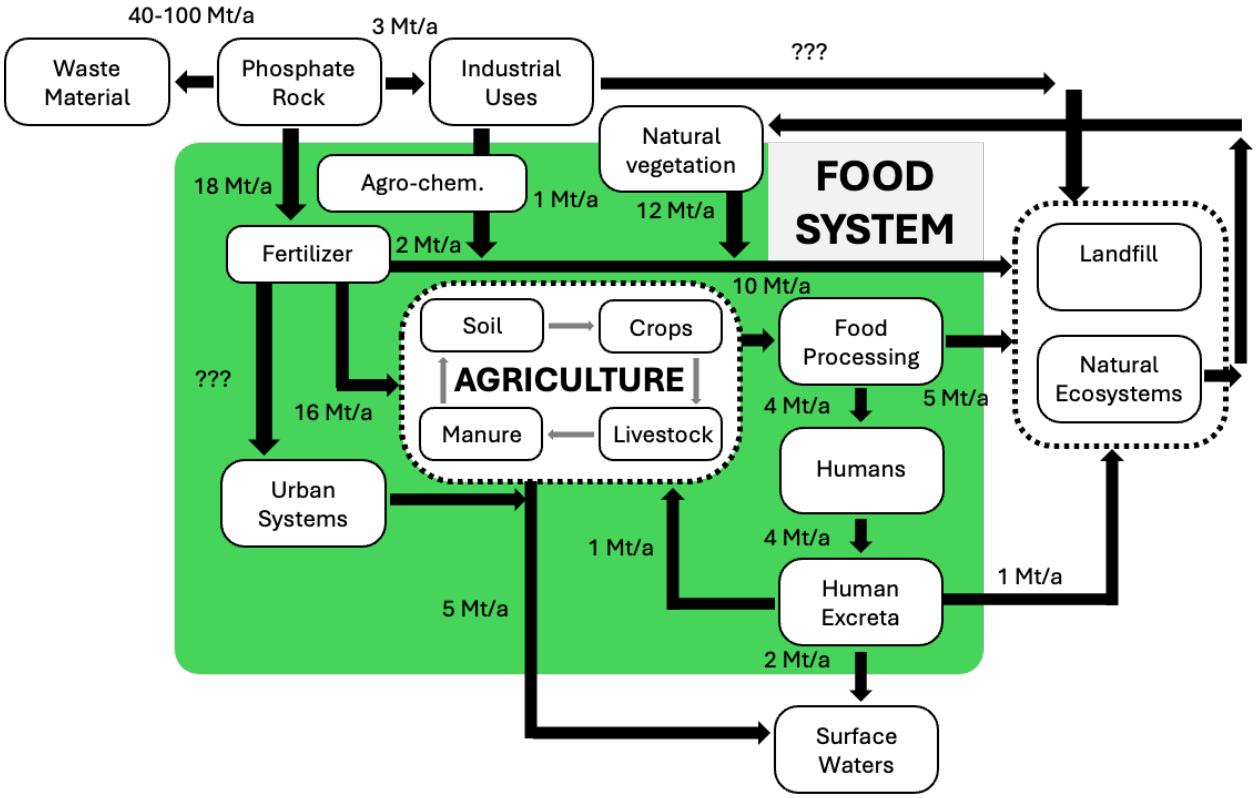

Figure 1. P flows in the US food system based on Cordell and White (2016).

Stakeholder views of Phosphorus Meaningful solutions to the "P Problem" require an understanding of different types of stakeholder perspectives (Merck et al., 2024). Expanding on this idea, Grieger et al (Grieger et al., 2024) recently conducted a study to identify stakeholder

views, needs, concerns, and challenges regarding P sustainability. The study targeted industry, government, academia, non-governmental organizations, and other civil groups, each identified as an expert within the domain of P as a resource. Based on responses from nearly 100 stakeholder participants from a range of sectors, areas of expertise, and geographies, Grieger et al (2024) conclude that the vast majority of stakeholders consider current practices for use of P to be linear, with no recovery of unused or waste P. In addition, the survey identified that stakeholders are very concerned about the ability to manage P. Stakeholder participants expressed a range of needs to improve P management systems, including:

- improved management practices;
- new technologies;
- enhanced regulations; and
- better approaches for stakeholder engagement.

The key technologies needed to enhance phosphorus sustainability include: enhanced predictive models (Askar et al., 2021; Karimi et al., 2023; Karimi & Obenour, 2024), recovery technologies for "unlocking legacy P" (Crane et al., 2024; Doydora et al., 2020; Hussein et al., 2024), and improved monitoring devices (e.g., sensors, arrays) (E. McLamore et al., 2023). (Grieger et al., 2024) noted that barriers to adoption of these emerging solutions are not limited to technological but include multiple factors within the sustainability framework (economic, social, and legal factors, among others).

(Deviney et al., 2023) recently called for coordinated stakeholder engagement with the collective aim of identifying needs and perspectives involved in sustainable phosphorus. The proposed multistate group aims to contribute a step toward filling this gap, and will collaborate with key organizations in this research area with extensive stakeholder engagement (e.g., STEPS NSF center, Sustainable Phosphorus Alliance).

Importance of Phosphorus sustainability

In addition to the stakeholder-driven needs delineated above, the P industry is driven by complex supply chain logistics (Baker et al., 2024). The global distribution of phosphate rock is in a handful of key locations. This creates major concern over supply chain issues for this finite resource. Due to the uneven distribution across the globe and current dependence on extractive mining, P fertilizer markets are vulnerable to exogenous shocks, including commodity market shocks, extreme weather events or natural disasters, and geopolitical instability (including trade disputes, disruption of shipping routes, and war). The work by Baker et al (2024) illuminates the importance of sustainable P practices for improving US resiliency, including:

- leveraging internal P recycling loops;
- improving plant P use efficiency; and
- utilizing legacy soil P.

Lowering risk related to the P supply chain is critical. (Elser et al., 2023) describe a looming "phosphogeddon" (i.e., phosphorus Armageddon) if improved P management systems are not

employed. Practices such as eco-prospecting, eco-mining, and eco-refining are the key to avoiding catastrophic failures in the P system.

Feasibility plan

The development of the proposed Multi-State group is built on a foundation of strong leadership and ongoing research projects that span NIFA, NSF and industry funding. The proposed project builds upon an existing Science and Technologies for Phosphorus Sustainability (STEPS) Center funded by the National Science Foundation (NSF; CBET-2019435). Expertise of initial participants are summarized below, and we have plans to grow our group by partnering with colleagues within the Multistate network. See Rationale section for details on team. In addition to our land grant participants, our group has numerous non-land grant participants that will engage with other MultiState efforts including, but not limited to, NC1194: Nanotechnology and Biosensors.

A geographical map of the personnel expertise and distribution of institutions is shown in Figure 2. Personnel expertise for the proposed Multi-State Project is described below and represents nine different departments at land grant institutions:

- Dr. McLamore (Agricultural Sciences, Clemson University) is an expert in sensors and decision support systems, and has experience as director of a NIFA CAP/Center of Excellence;
- Dr. Sozzani (Plant and Microbial Biology, North Carolina State University) is an expert in plant development, and is the Co-deputy Director of STEPS, Director for the Plant Improvement Platform at NCSU, and lead for the NSF AccelNet;
- Dr. Gomes (Mechanical Engineering, Iowa State University) is an expert in polymer systems and sensors/delivery systems. She is the site lead for the NSF Center for Soil Dynamic Technologies;
- Dr. Sahoo (Water Resources, Clemson University) is an expert in stormwater management and also watershed/water quality modeling related to P.
- Dr. Thuberty (Biology, Appalachian State University) works at the interface of local ecology and impacts of land use change on water resources, including nutrient pollution.
- Dr. Bhadha (Soil, Water and Ecosystem Science, University of Florida) is an expert in water quality, soil sustainability, sustainable agriculture and nutrient management.
- Dr. Nguyen (Tropical Plant and Soil Sciences, University of Hawaii) is an expert in plant-nutrient availability and bio-waste management.
- Dr. Porterfield (Agricultural and Biological Engineering, Purdue University) is an expert in bioregenerative systems, space biology, and non-invasive sensors.
- Dr. Diana Vanegas (Biosystems Engineering, Clemson University) is an expert in sustainable engineering, food and agricultural systems, and low resource communities.
- Dr. Yyy (Xxx Department, University of Puerto Rico at Mayagüez) is an expert in

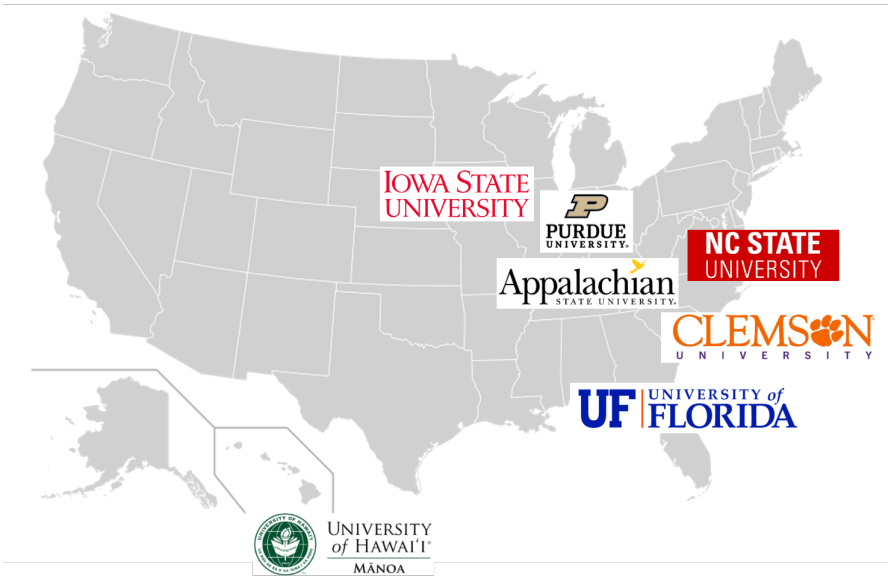

Figure 2. Geographic distribution of proposed team (land grant participants)

Non-land grant participants

- Al Shipley is the CEO of Science Wares, Inc., and serves as industry advisor.
- Luther Lyle, Director, Museum of The Cherokee of South Carolina

Key attributes of multistate effort

As P is a finite resource, each state deals with supply chain and environmental issues in a unique manner. A multi-state group on P management will establish a unique perspective to be documented and shared via annual reports, impact statements, and other documents. These documents will illuminate key issues such as fertilizer supply chain challenges, state-of-the-art monitoring/recovery technology, and best practices in P management, among others. Through partnerships with an existing NSF research center focused on P sustainability (STEPS), we will expand the impact of our work and disseminate documents broadly.

Anticipated impacts

We propose to curate and document information on P management practices as well as monitoring/recovery technology development. We will also include documentation describing historical management practices to guide future efforts in agriculture. As a component of this project, we will develop an open-source database with the intent to improve stakeholder engagement.

Related, Current, and Previous Work: This proposal represents an effort to strengthen leadership of Multistate projects in the Southern region. According to a review of the NIMSS database in September 2024 there are currently 155 active Multistate projects. The distribution of these projects is shown in Figure 3. The southern region is lowest (19%) amongst all regions. To complement the project, our initial team has representatives from the Western Region (University of Hawaii) as well as the Northcentral region (Iowa State University).

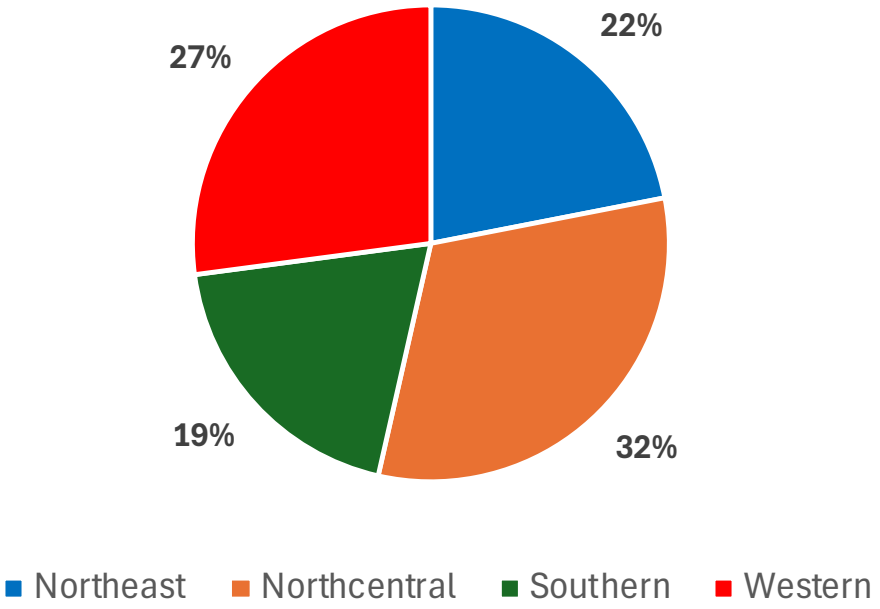

Figure 3. Pie chart showing regional breakdown of current Multistate groups in NIMSS (Fall 2024); n=155.

The proposed topic is unique within the current NIMSS multistate program. Table 1 shows seven active projects related to water that were identified as a potential overlap. Four projects are related (highlighted in grey) but focus on different aspects. For example, related projects focus on stormwater infrastructure, social sciences, or specialty crops. One project (S1089) covered generic pollutants but is focused on optimization of best management practices (BMPs) as well as mechanistic watershed models This project (S1089) is a group that our proposed team plans to collaborate with where appropriate if the proposed project is successful. Three other current Multistate projects are adjacent, but not highly relevant focus on soil/water physics (highlighted in blue) or policy/climate (highlighted in green). Although not highlighted in Table 2, Multistate project NC1194; McLamore and Gomes are members), occasionally focuses on nanotechnology development related to nutrients, but is primarily focused on biological materials. In addition, Bhadha is former chair and member of NCERA-59 (Soil Organic Matter: Formation, Function and Management), which we plan to partner with when appropriate.

Table 1. Current active Multistate projects related to water. Four projects which are related focus on different aspects than the proposed project. Other projects which are similar, but not highly relevant focus on soil/water physics (highlighted in blue) or policy/climate (highlighted in green).

NIMSS no.	Title	Scope (matrix)	PI	Dates
S1089	Advanced Understanding and Prediction of Pollutants in Critical Landscapes in Watersheds	Pollutant focus (water)	M. Savin	2020 - 2025

NC1190	Catalysts for Water Resources Protection and Restoration: Applied Social Science Research	Social science focus (water)	J. Peterson	2021 - 2026
NE2206	Green Stormwater Infrastructure and Agriculture	Ag. stormwater focus (water)	W. Cohick	2022 - 2027
NC1186	Water Management and Quality for Specialty Crop Production and Health	Specialty crop water quality focus (water)	J. Thurston	2020 - 2025
W4188	Soil, Water, and Environmental Physics to Sustain Agriculture and Natural Resources	Physics focus (complex systems)	W.T. Bowen	2019 - 2024
NE2045	Onsite Wastewater Treatment Systems: Assessing the Impact of Soil Variability and Climate Change	Soil/Climate variability focus (wastewater)	L. Townson	2020 - 2025
W5190	Management and Policy Challenges in a Water-Uncertain World	Policy focus (water)	G. Humiston	2024 - 2029

Outside of NIMSS, an NSF funded Science and Technology Center (STEPS) is focused on phosphorus sustainability. Members of our proposed project are leaders in STEPS (Sozzani, McLamore, Sahoo, Bhadha) and we plan to partner closely to identify mutual areas of interest. In addition, the Sustainable Phosphorus Alliance (SPA) is a non-profit organization operated out of Arizona State which is focused on a similar topic. The proposed objectives were carefully crafted to consider areas that would complement STEPS and SPA, while focusing in this work more on the NIFA Extension network. Drs. Sahoo and Bhadha have formal extension appoints, and we also have a number of extension experts in our institutions that have expressed interest in collaborating with the proposed Multistate group.

Although not discussed in detail here, four other Multistate projects were identified in NIMSS that are noteworthy and will be groups which we target for collaboration. Each of these current projects is related to nutrients, but are either animal science (NC2040; NC1182), food science (W5002), or agricultural yield focused only on nitrogen (NC1195). We plan to partner with W5002 in the future, if research in the topic of P in food processing/engineering gain traction.

Objectives: The goal of this Multistate project is to illuminate phosphorus dynamics and highlight opportunities in development of sustainable agricultural systems and related technologies. The proposed objectives for reaching this goal are:

Objective 1) Develop database for technologies relevant to agricultural P management.

Objective 2) Document current and emerging technologies for monitoring and tracking P in food/soil/water systems.

Objective 3) Increase understanding of the impact of P dynamics in freshwater ecosystems, as well as phosphorus fate and transport in the vadose zone.

Objective 4) Conduct studies investigating P management in the United States.

Objective 5) Maintain and grow the Multistate Community for research on P Dynamics in Agro-Ecosystems.

Methods: The methods for each objective are summarized below. For each objective, faculty lead(s) are identified for year 1, we anticipate the collaborative partnerships will grow as the group develops.

Objective 1) Develop database for technologies relevant to agricultural P management. Dr. McLamore (Clemson) will lead efforts in this objective. The two key tasks are:

- Open-source database: As a component of the proposal here, we have created an open-source database using Zenodo (https://zenodo.org/communities/panalytics). We will continue to build this database using the FAIR principles as described in the Zenodo repository (https://about.zenodo.org/principles/).
- Open-source protocols: We will develop protocols and training materials through the open-source platform Protocols I/O. We have extensive experience with developing open access protocols (Casso-Hartmann et al., 2024; Holberg et al., 2022; Huffaker, 2020; E. S. McLamore et al., 2020, 2023) through this platform and we will use this to disseminate materials related to analytical sciences and P monitoring. These protocols extend upon the information available in methodologies of scientific publications.
- Share data developed by research labs: As appropriate, the team will share data collected during research projects related to phosphorus dynamics using the Zenodo platform. No sensitive data or IP-restricted data will be garnered during this project. Data will include, but is not limited to:
    - Analyzed results of systematic literature reviews (*e.g.*, article DOIs, summary tables);
    - Metadata describing samples;
    - Metadata describing analytical technologies;
    - Illustrative data for validation of protocols; and
    - P concentration data from samples.

Objective 2) Document current and emerging technologies for monitoring and tracking P in food/soil/water systems. Drs McLamore (Clemson) and Gomes (Iowa State) will lead initial activities in this objective. We will focus on the following task:

- Systematic Literature reviews: Using the PRISMA framework (Page et al., 2021), we will conduct systematic literature review and meta-analyses focused on analytical instruments for monitoring and tracking phosphorus. Our team has extensive experience in conducting systematic literature reviews (E. S. McLamore et al., 2021; E. S. McLamore

& Datta, 2023; Vanegas et al., 2017) and we will build on this to curate and document state of the art technologies for monitoring and tracking phosphorus in food/soil/water systems.

- Data analysis methods: Members will share protocols and best practices for data analysis. For example, Clemson University will share all documents from training camps on the topics of: i) analytical sciences, ii) electrochemical data analysis for sensor development, and iii) water quality sampling.

Objective 3) Increase understanding of the impact of P dynamics in freshwater ecosystems, as well as phosphorus fate and transport in the vadose zone. Drs Sahoo (Clemson), Bhadha (Florida), Thuberty (Appalachian State), and Hue (Hawai‘i at Mānoa) will lead initial activities in this objective. We propose to work on the following two tasks to initiate collaboration amongst our group:

- Screening soil and water P: Soil and water samples from FL, IA, HI and IN will be collected from pre-determined locations across the collaborating states and analyzed for P concentrations across different fractions. For example: water samples will be tested for total P (TP), soluble reactive P (SRP) and particulate P (PP). In addition, soil (and in certain cases sediment) samples will be tested for different fractions following the modified Hedley fractionation method (Capasso et al., 2020). These analyses will be coupled with portable sensor technologies recently developed by McLamore (Ayivi et al., 2023; Garland et al., 2018; Mayer et al., 2024; E. S. McLamore et al., 2009, 2010, 2011; Moreira et al., 2024; Porterfield et al., 2009; Qian et al., 2024) and Gomes (Hjort et al., 2022, 2023; Johnson et al., 2022; Kucherenko et al., 2021; Soares et al., 2023).
- Advance P source tracing: We will merge datasets from the above task to conduct P source tracing research on soil and water samples together with isotopic tracer studies in water, and nuclear magnetic resonance (NMR) and X-ray absorption spectroscopy (XAS) analyses on soil across different edaphic conditions. NMR, XAS and other analytical techniques are conducted in FL, NC and SC as a component of the STEPS center.
- Vadose zone P characterization: The movement and transformation of both organic and inorganic P will be monitored and measured as a function of depth in the vadoze zone of various soil types and locations from FL, IA and HI. Key factors affecting such P dynamics will be identified and characterized.

Objective 4) Conduct studies investigating P management in the United States. Drs. McLamore (Clemson), Sahoo (Clemson), Lyle (Museum of the Cherokee of South Carolina), Nguyen (Hawai’i). We will focus on the following tasks:

- Historical use of P in Eastern US agroecosystems: In collaboration with the Museum of the Cherokee of South Carolina, we will through coordinated research and outreach to characterize historical use(s) of P in agroecology. This task will build on our NSF project to conduct chemical analysis of water and soil samples from historical sites near

Oconee Town site led by the partner Museum. We will disseminate data and research findings in the Zenodo database. If appropriate, we will also develop protocols for nanomaterial analysis and/or field research (e.g., sampling)

- Characterization of volcanic ash: Unusually high P requirements by some volcanic-ash derived Andisols will be closely studied and explained.

Objective 5) Maintain and grow the Multistate Community for research on Phosphorus Dynamics in Sustainable Agro-Ecosystems (all team effort). We intend to be highly strategic in formation and sustaining of this Multistate group and have a strategy for retaining and recruiting:

- Retain members: We aim to host a (hybrid) annual meeting according to the Multistate program requirements. During this annual meeting, the team will strategize on development of collaborative writing assignments. We will use the best practices for co-production writing developed at Appalachian State University (Hendren et al). We will also work carefully to select locations of annual meetings as to promote team collaboration, relationship building, and co-production using the best practices developed by the INFRAMES project (Hendren and Marasco-Plummer).
- Recruit new members: Our team plans to network with one another and colleagues at national scientific conferences and regional/local events to recruit new members to the group. One point of convergence will be the NSF STEPS center, but we also aim to recruit new members from the annual meetings of: Institute of Biological Engineering, Institute of Food Technologists, the Association for the Sciences of Limnology and Oceanography, American Chemical Society, and other relevant scientific meetings.

Measurement of Progress and Results:
OUTPUTS

Output:
Open-Source Database
Comment:
1. Open access database
2. Number of members to join database

Output:
Open-Source Protocols
Comment:
1. Publish open access protocols

Output:
Systematic literature reviews of technology performance
Comment:
1. Metadata from systematic reviews
2. Technology metadata

3. Review manuscripts
4. Perspective manuscripts
5. Commentary manuscripts
6. Trade journal/opinion papers

Output:

Increase understanding of the impact of P dynamics

Comment:

1. Research manuscripts
2. Open access protocols
3. Metadata for samples
4. Data from soil/water samples

Output:

Studies of phosphorus use in the United States

Comment:

1. Information for museums
2. News articles
3. Press releases (University)
4. Dissemination of data and research findings in open access database
5. Protocols for sampling/analysis

Output:

Recruit and retain new members to join Multistate project

Comment:

1. At least 10% growth in new members
2. Maintain balance of membership, with representation from extension, SAES/ARS scientists, and researchers

OUTCOMES OR PROJECTED IMPACTS

Impact: Publicly-accessible information and research protocols
Comments:

i. Increased research reproducibility via protocols
ii. Information on using P from volcanic-ash
iii. Information on efficient use of P

Impact: Repository of information documenting critical concepts in P sustainability
Comments:

i. Open-source data accessible to stakeholders and end users of technologies
ii. Clarify critical concepts in P monitoring technology
iii. Information access via public museum(s)
iv. Improved knowledge of fertilizer use
v. Understanding of volcanic ash uses in agriculture

Impact: Publicly available technology trade studies

Comments:

i. Illuminate technology challenges & opportunities
ii. Improved knowledge of fertilizer use
iii. Understanding of volcanic ash uses in agriculture

MILESTONES

Milestones:

Year: 2030

i. At least 10 researchers registered as database members throughput project;
ii. At least one protocol published per year;
iii. At least one peer reviewed manuscript published per year; and
iv. At least one protocol published per year.

Table 2. Measurement of Progress and Results

Objective	Task	Outputs	Outcomes	Milestones
1	Open-Source Database	□ Open access database □ Number of members to join database	□ Open-source data accessible to stakeholders and end users of technologies	□ At least 10 researchers registered □ Receive records/data from at least 5 members
	Open-Source Protocols	□ Publish open access protocols	□ Increased research reproducibility via protocols	□ At least one protocol published per year
2	Systematic literature reviews of technology performance	□ Metadata from systematic reviews □ Technology metadata □ Review manuscripts □ Perspective manuscripts □ Commentary manuscripts □ Trade journal/opinion papers	□ Clarify critical concepts in P monitoring technology □ Illuminate technology challenges & opportunities	□ At least one peer reviewed manuscript published per year (from systematic literature review)
3	Increase understanding of the impact of P dynamics	□ Research manuscripts □ Open access protocols □ Metadata for samples □ Data from soil/water samples	□ Information on using P from volcanic-ash □ Information on efficient use of P	□ At least one peer reviewed manuscript published per year □ At least one protocol published per year
4	Anthropology studies of phosphorus use in the US	□ Information for museums □ News articles □ Press releases (University)	□ Information access via public museum(s) □ Improved knowledge of fertilizer use	□ At least one information document produced for museum each two years

		□ Dissemination of data and research findings in open access database □ Protocols for sampling/analysis	□ Increased research reproducibility via protocols □ Understanding of volcanic ash uses in agriculture	□ At least two publication protocols for museum research
5	Recruit and retain new members to join Multistate project	□ At least 10% growth in new members □ Maintain balance of membership, with representation from extension, SAES/ARS scientists, and researchers	□ New tasks/concepts will broaden participation	□ Recruit at least one SAES or ARS scientist to the group during the first two years □ At least 5% growth in membership (total) after first three years □ At least 10% growth in membership (total) after first five years

Rationale: Our initial Multistate team represents seven universities, with four in the Southern region, one in the Western region, and two in the Northcentral region. A geographical map of the personnel expertise and distribution of institutions is shown in **Figure 2**. Expertise of our team covers each of the three objectives and we intend to grow the project team within the first cycle of performance. **Table 3** summarizes the area of specialization for the multistate group. We anticipate growth in numbers as the project evolves.

Table 3. Specialization of the members of the technical committee and other principal leaders

Name	Institution	Role	State	Area of Specialization
Eric McLamore	Clemson University	Main campus faculty	SC	Sensors, decision support
Ross Sozzani	North Carolina State University	Main campus faculty	NC	Synthetic and Systems Biology
Carmen Gomes	Iowa State University	Main campus faculty	IA	Polymer systems; biosensors; food engineering
Deb Sahoo	Clemson University	SAES faculty (SCWRC)	SC	Stormwater management; watershed modeling
Shea Thuberty	Appalachian State University	Main campus faculty	NC	ecology; land use change impacts; nutrient pollution
Jango Bhadha	University of Florida	SAES faculty (EREC)	FL	water quality, soil sustainability, sustainable agriculture; nutrient management
Hue Nguyen	University of Hawai‘i at Mānoa	Main campus faculty	HI	plant-nutrient availability; bio-waste management
Marshall Porterfield	Purdue University	Main campus faculty	IN	bioregenerative systems, space biology

Diana Vanegas	Clemson University	Main campus faculty	SC	sustainable engineering, food and agricultural systems, low resource communities

Key leaders and partners during initial group formation are listed below:

- Dr. McLamore (Clemson University) has experience as director of a NIFA CAP/Center of Excellence;
- Dr. Sozzani (North Carolina State University) is the Co-deputy Director of STEPS, Director for the Plant Improvement Platform at NCSU, and lead for the NSF AccelNet
- Dr. Gomes (Iowa State University) is the site lead for the NSF Center for Soil Dynamic Technologies and is an expert in sensors/delivery systems;
- Luther Lyle is a key partner and chair/founder of the Museum of the Cherokee of South Carolina

Outreach Plan: We have developed an entire objective which is focused on dissemination/outreach (Objective 1); all other objectives will contribute to the repository developed for this project. The key deliverable is the development of an open-source database created during preparation of this proposal (https://zenodo.org/communities/panalytics). The Zenodo community created for this proposed Multistate working group is accessible to all internet users via the link above, ensuring access to any interested party with an internet connection. We have initiated the process of storing refereed publications, information for workshops, protocols, and other important documents on the Zenodo community site. We are also storing information related to Extension services provided by our Universities (e.g., soil/water testing, upcoming public workshops). We will continue to populate this database as the Multistate projects grows. No sensitive material or intellectual property will be shared on the platform, and all documents are subject to the Zenodo open-source policy, referred to as "Open in every sense" (https://about.zenodo.org/#:~:text=Open%20in%20every%20sense,aspect%20are%20welcomed%20from%20anyone.)

In addition to this central Zenodo repository, we will disseminate information through presentations at scientific meetings, public meetings at local museums, and sharing of annual reports through our university websites to be curated alongside other existing Multistate efforts (e.g., IFAS repository, MERLOT repository, Clemson Extension site).

Organization and Governance: The standard form of governance from the Guidelines for Multistate Research Activities. All officers will be elected for a two-year term for continuity as described in the Guidelines. The group will elect a chair to lead the activities for a 12-month period, supported by a vice-chair and a secretary. Following nominations of leaders, a consensus vote will be conducted for electing leaders. Each position will serve for no more than one year and will rotate from secretary-to-vice chair-to-chair. The charge of the chair will be to: i) lead annual meeting, ii) oversee election of new leadership, and iii) provide guidance to incoming chair during transition.

We will form the following sub-committees for achieving our stated goal/objectives:

Sub-committee on analytical technologies: This team will hold meetings to work towards completion of objectives 1-2. The group will be led by Drs. McLamore and Gomes. Meeting format will be monthly in hybrid format. Students and faculty will focus on timely completion of the outputs described in Table 3.

Sub-committee on in silico modeling and prediction of P dynamics: This team will work towards attaining the outputs listed in objective 3; see Table 3. The group will consist of Drs Sahoo, Bhadha, Thuberty, and Hue.

Sub-committee on studies of non-traditional P use: This team will work towards outputs from Objective 4, and will be led by Drs McLamore, Sahoo and Nguyen, together with L. Lyle (museum director).

Our team will build on team science principles developed in a NSF Science and Technology Center (www.steps-center.org) that focuses on P sustainability and team convergence (Deviney et al., 2024). Five Co-PI's of this proposal are members/leaders of this convergence research center and will work to integrate best practices of team science in this Multistate effort (Sozzani-STEPS deputy director; McLamore-center leadership; Bhadha-research leader, Thuberty-research member, Sahoo-research member).

Literature Cited

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