NC Plant Sciences Initiative Task Forces Proceedings

NC STATE UNIVERSITY

College of Agriculture and Life Sciences

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NC Plant Sciences Initiative
Task Forces Proceedings

NC State University
College of Agriculture
and Life Sciences

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Contents

Executive Summary

Overview

In the first quarter of 2016, the leadership of North Carolina State University (NC State) College of Agriculture and Life Sciences (CALS) began convening thought leaders in the agricultural, life sciences, and biotechnology sectors to provide guidance and direction for the North Carolina Plant Sciences Initiative (NC PSI). Members were drawn from both the private and public sectors and represented a diverse group of stakeholders both internal and external to NC State.

At the inaugural joint meeting in March, the thought leaders were asked to think "outside of the box" as they envisioned how best to establish the world's foremost plant sciences research and training center. Four task forces, which included a series of sub task forces, met over the course of the following year to discuss and develop recommendations regarding key elements of an implementation plan for NC PSI. These proceedings represent the culmination of the various working groups' findings and summarize recommendations to the NC PSI leadership for developing an organizational model that will be responsive to the ultimate goals of the initiative.

The members view the results of their work as a "living document" that can help to guide the NC PSI leadership as it moves forward with implementation.

Background

A recent report[1] regarding the governance of the NC PSI noted the following:

> *The tradition at universities across the United States is for the academy to be partitioned into distinct colleges and departments in a system of independent and distinct academic disciplines. This traditional model concentrates faculty, and their students, into relatively inward looking siloes of inquiry focused on the specialized content of their discipline. … While there are certainly advantages to the traditional academic department model, there is increasing recognition that many of the leading challenges and questions in academic inquiry are of a level of complexity that any one discipline lacks the scope of inquiry required to adequately address the challenge. Often comprising challenges that are multidimensional and systemic, many grand challenges require the application of transdisciplinary team science. … Plant Science represents one of the traditional disciplinary focus areas that especially lends itself to interface with other disciplines in addressing major challenges and research questions.*

From its earliest conception, the NC PSI was envisioned to be a world-class transdisciplinary[2] research initiative. A well-respected definition of transdisciplinary research can be found in Gray, 2008: "Transdisciplinary research refers to scientific inquiry that cuts across disciplines, integrating and synthesizing content, theory and methodology from any discipline area which

1. Battelle Technology Partnership Practice. 2015, March. *The North Carolina Plant Sciences Initiative: Governance White Paper*. Columbus, OH: Battelle.
2. Gray, Barbara. 2008, Aug. Enhancing transdisciplinary research through collaborative leadership. American Journal of Preventive Medicine 35(2): S124-S132.

will shed light on the research questions." Transdisciplinarity, as distinguished from multidisciplinarity and interdisciplinarity, requires that researchers invent new science together by exploring research questions at the intersection of their respective fields, conducting joint research projects and "developing methodologies that can be used to re-integrate knowledge."

Transdisciplinary team science is essential to address grand scientific and technological challenges because the biggest questions demand solutions beyond the capabilities of a single discipline. Facilitation of transdisciplinary research teams is key to advancing progress and innovation in a complex area such as agriculture. Major issues facing agricultural producers (such as the expanding challenge of herbicide-resistant weeds, emerging diseases and pests, and climate variability) require solutions engaging expertise in plant pathology, entomology, crop science, soil science, horticulture, engineering, economics, and other disciplines to develop integrated solutions to global food challenges.

We envision the NC PSI as such an interdisciplinary effort, and that its leaders will seek to do the following:

- Foster the spirit of transdisciplinary research to solve global challenges with national and local importance.
- Create innovative and progressive partnerships among universities, industry, and government.
- Maximize the integration of research, teaching, and outreach programs.
- Create the premier destination for plant sciences in the world.
- Allow North Carolina to have a competitive advantage locally to globally.
- Help farmers in North Carolina to be economically viable.
- Leverage local assets to create the "Silicon Valley" of plant sciences.

Task Force Results

Task Force Framework

To undertake the important work of developing an implementation plan for the NC PSI, thought leaders were convened into a series of task forces to focus on key elements of the initiative's operating plan. To help ensure a true public and private partnership, each task force was co-chaired by a representative from private industry and a representative from NC State. Members of each task force widely understood that it would be critically important in the development of the NC PSI to focus not solely on the "what," but also to pay close attention to the "how." The following framework was used to organize the various operational planning elements:

- ***Governance and Leadership Task Force***

  Charge: Develop a philosophy, guiding principles, and operational model for NC PSI

  A separate sub task force was formed to help ensure that commercialization outcomes are embedded into NC PSI projects:

  - ***Commercialization and Entrepreneurship Sub Task Force***

- ***Research and Technology Task Force***

  Charge: Guide the scientific goals of NC PSI.

  Three sub task forces were formed to focus on technology platform identification:

- ***Plant Improvement Platform Sub Task Force***
- ***Plant Data Sciences Platform Sub Task Force***
- ***Food Systems, Environmental Sustainability, and Resilience Platform Sub Task Force***

- ***Workforce Development and Public Engagement Task Force***

  Charge: Provide advice and structure for NC PSI on how to communicate unbiased information to stakeholders, disseminate discoveries, and train the agbioscience workforce of tomorrow.

  Three sub task forces were formed to focus on the various components of this charge:

  - ***Science Policy and Communications Sub Task Force***
  - ***Research Translation and Delivery Sub Task Force***
  - ***Workforce Education and Development Sub Task Force***

- ***Advocacy and Resource Development Task Force***

  Charge: Engage stakeholders from industry, government, and academia.

Summary of Task Force Recommendations

Over the course of a year, the various task forces and sub task forces met to develop recommendations specific to each charge with an end goal of developing an NC PSI organizational model that will be responsive to the initiative's ultimate goals. Table ES-1 provides a summary of the recommendations. The actual findings from each task force, as well as detailed information for each recommendation, are summarized in the chapters that follow.

Table ES-1. Summary of Task Force Recommendations for the NC PSI

Recommendation	Summary
Governance and Leadership Task Force, including recommendations of the Commercialization and Entrepreneurship Sub Task Force	
Adopt an NC PSI operating philosophy.	A suggested vision for the NC PSI is articulated and key guiding principles are presented.
Create an NC PSI organizational chart.	An NC PSI organization chart is provided that details key positions and ensures the input of advisory councils.
Hire the NC PSI executive director.	A job description for the executive director is suggested, including a summary of the position; and essential duties and responsibilities, qualifications, and reporting structure are outlined.
Hire a dedicated commercialization and entrepreneurship director.	A job description for the commercialization and entrepreneurship director is summarized, and essential duties and reporting structure are outlined.
Develop guidelines for project life cycle management.	Guidelines are recommended for project life cycle management within the NC PSI.
Allow for physical rotation of space.	A model for physical space is outlined that is focused on creating networks, catalyzing interactions, and spurring multiple contact points. This model will require that research teams be dynamic, with researchers and students cycling in and out of the building as projects evolve.
Provide commercialization support for NC PSI projects.	Mechanisms to support the creation of startup companies are suggested, including the development of a Commercialization Mentor Network and the creation of an incubator and pre-seed fund.
Ensure NC State's organizational culture (Including its *Reappointment, Promotion, and Tenure Policies and Practices*) recognizes, fosters, supports, and rewards commercialization and entrepreneurship activities.	Suggestions are provided for ways to ensure that the University's policies and cultures are aligned with the desire to ensure that commercialization and entrepreneurship activities are recognized and valued.
Create an NC PSI Implementation and Launch Advisory Council.	Recognizing that the development of an effective implementation and launch plan for NC PSI will be a complex endeavor, it is suggested that members from the various task forces continue to be consulted as the implementation plan is developed.
Research and Technology Task Force, including recommendations of the Technology Platform Sub Task Forces	
Create criteria and guidance by which research platforms should be chosen.	Guidelines are recommended for the criteria by which research platforms will be chosen to help ensure that they tackle global grand challenges that have relevance to both national issues and problems specific to North Carolina.

Recommendation	Summary
Select inaugural NC PSI platforms.	Three platforms are recommended as the inaugural platforms of NC PSI: Plant Improvement; Plant Data Sciences; and Food Systems, Environmental Sustainability, and Resilience.
Appoint dedicated platform directors.	A job description for the platform directors is suggested, including a summary of the position and qualifications being sought in an ideal candidate.
Focus projects and initiatives at the intersection of the proposed NC PSI platforms.	Suggestions are provided for ways to ensure that the platforms represent a portfolio of projects that are complex, highly integrated and connected, driven by data and informatics, and represent sustainable food systems that are predictive and proactive.
Continue to engage the Research and Technology Platform Sub Task Forces.	Because the development of an effective implementation and launch plan for NC PSI will be a complex endeavor, it is suggested that members from the Technology Platform Sub Task Forces continue to be consulted as the implementation plan is developed.
Develop a space allocation rubric.	A model for space allocation is outlined that focuses on flexible space that can be reconfigured depending on the current needs of the platforms and projects.
Workforce Development and Public Engagement Task Force	
Science Policy and Communications Sub Task Force	
Hire a communications and external relations specialist dedicated to advancing the NC PSI and integrating its communication activities within the broader CALS efforts.	A job description for the communications and external relations specialist is summarized and essential duties are outlined.
Create the Communications Plan Phase I – NC PSI Realization and Launch.	A communication strategy is outlined to support the launch of the NC PSI.
Create the Communications Plan Phase II – Sustaining and Strategic Communications.	A communication strategy is outlined to support the ongoing, intentional communication efforts that are designed to connect desired audiences to the NC PSI's purpose and facilitate progress toward defined objectives.
Shape and deliver communications that position the NC PSI as a "trusted source."	Suggestions are provided for ways in which to ensure that the NC PSI is viewed as a trusted source of information and knowledge dissemination.
Create a Communications Advisory Council.	Because the development of an effective implementation and launch plan for NC PSI will be a complex endeavor, we suggest that members from the Science Policy and Communications Sub Task Force continue to be consulted as the implementation plan is developed.
Research Translation and Delivery Sub Task Force	
Ensure that Cooperative Extension has a pivotal role, from beginning to end, for each project.	For NC PSI to be effective, researchers must understand the needs of industry and projects must have expected outcomes that meet those needs (a continual feedback loop is needed from beginning to end). A model is suggested that ensures that every project team represents

Recommendation	Summary
	meaningful collaboration between Cooperative Extension and researchers on the main campus.
Ensure that project teams represent a diverse group of individuals to guarantee a robust understanding of needs as well as to be more encompassing in how information is disseminated to broader audiences.	A model for incorporating stakeholders that represent "oblique angles" (individuals and groups who are not always part of a traditional stakeholder and collaborative structure) is recommended to enable fresh perspectives and build support for all of agriculture.
Implement a formal process and create mechanisms to ensure that the capabilities and capacities that Cooperative Extension represents are used and embraced, thereby creating a culture in which the role of Cooperative Extension is valued.	Suggestions are provided for ways in which to ensure that NC State's policies and cultures recognize and value Cooperative Extension activities.
Workforce Education and Development Sub Task Force[3]	
Hire a dedicated professional development coordinator.	A job description for the professional development coordinator is summarized, and essential duties and reporting structure are outlined.
Develop "Agbioscience Leaders of the Future," an initiative that includes technical expertise, experiential programs, and hands-on curricula.	Suggestions for specific programmatic efforts are outlined that focus on providing workforce development initiatives geared at providing hands-on and experiential learning opportunities for students.
Advocacy and Resource Development Task Force	
Continue to engage the Advocacy and Resource Development Task Force.	Because the development of an effective funding development plan for NC PSI will be a complex endeavor, we suggest that the Advocacy and Resource Development Task Force continue to convene to provide guidance and assistance as the implementation plan is developed.

Reflections and Next Steps

On May 1, 2017, the members of each task force assembled to review and discuss the findings and recommendations that had been compiled in this *Task Forces Proceedings* document. During this meeting, the members were asked to consider both areas of synergies across the work product of each task force as well as missing components that require further exploration during implementation planning. Task force members recommend that the following topics be further explored and vetted as the NC PSI Implementation Plan is developed:

3. The members of the Workforce Education and Development Sub Task Force did not limit their analysis only to issues that the NC PSI should address. The sub task force also examined issues that should be addressed by CALS. These additional recommendations to NC State's CALS leadership regarding the continued evolution of the college's workforce and career preparedness efforts begin on page 80 of this document.

- Institute a focus for the NC PSI that goes beyond simply plant science research to also examine the broader issues of farm sustainability systems.
- Ensure that the NC PSI serves as a model for how research is pursued and how faculty are evaluated.
- Help to create a pipeline of students interested in the plant sciences and agriculture.
- Establish the NC PSI as a trusted source for agriculture and ag-based research and information, both locally and globally.
- Communicate the NC PSI value proposition to garner understanding and support for the initiative.
- Continue to engage advisory groups representing diverse viewpoints to ensure the creation of a solution-based NC PSI operating model.

The activities of the coming year and beyond will build firmly on the foundation of the extensive efforts of the task forces, whose work is laid out in detail in the pages that follow. Collectively, these efforts provide a strong framework for the formation of the NC PSI operating model. The thoughtful guidance and insights found within these recommendations will help to ensure that the NC PSI will be truly visionary and successful.

During the summer of 2017, the NC PSI launch director will be hired to serve as the strategic lead for the NC PSI during its nascent prebuilding phase. We envision that this critical and highly visible role will cultivate powerful relationships within the corporate, academic, and public spheres and act as the public face for the NC PSI in the early stages as he or she works with NC State and CALS administration to develop an implementation plan for the initiative and continues to rally support for the building and program. CALS will also be working internally with faculty to begin to develop projects.

Two advisory groups have been created based on this report – one internal and one external – to help guide the action plan. Assistance will be sought in thinking through priorities based on available resources. An Implementation Task Force will also be formed to help guide the launch director.

Governance and Leadership Task Force

Introduction and Overview

A recent report[4] regarding the governance of the North Carolina Plant Sciences Initiative (NC PSI), noted the following:

> *The tradition at universities across the United States is for the academy to be partitioned into distinct colleges and departments in a system of independent and distinct academic disciplines. This traditional model concentrates faculty, and their students, into relatively inward looking siloes of inquiry focused on the specialized content of their discipline. … While there are certainly advantages to the traditional academic department model, there is increasing recognition that many of the leading challenges and questions in academic inquiry are of a level of complexity that any one discipline lacks the scope of inquiry required to adequately address the challenge. Often comprising challenges that are multidimensional and systemic, many grand challenges require the application of transdisciplinary team science. … Plant science represents one of the traditional disciplinary focus areas that especially lends itself to interface with other disciplines in addressing major challenges and research questions.*

From its earliest conception, the NC PSI was envisioned to be a world-class transdisciplinary[5] research center that would seek to do the following:

- Foster the spirit of transdisciplinary research to solve global challenges with national and local importance.
- Create innovative and progressive partnerships among universities, industry, and government.
- Maximize the integration of research, teaching, and outreach programs.
- Be the premier destination for plant sciences in the world.
- Allow North Carolina to have a competitive advantage locally to globally.
- Leverage local assets to create the "Silicon Valley" of plant sciences.

It was also widely understood that it would be critically important in the development of the NC PSI to focus not solely on the "what," but also to pay close attention to the "how."

4. Battelle Technology Partnership Practice. 2015, March. *The North Carolina Plant Sciences Initiative: Governance White Paper*. Columbus, OH: Battelle.

5. Gray, Barbara. 2008, Aug. Enhancing transdisciplinary research through collaborative leadership. American Journal of Preventive Medicine 35(2): S124-S132. A well-respected definition of transdisciplinary research can be found in Gray, 2008: "Transdisciplinary research refers to scientific inquiry that cuts "across disciplines, integrating and synthesizing content, theory and methodology from any discipline area which will shed light on the research questions." Transdisciplinarity, as distinguished from multidisciplinarity and interdisciplinarity, requires that researchers invent new science together by exploring research questions at the intersection of their respective fields, conducting joint research projects and "developing methodologies that can be used to re-integrate knowledge."

Importance of the Governance and Leadership Model to Ensuring NC PSI's Success

To ensure that recommendations regarding an effective operational model that can best achieve the goals of the NC PSI were put forth in the initiative's development and implementation, a Government and Leadership Task Force was formed (Attachment G&L-A lists task force members). These industry, government, and academic leaders will help to guide the planning and development of the NC PSI by providing advice and structure in regards to governance, leadership, and an operating model for the NC PSI. The overall charge of the Governance and Leadership Task Force was to help North Carolina State University (NC State) College of Agriculture and Life Sciences (CALS) design an organizational structure that works for NC State and guides NC PSI Leadership in decisions about space allocation, project funding, and enhancing transdisciplinary research and innovation. Specifically, the Governance and Leadership Task Force sought to provide advice and structure for the NC PSI in the following areas:

- Statement of operating philosophy
- Organizational chart for the NC PSI, including advisory councils
- Operations management system recommendations, such as central, distributed by research platform, or distributed by research program
- Job description and recommended team members for the NC PSI executive director
- Criteria to be used to allocate and re-allocate lab and office space in the Plant Sciences Building
- Performance metrics by which faculty will be measured
- Sources of NC PSI project funding

During its work, the Governance Task Force recognized that additional thought should be given to how the NC PSI would foster the application of its research into the commercial marketplace. To help develop recommendations around this topic, a separate Commercialization and Entrepreneurship Sub Task Force was convened to help ensure that commercialization outcomes are embedded into NC PSI projects (Attachment G&L-B lists sub task force members). While a summary of the key findings of the Commercialization Sub Task Force are incorporated into these proceedings, the full findings and recommendations of the group can be found in Attachment G&L-C.

These proceedings represent the culmination of the work and findings of both the Governance and Leadership Task Force and its Commercialization and Entrepreneurship Sub Task Force and provide recommendations to the NC PSI leadership for developing a new transdisciplinary operating model. It should be noted that the members view the results of their work as a "living document" that can help to guide the NC PSI leadership as it moves forward with implementation. Further, the members feel strongly that every effort must be made to ensure that the NC PSI's operational model is responsive to the agricultural production and agbioscience industrial needs of North Carolina. In the end, it is the goal of the Governance Task Force to create a new transdisciplinary operating model that encourages the kind of "outside of the box" thinking that the NC PSI will require to be truly visionary and successful so that it is positioned to have lasting impact.

Governance and Leadership Recommendations

Based on the analyses and discussions undertaken, the members of the Governance Task Force respectfully submit the following recommendations to the NC PSI leadership team for consideration in the development of the NC PSI.

Recommendation 1: Adopt an NC PSI Operating Philosophy

While ultimately the vision of the NC PSI needs to be created by its leadership with input from its stakeholders, we recommend that the NC PSI operating philosophy include the following components:

Vision: Be the premier destination for plant sciences in the world by leveraging North Carolina's unique assets to create the "Silicon Valley" of plant sciences.

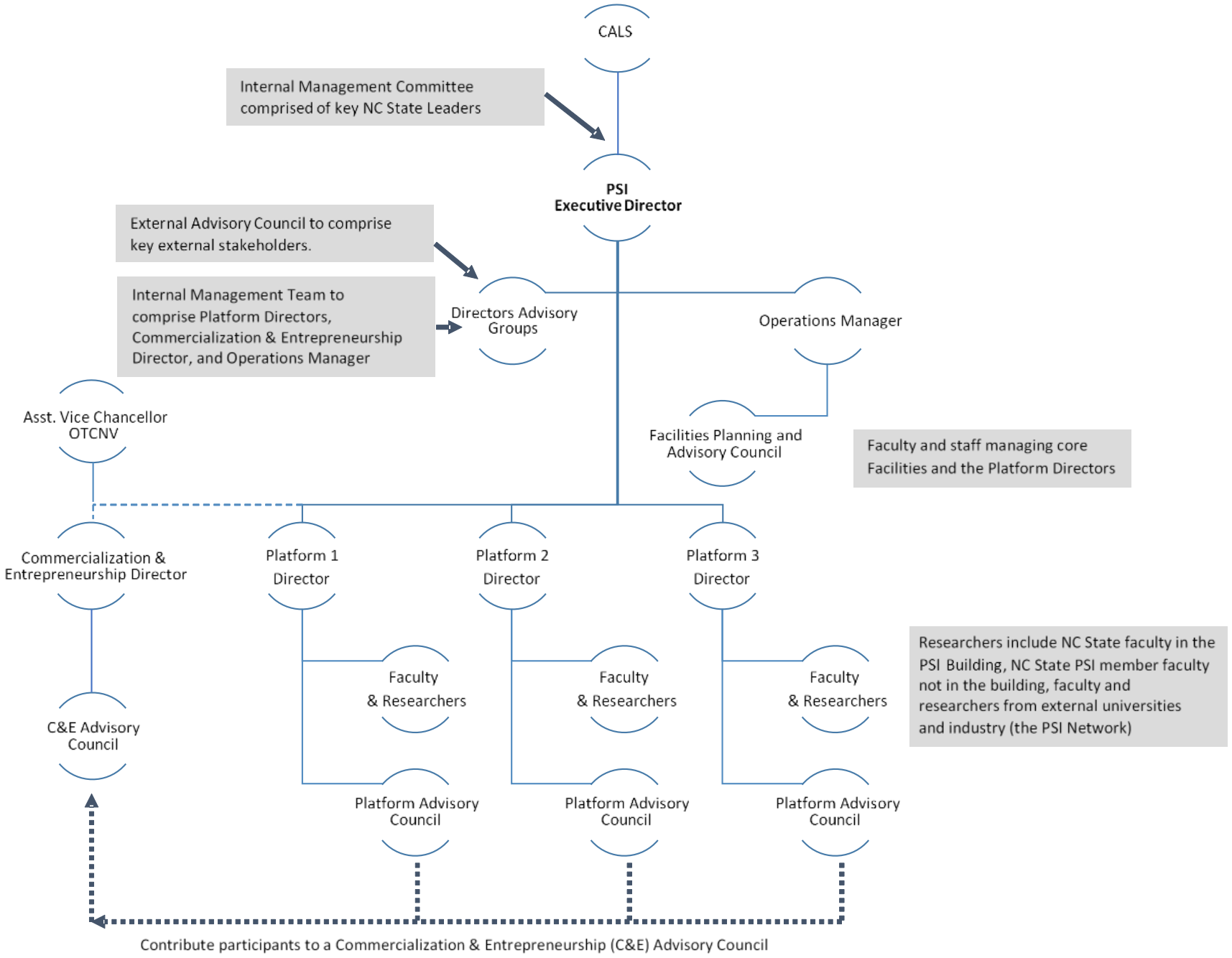
The guiding principles of the NC PSI should encompass the spirit of the following statements:

- Mandate and support transdisciplinary research by creating an environment and culture in which such research can thrive.
- Create a thriving community of partnerships – create, build, and manage new networks and reorganize as the science and technology evolves.
- Empower a visionary leader to create an innovative culture that fosters premier plant sciences research.
- Encourage flexibility, natural evolution, and transformative disruption of technology through a mixed-model approach[6] from discovery to commercialization.
- Avoid importing and/or defaulting to traditional institutional structures.
- Solve global grand challenges that have local economic relevancy.
- Provide transdisciplinary training of the future workforce – the next generation of transdisciplinary researchers.
- Focus key performance indicators on both traditional academic and transformative outcomes.

Recommendation 2: Create an NC PSI Organizational Chart

Figure G&L-1 illustrates the recommended organizational chart for NC PSI. With regards to operational management systems, we believe that it would be premature for the Government Task Force to advise on specifics of an operational management system, and that those specifics should be left to the discretion of the NC PSI executive director, the dean of CALS, and the Internal Management Committee.

6. Details regarding the mixed-model approach can be found under Recommendation 6.


CALS
Internal Management Committee comprised of key NC State Leaders
PSI Executive Director
External Advisory Council to comprise key external stakeholders.
Internal Management Team to comprise Platform Directors, Commercialization & Entrepreneurship Director, and Operations Manager
Directors Advisory Groups
Operations Manager
Asst. Vice Chancellor OTCNV
Facilities Planning and Advisory Council
Faculty and staff managing core Facilities and the Platform Directors
Commercialization & Entrepreneurship Director
Platform 1 Director
Platform 2 Director
Platform 3 Director
Faculty & Researchers
Faculty & Researchers
Faculty & Researchers
Researchers include NC State faculty in the PSI Building, NC State PSI member faculty not in the building, faculty and researchers from external universities and industry (the PSI Network)
C&E Advisory Council
Platform Advisory Council
Platform Advisory Council
Platform Advisory Council
Contribute participants to a Commercialization & Entrepreneurship (C&E) Advisory Council

Recommendation 3: Hire the NC PSI Executive Director

Recruiting an innovative and collaborative leader (executive director) for the NC PSI will be critical to optimize success. The executive director will be expected to oversee many aspects of the NC PSI, including setting aggressive goals for basic and applied research, establishing an effective outreach program for knowledge dissemination, and enhancing student learning. In carrying out the vision for the NC PSI, the executive director is expected to work closely with, and seek input from, the NC PSI External Advisory Council, the NC PSI Internal Management Committee, CALS administration, and any other committees and councils that may be formed as a part of the leadership of the NC PSI.

Within this leadership role, the executive director will have the challenge of balancing the need for both basic and applied research, while serving the needs of stakeholders in North Carolina, the nation, and the world. As such, the NC PSI platform directors (as identified in this report) will be established under the direction of the executive director. The executive director will also focus on building transdisciplinary teams to solve the grand global challenges of agriculture and plant sciences, forming partnerships among industry, government, and academia and creating unique experiences for undergraduate and graduate students.

As the NC PSI develops into a new organizational model, the hope is that a new way of thinking will also evolve. The ultimate goal is to “think and do” – act in groundbreaking ways – to create a novel transdisciplinary model that encourages the kind of “outside of the box” thinking that the NC PSI will require to be truly visionary and successful.

Indeed, what is needed is a visionary executive director, someone who has a true passion for building a world-class plant science institute and who is willing to take risks to achieve that vision. In the view of some Governance Task Force members, the NC PSI executive director should have considerable latitude in making decisions on behalf of the initiative, the building, and how the building is operated, based on organizational models that they have seen work well in industry and at other institutional settings. As such, the Governance Task Force aimed to ensure that the language in the “NC PSI Executive Director Job Description” that follows stresses the executive function of the position. While it is unclear if such a leader will come from academia or industry, the ideal candidate will have experience in both venues. Given not only the scientific but also the economic development goals of the NC PSI and Plant Sciences Building for North Carolina, as envisioned by industry, producers, academia, and public sector leaders within the state, the ideal leader will fully embrace the importance of the continuum of basic, applied, and translational research, as well as commercial research partnerships, technology transfer activities, and the internal incubation of new business ventures based upon NC PSI research innovations.

NC PSI Executive Director Job Description

Summary

The executive director is responsible for providing strategic leadership for the NC PSI by working with NC State leadership, the External Advisory Council, and other NC PSI stakeholders to establish long-range goals, strategies, plans, and policies and to develop and engage a network of partners to make NC PSI the premier destination for plant sciences.

Essential Duties and Responsibilities

Reporting directly to the dean of NC State CALS and the Internal Management Committee, the executive director will make the NC PSI the premier destination for plant sciences by doing the following:

- Building a dynamic community of innovative researchers, to include faculty, postdoctoral scholars, students
- Developing and leading the NC PSI's strategic and technical vision
- Promoting and facilitating transdisciplinary research, innovation, entrepreneurship, and commercialization
- Developing strong linkages with other colleges and research centers across NC State and throughout North Carolina
- Developing partnerships with the private and public sectors, regionally, statewide, nationally, and internationally
- Acting as the nexus between the NC PSI and its broad group of stakeholders with respect to NC PSI research initiatives and subsequent economic benefits in order to communicate its impact and relevance
- Advising and evaluating the impact of NC PSI strategies, programs, and economic development initiatives
- Providing financial oversight to ensure financial health and sustainability by increasing internal and external research opportunities for faculty, postdoctoral fellows, and graduate students
- Providing oversight of systems that will improve the overall operation and effectiveness of the NC PSI
- Fundraising and growing an endowment for operational support

Qualifications

- Expertise in plant science research and commercialization, either within academia, industry, or government, or within a combination of all three
- A proven track record in organizational team building
- Prior leadership at a significant science-oriented or technology-oriented organization in academia, industry, government, or the nonprofit sector
- A commitment to building a world-class organization that will solve global grand challenges with relevancy to plant science research
- Experience and a commitment to advancing nontraditional transdisciplinary team science approaches and training
- Possession of the gravitas, professional credentials, and leadership ability required to lead an organization comprising world-class scientists and leading industry researchers while being responsive to the inputs of key external stakeholder groups in North Carolina
- A commitment to realizing the translation of innovations into commercial products, technologies, and solutions

Reporting Structure and Advisory Council

The executive director will report to the dean of NC State CALS and the Internal Management Committee. To help ensure that the NC PSI achieves its goal of being a world-class transdisciplinary research center, the Internal Management Committee will be composed of the following:

- Dean of the CALS (serving as committee chair)
- Dean of the College of Engineering
- Dean of the College of Sciences
- Dean of the College of Natural Resources
- Dean of the Poole College of Management
- Vice Chancellor for Research, Innovation, and Economic Development
- Provost

The executive director will also seek the counsel of an External Advisory Council composed of twelve individuals who serve as key champions and provide sound guidance and advice. The members of the External Advisory Council serve three-year terms with two members rotating off the council each year. The External Advisory Council consists of agbioscience industry, academic, government, innovation, and commercialization thought leaders.

Recommendation 4: Hire a Dedicated Commercialization and Entrepreneurship Director

Performing good science and making important discoveries on the frontiers of advanced agbioscience represent core goals of the NC PSI. The NC PSI is also being developed with an eye toward generating significant agbioscience-based economic development and job growth in North Carolina. This economic development may stem from enhancements to existing production agriculture (sustaining and growing agricultural productivity) and throughout the agbioscience value chain by commercializing innovations via existing, newly recruited, or startup NC agbioscience company operations.

One important finding that arose from *The North Carolina Plant Sciences Initiative: An Economic Feasibility Study*[7] was that our industry stakeholders need CALS to foster the creation of more small companies. Like the pharmaceutical industry, the plant science industry now has to reinvent itself, looking outside the walls of big agbiotech for early-stage innovation (adapted from B. Orelli, BioWorld™[8]). Agbioscience is a highly specialized business sector, sharing much in common with biomedical sciences in terms of the impact of the regulatory environment on business development, long time horizons from product conception to launch, and large-scale capital requirements to move products along the commercialization pipeline. Therefore, providing focused support to help understand the commercial market potential of research projects will be critical to the success of the NC PSI.

Similarly, any entrepreneurial plant sciences company will need support to bring innovative technologies through the proof-of-concept stage. Once proof of concept has been shown, these new companies would be targets for licensing, merger, or acquisition. Multiple potential challenges exist in the pathway from university innovation to successful acquisition. Not the least of these is the competing responsibilities placed on faculty, and the challenge of fostering “entrepreneurial” faculty and connecting them with regional entrepreneurs. The NC PSI has multiple opportunities to support, incentivize, and teach entrepreneurship to faculty.

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7. NC State University CALS and NC Department of Agriculture and Consumer Services. 2014, Dec. *The North Carolina Plant Sciences Initiative: An Economic Feasibility Study.* Raleigh: NC State University.

8. Orelli, Bryan. 2017. Pharma reinvents itself; experiments with innovation. BioWorld™. Philadelphia: PA: Clarivate Analytics. bioworld.com/content/pharma-reinvents-itself-experiments-innovation

The complexity of the agbioscience business-development ecosystem is such that it will behoove the NC PSI to have a dedicated commercialization and entrepreneurship director (CED). This person and his/her staff will work within the NC State Office of Technology Commercialization and New Ventures (OTCNV) to focus on assuring translation of discoveries to benefit North Carolina and will coordinate NC PSI approaches to the commercialization of innovations. The CED will wear many hats, but the position's key role will be to help ensure that the NC PSI evolves into a critical component of the NC business and economic development ecosystem.

The CED is an extremely important position and brings to the NC PSI a perspective and skill set that will complement those of the platform directors. The members of the Governance Task Force feel that close ties to producers and the agbioscience industry is a significant priority and that a deep understanding of the commercial needs of these stakeholders will help support the direction of NC PSI projects. By having a team in the building that concentrates on such tasks as commercialization, business development, business incubation services, and technology licensing, each platform director will have access to a professionally staffed resource for advancing innovations toward commercialization.

The Governance Task Force proposes that the CED be an OTCNV staff member who is housed within the Plant Sciences Building, reporting directly to the assistant vice chancellor for OTCNV with a dotted line of responsibility to the NC PSI executive director. Thus, all intellectual property (IP) generated by the NC PSI will be handled by OTCNV with regards to such issues as disclosures and patent filings. Under this staffing model, the Governance Task Force believes that the position must be dedicated to the NC PSI and not pulled in other directions or given other priorities. This clarity of role will be critical to the CED's success.

In partnership with OTCNV staff and other centralized procedures, the CED will facilitate commercialization. The Governance Task Force proposes that the CED will do the following:

- Actively scout for disruptive technologies and make connections early in faculty development of technology.
- Work with NC PSI developed innovations and IP to advance them along the commercialization pathway and maximize their value.
- Optimize the entrepreneurial environment for plant-science business startups, including building closer ties to the agbiotech community.
- Coordinate commercialization support programs.
- Leverage existing faculty and student technology entrepreneurship training and develop additional incubator and accelerator programming as needed.
- Raise innovation funds focused on agbiotech to secure access to earlier-stage pre-seed capital (proof of concept) and seed capital to advance technologies and early-stage business enterprise toward later equity capital and growth rounds.
- Develop a network of industry mentors focused on plant sciences.

The Governance Task Force also discussed whether the CED should build and manage an NC PSI incubator and accelerator and possibly oversee and run the proposed business incubation space, but ultimately concedes that these responsibilities may be more in the purview of NC State.

The CED will benefit from having a well-connected and diverse advisory council. While the final makeup of an advisory council should be decided by the NC PSI executive director and the CED, the following categories of members should be considered for the advisory council:

- Assistant vice chancellor for OTCNV
- Executive director of the NC State Entrepreneurship Initiative
- Executive director of the Entrepreneurship Collaborative in the Poole College of Management at NC State
- Business and technology acquisitions and relationship managers from local agbioscience companies, such as Bayer CropScience, BASF, Novozymes, and Syngenta
- Entrepreneurs based in North Carolina with experience in plant-science–oriented business startups
- Local biotech business incubator and accelerator leadership
- Head of the AgBio[sphere] program at the NC Biotechnology Center
- Representatives from venture capital funds investing in agbioscience business ventures
- Vice president for Business and Technology Development at the NC Biotechnology Center

It is important to note that a critical component of the CED's role will be to work within the existing NC State commercialization and entrepreneurship infrastructure, including the efforts undertaken by NC State's OTCNV. While the CED position within the NC PSI will be critical to ensure that "high touch" requirements for technology commercialization and entrepreneurship are met, it is extremely important that this position work collaboratively and effectively within the existing NC State infrastructure and elsewhere within the region to ensure that all assets are leveraged to the fullest. There should be no tolerance for creating a new "empire" or silo, nor for creating a redundancy of expertise and efforts.

Recommendation 5: Develop Guidelines for Project Life Cycle Management

NC PSI must have a diverse portfolio of projects representing not only various topics but also projects at different stages of the research life cycle. The following recommendations should be viewed as general guidelines for the NC PSI executive director and not as a blueprint that is set in stone.

In addition, while this recommendation is focused on project life cycle management, the Governance Task Force understands that the identified technology platforms must also evolve, not just the projects. Similar criteria for periodic review of the technology platforms should also be considered.

Finally, the performance of the overall NC PSI must also be continually assessed. CALS has developed a series of metrics for the Golden LEAF Foundation focused on defining success. (For more detailed information, please see Attachment G&L-D.) It is the intent to flow these measures down through to the project level. Not only do these metrics need to be incorporated into the criteria identified in the narrative that follows. They also must be used to ascertain the initiative's overall success. Furthermore, these metrics need to be communicated to faculty so that they clearly understand "what success looks like" for the NC PSI and thus how projects and performance will be measured.

With this overview in mind, the following guidelines are recommended for project life cycle management within the NC PSI.

Criteria for New Projects

We envision that space allocation would encourage a diverse project mix that includes either of the following:

- Recently funded large projects that fit within the platform areas that require transdisciplinary space due to the nature of the research and that could take advantage of core labs and equipment within the NC PSI Building.
- Seed grant projects (assuming funding is available) that are of high risk and high reward that fit within the platform areas and need assistance with the early stage of research development. These projects would be more exploratory in nature (proof of concept) and be considered high-risk starter grants.

Projects must meet the following conditions:

- Be transdisciplinary in scope.
- Have the potential to spin out IP, generate commercial products, and/or create startup companies. For longer-term, more basic research efforts, the projects must still be able to identify the industrial problem that the research is seeking to solve or the potential market demand for the research taking place.
- Able to take advantage of the core facilities within the building.

Projects should be selected after a proposal-based review by the executive director, Advisory Council, and technical subject matter experts (which may be different for each proposal) based on the following information:

- Scientific merit with viable technical plan including timeline and deliverables
- Research leadership team qualifications and experience with a history of successful extramural funding
- Fit into an NC PSI platform
- Translation potential and value creation plan
- Transdisciplinary and collaborative nature of research
- Principal investigators (PIs) with track records of solid research funding
- Business plan or similar commercialization plan and/or plan for follow-on funding
- Description of the rationale and significance of the project's expected outcome(s), including the economic benefit to North Carolina
- Market assessment
- Patentability assessment by OTCNV
- Regulatory assessment and engagement in ensuring a feasible regulatory environment
- Priority to projects that have secured funding

Projects could be selected via an open process similar to the Game-Changing Research Incentive Program (GRIP)[9] that is run by the NC State Office of Research, Innovation, and Economic Development and is intended to incentivize and support visionary research ideas that will result in large-scale extramural funding, award-winning research impacts, and first-class transdisciplinary graduate education and training. Further, there could be co-sponsorship by stakeholders.

9. NC State University. 2017, March. Game-changing Research Incentive Program (GRIP). research.ncsu.edu/rdo/funding/internal-funding/grip

Criteria for Ongoing Projects

Ongoing space allocation for projects should be based on a periodic review of each project – by the executive director, platform director, and platform advisory council – based on the following criteria:

- Technical progress – research productivity that is transdisciplinary
- Progress toward predetermined research and translation milestones based on a timeline
- Success in retaining and securing additional extramural funding
- Engagement of external audiences, industry, and stakeholders
- Alignment with the platform focus
- Integration of students and postdoctoral scholars and the value of their experience

While the guidelines outlined above provide the framework, we recommend that the NC PSI incorporate a rigorous milestone-based system to ensure that projects move through the research and commercialization pipeline to maximize the likelihood that desired outcomes are reached. Stage-Gate® is one such model that might serve as the basis for developing NC PSI's project management process. Stage-Gate® is a project management technique in which an initiative or project is divided into stages or phases, separated by gates. At each gate, the continuation of the process is decided by a manager or steering committee. The decision is based on information available at the time, including the business case, risk analysis, and the availability of necessary resources. (Attachment G&L-C provides more detailed information.)

Although we envision that all projects will work within a Stage-Gate® type of process as outlined above, the level of governance and oversight will be different (including review processes, timing, and outputs) depending on each project's length, size, and complexity. NC PSI leadership must have the ability to determine how the Stage-Gate® process will be managed for each project. There cannot be a "one size fits all" model for project life cycle management – that would be too deterministic. NC PSI leadership must be free to operate by having different models for project management.

Criteria for Closing Projects

Projects are to be closed when the following occur:

- Milestones are achieved.
- Funding ends and project is unable to attract new funds.
- Projects have proven to be nonproductive or non-transdisciplinary.
- Funding does not offset cost of space.
- Project results in a new company that moves to accelerator or incubator.
- Space is needed for an emerging threat identified within the field that is deemed to have a greater priority for research focus.

When projects are "closed," they respond as follows:

- Go back to home-department-based NC State labs for more work.
- Go to industry for commercialization.
- Transition into startup company opportunity.
- End if no new funding is available.

In any circumstance, it is understood that the NC PSI will make every attempt to ensure degree-earning students are supported to degree completion.

Recommendation 6: Allow for Physical Rotation of Space

To foster transdisciplinary research, we recommend that the physical space of the NC PSI be focused on creating networks, catalyzing interactions, and spurring multiple contact points. To accomplish this environment, research teams will need to be dynamic, with researchers and students cycling in and out of the building as projects evolve.

The Governance Task Force understands that there cannot be one single model for space rotation – projects will have varying periods of performance as well as varying sizes, which in turn will require different space configurations and durations. Due to this variability, we recommend that a mixed-model physical space rotation system be developed along the following guidelines:

- Executive director and operations staff – Permanent space in the building.
- Platform director and staff – Permanent space in the building and hoteling at department.
- Short-term project – Space in the department and hoteling at the NC PSI.
- Large, long-term projects – Lab space is provided in the NC PSI. The PI is provided office space in the NC PSI (although may choose to stay in their home department). Key postdocs or lead graduate students have space within the NC PSI.

Overall, space should be provided for projects, not specific individuals per se. We envision that "hotel space" would be provided for postdocs, graduate students, and undergraduates working on projects.

This vision will require that the architects design the building space with maximum flexibility as a prime consideration.

Governance Task Force members agreed that the NC PSI will need to clearly establish upfront its expectation that researchers will rotate in and out of the building. A contract should be developed to oversee project admittance into the NC PSI so that a clear understanding exists of how a researcher will return to his/her home department. We recommend that the Purdue and City University of New York (CUNY) models be more closely examined to determine applicability and feasibility to NC State.[10]

Once a project is granted space within the NC PSI, continuation of space will be based on the project life cycle management review, with progress being assessed based on the Stage-Gate® system. Therefore, it will be important that clear milestones are developed and understood. Review periods will need to align to the type of project (such as small commercialization focus versus large federally funded research project). We recommend that consideration should be given to developing a policy that would limit a researcher to five years, but with the possibility of extensions based on success.

10. The Governance Task Force undertook a benchmark analysis to better understand various organizational models being utilized by successful transdisciplinary centers (see Attachment G&L-E). Over the course of their work, Governance Task Force members benefited from conversations with both Dr. Gillian Small, former CUNY Vice Chancellor for Research, and Dr. Alan Rebar, NC State's Vice Chancellor for Research, Innovation and Economic Development and Purdue's former Senior Associate Vice President for Research and Executive Director of Discovery Park, who provided valuable insight into and information about these other centers' organizational models.

Among the advantages of rotation is that by rotating researchers back to the departments, the NC PSI is seeding these transdisciplinary concepts within the departments.

Recommendation 7: Provide Commercialization Support for NC PSI Projects

As part of the life cycle management process described in Governance Task Force Recommendation 5, the CED will work with OTCNV to assess projects for various commercial outcomes, including corporate partnerships, licensing, or the creation of a new business based on the IP being generated. To help support the creation of startup companies, the Governance Task Force recommends that the NC PSI create specific commercialization support vehicles, including the following:

- NC PSI Commercialization Mentor Network – envisioned as executives in residence who have specific plant science industry knowledge and can work with project teams to assess commercial viability of efforts.
- NC PSI Incubator – envisioned as a 6,000-square-foot set-aside within the building (5,000 square feet for shared laboratory and office space that is rented at a rate equal to the fully allocated costs of the NC PSI without overhead and 1,000 square feet of space for common-use equipment). Annual leases would be available to qualified startups that would be renewable for up to two years. The feasibility and implications of developing an NC PSI Incubator on-site needs to be further explored to understand the implications of housing private companies in a building financed by tax-exempt bonds. NC State's Office of General Counsel (Rob Hoon) and Office of Finance and Administration (Lori Johnson) should be consulted to better understand the issues at hand.
- NC PSI Seed Fund – envisioned as a source of risk capital for projects with proof-of-concept needs. The pre-seed fund would serve as an early round of financing that is designed to help a company achieve certain intermediate milestones to become more attractive for later-stage risk capital investments. The NC PSI Seed Fund will need to be capitalized so funds can be invested in such opportunities. It is suggested that the Chancellor's Innovation Fund (funding that is available to advance the development of technologies with commercial potential of about $75,000, mentor support, and project management) be explored and leveraged if possible.

Recommendation 8: Ensure NC State's Organizational Culture (Including its Reappointment, Promotion, and Tenure Policies and Practices) Recognizes, Fosters, Supports, and Rewards Commercialization and Entrepreneurship Activities

The Association of Public and Land-grant Universities (APLU) report, *Consideration of Technology Transfer in Tenure and Promotion* (November 17, 2015), states that "the historical tri-partite mission of a public research university in teaching, research, and service has often been expanded to include economic development." The APLU report goes on to state that faculty activity in technology transfer and commercialization are therefore an important part of the university mission and should be rewarded. While NC State's *Reappointment, Promotion,*

and Tenure Policy already includes a specific[11] statement that is supportive of recognizing technological and managerial innovation, we recognize that the overall "culture" of the university must continue to evolve to ensure that commercialization and entrepreneurship activities are recognized and valued. This will also require a shift in mindset on campus to ensure that the value of commercialization and entrepreneurship is appreciated at both the college and department levels as well as among the voting faculty.

In addition, the formation of transdisciplinary research teams needs to be recognized as a metric for reappointment, promotion, and tenure to clearly illustrate that NC State values transdisciplinary teamwork. Nuanced metrics could include proceedings and their relative importance in different disciplines as compared with peer-reviewed publications.

The lack of an innovation culture is further exacerbated by a lack of understanding of the commercial market and its opportunities. Overall, the issue is not one of financial capital or physical infrastructure, but instead of human capital – the individuals who can understand a good idea and bring it to the market. NC State must stand ready to support faculty and students who are already entrepreneurial, or are capable of being so, and "catch them in the act of entrepreneurship" through projects of the NC PSI.

Entrepreneurial education opportunities are important because they are the first step in changing the culture of an organization. Entrepreneurship education is likely to require a mix of formal classroom training and non-classroom-based education, including mentorship. NC State has already developed a series of courses and other programs and initiatives (see Attachment G&L-C) that CALS and the NC PSI should leverage.

Recommendation 9: Create an NC PSI Implementation and Launch Advisory Council

The overwhelming recommendation that NC State CALS received in its external review of the NC PSI strategic plan was that the success or failure of the NC PSI will hinge on the establishment of strong leadership early in the project. As such, CALS, with support from the NC Farm Bureau, has established the position of NC PSI launch director as a crucial first step in building the leadership team that will drive the NC PSI forward. The launch director will serve prior to the recruitment of the executive director and will be the strategic lead for the NC PSI during the nascent phase of the project before the completion of the Plant Sciences Building on Centennial Campus. Among the launch director's top responsibilities will be building a high-performing scientific program to meet NC PSI's impact goals, as well as leading the processes of planning and implementing the Initiative's organizational structure.

Developing an effective implementation and launch plan for the NC PSI will be a complex endeavor calling for a wide range of expertise and the ability to bring together the variety of recommendations and ideas that the various task forces will have generated. The launch director will benefit from having a well-connected and diverse advisory council. While the final makeup of a Launch Advisory Council should be decided by the launch director and NC State leadership, we suggest that a select number of members from the various task forces continue to be consulted if deemed helpful as the launch plan is developed.

In addition, the following recommendations will need to be acted upon in preparation for operating the NC PSI during the launch period:

- Engage in continued communication with NC PSI stakeholders to ensure a successful start of the NC PSI.
- Begin identifying fundraising sources and opportunities to initiate the funding portfolio for the NC PSI and NC PSI Seed Fund.
- Draft a defined rubric for evaluating proposed projects and project teams entering the NC PSI that includes recommended guidelines from this report and those established by the Golden LEAF Foundation. This rubric should be shared with the NC State community to foster transparency in populating the NC PSI.
- Begin budgetary planning, including allocation of staff positions.

Attachment G&L-A:
Governance and Leadership Task Force Members

Co-chairs

Michiel van Lookeren Campagne, Head, Seeds Research, Syngenta

Amy Grunden, Professor of Microbiology, Plant and Microbial Biology, NC State

Members

- Luke Bozeman, Director of Research and Development, BASF Crop Protection
- Ruben Carbonell, Executive Director, Kenan Institute for Engineering, Technology and Science; Director, Golden LEAF Biomanufacturing Training and Education Center (BTEC), NC State
- Fred Gould, William Neal Reynolds Professor of Entomology and Plant Pathology, NC State;
  Co-director, Genetic Engineering and Society Center, NC State
- Denis Gray, Professor of Psychology, NC State
- Ulf Groeger, Vice President, Global Research Fungicides, BASF Crop Protection
- Charles Hall, Chief Executive Officer, NC Soybean Producers Association
- Richard Kouri, Professor of the Practice, Management, Innovation, and Entrepreneurship, NC State
- Karen LeVert, President, Southeast TechInventures; Chief Operating Officer, Ag TechInventures
- Terri Lomax, Executive Vice President of Discovery-Science-Technology, RTI International
- David Marshall, Professor of Entomology and Plant Pathology and the U.S. Department of Agriculture–Agricultural Research Service (USDA–ARS) Plant Science Unit Research Leader, NC State
- Alan Rebar, Vice Chancellor, Office of Research, Innovation, and Economic Development, NC State
- Michael Tiemann, Vice President, Open Source Affairs, Red Hat

Attachment G&L-B:
Commercialization and Entrepreneurship Sub Task Force Members

Co-chairs

Mark Stowers, Vice President and Global Head of Research and Development, HM Clause

Deborah Thompson, Director of Research Partnerships, CALS, NC State

Members

- Amy Grunden, Professor of Microbiology, Plant and Microbial Biology, NC State
- Richard Kouri, Professor of the Practice, Management, Innovation and Entrepreneurship, NC State
- Karen LeVert, President, Southeast TechInventures; Chief Operating Officer, Ag TechInventures
- Steve Markham, Professor, Poole College of Management, NC State; Director, The Entrepreneurship Collaborative, Department of Management, Innovation and Entrepreneurship, NC State
- Adam Monroe, President, Novozymes North America
- Kelly Sexton, Assistant Vice Chancellor, OTCNV, NC State
- Scott Uknes, Founder, Co-Chief Executive Officer, Vice President of Paradigm Genetics (PDGM) and Director, AgBiome
- Michiel van Lookeren Campagne, Head, Seeds Research, Syngenta

Attachment G&L-C:
Commercialization and Entrepreneurship Sub Task Force

Background

Performing good science and making important discoveries on the frontiers of advanced agbioscience represent core goals of the NC PSI. The NC PSI is also being developed with an eye toward generating significant agbioscience-based economic development and job growth in North Carolina. This economic development may stem from enhancements to existing production agriculture (sustaining and growing agricultural productivity) and through the commercialization of innovations by existing, newly recruited, or startup NC agbioscience company operations.

One clear guidance that arose from *The North Carolina Plant Sciences Initiative: An Economic Feasibility Study* was that our industry stakeholders need CALS to create more small companies. Like the pharmaceutical industry, the plant science industry now has to reinvent itself, looking outside the walls of big agbiotech for early-stage innovation (adapted from B. Orelli, BioWorld™[12]). Agbioscience is a highly specialized business sector, sharing much in common with biomedical sciences in terms of the impact of the regulatory environment on business development, long time horizons from product conception to launch, and large-scale capital requirements to move products along the commercialization pipeline.

Similarly, any entrepreneurial plant sciences company will need support to bring innovative technologies through the proof-of-concept stage. Once proof of concept has been shown, these new companies would be targets for licensing, merger, or acquisition. Multiple potential challenges exist in the pathway from university innovation to successful acquisition. Not the least of these is the competing responsibilities placed on faculty, and the challenge of fostering "entrepreneurial" faculty and connecting them with regional entrepreneurs. The NC PSI has multiple opportunities to support, incentivize, and teach entrepreneurship to faculty.

This white paper lays out a series of recommendations, within the context of the work already conducted by the NC PSI Governance Task Force, to help ensure that commercialization outcomes are embedded into the projects of the NC PSI.

NC PSI Commercialization and Entrepreneurship Recommendations

Recommendation 1: Hire a Dedicated Commercialization and Entrepreneurship Director

Due to the complexity of the agbioscience-business development ecosystem, the NC PSI study recommended the creation of a commercialization and entrepreneurship director (CED), dedicated to the NC PSI. This person and his/her staff will collaborate with the Office of Technology Commercialization and New Ventures (OTCNV) to focus on assuring translation of discoveries to benefit North Carolina and will coordinate NC PSI approaches to the

12. Orelli, Bryan. 2017. Pharma reinvents itself; experiments with innovation. BioWorld™. Philadelphia: PA: Clarivate Analytics. bioworld.com/content/pharma-reinvents-itself-experiments-innovation

commercialization of innovations. The CED will wear many hats, but the key role will be to help ensure that the NC PSI evolves into a critical component of the NC business and economic development ecosystem.

The CED is an extremely important position and brings to the NC PSI a perspective and skill set that will complement those of the platform directors. The members of the task force feel that close ties to producers and the agbioscience industry is a significant priority and that a deep understanding of the commercial needs of these stakeholders will help support the direction of NC PSI projects. By having a team in the building that concentrates on such issues as commercialization, business development, business incubation services, and technology licensing, each platform director will have access to a professionally staffed resource for advancing innovations toward commercialization.

The task force proposes that the CED be an OTCNV staff member who is housed within the Plant Sciences Building, reporting directly to the assistant vice chancellor for OTCNV with a dotted line of responsibility to the NC PSI executive director. Thus, all intellectual property (IP) generated by the NC PSI will be handled by OTCNV with regards to such actions as disclosures and patent filings. Under this staffing model, the Commercialization Sub Task Force believes that it will be critical to ensure that the position is dedicated to the NC PSI and not pulled in other directions or given other priorities.

In partnership with OTCNV staff and other centralized procedures, the CED will facilitate the commercialization process. The task force proposes that he/she will do the following:

- Actively scout for disruptive technologies and make connections early in faculty development of technology.
- Work with NC PSI–developed innovations and IP to advance them along the commercialization pathway and maximize their value.
- Optimize the entrepreneurial environment for plant-science business startups, including building closer ties to the agbiotech community.
- Coordinate commercialization support programs.
- Leverage existing faculty and student technology entrepreneurship training and develop additional incubator and accelerator programming as needed.
- Raise innovation funds focused on agbiotech to secure access to earlier-stage pre-seed (proof of concept) and seed capital to advance technologies and early-stage business enterprise toward later equity capital and growth rounds.
- Develop a network of industry mentors focused on plant sciences.

The task force also discussed whether the CED should build and manage a NC PSI incubator and accelerator and possibly oversee and run the proposed business incubation space, but ultimately concedes that these responsibilities may be more in the purview of NC State.

It is important to note that a critical component of the CED's role will be to work within the existing NC State commercialization and entrepreneurship infrastructure, including the efforts undertaken by NC State's OTCNV. While the CED position within NC PSI will be critical to ensure that "high touch" requirements for technology commercialization and entrepreneurship are met, it is extremely important that this position work collaboratively and effectively within the existing NC State infrastructure and elsewhere within the region to ensure that all assets are leveraged to the fullest. There should be no tolerance for creating a new "empire" or silo, nor for creating a redundancy of expertise and efforts.

Recommendation 2: Create a Commercialization and Entrepreneurship Advisory Council

Business development and commercialization of technology in plant sciences is a complex space calling for expertise in entrepreneurship, technology transfer, technology evaluation and market assessment, capital access, business incubator operations, state incentive programs, and small business innovation research (SBIR) programs, and business acquisitions, to name just a few areas. The CED will benefit from having a well-connected and diverse advisory council. While the final make-up of an advisory council should be decided by the NC PSI executive director and the CED, the following categories of members should be considered for the advisory council:

- Assistant vice chancellor for OCTNV
- Executive director of the NC State Entrepreneurship Initiative
- Executive director of the Entrepreneurship Collaborative in the Poole College of Management at NC State
- Business and technology acquisitions and relationship managers from local agbioscience companies such as Bayer CropScience, BASF, Novozymes, and Syngenta
- Entrepreneurs based in NC with experience in plant-science-oriented business startups
- Local biotech business accelerator and incubator leadership
- Head of the AgBio[sphere] program at the NC Biotechnology Center
- Representatives from venture capital funds investing in agbioscience business ventures
- Vice president for business and technology development at the NC Biotechnology Center.

Recommendation 3: Develop Guidelines to Ensure Projects Include a Commercialization Focus

The NC PSI Governance and Leadership Task Force has proposed that projects applying for space in the Plant Sciences Building should meet the following conditions:

- Be transdisciplinary.
- Create economic benefit to North Carolina.
- Have the potential to generate valuable IP, generate commercial products, and/or create startup companies.
- Be able to take advantage of the core facilities within the building.
- Possess sufficient funding to meet the fully allocated costs of operating within the NC PSI.

Further, we envision that space allocation would encourage a diverse project mix:

- Recently funded large projects that fit within the platform areas that require transdisciplinary space due to nature of the research and could take advantage of core labs and equipment within the Plant Sciences Building.
- Seed grant projects (assuming funding is available) that are of high risk and high reward that fit within the platform areas and need assistance with proof-of-concept stage of research development. These would be more exploratory in nature (proof of concept) and be considered high-risk starter grants.

To meet these goals and objectives, the following guidelines are suggested for all projects being proposed for admittance to the NC PSI.

Suggested Guidelines for NC PSI Proposal Preparation and Evaluation

Preparation

- All prospective research leaders are required to attend an orientation to the NC PSI which will consist of four modules: research plan and budget preparation for the NC PSI, IP management, economic analysis of the project, and communicating ideas.

Preproposal

- Preproposals (two pages) are required for all projects.
- Preproposals are intended to demonstrate that the project will meet the project requirements and have the potential for a high project score.
- Preproposals must be reviewed and advanced by the NC PSI executive director supported by an ad hoc review panel representing multiple scientific and technical disciplines and business expertise.

Proposal

- Scientific merit with viable technical plan including timeline and deliverables
- Research leadership team qualifications and experience with a history of successful extramural funding
- Fit into an NC PSI technology platform
- Collaborative in nature
- Commercialization plan and/or plan for follow-on funding
- Priority to projects already funded that meet project scope and scoring requirements
- Economic benefit to North Carolina
- Reviewed and advanced by the NC PSI executive director supported by an ad hoc review panel representing multiple scientific and technical disciplines and business expertise

Suggested Guidelines for Business and Economic Elements in All NC PSI Proposals

Preproposal and Proposal (increased level of detail in proposal)

- Description of the rationale and significance of the project's expected outcome(s)
- Patentability assessment by OTCNV
- Regulatory assessment and engagement in ensuring a feasible regulatory environment
- Business plan or similar commercialization plan validated by assigned commercialization mentor

Suggested Guidelines for Project Governance

Annual Reviews for All Projects Based on the Following Assessment Criteria

- Compliance with the project requirements
- Alignment with the platform focus
- Consistency with the original research plan
- Integration of students and postdoctoral scholars and the value of their experience
- Facilitation of project life cycle management (management of each phase of project development – from initiation, through planning, execution, and closure)
- Completion by an ad hoc committee of scientific, technical, and business experts

Publication and Communications Approval Process

- Compliance with all NC State policies and regulations
- Compliance with NC State IP policies – to encourage the filing of patent applications on promising inventions

Engagement with Assigned Commercialization Mentor

- The assigned commercialization mentor is placed with the research leader to provide support for potential business and commercial opportunities.
- Research leader and commercialization mentor should meet quarterly to review project progress.

Suggested Guidelines for NC PSI Functions Supporting Project Development and Management

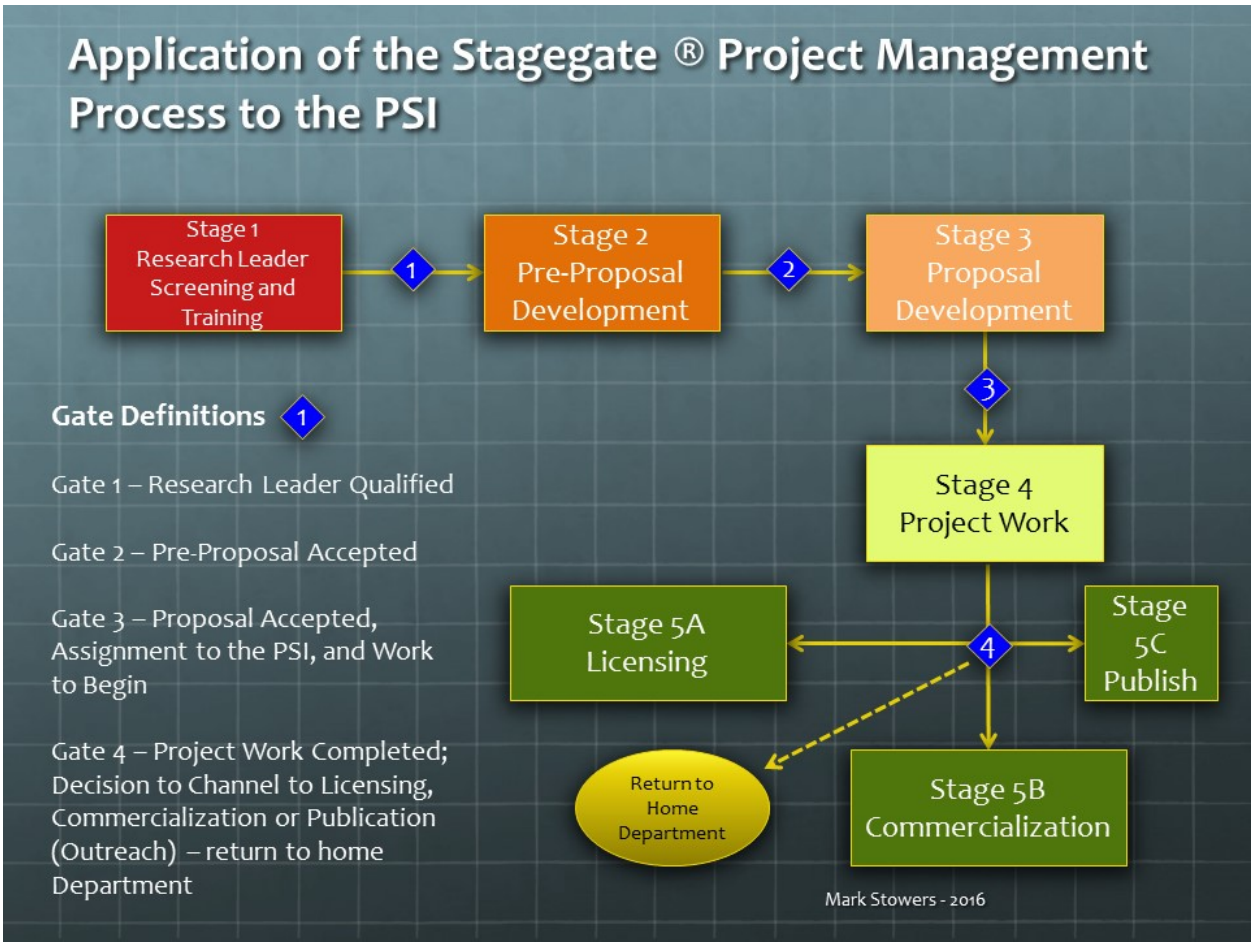
- Preproposal Review – The NC PSI executive director, CED, each platform director, and ad hoc reviewers representing relevant scientific, technical, and business expertise appointed by the NC PSI executive director
- Proposal Review – The NC PSI executive director, CED, each platform director, and ad hoc reviewers representing relevant scientific, technical, and business expertise appointed by the NC PSI executive director
- Annual Reviews – Platform advisory council with ex officio representatives: platform director, NC PSI executive director, and CED.

Recommendation 4: Implement a Stage-Gate® Project Management Approach

While the guidelines outlined above provide the process framework, the NC PSI will need to incorporate a rigorous milestone-based system to ensure that projects move through the research and commercialization pipelines to maximize the likelihood that desired outcomes are reached. One such model is discussed below in further detail. This discussion might serve as the basis for developing NC PSI's project management process:

- Stage-Gate® is a project management technique in which an initiative or project is divided into stages or phases, separated by gates. At each gate, the continuation of the process is decided by a manager or steering committee. The decision is based on information available at the time, including the business case, risk analysis, and the availability of necessary resources.
- The focus will be to address business and commercial elements of the NC PSI project(s), but this general approach could be applied to the scientific, technical, and budget-related aspects of an NC PSI project.

Figure G&L-C-1. Application of the Stage-Gate® Project Management Process to the NC PSI



Stage 1 – Screening and Training

- Initial Proposal Concept Review and Research Leader Qualification Review – Approval by NC PSI executive director, platform directors, and department chair
- Research Leader Training – To be developed and provided by NC State faculty or other relevant persons and coordinated by the CED
    - Research plan and budget preparation for the NC PSI
    - IP management
    - Economic analysis of the project, which should include companies or other external stakeholders who are interested in the research and specifically why they are interested (i.e., the perceived economic benefit and impact of the research)
    - Communicating ideas
- Gate 1
    - Research leader is qualified after approval from NC PSI executive director, platform directors, and department chair, and completion of research leader training.
    - Commercialization mentor for research leader is assigned (mentor pool is needed, such as, executives in residence) to support the development of the

project concept, business basis for the project, and conformance to preproposal guidelines.
    - Research leader can develop preproposal for approval to enter the NC PSI with a project plan.

Stage 2 – Preproposal Development

- Preproposal Guidelines
    - Description of the rationale and significance of the project's expected outcome(s)
    - Expected deliverables that result in patent applications (including high-level assessment of competing patent landscape)
    - Assessment of the potential for regulatory review, such as GMO, new food, or new drug
    - Market assessment and valuation
    - Expected commercial outcome, such as license (including possible companies that might be interested in the project), startup, or other
- Gate 2
    - Preproposal is accepted, and the research leader is requested to develop and submit a proposal.
    - Engagement continues with the assigned commercialization mentor.

Stage 3 – Proposal Development

- Proposal Guidelines
    - Detailed description of the rationale and significance of the project's expected outcome(s)
    - Detailed description of the expected deliverables that result in patent applications (including high-level assessment of competing patent landscape)
    - Detailed assessment of the potential for regulatory review, such as GMO, new food, or new drug
    - Detailed assessment of market and valuation
    - Detailed description of the expected commercial outcome, such as license, startup, or other
- Gate 3
    - Proposal is accepted.
    - Research leader, department chair, and NC PSI management negotiate the transition to the NC PSI.
    - Engagement continues with the assigned commercialization mentor.

Stage 4 – Project Work

- Semiannual Project Reviews
    - Compliance with the project requirements
    - Alignment with the platform focus
    - Integration of students and the value of their experiences
    - Facilitation of the project life cycle management
    - Completion by an ad hoc committee of scientific, technical, and business expertise
    - Project life cycle management – NC PSI management team
    - Portfolio of projects reviewed annually to determine the projected vacancy (or availability to accept new projects)
    - Commercial development of all projects completed annually, and outcomes reported to the NC PSI executive director
- Gate 4

    - Project completed

Decision to proceed with licensing, commercialization, or outreach (publication)

Stage 5 – Project Deliverables

- Stage 5A – Licensing
    - Faculty partnering with potential licensees
    - Facilitated by the CED and managed by the NC State OTCNV
        - Developed and executed by OTCNV – Nondisclosure agreements, material transfer agreements, sponsored research (in collaboration with sponsored programs), licenses, startup licenses, and equity agreements
- Stage 5B – Commercialization (definition and detailed description to follow in next recommendation)
    - Allocation to NC PSI Incubator – NC PSI-related potential startups through incorporation and subsequent financing; managed by OTCNV in coordination with the CED
- Stage 5C – Outreach and Publication
    - Approved by the NC PSI executive director in compliance with NC State guidelines

Return to "Home" Department

- As projects are completed, faculty research leaders are expected to return to their "home" departments.
- NC PSI executive director, home department chair, and faculty research leaders affect a transition from the NC PSI to the department.

Recommendation 5: Provide Commercialization Support for NC PSI Projects (Stage 5B)

Commercialization Process

- New Business Launch Preparation (Qualification Process)
    - Prior to project completion, the CED with research leaders and assigned commercialization mentor identify Stage 5 scenarios and facilitate NC PSI project exit to Stage 5A or Stage 5B.
    - Interim leadership is secured.
    - Opportunity Plan is developed with assigned commercialization mentor, leveraging training and education opportunities through OTCNV's Investor Ready Business Course for research leaders.
    - Management team is identified.
    - Investor pitch is developed and introduced to potential investors.
- New Business Launch and Incubation
    - Project funded that has the potential to spin out as startup (early-stage proof-of-concept funding)
    - Partnered with NC PSI governance
    - Utilization of corporate lab suites at incubation space (6,000 square feet) within the NC PSI
- Sustainable Business – Moves away from the NC PSI

NC PSI Incubator Governance

The feasibility and implications of developing an NC PSI Incubator on-site needs to be further explored to understand the implications of housing private companies in a building financed by

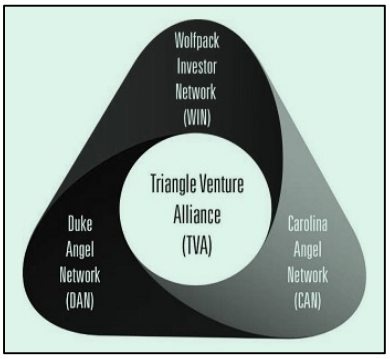
tax-exempt bonds. NC State's Office of General Counsel (Rob Hoon) and Office of Finance and Administration (Lori Johnson) should be consulted to better understand the issues at hand. Ideally, we envision that an NC PSI Incubator could be developed that would allow for the following:

- Annual leases to qualified startups renewable up to two years
- Allocation of 6,000 square feet of laboratory space from corporate lab suites (in current conceptual space allocation for the Plant Sciences Building)
- Space usage – 5,000 square feet for shared laboratory and office space, which is rented at a rate equal to the fully allocated costs of the NC PSI without overhead, and 1,000 square feet of space for common-use equipment
- Operating costs of the Incubator to the NC PSI – Employment costs of a lab manager who is responsible for the day-to-day running and maintenance of the lab and equipment
- Capital equipment – funded through the NC PSI, NC State, or donations.

Commercialization Support

- Commercialization and Entrepreneurship Director
  - Member of the NC PSI management team
  - Primary person responsible for the translation of projects to businesses
- NC PSI Commercialization Mentor Network
  - CED managed
  - Executives in residence for all NC PSI research leaders
- University Level Support
  - Investor Ready Business Plan Course (Poole College of Management Technology Entrepreneurship and Commercialization, TEC)
  - Chancellor's Innovation Fund (funding to advance the development of technologies with commercial potential about $75,000, mentor support, and project management)
  - Executive in Residence (OTCNV)
  - Wolfpack Investor Network (WIN)
- Area Support
  - Venture Mentor Service (Council for Entrepreneurial Development)
  - NC Biotechnology Center
  - Blackstone Entrepreneurs Network
  - NC Center of Innovation Network (COIN)
  - Triangle Venture Alliance

Figure G&L-C-2. Triangle Venture Alliance



Budgetary Needs

We recommend funding sources be identified early, in harmony with and not duplicative to existing university level or other resources. We anticipate three areas where that funding would be needed to sustain these efforts:

- Support of a commercialization mentor network – executives in residence
- Support for business plan development (economic and other analyses)
- Capital expenses for equipment in a common core lab

CALS Commercialization and Entrepreneurship Recommendations

The success of NC PSI's efforts is predicated on the ability of NC State to foster a culture of commercialization and entrepreneurship among its faculty and staff. To this end, the following recommendations are made.

Recommendation 6: Ensure CALS Faculty Promotion and Tenure Metrics Recognize and Reward Commercialization and Entrepreneurship Activities

The Association of Public and Land-grant Universities (APLU) report, *Consideration of Technology Transfer in Tenure and Promotion,*[13] states that "the historical tri-partite mission of a public research university in teaching, research, and service has often been expanded to include economic development." They report goes on to state that faculty activity in technology transfer and commercialization are therefore an important part of the university mission and should be rewarded. While NC State's *Reappointment, Promotion, and Tenure Policy*[14] already includes a specific statement that is supportive of recognizing technological and managerial innovation, we recognize that the overall "culture" of NC State must continue to evolve to ensure that commercialization and entrepreneurship activities are recognized and valued. This will also require a shift in mindset on campus to ensure that the value of commercialization and entrepreneurship is appreciated at both the college and department levels as well as among the voting faculty.

In addition, transdisciplinary research teams need to be recognized as a metric for reappointment, promotion, and tenure to clearly illustrate that NC State values transdisciplinary teamwork. Nuanced metrics could include proceedings and their relative importance in different disciplines as compared with peer-reviewed publications.

Recommendation 7: Foster Entrepreneurial Faculty

The lack of an innovation culture is further exacerbated by a lack of understanding of the commercial market and opportunities. Overall, the issue is not one of financial capital or physical infrastructure, but instead of human capital – the individuals who can understand a good idea and bring it to the market. CALS must stand ready to support faculty who are already, or are capable of being, entrepreneurial and "catch them in the act of entrepreneurship" through projects of the NC PSI.

It will be important to focus on students in addition to faculty when examining models of entrepreneurship. The undergraduate model for entrepreneurship can typically be faster than the graduate model as the technological complexity of the inventions created is lower. Many

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13. Genshaft, Judy, Jonathan Wickert, Bernadette Gray-Little, Karen Hanson, Richard Marchase, Peter E. Schiffer, and R. Michael Tanner. 2015, Nov 17. *Consideration of Technology Transfer in Tenure and Promotion*. Washington, DC: Association of Public and Land-grant Universities.

14. NC State University, Office of the Executive Vice-Chancellor and Provost. 2017. *Reappointment, Promotion, and Tenure Policy.* Raleigh: NC State. provost.ncsu.edu/faculty-resources/reappointment-promotion-and-tenure

faculty prefer to allow a third party to take the lead as the entrepreneur to launch a startup company based on a faculty research discovery. In some cases, this may be a graduate student or postdoc; in other cases, the third party may be an entrepreneur who is external to NC State. Either way, this model has the advantage of allowing the faculty member to retain both a tenured position and an interest in the company as the scientific advisor. The conversation with faculty should be on how their research can transfer into the marketplace with an entrepreneurial partner.

To empower graduate students and postdoctoral fellows to take leadership roles within startup companies, the graduate program office will need to integrate entrepreneurial educational components into the curriculum, recognizing that many students will not remain in academia, but instead will go into industry or startup companies.

Entrepreneurship education is likely to require a mix of formal classroom training and non-classroom-based education, including mentorship. North Carolina and NC State University have already developed a series of courses and other programs and initiatives that CALS and NC PSI should leverage, including the following:

- The OTCNV has approximately 75 executives in residence dedicated to work with NC State faculty. It has also recently applied for a National Science Foundation (NSF) I-Corps Site award.
- The OTCNV offers twice-yearly PackStart Workshops to provide NC State startup teams with access to information and resources needed to launch startup companies.
- The Poole College of Management TEC coursework.
- Blackstone Entrepreneurs Network.
- The Council for Entrepreneurial Development and NC State's OTCNV have partnered to offer entrepreneurship mentoring to university startups. The Venture Mentor Service program is licensed by the Council for Entrepreneurial Development from MIT.
- NC Center of Innovation Network (COIN) is an inclusive member network bringing together scientists, technologists, and engineers, as well as those industries that impact their growth.
- NC Biotechnology Center (NCBiotech) has programs that support biotechnology startup companies including free guidance on business development and low-interest loans.

Attachment G&L-D:
Outcome Metrics for Golden LEAF Foundation

	AGRICULTURE
1.	**Number of new plant varieties developed and disclosed for commercialization and breeding lines disclosed for breeding use by NC State and public and private breeders (annual report)**
2.	**Value (economic) of NC PSI–developed plant varieties and breeding lines (all crops)**
3.	**Number of county tests (research and demonstration) containing NC PSI–developed (or in-development) varieties in rural communities (test farms, private land, and research stations)**
4.	**Number of novel technologies developed by NC PSI**
5.	**Licensed patented technologies and any associated startups**
	ECONOMIC DEVELOPMENT
6.	**Number of new plant sciences positions employed in North Carolina, and its regions (mountains, piedmont, and coastal plain)**
7.	**Number of positions and percentage of growth in the plant sciences private sectors: tobacco production; agricultural chemicals; bioprocessing; fruit and vegetable production; agricultural machinery and equipment; nursery/floriculture and other food crops; other crop production; cotton production; bean and grain production; agricultural production services**
8.	**Growth in NC employment change (percentage of growth) in the plant sciences sector for NC workers compared with U.S. workers in the following classifications:** • Agricultural/Plant-Related Research and Development • Tobacco Production • Agricultural Chemicals • Bioprocessing • Fruit and Vegetable Production • Agricultural Machinery and Equipment • Nursery/Floriculture and Other Food Crops • Other Crop Production • Cotton Production • Bean and Grain Production • Agricultural Production Services • Agricultural Product Wholesale • Enabling Agricultural Technologies • Agricultural Efficiency Services (i.e., water savings).

9.	**Average annual wages in the plant sciences sector for NC workers compared with U.S. workers in the following classifications:** • Agricultural/Plant-Related Research and Development • Tobacco Production • Agricultural Chemicals • Bioprocessing • Fruit and Vegetable Production • Agricultural Machinery and Equipment • Nursery/Floriculture and Other Food Crops • Other Crop Production • Cotton Production • Bean and Grain Production • Agricultural Production Services • Agricultural Product Wholesale
10.	**Track changes in yield values for selected crops in NC by product and county.** • Use baseline of soybeans, tobacco, blueberries, sweet potatoes, tomatoes, and peanuts. • Use NC Department of Agriculture information to track changes in yield values.
11.	**Dollar value of sponsored programs (research contracts and grants from NC commodity groups, private companies, and government grants) to engage CALS faculty in NC PSI relevant** research and development
12.	**NC PSI gifts/support** • Track success for NC PSI–related gifts and support
	WORKFORCE PREPAREDNESS AND EDUCATION
13.	**Increased number and career readiness of undergraduate, graduate, and Agricultural Institute students majoring in plant science fields** a. Number of undergraduate, graduate, and Agricultural Institute students majoring in plant science fields and in related fields, such as agricultural and resources economics, biological and agricultural engineering, and entomology and plant pathology b. Increasing number of students from other colleges at NC State taking agriculture and plant sciences courses c. Percentage of graduates who remain in North Carolina after graduation d. Percentage of students participating in career development activities, such as internships, study abroad experiences, and research experiences
14.	**Number of plant science–related credentials or certifications earned by individuals attending Cooperative Extension programs.**
15.	**Cooperative Extension–based plant sciences programing**: • Number of participants attending Cooperative Extension plant science educational programs • Number of face-to-face plant-science-related Cooperative Extension contacts • Number of non–face-to-face plant-science-related Cooperative Extension contacts

Attachment G&L-E:
Best Practices Analysis of Transdisciplinary Research Institutes

The Governance Task Force undertook a benchmark analysis of three transdisciplinary centers of a similar nature to ascertain how they handled certain aspects of their operations. Four centers were asked to participate, and the following three were willing to share information:

- City University of New York (CUNY) Advanced Science Research Center
- Purdue University Birck Nanotechnology Center
- Virginia Tech Institute for Critical Technology and Applied Science.

The information collected during interviews with the center directors is provided below.

CUNY Advanced Science Research Center

Responses were provided by Dr. Gillian Small – former Vice Chancellor for Research, CUNY, and Executive Director of the CUNY Advanced Science Research Center.

"The ASRC focuses on CUNY initiatives in five dynamic fields of applied science: Nanoscience, Photonics, Structural Biology, Neuroscience, and Environmental Sciences. Through its innovative architectural design, the center reflects a uniquely collaborative culture, where scientists work across disciplines to take on some of global science's most vital and tantalizing challenges."[15]

1. **How does the CUNY Advanced Science Research Center measure the performance or success of individual projects as well as individual PIs/faculty that use your facilities?** How do these metrics then play into who stays within the facility and who is asked to leave?

There are four ways in which faculty are admitted into the ASRC:

(1) The ASRC does have a core of permanent top-level scientists over each of five theme areas for the building. They have a lab and offices in the building on renewable five-year terms. Each of these directors also were given ability to hire three new faculty, each who would be admitted on the same deal. So, there is a core of 20 implanted faculty in the building who do NOT have offices at their home colleges/departments. These all have reduced teaching loads. These faculty were selected independent of department needs, and candidates were even allowed to select to what CUNY department they would like to be attached.

(2) Many faculty come just to use the core facilities in the building, and they have no office or assigned space.

(3) There are "affiliate" positions for which faculty can apply. To qualify, they need to demonstrate project need and a research connection with one or more of the 20 permanent faculty in the building. This is designed to assure collaboration occurs. They have a formal committee that reviews applications. They receive office and bench space on one-year renewable terms. Typically, they keep their offices/labs in their own department (they have found it very difficult for faculty to take a risk on giving up home

15. City University of New York (CUNY). 2017. Advanced Science Research Center. New York: CUNY. asrc.cuny.edu

department space when only assured one-year access – even though it is renewable). Most of these affiliates use the building circa one to two days a week, have a locker in the building, and then work from their home department the rest of the week.

(4) There are "longer-term affiliates" who can get space on a longer-term basis, again via an application process. They would need to have major funding. Whatever term they are given would again likely be renewable upon review.

Her recommendation to the PSI is to have an agreed term of admission to the PSI and then make that a renewable term upon review. Key review parameters would relate to collaboration with others in the building and success in bringing in external funds.

2. **How is space at the CUNY Advanced Science Research Center rotated with normal academic/department space?** In other words – whether or not a PI's project is successful – eventually all projects may come to an end and faculty working on those projects will presumably no longer be in need of space at the Center. How does an "expat," so to speak, return home to their department and be guaranteed lab space after significant time "away" at the Center? What sort of arrangements, or guarantees, if any, were made by departments or the Center in advance for such an eventuality?

As noted above, most affiliates are on one-year renewable project terms and have retained their home department offices and labs. They have not yet had a situation where an affiliate gave up home department space.

She recommended that, if PSI used longer affiliate cycles of two to three years, then perhaps home department space could be temporarily vacated with an agreement to revert back if needed. So, a department would need to find a nonpermanent use for vacated space.

3. **Does the CUNY Advanced Science Research Center have any type of emerging research fund or "seed" fund for really interesting/cutting-edge transdisciplinary projects that are too "early" to be able to apply and receive a federal grant?** Does the Center have mechanisms (either internal or through external funding sources) to "seed" junior faculty or cutting-edge research that can't receive funding anywhere else but appear to be of interest?

CUNY has a small internal fund that makes $10,000 small grants available. Applicants have to use this as true seed funding toward a demonstrated goal of proposing a main grant from external funding sources – and applicants have to show collaboration with one of the 20 permanent faculty in the ASRC. They have awarded about 15 of these per year out of circa 35 applications received annually.

The ASRC also has a program for postdoc salary support that works for faculty who do not want to relocate to the building from their home department on a project, but would like to have a postdoc in the building working on their project. Awards are $50,000 for salary and fringe. They have done two of these each year and they are very popular.

4. **What is the model used by the CUNY Advanced Science Research Center for commercialization of research?** Does the Center handle its own technology transfer, IP, licensing, entrepreneurship, etc.? Or does it work within the University's broader infrastructure (i.e., University Technology Transfer Office)? Or has it set up something outside the University? Or does it partner/leverage other organizations within the region? Bottom line: What could NC State learn from your commercialization model?

CUNY has a single system for technology transfer. They typically file Provisionals on IP that looks useful. They deliberately have an entrepreneur in charge of the office, rather than a lawyer. Faculty generating IP are requested to get NSF I-CORPs training.

The University has generous IP terms, providing 50 percent of royalties to the faculty after University costs are recovered.

The Colleges in CUNY all have different costs, but they operate with a goal of returning 10 percent of net indirect costs to the faculty as encouragement for getting grants.

Further Information (from website at asrc.cuny.edu/about)

Located on the south end of the City College campus in Upper Manhattan, the striking, 200,000-square-foot ASRC building embodies a bold vision of 21st Century discovery. At the center's core is a world-class facility designed to inspire an innovative approach to the scientific method itself, one that links a new wave of talented scientists with hundreds of top researchers from CUNY campuses across the city.

The ASRC focuses CUNY initiatives in five of the most energized areas of global research: Nanoscience. Photonics. Structural Biology. Neuroscience. Environmental Sciences.

These are diverse and seemingly distinct fields, but they intersect in many of the most significant research quests of our time. It was the opportunity for myriad collaborations – particularly between labs in areas that are already in CUNY's spheres of strength – that guided the center's planners. Led by Vice Chancellor for Research Gillian Small, what they have conceived is the DNA of a distinctive research culture – creative, collaborative, convergent – to take on scientific challenges ranging from Alzheimer's disease to the future of the global water supply.

Architecture that Promotes Collaboration

This is not a standard science building that lays out a biology floor and a chemistry floor and a physics floor, each in its own world. "Each of our five flagship initiatives was carefully selected for its interdisciplinary nature, and the people who work at the ASRC embrace that concept," says Vice Chancellor Small, who also serves as the Center's executive director. "Structural biologists, for example, may want to work with the nanotech people, while researchers in photonics may want to collaborate with those in the neurosciences. That's what creates transformational science."

The five flagship initiatives do, indeed, have their own floors in the ASRC, but they are linked by design. With its flowing floor plans and wide-open central stairway, the glass-encased building promotes intellectual cross-pollination and partnerships between labs – a literal vertical integration of big ideas. And researchers from every corner of the five initiatives are working

side by side in ASRC's core facilities, sharing equipment that is among the most advanced of its kind.

The ground floor, for instance, features a Nanoscience Facility that includes a 5,000-square-foot cleanroom where faculty and students throughout CUNY, as well as researchers from government and industry, are able to design and fabricate a wide range of micro and nano structures. The ASRC also offers state-of-the-art nuclear magnetic resonance spectrometers, and a data analytic center that includes a wall of screens for visualization. And a rooftop observatory uses advanced environmental-sensing equipment to collect and analyze earth and atmospheric data from satellites.

Creating an Integrated Science Network

The ASRC operates as the nucleus of a University-wide science enterprise, fostering the development of an integrated research network that brings together faculty, students and postdoctoral fellows from CUNY's colleges across the five boroughs. Twenty new faculty, including directors for each of the five initiatives, form the Center's core faculty. Each has an appointment at a senior college and is being joined by current CUNY faculty who are using the center's facilities to advance the scope and scale of their work.

Additional faculty will continue to arrive over the next few years, bringing specialized research pursuits that will not only help energize and define the ASRC, but the next generation of science in New York City. Like many of the CUNY researchers who are already part of the center, these new faculty are being drawn by the opportunity to work in an innovative, entrepreneurial research environment. Here's how a ground-breaking collaboration might work:

On the neuroscience floor, researchers are engaged in mapping the brain's biochemical circuitry to solve complex puzzles such as Alzheimer's disease. These neuroscientists then join forces with their colleagues on the nanoscience floor, who are working with matter on a molecular scale to make advances that might lead to new medical treatments. The nanoscientists, in turn, discover collaborations on the photonics floor, where researchers are developing methods of using light to detect bioterror bacteria – or diagnosing cancer without a biopsy. Furthermore, researchers throughout the center might find opportunities for partnership on the structural biology floor, where biologists, chemists, physicists and engineers come together to push the frontiers of applied research in all life sciences.

To make this ambitious concept work, Vice Chancellor Small has focused her ongoing recruitment of directors on a special breed of scientist. "We seek individuals who are both scientists and leaders – people who are doing their own research at a very high level and also have the talent to bring faculty together," she said. "We expect the directors to develop collaborations within CUNY, but we want that spirit to extend to research partnerships with peer institutions in New York and across the country."

So far, three such exceptional scientist-leaders have accepted this challenge: Charles J. Vörösmarty, an internationally renowned expert in global water issues who leads the ASRC's Environmental Sciences Initiative; Kevin H. Gardner, a prominent biophysicist who directs the Structural Biology Initiative; and Rein Ulijn, a pioneering chemist who oversees the Nanoscience Initiative. "They are our models for ASRC directors," says Dr. Small. "Each has an international reputation for excellence in his primary area, but also for thinking broadly and collaboratively across disciplines to solve the most challenging questions in their fields."

The team that Dr. Vörösmarty has assembled is exploring the most diffuse threats to human health – worldwide air and water issues, climate and weather, and the physical world's role in spreading disease. The initiative includes a rooftop observatory where sophisticated sensing devices collect and analyze earth and atmospheric data from satellites. And the environmental team is working on an array of research related to the biomedical interests of the center's four other teams.

Dr. Gardner, meanwhile, brings together several labs working at the intersection of biology, chemistry and physics to examine the large molecules that drive most of the functions of cells. Dr. Gardner is an expert in the use of nuclear magnetic resonance (NMR) spectroscopy to study how cells sense and adapt to the environments around them – research that can lead to applications from drug discovery to bioengineering.

And Dr. Ulijn, a rising young scientist with an international reputation for inventiveness, is leading a dynamic research team that studies matter on a molecular scale from 1 to 100 billionths of a meter. Nanoscience is a major source of important scientific developments, creating extraordinary new materials and devices with a broad range of applications in fields ranging from biomedicine to food science and green energy.

CUNY Advanced Science Research Center (ASRC) Use and Affiliation Policy

The CUNY Advanced Science Research Center (ASRC) is a University-wide facility open for use by researchers – faculty, students, and research staff – across all 24 of the campuses and schools of CUNY. The ASRC was conceived to break down some of the traditional walls in science and to incubate a culture of collaboration; thus, an open and inviting environment for researchers across disciplines is key to its success. Toward that end the policy below identifies additional levels of access that go beyond day-to-day use of the core facilities of the building in the hopes of encouraging ongoing, specialized use of all ASRC resources.

Core Facility User – *CUNY or external student, staff, or faculty, government and/or industrial users:*

A *Core Facility User* is a researcher interested in utilizing shared instrumentation available within the ASRC. Such researchers can be employed by a wide range of research entities, including academic institutions (in or outside of CUNY), governmental/non-governmental research institutes, and the private sector. All applicants must agree to adhere to the usage policies specific to each core facility, which will include:

1. equipment scheduling, usage, and safety procedures,
2. mechanisms of payment, and
3. acknowledgement of use of ASRC resources in presentations and publications.

Specific information, including rate schedules and sample acknowledgment text, will be available on the websites of each core facility and will also be provided to prospective users.

Access for student/staff academic participants will require signatures and formal approval by both the applicants and their affiliated principal investigators.

ASRC Affiliate Faculty – *Both CUNY and Non-CUNY Faculty:*

Context: The objective of the *ASRC Affiliate Faculty* is to provide productive research-active faculty an opportunity to collaborate with ASRC faculty and staff. Thus, ASRC Affiliate Faculty will take best advantage of the ASRC facilities and space to help establish, broaden, and expand collaborative research programs with the ASRC. This will also bring greater breadth, depth, and visibility of research programs to the ASRC and to the CUNY campuses, and will stimulate collaborative opportunities.

Criteria: Faculty applying for Affiliate status should be clearly research active, with corresponding track records of external research proposal submissions, external funding, publications, and trainee supervision appropriate to their career stage. It is expected that affiliate faculty positions will be for 1-year renewable terms. There will be a limit to the number of ASRC Affiliate Faculty each year according to space availability. Applications will be reviewed by a committee.

Practical aspects:

- **Time spent at the ASRC:** While each ASRC affiliate member will remain predominantly based at their home institution, it is expected that the affiliate member will spend a meaningful amount of time engaging in ASRC activities, up to two days per week at the ASRC.
- **Equipment:** User fees will be charged at the agreed-upon rates for academic researchers.
- **Space:** During their time at the ASRC, Affiliates will have access to laboratory space, shared desk space (used by other affiliates on other days), and meeting space.
- **PhD students of the Affiliate(s):** Administrative, teaching, and coursework for PhD students will take place as normal and at the usual locations (e.g., their home campus or Graduate Center). When students are at the ASRC they will have access to laboratory and computing facilities as well as desk space. PhD students may take advantage of special rates at CCNY's student accommodations ("The Towers") next door to the ASRC, as available.
- **Direct and Indirect Costs:** A grant led by an ASRC affiliate will continue to be submitted through the faculty member's home college. Direct costs should be budgeted to pay for equipment and consumable usage at the ASRC by the affiliates and/or their students and staff. When grants require direct effort by ASRC faculty, the indirect costs associated with a grant will be apportioned to the home campus and the ASRC commensurate with the level of effort contributed by each ASRC and non-ASRC faculty.

ASRC Visiting Faculty – *CUNY and external faculty, government and industrial collaborators:*

Scientists wanting to spend prolonged periods of time (e.g., a month or longer) at the ASRC, including visitors on sabbatical or similar non-teaching periods, should apply for *ASRC Visiting Faculty* status. Such stays are intended to support dedicated efforts to a focused project that takes advantage of the ASRC environment, such as conducting scientific research projects, developing major collaborative proposals, *etc*. ASRC Visiting Faculty will be granted additional benefits and access to Center facilities, including longer-term hoteling space and resources, as

jointly agreed upon by the relevant ASRC Initiative Director and Visiting Faculty. *The same criteria and procedures as Affiliate Faculty apply, with the addition of a description of project(s) to be conducted.*

Application Procedure for Affiliate and Visiting Faculty:

Applicants will be required to submit a current CV and provide documentation that details significant, recent success (within the last 5 years) in multiple categories below:

- Submitting extramural funding by listing grants and their role(s) on each
- Publishing papers with impact in their field of study by highlighting 3 peer-reviewed journal articles and providing short justifications indicating why they have been impactful in their area of science and beyond
- Participating in scientific conferences, workshops, seminars and other activities, describing roles in attending, speaking at, or organizing national and international such events

All applicants must submit a brief statement (one page) on their collaborative and interdisciplinary approach to research, as well as their vision of how they will contribute to the spirit and vision of ASRC.

In addition, ASRC Visiting Faculty applicants are required to provide a two-page description of the research, collaborations, or other projects they intend to pursue during their stay.

The ASRC Executive Director, Initiative Directors, and at least two faculty members of the ASRC Advisory Committee will serve as the Review Committee for all applications. Metrics of past success will be considered in the context of the applicant's career stage.

Purdue University Birck Nanotechnology Center (BNC)

Responses were provided by Dr. Ali Shakouri – Professor of Electrical and Computer Engineering, and Director of the Birck Nanotechnology Center, Purdue University.

About the Center: "*The BNC leverages advances in nanoscale science and engineering to create innovative nanotechnologies addressing societal challenges and opportunities in computing, communications, the environment, security, energy independence, and health. In turn, the BNC exploits the accelerating progress in nanotechnology utilizing the most advanced nanoscale instrumentation to pursue answers to fundamental questions in the life and physical sciences. The interplay between these two complementary arcs of inquiry fosters a stimulating interdisciplinary environment for discovery that will engage us well into the 21st century."*[16]

1. **How does the Birck Nanotechnology Center measure the performance or success of individual projects as well as individual PIs/faculty that use your facilities?** How do these metrics then play into who stays within the facility and who is asked to leave?

16. Purdue University. 2017. Birck Nanotechnology Center. West Lafayette, IN: Purdue University. nanohub.org/groups/bnc

It is not super-formal, but they do consider two primary factors in whether to allow a project to proceed at the Center, notably:

- *What percentage of the proposed work needs to take place at the Birck Nanotechnology Center?*
- *How multidisciplinary is the proposal?*

The Center operates as a charge center and, therefore, in any given time period, the administration can use the charge data to see the actual usage of the Center overall and of individual labs and equipment.

In reviewing performance, the Center does look at the publications produced associated with Center usage. They also examine and maintain a network diagram that tracks joint publications between the Center and individual faculty/departments.

In terms of who stays and who is asked to leave, this has not come up yet. In the last 4–5 years of operation no one has been asked to leave. There have been exits of faculty but these have occurred due to retirement or the faculty concerned moved to a different unit at the University based on their interests and needs.

2. **How is space at the Birck Nanotechnology Center rotated with normal academic/department space?** In other words – whether or not a PI's project is successful – eventually all projects may come to an end and faculty working on those projects will presumably no longer be in need of space at the Center. How does an "expat," so to speak, return home to their department and be guaranteed lab space after significant time "away" at the Center? What sort of arrangements, or guarantees, if any, were made by departments or the Center in advance for such an eventuality?

None of the space is actually assigned to individual faculty; rather all labs in the building are assigned to a function (such as optical characterization, chemistry, etc.). Faculty go where the equipment and their work is the best fit, and the Center doesn't formally assign a certain amount of square footage or bench space to a scientist.

Among the faculty working at the Center half of them maintain space in home departments as well. New faculty coming to the University and Birck are encouraged to sustain a department presence. Those faculty who have the primary responsibility for specific labs and equipment tend to be full-time in Birck and are provided with office space. The building also maintains shared flex office space with an online reservation system.

Further Information

The Birck Nanotechnology Center opened in July of 2005. This facility comprises 186,000 square feet, providing office space for 45 faculty, 21 clerical and technical staff, and up to 180 graduate students. The heart of the building is a 25,000-square-foot Class 1-10-100 nanofabrication cleanroom (Scifres Nanofabrication Laboratory), part of which is configured as a biomolecular cleanroom with separate entry and gowning areas and isolated air flow. The building also includes over 22,000 square feet of laboratory space external to the cleanroom, including special low-vibration rooms for nanostructures research, with temperature control to less than 0.1 °C. In addition to the Hall Nanometrology Laboratory there are other laboratories

specialized for nanophotonics, crystal growth, bio-nanotechnology, molecular electronics, MEMS and NEMS, surface analysis, SEM/TEM, electrical characterization, RF systems, instruction and training, and precision micro-machining. In addition, a unique nanotechnology incubator facility is provided for interaction with industry.

Equipment

The entire set of resources provided by this 186,000-square-foot facility are designed to support collaborative interdisciplinary research in nanotechnology.

Operations

One of the most advanced facilities of its kind in the world, the BNC facility is designed to support multidisciplinary research in nanotechnology and to foster interaction between researchers and research disciplines.

3. **Does the Birck Nanotechnology Center have any type of emerging research fund or "seed" fund for really interesting/cutting-edge transdisciplinary projects that are too "early" to be able to apply and receive a federal grant?** Does the Center have mechanisms (either internal or through external funding sources) to "seed" junior faculty or cutting-edge research that can't receive funding anywhere else but appear to be of interest?

   Birck does have a small endowment and is able to award small grants to use equipment and receive staff support. Overall they really are quite limited in the amount of support they can provide, beyond in-kind support.

4. **What is the model used by the Birck Nanotechnology Center for commercialization of research?** Does the Center handle its own technology transfer, IP, licensing, entrepreneurship, etc.? Or does it work within the University's broader infrastructure (i.e., University Technology Transfer Office)? Or has it set up something outside the University? Or does it partner/leverage other organizations within the region? Bottom line: What can NC State learn from your commercialization model?

   A main premise for Discovery Park was "discovery and delivery," so it (with Birck Nanotechnology Center as part of it) actively encourages commercialization activity and faculty business startups. There is Purdue funding available to assist with company seed funding and startup. The University overall handles technology transfer and licensing.

   Small companies are able to use the facilities of Birck at a "break-even" rate.

   Professor Shakouri noted that the flex-space model works well, but it needs to be carefully thought through especially in terms of having designated staff to take care of spaces and be responsible for equipment. There needs to be a base of recurring funds to provide this staff oversight and support.

   The following website contains considerable detail on policies and procedures, rates for facilities usage, etc.: nanohub.org/groups/bnc/users

Virginia Tech Institute for Critical Technology and Applied Science

Responses were provided by Dr. Roop Mahajan – Lewis A. Hester Chair in Engineering and the former director of the Institute for Critical Technology and Applied Science at Virginia Tech.

1. **How does the Institute for Critical Technology and Applied Science (ICTAS) measure the performance or success of individual projects as well as individual PIs/faculty that use your facilities?** How do these metrics then play into who stays within the facility and who is asked to leave?

   Our metrics are: increase your h-index and external research grants by a factor of 2 in six years. Depending on where our faculty are in their career and research recognition, the goal could simply be going for a large grant (NSF-ERC, STC ...) and being among the top three in the nation in the selected field of research

2. **How is space at ICTAS rotated with normal academic/department space?** In other words – whether or not a PI's project is successful – eventually all projects may come to an end and faculty working on those projects will presumably no longer be in need of space at the Institute. How does an "expat," so to speak, return home to their department and be guaranteed lab space after significant time "away" at the Institute? What sort of arrangements, or guarantees, if any, were made by departments or the Institute in advance for such an eventuality?

   Except in a few cases, all the faculty members occupying our laboratories have a clear agreement upfront that they need to maintain their space in their home offices. There is always some angst when the faculty members are given notice to vacate but we have been able to manage this.

3. **Does ICTAS have any type of emerging research fund or "seed" fund for really interesting/cutting-edge transdisciplinary projects that are too "early" to be able to apply and receive a federal grant?** Does the Institute have mechanisms (either internal or through external funding sources) to "seed" junior faculty or cutting-edge research that can't receive funding anywhere else but appear to be of interest?

   I have been keeping 8.9% of my discretionary research fund for Black Swan or outlier technologies. There is a story behind 8.9%, which is actually quite interesting and powerful. Hint: think of Bell Labs

4. **What is the model used by ICTAS for commercialization of research?** Does the Institute handle its own technology transfer, IP, licensing, entrepreneurship, etc.? Or does it work within the University's broader infrastructure (i.e., University Technology Transfer Office)? Or has it set up something outside the University? Or does it partner/leverage other organizations within the region? Bottom line: What could NC State learn from your commercialization model?

   We work with our VTIP office but, since they are generally very conservative and want some users lined up before filing for a patent, ICTAS, if convinced, picks up most if not all of the patenting expenses with an agreement with the VTIP office that if licensing

revenues are generated, ICTAS will be reimbursed its expenses. We have not worked out an arrangement yet where ICTAS can share some of the revenues beyond just recovering our expenses. NC State may want to consider this option seriously.

Research and Technology Task Force

Introduction and Overview

Transdisciplinary team science is essential to address grand scientific and technological challenges because the biggest questions demand solutions beyond the capabilities of a single discipline. Facilitation of transdisciplinary research teams is key to advancing progress and innovation in a complex area such as agriculture. Major issues facing agricultural producers (such as the expanding challenge of herbicide-resistant weeds, emerging diseases and pests, and climate variability) require solutions engaging expertise in plant pathology, entomology, crop science, soil science, horticulture, engineering, economics, and other disciplines to develop integrated solutions to global food challenges.

From its conception, the NC PSI was envisioned to be a world-class research center that would do the following:

- Foster the spirit of transdisciplinary research to solve global challenges with national and local importance.
- Create innovative and progressive partnerships among universities, industry, and government.
- Maximize the integration of research, teaching, and outreach programs.
- Allow North Carolina to have a competitive advantage locally to globally.
- Help farmers in North Carolina to be economically viable.
- Be the premier destination for plant sciences in the world.

To help guide the scientific research and technology planning of the NC PSI, a Research and Technology Task Force was formed (Attachment R&T-A lists task force members), composed of industry, production, and academic leaders. The overall charge of this Research and Technology Task Force was to help the NC State CALS determine the appropriate scientific research platforms for NC PSI teams to pursue, based on existing research strengths and each platform's importance in the marketplace. Specifically, the Research and Technology Task Force sought to provide advice and structure for the NC PSI in the following areas:

- Platforms that would provide the research challenges and technologies upon which a diversity of transdisciplinary projects can be based
- Criteria and guidance by which research platforms will be chosen in the future
- Rubric for space allocation for the research platforms

Three sub task forces were convened to solicit external expertise, information, and guidance regarding research concepts and technology opportunities (Attachment R&T-B lists sub task force members). These proceedings represent the findings from both the Research and Technology Task Force and its sub task forces and provide a series of recommendations to the NC PSI leadership for developing transdisciplinary and interconnected research and technology platforms. It should be noted that the members view the results of their work as a "living document" that can help to guide the NC PSI leadership as it moves forward with implementation.

Research and Technology Recommendations

Based on the analyses and discussions undertaken, the members of the Research and Technology Task Force respectfully submit the following recommendations to the NC PSI leadership team for consideration in the initiative's development.

Recommendation 1: Create Criteria and Guidance by which Research Platforms Should be Chosen

Criteria were developed for identifying research and technology platforms (see Recommendation 2) that will meet the overarching goals of the NC PSI. At the highest level, we recommend that the platforms must tackle global grand challenges that have relevance to both national problems and those specific to North Carolina. Platforms should provide foundational research relevant to NC agbioscience industry, producers, and consumers. The platforms should be anchored in NC State research strengths and have the potential for attracting external partnerships. Impacts beyond research, such as longevity of the platform and length of time between discovery and translation of the research to practices, were also important considerations. A complete list of recommended criteria and guidelines are provided in Attachment R&T-C. Recognizing that the NC PSI technology platforms will evolve over time, we recommend that the NC PSI leadership constantly review the landscape of opportunities based on the recommended criteria to ascertain when other platforms may become relevant to the NC agbioscience ecosystem.

Recommendation 2: Select Inaugural NC PSI Platforms

Platforms provide technologies and research challenges upon which transdisciplinary projects will be built. The members of the Research and Technology Task Force desire to create an initiative with platforms that will do the following:

- Advance science that addresses questions of major significance – global grand challenges – in new ways.
- Represent world-class research excellence.
- Be transdisciplinary and transorganizational.
- Develop analytical tools, instrumentation, and technologies that facilitate research and development (R&D), inform policy, and ultimately promote greater efficiency and profitability in the field.
- Develop broad, collaborative partnerships to facilitate the translation of discoveries and innovations into commercial solutions.
- Translate knowledge and innovations into applications that benefit NC agricultural producers as early adopters.
- Produce graduate students and postdocs who have achieved transdisciplinary training across the platforms (so-called "T"-trained skills) and who have received focused mentoring in a key faculty lab within one of the platforms.
- Attract funding.

The transdisciplinary excellence in research and technology envisioned for the NC PSI extends beyond the areas delineated in *The NC PSI Economic Feasibility Study* to one of overarching

interactions and integrated approaches to addressing grand challenges in agriculture. Emerging trends that link data sciences, food systems, sustainability and resilience, and plant improvement offer the NC PSI a chance to seed the discoveries that will meet both industry and producer demands. With infrastructure that guarantees quality, accurate and real-time data tracking, and a seamless interaction among the platforms, the NC PSI will have the connectivity to capitalize on opportunities to co-develop technologies that increase profitability, inform policy, and revolutionize current practices in industry and farming. To this end, after significant analysis, research, and deliberation, we recommend the following three platforms as the inaugural platforms of NC PSI: Plant Improvement; Plant Data Sciences; and Food Systems, Environmental Sustainability, and Resilience.

Plant Improvement Platform

The Plant Improvement Platform will comprise three primary research strengths identified in *The NC PSI Economic Feasibility Study*:

Crop Protection from Biotic Stress – In agriculture, biotic stress is stress to plants caused by pests (the collective term for microbes, weeds, insects, and other organisms that have a negative impact on plant health and yield). Preventing and controlling the impact and spread of pests are key challenges for agbioscience. Addressing biotic stress agents is an ongoing battle for agronomists because natural organisms can evolve resistance to pesticides, herbicides, and control practices. Increasingly, integrated management practices are deployed as pest organisms develop resistance. Integrated practices include biological controls, chemical controls, cultivation practices, and genetics (for breeding resistance into the crops).

Big issues in this research area include the following:

- Expanding basic knowledge of the genomics of pathogenic organisms, the mechanisms by which they cause plant diseases, and their ongoing molecular evolution
- Identification of crop traits associated with pest resistance and traits for tolerance of pesticides, herbicides, and other crop protection chemicals
- Development of biological or chemical fungicides, herbicides, and other pesticides for crop protection
- Improvement of integrated pest management strategies

Plant Adaptation to Abiotic Stress and Marginal Conditions – Both in North Carolina and around the globe, significant agricultural land exists on the margins of sustainable agricultural productivity. Whether because of water, climate, soil fertility, salinity, occasional freeze pressures, or other factors, such land is under permanent or periodic abiotic stress conditions that limit agricultural crop yields. The pressures placed on agronomic land to feed expanding populations can lead to cascading problems with such factors as declining soil fertility, soil stability, and water resource availability. Similarly, the pressure to increase food production leads to more marginal lands being pressed into production. The potential impacts of global climate change will further influence agricultural land productivity and the likely frequency of abiotic and biotic plant stress events.

Research to enhance plant yield in marginal environments is likely to have benefits along three principal pathways:

- It will identify crops, crop cultivars, and plant traits associated with enhanced performance in various conditions of abiotic stress, providing opportunities for increasing agronomic yield on marginal lands.
- It will identify traits associated with performance under stress conditions. These traits may be incorporated into crop cultivars grown in high-productivity environments and may enable crops to weather occasional unforeseen stress events. The development of new and improved crop cultivars using traits discovered for performance on marginal land are also generally associated with resource use efficiency (such as requiring lower levels of water resource inputs and fertilizer applications to perform at high-yield levels).
- It will develop tools and technologies for measuring stress conditions and quantitative effects on plant phenotype and gene expression.

Agri-symbiotics (plant symbiotic interactions with nonplant organisms) – This area focuses on advancing scientific understanding of the beneficial biological interactions between plants and other organisms (especially microbes, but also including fungi and invertebrates), and applying knowledge of such symbioses to technologies for advancing agricultural yield. Agri-symbiotics is a fast-emerging field of inquiry with considerable "room to operate" and opportunities for precompetitive collaborative research between academia and industry. It is inherently transdisciplinary, requiring engagement of expertise in bacteriology, virology, mycology, basic microbiology, biochemistry, molecular biology and genomics, metagenomics and microbiomics, epigenomics, and evolutionary and developmental biology, to name just some of the varied fields that can be engaged.

Big issues in this research area include the following:

- Expanding basic knowledge of plant-microbe interactions and their impacts on such factors as plant growth, metabolism, nutrition uptake, disease and pest resistance, and resistance to abiotic stress.
- Developing biological inputs for agriculture for the control of pests and diseases (biological control agents), providing an alternative to agricultural chemicals. The development and application of inoculants, probiotics, and other technologies can enhance the yield potential of crops.

While each of these fields stands alone as a research area of critical importance, the strongest potential for impact in addressing the complex problems facing agriculture lies at the convergence of technologies that span the various research fields, ranging from conventional plant breeding to gene editing to informatics. Targeted areas of convergence that could be addressed include the following:

- **Multiple and cross-crop improvements.** Plant physiological or developmental processes affect important traits in complex systems where findings could be translated to multiple crops.
- **Integrated improvements of stress tolerance.** Plants perceive and respond to stress through multiple pathways and experience stressors – biotic and abiotic – concurrently. Manipulating drivers of stress tolerance, identifying molecular signals of stress, and designing strategies for intervention before negative plant responses requires understanding the mechanisms by which plants integrate signals from multiple stresses.
- **Biochemistry.** Identifying protein function underlying important traits in plants and microbes in agricultural systems will lead to new targets for plant breeding or gene editing.

- **Plant-microbial interactions.** Tools can be used to intercept signals for pathogen stress before negative plant responses as well as agri-symbiotic interactions with microbes in soil.
- **Integrative application.** Crop improvement can occur only if growers implement the technology, use the products, or change management practices. North Carolina Cooperative Extension will bring important partners to the table who cross crop and disciplinary boundaries, drive beyond current industry priorities, and are application guided.

Relevance of Platform to NC Agbioscience Industry, Producers, and Consumers

North Carolina is in a "transition zone" for various crops – existing at the southern extreme of northern crop ranges and the northern extreme of southern crop ranges. With their diverse agronomic conditions and crop profiles, NC producers need to find solutions for combating a wide range of issues, from pest and weed control to improving soil conditions, to yield improvement. Companies interested in this research platform include all the major agbioscience companies as well as smaller companies that also operate in this space.

Existing Research Strengths

The NC PSI Economic Feasibility Study uncovered significant research strengths at NC State within this research platform. Relevant research clusters identified by application of Battelle's OmniViz™ pattern recognition software tool[17] for analysis of publication abstracts to identify distinct clusters of R&D activity include the following:

- Plant growth and development or plant physiology (501 publications)
- Genetic profiling of plants and plant diseases (441 publications)
- Soil ecology and plant nutrition (360 publications)
- Insect pests and their adaptation, resistance, and population genetics (275 publications)
- Crop genetic engineering for disease resistance (256 publications)
- Weed management and herbicides (182 publications)
- Microbiology, microbial growth, and growth inhibition (91 publications)
- Plant drought resistance (46 publications)
- Mycotoxins and producing organisms (19 publications)
- Pesticide efficacy (10 publications)

Relevant NC State centers and programs include the following:

- Plant Breeding and Applied Genomics
- Center for Integrated Fungal Research (CIFR)
- United States Department of Agriculture Agricultural Research Service (USDA–ARS) Food Science Research Unit
- Agrosphere Modeling for Producing Large Increases in Food Yield (AMPLIFY)
- NC Cooperative Extension network and partnership with the North Carolina Department of Agriculture and Consumer Services (NCDA&CS) – 18 agricultural research stations

17. The Battelle OmniViz™ analysis uses real-text cluster analysis of R&D activity as indicated by publications abstract and title data. Battelle uses the OmniViz™ pattern recognition software to group publication abstracts based on the actual use of words in the abstracts and titles, allowing for free association based on the usage of words and phrases, rather than forcing clustering based on preselected key words. Thus, the analysis goes beyond predetermined, high-level classifications, such as publication field. Instead, this process analyzes the text of the abstracts for each publication to identify how these key indicators connect or "cluster" around key themes.

- USDA Southeast Regional Climate Hub, the NC State Weather and Climate Network, and the U.S. Geological Survey (USGS) Southeast Climate Research Center

Plant Data Sciences Platform

The Plant Data Sciences Platform was defined as the acquisition, processing, movement, and interpretation of data pertinent to crop production, from upstream basic research to downstream use by growers and consumers. Two areas of research have been identified where significant work has been and will be conducted in both industry and academia:

Sensor Data for Precision Agriculture – Machinery manufacturers are focused on using sensor data to optimize yield and reduce farmers' costs. An automated and reliable process could measure actual conditions in the field (including crop conditions, nitrogen levels, pathogen pressures, and insect presence) and provide a real-time recommendation based on these data. The creation of sensors that could reliably function in harsh environments for extended periods would be very helpful to manufacturers. NC State is well-positioned to explore the extensions of plant sensor technologies that provide new environmental and biometric sensors for plants.

Genotype Modifications and their Translation to Phenotype and Environmental Responses in Crop Plants – There has long been a drive to better understand the effects of single and multiple genes on plant phenotype as researchers seek to improve the viability of crop plants in the field. Collection of additional data at multiple scales (including genotypic, phenotypic, climate, market) could be used to provide further insight into crop viability. Significant resources would be needed to collect and analyze data in all these spaces. The space where the agricultural industry may be most inclined to collaborate and contribute is in high-throughput phenotyping in the field. Plant biologists at NC State are well suited to undertake the high-risk and high-reward problems of understanding mechanisms associated with the genotype→ phenotype→ environment response in plants, ultimately leading to better management practices for producers.

Relevance of Platform to NC Agbioscience Industry, Producers, and Consumers

The Plant Data Sciences Platform represents a key area in which industry and NC State can collaborate to further the goals of the NC PSI. Industry already has significant experience in collecting field data for improvement of farming objectives. Ongoing data science initiatives, Internet of Things, and big data research at NC State can provide the approaches needed to collect, integrate, and use data collected across NC PSI stakeholders to make decisions in agriculture. Ultimately, the development of a common database and tools to mine the data may be useful to all parties involved, from NC PSI researchers to the agbioscience industry and individual growers. This raises the possibility of collaboration in areas where data collection and analysis provide benefits to the whole industry without negatively affecting any one manufacturer or producer.

Additional areas that would be of high impact and relevance to industry would be efforts focused on (1) cultivating a cutting-edge workforce proficient in analytics and agriculture, (2) developing products that can be applied across a multitude of North Carolina's diverse crops, (3) promoting upstream discoveries that could be useful across a variety of products, and (4) constructing algorithms that have application to livestock ag sectors.

Targets likely to be addressed might include the following:

- Data mining and algorithm development for heterogeneous data
- Sensor technology for basic research and field applications
- Heterogeneous data integration for improved breeding and genomic strategies
- Prototyping systems and translating results to crop production and utilization.

Existing Research Strengths

The focus of the Plant Data Sciences Platform needs to be on a systemic scale – not one gene at a time. Data types that should be included as part of the platform research foci include environmental, economic, phenotypic, molecular, and genetic. There is a significant opportunity to link data mining with existing research station work. Further, many areas of research opportunities exist that overlap the other proposed platforms, particularly in the areas of soil-microbe interactions and in molecular biology and biochemistry of crop plants.

The NC PSI Economic Feasibility Study uncovered significant research strength at NC State within this research platform. Relevant OmniViz™ identified research clusters include the following:

- Plant growth, metabolism, and production (501 publications)
- Water resources, runoff, and soils (67 publications)
- Soil ecology and plant nutrients (360 publications)
- Analytical methods and modeling (52 publications).

This platform complements one of the NC State cluster-hiring focus areas in geospatial analytics. NC State has been making strategic hires to develop new transdisciplinary research and a PhD program in geospatial analytics to address the extensive research needs in both basic geospatial sciences and the corresponding computer science and mathematical modeling disciplines. These faculty additions will allow NC State to significantly expand its research initiatives in spatial analytics and algorithmic development and computation, mobile geographic information systems (GIS), spatial data mining, and remote sensing.

Relevant NC State centers and programs include the following:

- Center for Geospatial Analytics.
- AMPLIFY.
- Center for Advanced Self-Powered Systems of Integrated Sensors and Technologies (ASSIST) – NSF Engineering Research Center.
- College of Engineering at NC State contains significant expertise in research fields that may be applied to a transdisciplinary center in precision agriculture. This includes multiple faculty in the Departments of Electrical and Computer Engineering, Computer Science, and Mechanical and Aerospace Engineering with expertise in the following:
    - Artificial intelligence, intelligent agents, computational intelligence, and machine learning
    - Sensor technology and the Internet of Things
    - Image analysis and computer vision
    - Robotics and mechatronics
    - Algorithm development for autonomous operation
    - Communications and signal processing
    - Unmanned aerial vehicles and remotely piloted vehicles (for tasks such as automated phenotyping in the field)

- USDA Southeast Regional Climate Hub, NC State Weather and Climate Network, and USGS Southeast Climate Research Center.

Connectivity with Plant Improvement Platform

There could be great opportunities for the NC PSI to partner with industry to co-develop technologies aimed at integrating and synthesizing plant data, as well as machine learning that can be applied to plant systems. Targets at the intersection of the two platforms might include the following:

1. **Application of "big data" over multiple scales**: Integration of population-wide variation across multiple experiments; integration of data from many factors that affect plants and their responses; integration of data from plant to field and beyond; integration of biological and physical data; capture of currently available data or data from existing experiments that would not be collected through improved experimental design
2. **Predictive modeling**: Identification of the best targets from large datasets; understanding key nodes in complex networks
3. **Sensor technologies**: Tools that would be co-developed with data sciences experts to obtain pertinent data for Plant Improvement Platform projects

Food Systems, Environmental Sustainability, and Resilience Platform

The Food Systems, Environmental Sustainability, and Resilience Platform was defined within the following parameters:

- **Goal:** Create a **resilient** food system that reduces food insecurity, improves diet-related health outcomes, protects the environment for future generations, and is profitable for producers.
- **Environmental sustainability**: Agriculture should be conducted in a way that does not limit future generations from producing the food they need by degrading soil, water, biodiversity, or the people who produce the food.
- **Food system challenge**s, including climate change, will impact access to and affordability of food and the ability of farmers to reliably produce at a profitable level. North Carolina, particularly in the eastern counties, can be especially vulnerable to climate change.
- **Reducing food insecurity** is not tied only to improving crop yields through biological and technological innovation, but also to improving access (availability, affordability, convenience, education) to healthy foods.

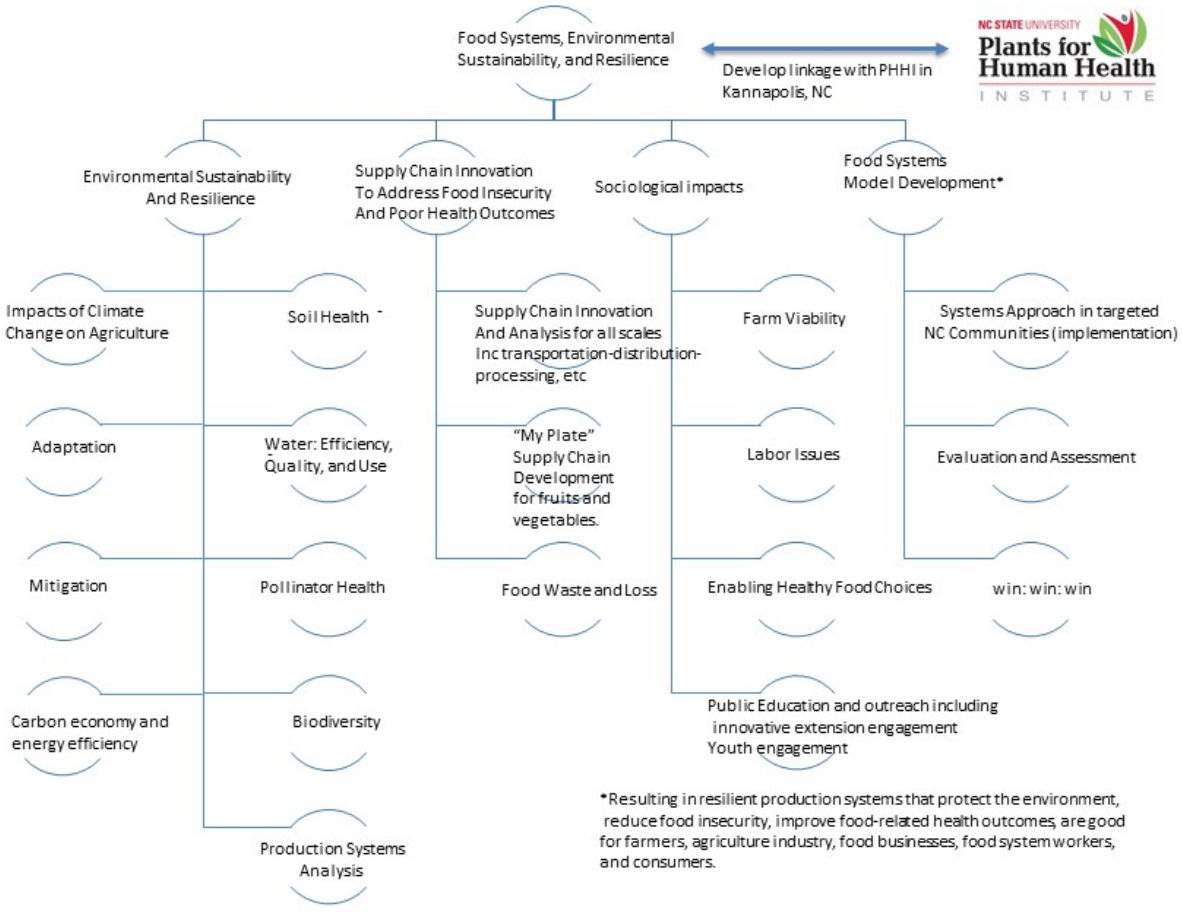
The platform concept was further defined as focusing on North Carolina's impact as a model first (farm viability, food insecurity, health outcomes) and making the NC PSI the "go-to" entity for scientific assessment and systems analysis. Food systems would be redesigned from the top down and bottom up, and all along the supply chain from farm to fork to waste. This redesign would be data informed, reliable, transparent, respected, and deeply valued by all – from industry to the public. Further, the platform would represent an opportunity to rethink the food system – with farmers, agriculture workers, food and agriculture businesses, regulatory agencies, the environment, health outcomes, and food security all in mind – striving for "win-win-win" and common ground among the different sets of stakeholders.

Due to the breadth and scope of the areas of opportunity identified, we recommend that NC PSI leadership could better serve the platform by making it more focused in the following ways:

- Focus on evaluation and assessment. This needs to be the higher-order level of organization.
- Focus systemically, using communities as models. Identify the issues that are preventing food security, and then design systems to correct.
- Have the end points in mind, and make those points the foci of the platforms.

Targets likely to be addressed might include those depicted in Figure R&T-1. We envision that these targets will bring together researchers with expertise in very diverse areas to form transdisciplinary project teams. Further, the figure is meant to illustrate the complexity of the many areas of opportunity under this platform, as well as the possibility for numerous and diverse collaborations among the individual areas.

Figure R&T-1: Targets Likely to be addressed in a Food Systems, Environmental Sustainability, and Resilience Platform in the NC PSI



Relevance of Platform to NC Agbioscience Industry, Producers, and Consumers

- All entities are interested in sustainability of natural resource base.
- May lead to new product development in new areas and markets of opportunity.
- Can build trust between the public, industry, and our institutions.

- Can provide new opportunities for producers and food businesses, and enhance their viability.
- Can alleviate important societal issues in North Carolina that are costly and cause great suffering.
- Process models successful in North Carolina can be extended nationally and globally.

Existing Research Strengths

- NC State Center for Environmental Farming Systems (CEFS)
- Production system scientists in several departments working on sustainability
- Core group working on supply chain innovations, with many supply chain partners
- Food waste team
- Strong sociological and economics expertise
- Researchers working on climate change mitigation and adaptation in agriculture
- Researchers working on water systems and resiliency

Recommendation 3: Have Dedicated Platform Directors

Strong scientific leadership for each of the identified research platforms is a critical component of NC PSI's future success. Each of the platforms needs a director to manage transdisciplinary team development and guide overarching research activity. Given that the teams under each platform director will be deliberately transdisciplinary in nature, each director will need to have the academic status and credentials that empower him/her to guide complex projects with multiple stakeholders and engaged disciplines. It is likely that the success of the NC PSI will very much depend on the persons holding these positions, and it would be ideal if each could be a very well-regarded academic in his/her own right, committed to both transdisciplinary research advancement and to innovation and commercialization that seek to meet the needs of agricultural production and the downstream agbioscience industrial value-chain.

The platform directors need to have similar characteristics to the NC PSI's executive director in terms of leadership ability. However, given their direct focus on setting and guiding scientific direction within each platform, they are most likely to come from academic positions (either from within NC State or specially recruited to the positions). Platform directors should ideally have some or all of the following characteristics:

- Substantial academic credentials in key scientific disciplines associated with the technology platform, including research specifically focused on the platform's stated goals
- Strong track record of success in leadership, innovation, collaboration, team-based science across industry-academic-government partnerships supporting transdisciplinary R&D
- A commitment to the ultimate mission of building a world-class, transdisciplinary R&D platform that will make significant scientific and technological contributions to the field
- A commitment to maximizing transdisciplinary collaborations for advancing scientific inquiry and technological development in the platform
- A commitment not only to advancing scientific discovery and innovation but also to realizing the translation of innovations into commercial products, technologies, and solutions
- Administrative experience in managing research budgets and research teams comprising multiple faculty members and scientists

We envision that each platform director will “anchor” each platform, and as such will be given lab and office space within the Plant Sciences Building. While most occupancy of the NC PSI will be project-driven, platform directors would have their full research programs (transdisciplinary and individual projects) housed in NC PSI space to accommodate their roles in day-to-day management of the platforms. This space will be granted so long as that platform remains an area of research focus for the NC PSI and the platform director serves in the position. While we envision that each platform will be reviewed every five to ten years, each platform director would serve for a five-year term, consistent with the length of terms for department heads.

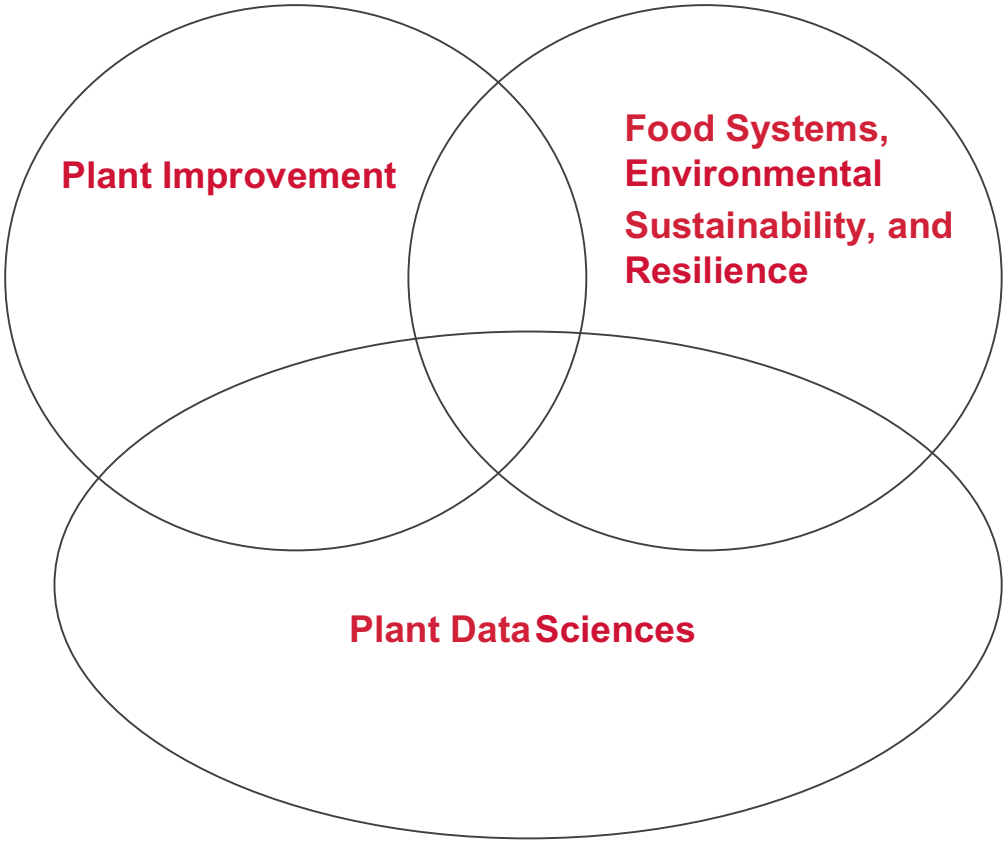
Each platform director will benefit from having a well-connected and diverse advisory council composed of research scientists representing various aspects of the field (including faculty and scientists at external organizations – industry, government, foundations, or other stakeholder organizations). The goal of each of these advisory councils will be to assist in the review and development of potential platform research foci, provide oversight of project selection and performance reviews, and assist with connecting the platform to new potential partners, perhaps in emerging areas in the field.

Recommendation 4: Focus Projects and Initiatives at the Intersection of the Proposed NC PSI Platforms

We envision that a productive and effective NC PSI research and technology agenda will be the result of a portfolio of projects that are complex, highly integrated, and connected; driven by data and informatics; and that represent sustainable food systems that are predictive and proactive. It is further envisioned that the process learnings and research will be applied and can be translated beyond North Carolina’s agricultural needs to national and global challenges.

Figure R&T-2 shows a Venn diagram as a visual depiction of the interconnectedness of the three identified platforms. Projects and principal investigators (PIs), including the recruitment of new positions, should be focused in the areas of overlap.

Figure R&T-2. Schematic Representation of NC PSI Research Platform Interactions



Underlying the above schematic representation are continual feedback loops among the platforms. Success depends on communication at all stages – deciding what to do, doing the work, and delivering outputs. Producers know the issues that most affect their bottom line. Industry can move research into products. Cooperative Extension brings the relationships that connect the research activities to defined outputs, as well as the process for ensuring that outputs are delivered to stakeholders.

Outcomes and successes of interconnected platforms include the following:

- Viewed globally as cutting-edge advancement of the science
- Engaged value chain stakeholders
- More profitable producers who see relevance
- Trained students
- Creation of resilient, ecological sustainability with improved consumer health and food security
- Opportunities for viability in the rural communities through food systems – economic sustainability
- Convergence of the current platforms and emergence of new focus areas

The Research and Technology Task Force envisions that a certain number of “anchor tenant” PIs – who will have the Plant Sciences Building as their primary lab and office location – will

emerge as the NC PSI evolves. Perhaps numbering three to four per platform as an initial target, these PIs will represent faculty who are contributing to multiple NC PSI projects, perhaps spanning multiple platforms. These faculty would act as the catalysts in sparking the convergence of the platforms and in fostering new collaborative interactions among the Plant Sciences Building occupants.

Recommendation 5: Continue to Engage the Research and Technology Platform Sub Task Forces

Developing an effective implementation and launch plan for the NC PSI will be a complex endeavor calling for a wide range of expertise and the ability to continue vetting and developing the research and technology platform areas. The launch director and subsequent research and technology platform directors will benefit from having well-connected and diverse advisory councils for each research and technology platform identified. While the final makeup of an advisory council should be decided by the launch director and NC PSI leadership, we suggest that a select number of members from the various sub task forces continue to be consulted if deemed helpful as the launch plan is developed. When the initial platform advisory councils are formed, concerted efforts should be made to launch the platforms in an integrated manner so that maximum intersection will occur.

As the next step in the progression of the research platforms, we recommend that this Research and Technology Task Force report be a starting point to develop more detailed white papers for each platform area. This process could be guided by the launch director and the matrix specified in Attachment R&T-C.

Recommendation 6: Develop a Space Allocation Rubric

A truly transdisciplinary space does not simply duplicate other buildings on campus. The NC PSI is not trying to reinvent the academy that NC State already has. What is needed is a facility that attracts the types of project teams and individuals that will embrace transdisciplinary research. This will require flexible space that can be reconfigured depending on the current needs of the platforms and projects.

A space rubric model is being proposed along the following dimensions:

- Plant Improvement Platform: We envision that a highly productive, large program would have nine to ten people involved. A midsize project or program would have two to three people involved. A small, short-term project might have only one person involved.
- Plant Data Sciences Platform: It would be typical for a large program to be working on three to four projects at a time that would require two people per project, so eight to nine individuals working at desks.
- Food Systems, Environmental Sustainability, and Resilience Platform: Both types of projects could be performed (similar to both Plant Improvement and Plant Data Sciences), and therefore flexibility will be required.

With that in mind, the following ideas and concepts concerning space needs for the building are recommended:

- Plant genotyping lab.
- Imaging and microscopy facility.

- Analytics labs with mass spectrometry and metabolomics capabilities (as for food composition analysis under a Food Systems Platform project).
- Phenotyping development lab and greenhouses (growth chambers; room to develop phenotyping; not high throughput).
- Fabrication (sensors and fabrication development).
    a. Cleanroom-like facility for prototyping (not scale-up)
    b. Work area that would allow for space and tools to handle both plants and soil, acting as shared space for development of sensors (or other collaborations with engineering) and for the optimization of how to get reliable data from plants such as validation of a new optical system)
- Wired greenhouse or wired chambers (real-time data).
- High-performance computing cluster – fast access to HP computing clusters and control room with 3-D imaging.
- Archival space – Information management system or biorepository. Replicate Hunt Library as a model for bio-archiving and meta data (such as bookBot but for biorepository).
- Industrial space for competitive research.
- Ground-floor walk-in cold rooms (including space for seed storage).
- Media prep space.
- Sterile culturing areas that could accommodate both aerobic and anaerobic microorganisms.
- Space for business incubator.
- Shared conference space and meeting space.
- Examine how busy the labs and facilities are that already exist on campus that are relevant to the technology platforms.
- Examine whether a BSL-3 facility is needed.
- Determine the most efficient model for data generation (for example, core labs or even external facilities for genotyping, metabolomics, and other tasks).

It will also be important that space design promotes adjacencies rather than silos. Ideas to do this include the following:

- Spread the core facilities throughout the building.
- Distribute meeting space and functionality throughout the building.

In alignment with the recommendations from the Governance and Leadership Task Force, clear expectations for occupancy must be in place at the outset, involving research goals, metrics, and mechanisms by which progress will be tracked.

As an overall guiding principle, the building design should reflect the transdisciplinary and transorganizational concept of the three research and technology platforms.

Attachment R&T-A: Research and Technology Task Force Members

Co-chairs

Rebecca Boston, Assistant Director, NC Agricultural Research Service (NCARS); William Neal Reynolds Distinguished Professor of Plant and Microbial Biology, NC State

Richard Trethewey, Vice President, Digitalization in Research & Development, BASF

Karin Herbers, Vice President, Research Project Management and Integrated Trait Knowledge, BASF

Members

- Rodolphe Barrangou, Todd R. Klaenhammer Distinguished Scholar in Probiotics Research; Associate Professor, Food, Bioprocessing and Nutrition Science, NC State
- Philip Benfey, Paul Kramer Professor of Biology in Trinity College of Arts and Sciences, Duke University
- Hannah Burrack, Associate Professor and Cooperative Extension Specialist, Entomology and Plant Pathology, NC State
- Tommy Carter, Professor of Crop Science, NC State; Research Geneticist, USDA–ARS
- Nancy Creamer, Professor of Horticultural Science, NC State; Director, Center for Environmental Farming Systems
- Colleen Doherty, Assistant Professor of Biochemistry, NC State
- Rod Gurganus, Agricultural Agent and Director, Beaufort County Cooperative Extension, NC State
- Kendall Hill, Owner, Tull Hill Farms, Inc.
- Geoff Kneen, Vice President, Head of Strategic Initiatives, Regional Alliance Manager, Bayer CropScience
- Cal Lewis, Owner, Lewis Nursery and Farms, Inc.
- Cranos Williams, Assistant Professor of Electrical and Computer Engineering, NC State

Attachment R&T-B:
Platform Sub Task Force Members

PLANT IMPROVEMENT PLATFORM SUB TASK FORCE

Chair

Hannah Burrack, Entomology and Plant Pathology, Associate Professor and Cooperative Extension Specialist, NC State

Participants to Date

- Peter Balint-Kurti, Entomology and Plant Pathology, USDA–ARS
- Wes Bruce, BASF
- Gina Fernandez, Horticultural Science, NC State
- Fred Gould, William Neal Reynolds Professor of Entomology and Plant Pathology, NC State;
  Co-director, Genetic Engineering and Society Center, NC State
- Karin Herbers, Vice President, Research Project Management and Integrated Trait Knowledge, BASF
- Jim Holland, Crop and Soil Sciences, USDA–ARS
- Ian Jepson, Syngenta
- Geoff Kneen, Vice President, Head of Strategic Initiatives, Regional Alliance Manager, Bayer CropScience
- Angela Post, Crop and Soil Sciences, NC State
- Lina Quesada-Ocampo, Entomology and Plant Pathology, NC State
- Dominic Reisig, Entomology and Plant Pathology, NC State
- Dave Ritchie, Entomology and Plant Pathology, Cooperative Extension Specialist, NC State
- Heike Sederoff, Plant and Microbial Biology, NC State
- Steve Shafer, Soil Health Institute
- Deborah Thompson, Director of Research Partnerships, CALS, NC State
- Scott Uknes, Founder, Co-Chief Executive Officer, Vice President of PDGM, and Director, AgBiome
- Todd Wehner, Horticultural Science, NC State
- Ross Whetten, Forestry and Environmental Resources, NC State

PLANT DATA SCIENCES PLATFORM SUB TASK FORCE

Co-chairs

Colleen Doherty, Assistant Professor of Biochemistry, NC State

Cranos Williams, Assistant Professor of Electrical and Computer Engineering, NC State

Participants to Date

- Paul Bonnett, Syngenta
- Alper Bozkurt, Electrical and Computer Engineering, NC State
- Stewart Collis, aWhere

- Ian Davis, Monsanto
- Ben Gray, Benson Hill Biosystems
- Michael Kudenov, Electrical and Computer Engineering, NC State
- Drew Marticorena, aWhere (formerly with CEFS, NC State)
- Dahlia Nielsen, Biological Sciences, NC State
- Kemafor Ogan, Computer Science, Engineering, NC State
- Bharat Vedak, Retired John Deere executive
- Alyson Wilson, Statistics, NC State
- Kelly Zering, Agricultural and Resource Economics, NC State

FOOD SYSTEMS, ENVIRONMENTAL SUSTAINABILITY, AND RESILIENCE PLATFORM SUB TASK FORCE

Co-chairs

Nancy Creamer, Professor of Horticultural Science, NC State; Director, Center for Environmental Farming Systems

Rod Gurganus, Agricultural Agent and Director, Beaufort County Cooperative Extension, NC State

Participants to Date

- Dara Bloom, Agricultural and Human Sciences, NC State
- Mike Boyette, Biological and Agricultural Engineering, NC State
- Rick DeRose, Syngenta Crop Protection
- Karin Herbers, Vice President, Research Project Management and Integrated Trait Knowledge, BASF
- David Marshall, Professor of Entomology and Plant Pathology and U.S. Department of Agriculture Agricultural Research Service (USDA–ARS) Plant Science Unit Research Leader, NC State
- Laura McConnell, Bayer CropScience
- Chris Reberg-Horton, Crop and Soil Sciences, NC State
- Michelle Schroeder-Moreno, Crop and Soil Sciences, NC State
- Richard Trethewey, Vice President, Digitalization in Research & Development, BASF

Note: We recommend that more individuals be engaged to participate in the NC PSI platform advisory councils as the strategic planning process progresses.

Attachment R&T-C:
Recommended Criteria to Guide NC PSI Research and Technology Platform Identification

Relevance to Global Grand Challenges	• What are the global grand challenges that the platform will seek to address? What will be the top three to five research questions or themes around which the platform will focus its attention? • How is the research driven by the need to be transdisciplinary or enhanced by being transdisciplinary?
Relevance to NC Agbioscience Industry	• What companies in North Carolina are engaged in this area? Are any of them interested in furthering research in this field through collaborative partnerships with the NC PSI? • What are potential products, technologies, or research concepts that could be developed based on advancing this scientific or technological area? Would any of these potential products and technologies have the opportunity to be commercialized through entrepreneurial efforts in North Carolina? • Can these research concepts be translated to address global grand challenges? • Do these research concepts have the potential to go beyond addressing industry needs and improve or revolutionize industry practices?
Relevance to NC Producers and Consumers	• Will the research be relevant to North Carolina agricultural production and its value-chain? If yes, under what time frame? How so? • What are the anticipated markets and needs of the innovation and research? What are future trends and opportunities and the translation of the innovation and research? • Will the research focus be crop-specific, have cross-species relevance, or model a systems approach? • Will the research help to rethink the food “system” by focusing on resilient and sustainable models for farmers and agriculture workers and leading to thriving rural communities. How so? • Will the research address food insecurity and its impact on consumers’ health outcomes? How so?
Fit to NC State Research Strengths	• Has a critical mass of current NC State faculty been identified across the university with research capabilities and interests in this research platform? • Are there existing research centers or areas of research excellence at NC State that can be identified that relate to this platform? • Are there colleges, departments, ag experiment stations, or Cooperative Extension efforts across NC State that have an interest in this research platform? How is the research platform different than an already existing unit? How will it require or be enhanced by transdisciplinary efforts?
Potential for External to NC State Research Collaborations	• Are there other universities or other public-sector organizations within North Carolina that have strengths related to the platform that could be engaged with the NC PSI?

	• Are there research institutions or other public-sector organizations around the world that have strengths related to the platform that could be engaged with the NC PSI? • Who are the leading external experts that could be engaged or hired to be part of the NC PSI?
Potential to Provide Other Impacts	• What are the education and training opportunities that lend themselves to the research platform? • What other types of functional impacts, beyond the economic impact to industry and producers, might this research platform produce (such as improving health)?

Long-Term Potential	• Will the platform be relevant when the NC PSI opens its doors?
	  • Length of time for someone to achieve academic excellence on the world stage and gain dominance in the field?
	  • Length of time to generate major innovations in the field?
	  • Length of time for translation of research to applications and commercialization?

Workforce Development and Public Engagement Task Force

Introduction and Overview

The Workforce Development and Public Engagement Task Force assembled with this charge in mind: to provide advice and structure for NC PSI on how to communicate unbiased information to stakeholders, disseminate discoveries, and train the agbioscience workforce of tomorrow. To fulfill this charge, the Workforce Development and Public Engagement Task Force formed three sub task forces:

- Science Policy and Communications Sub Task Force
- Research Translation and Delivery Sub Task Force
- Workforce Education and Development Sub Task Force

Their work is described in the sections that follow and forms the basis for the recommendations made by the Workforce Development and Public Engagement Task Force.

Science Policy and Communications Sub Task Force

Introduction and Overview

Agriculture is in a state of change, continuing to evolve with the application of new science and technology. North Carolina's demographics are also changing – with a projected growth of 100,000 new residents moving to the Triangle, Triad, and Charlotte every year.

Even though agriculture is the state's number one economic driver, most NC residents are three or more generations removed from the farm. Their perceptions of how food is raised and grown do not align with modern agriculture and have led to a flood of false information, the demonization of certain agricultural practices, and the rise of unnecessary alarm among consumers and policymakers.

North Carolina needs an unbiased, credible resource to foster statewide agricultural awareness that incorporates evidenced-based stories and information from farmers, researchers, and other experts (including academics, environmentalists, health care professionals, nutritionists, and food retailers). This resource must be inclusive and consistently provide a diversity of voices and topics – from genetically modified organisms (GMOs) to efficient and responsible crop production and animal care, and all points in between. Such an initiative will require a multimedia presence as well as programmatic outreach in communities across the state.

Importance of a Strong Communications Plan to Ensuring the NC PSI's Success

Against this backdrop, NC State is developing the NC PSI, which will be a game-changer for plant sciences research, academics, and transdisciplinary collaboration. This initiative will further position NC State and North Carolina as the global hub for agricultural biotechnology research and product translation.

The NC PSI will also provide a unique opportunity to be a leading voice for plant sciences in the production of food, fiber, fuel, and medicine. The NC PSI has the potential to provide experiential agricultural awareness programs where citizens can visit labs, touch crops, and learn about plant sciences research and innovation with tours and structured programs.

To develop recommendations that would lead to an effective communications plan, a Science Policy and Communications Sub Task Force was formed (Attachment SP&C-A lists sub task force members), composed of industry and higher-education communications leaders. The charge of the Science Policy and Communications Sub Task Force was to help NC CALS explore opportunities and make recommendations on how the NC PSI might proceed in developing and maintaining effective plant sciences awareness and educational activities. In doing so, the Science Policy and Communications Sub Task Force was to engage stakeholders to define optimal NC PSI communications strategies and resources that elevate influencers', policymakers', educators', and consumers' awareness of how science improves access to safe, affordable foods for a growing population. Specifically, the Science Policy and Communications Sub Task Force was to develop recommendations related to the following:

- Identification of key audiences, their concerns, and the impact they have
- Effective educational communications strategies
- Defined measurement system to determine effectiveness
- Process to capture ongoing feedback from key NC PSI stakeholders

This white paper represents the culmination of the work and findings of the Science Policy and Communications Sub Task Force and provides a series of recommendations to the NC PSI leadership with regards to developing an effective communications plan.

Science Policy and Communications Recommendations

Based on the analyses and discussions undertaken, the members of the Science Policy and Communications Sub Task Force respectfully submit the following recommendations to the NC PSI leadership team for consideration in the development of the NC PSI.

Recommendation 1: Hire a Communications and External Relations Specialist Dedicated to Advancing the NC PSI and Integrating its Communication Activities within the Broader CALS Efforts

The NC PSI should hire a communications and external relations specialist who would be responsible for the development and execution of NC PSI operational and strategic communications, as well as necessary marketing and public relations initiatives. We envision that this position would work in close partnership with the NCARS and CALS administration, as well as the CALS Communications team.

The communications and external relations specialist would be responsible for the creation and ongoing evaluation of the NC PSI communications strategy, including oversight and creation of needed content and communications tactics (working in collaboration with CALS communications team and resources). Specific tasks to be performed are envisioned to include the following:

- Create in collaboration with CALS Communications content that elevates the NC PSI across multiple media and platforms.
- Create and execute public relations and engagement initiatives to connect key audiences to how science and technology are used to raise and grow the foods we eat – across a diverse spectrum of agricultural practices.
- Work closely with NC PSI administration and researchers, partners, and stakeholders to develop and create marketing copy that elevates academic and career opportunities in agriculture and the plant sciences – thereby recruiting future students and developing tomorrow's workforce.
- Work closely with CALS administration and NC State Cooperative Extension, partners, and stakeholders to help develop and deliver key news and information highlighting the impact the NC PSI has in enhancing the state's agricultural infrastructure – targets include elected officials, commodity and community organizations and foundations, and the farmers and growers across our state.
- Work closely with CALS and NC PSI administration, partners, and stakeholders to develop and deliver marketing copy that elevates the NC PSI, CALS, NC State, and North Carolina as the global leaders for plant sciences research, education, and opportunity. Coordinate this effort with needs of partners and stakeholders where possible.

- Create compelling communications stories that appeal to current CALS students, alumni, internal constituents, peers, and influencers who follow NC State, CALS, and the NC PSI, and increase inbound traffic while following best practices for web content strategy.
- Edit content contributed by other content creators from across the college, within the NC PSI and other entities, ensuring consistency of message, voice, and tone for campuswide and statewide communications.

Recommendation 2: Create the Communications Plan Phase I – NC PSI Realization and Launch

To support the launch of the NC PSI, we recommend that a "Realization and Launch Plan" be developed to oversee the communications needs of the initiative during the prelaunch to launch timeframe. The NC PSI Realization and Launch Communications Plan should focus on the following:

- **Funder Communications** – Status of progress, communications to help solidify necessary funding sources
- **Faculty Recruitment and Retention** – Attracting world-class faculty to NC State
- **Student Recruitment** – Attracting students to undergraduate and graduate programs
- **Stakeholder Communications** – Progress reports, highlights, and stories that point to successes and areas of opportunity and need
- **Public Communications** – Reporting on events such as major milestones, human interest stories highlighting initial results and their impacts, grants, awards, faculty hires, and program launches

Recommendation 3: Create the Communications Plan Phase II – Sustaining and Strategic Communications

To support and to reinforce NC PSI's mission to be the global leader in plant sciences research, education, and innovation, a thoughtful and well-executed communications strategy must be developed and implemented. We envision that this Phase II Communications Plan would be implemented post-launch and be framed as an intentional communications strategy that connects desired audiences to purpose and facilitates progress toward defined objectives.

We envision that this communications plan would create and implement external communications strategies with the following attributes:

- Communications are intentional and strategic –
  telling the stories of the NC PSI rooted in the following:
  - **Discovery** – Plant sciences research and innovation breakthroughs
  - **Opportunity** – Breadth of transdisciplinary opportunities made possible through plant sciences research, innovation, and education, and how and why the NC PSI is uniquely qualified and capable to make these opportunities a reality. Focus on education and workforce development and faculty positions and programs.
  - **Teaching** – Training graduate and postgraduate agricultural and life science students, and education for a lifetime through NC State Extension and other venues.
  - **Extension** – NC State Cooperative Extension and other efforts that bring NC PSI resources, research, and applied innovation to North Carolina and global communities – including transferring research into solutions and practices, as well as public-private ventures and trusts.

    - **Activities, Achievements, Experiences, Impacts** – Stories, news, promotion, and coverage of the NC PSI and relevant partner events, faculty and staff awards, student and alumni profiles, and submitted content, as well as emerging opportunities and partnerships.
- Communications reinforce this NC PSI purpose: to be the global leader in plant sciences research, education, and innovation and how it integrates with CALS mission and core messages.

We envision that the **internal** focus of the communications plan would be to create and implement internal communication strategies that do the following:

- Disseminate information vital to the NC PSI among university and college administration, faculty, staff, and Cooperative Extension professionals – top-down and bottom-up communications paths.
- Facilitate the exchange of ideas and encourage transdisciplinary partnerships and innovation.
- Assist with the generation and transfer of information to external stakeholders – providing faculty, staff, and Cooperative Extension personnel skills training where necessary and production assistance when needed.

We recommend that the Key Audiences and Key Messages summarized in Table SP&C-1 and outlined in greater detail in Attachment SP&C-B be central to both the external and internal communications plan that is developed. While the Science Policy and Communications Sub Task Force members have spent considerable time researching and discussing the key audiences and key messages outlined in the matrix provided in Attachment SP&C-B, we recognize that this work will need to be updated at the time of launch. In addition, we recommend that an environmental scan be conducted at that time to better understand what other entities (both internal and external to NC State) are already involved in key messaging activities so that priorities can be determined and potential partnerships can be developed. Examples of other entities' involvement in the identified key messages are also provided in Attachment SP&C-B.

Table SP&C-1. Summary of Key Messages and Key Audiences

Key Message/Key Audience	Students	Educators	Media	Consumers	Elected Officials	Comm-unity Leaders	Growers/ Producers	Reg-ulators	Food Scientists/ Res-earchers	Nutri-tionists/ Physicians	Food Industry Prof-essionals	Food Evang-elists
General Awareness	X	X	X	X						Conveyor	Conveyor	Conveyor
Environmental				X	X			X				
Freedom to Operate			X	X	X	X	X					
Opportunities	X		X				X		X	X	X	X

Components of the communications plan would include the following:

- Develop a year-long editorial board to position the NC PSI as the global leader in plant science research. This will aid in attracting world-class faculty to NC State.
- Develop a K–12 education communications plan focused on highlighting long-term agbioscience opportunities.
- Prioritize what needs to be done:
    - First, develop a plan to communicate the opportunities that the agbiosciences afford to both the world and North Carolina specifically, which will help attract interest to the NC PSI from researchers, industry, and potential students.
    - Second, develop general awareness of the importance of plant sciences with select audiences – legislature, elected officials, regulators.

- Third, develop general awareness around the identified themes of opportunities, freedom to operate, and the environment.

Recommendation 4: Shape and Deliver Communications that Position the NC PSI as a "Trusted Source"

To be trusted, the NC PSI must demonstrate "trustworthiness." Industry, trade, and government groups tend to be less trusted than academics, medical doctors, and those in the independent scientific community.

Trust influences attitudes toward science and technology. People tend to trust those with similar worldviews and values. They also tend to seek out information that aligns with their worldviews and values.

To establish and nurture trustworthiness, we recommend the following:

1) Develop and adhere to principles of trustworthiness that include the following:
    a. Demonstrating independence
    b. Providing balanced perspectives
    c. Celebrating choice
    d. Establishing local, on-the-ground expertise
2) Respect all audiences.
3) Engage in two-way communications, including events like focus groups and public dialogues, as well as the use of web-based platforms and resources.
4) Acknowledge that nonexperts have valuable input.
5) Correct scientific misperceptions, while recognizing that uncertainties are interpreted differently by people (including experts) with different worldviews.

To increase resonance of public communications, we recommend that messaging should be values-based and nurture familiarity and comfort with the information provided. As such, messaging should seek to point out where and how consumers can exercise their choice, while providing trustworthy and balanced information to increase familiarity and correct misperceptions.

Recommendation 5: Create a Communications Advisory Council

Developing an effective communications plan for the NC PSI will be a complex endeavor calling for a wide range of expertise and ideas. The communications and external relations specialist will benefit from having a well-connected and diverse advisory council. While the final makeup of an advisory council should be decided by the NC PSI Executive Director and the communications and external relations specialist, we suggest that the members of this Science Policy and Communications Sub Task Force continue to be consulted if deemed helpful as the launch plan is developed in the near future.

Attachment SP&C-A: Sub Task Force on Science Policy and Communications Members

Co-chairs

Richard Campbell, Chief Communications Officer, CALS, NC State
Vern Hawkins, President, Syngenta Crop Protection North America

Members

- Alan Ayers, Director, State Affairs/Stewardship, Bayer CropScience
- Jennifer Kuzma, Distinguished Professor of Public and International Affairs, NC State; Co-director, Genetic Engineering and Society Center, NC State
- Janis McFarland, Head, Regulatory and Stewardship, Syngenta Crop Protection North America
- Chris Tutino, Senior Communications Manager, Syngenta Crop Protection

Attachment SP&C-B: Key Messaging/Key Audience Matrix

Key Message/Key Audience	Students					Educators				Media				
		Undergrad		Grad		K-12 Teachers		Non-Ag		Editorial Boards				Social Media
	K-12	Ag-Specific	Non-Ag	Ag-Specific	Non-Ag	Ag Ed	Generalists	Professors	Extension	Print	Broadcast	Ag-Media	Associations	Influencers
General Awareness														
Why Should I Care?	X		X		X	X	X	X	Conveyor	X	X	Conveyor	Conveyor	X
Advancements in Technology	X		X		X	X	X	X	Conveyor	X	X	Conveyor	Conveyor	X
Difference between genetics/breeding/gene transformation	X		X		X	X	X	X	Conveyor	X	X	Conveyor	Conveyor	X
GMOs - what they are and what they are not	X		X		X	X	X	X	Conveyor	X	X	Conveyor	Conveyor	X
Complexity/Risk of Farming Model	X		X		X	X	X	X	Conveyor	X	X	Conveyor	Conveyor	X
Who Should I Trust	X		X		X	X	X	X	Conveyor	X	X	Conveyor	Conveyor	X
What is scientifically-based?	X		X		X	X	X	X	Conveyor	X	X	Conveyor	Conveyor	X
Who is a trusted source of knowledge?	X		X		X	X	X	X	Conveyor	X	X	Conveyor	Conveyor	X
Environmental														
Modern Ag has Reduced Impacts on Water, Soil, Fertility	X		X			Conveyor	X	X	Conveyor	X	X	Conveyor	Conveyor	X
Farmers are Solid Stewards of Land	X		X			Conveyor	X	X	Conveyor	X	X	Conveyor	Conveyor	X
Science drives continuous improvement	X		X			Conveyor	X	X	Conveyor	X	X	Conveyor	Conveyor	X
Freedom to Operate														
Challenge of Conventional and Organic Farming										X	X	Conveyor		X
Inherent Risk of Farming										X	X	Conveyor		X
Significant Variable with Significant Restrictions										X	X	Conveyor		X
Technological Improvements Alters the Equation										X	X	Conveyor		X
Opportunities														
Agbiosciences solves Global Grand Challenges		X	X	X	X	Conveyor	X	X	X	X	X	X	X	X
Opportunities include Economic, Societal, Human		X	X	X	X	Conveyor	X	X	X	X	X	X	X	X
Ag is "Cool"	X		X		X	Conveyor	X		Conveyor	X	X			X

Attachment SP&C-B: Key Messaging/Key Audience Matrix, cont.

Key Message/Key Audience	Consumers	Elected Officials	Community Leaders	Growers/ Producers	Regulators	Food Scientists/ Researchers	Nutritionists/ Physicians	Food Industry Professionals	Food Evangelists
General Awareness									
Why Should I Care?	X	X	X	Conveyor	X	Conveyor	Conveyor	Conveyor	Conveyor
Advancements in Technology	X	X	X	Conveyor	X	Conveyor	Conveyor	Conveyor	Conveyor
Difference between genetics/breeding/gene transformation	X	X	X	Conveyor	X	Conveyor	Conveyor	Conveyor	Conveyor
GMOs - what they are and what they are not	X	X	X	Conveyor	X	Conveyor	Conveyor	Conveyor	Conveyor
Complexity/Risk of Farming Model	X	X	X	Conveyor	X	Conveyor	Conveyor	Conveyor	Conveyor
Who Should I Trust	X	X	X	Conveyor	X	Conveyor	Conveyor	Conveyor	Conveyor
What is scientifically-based?	X	X	X	Conveyor	X	Conveyor	Conveyor	Conveyor	Conveyor
Who is a trusted source of knowledge?	X	X	X	Conveyor	X	Conveyor	Conveyor	Conveyor	Conveyor
Environmental									
Modern Ag has Reduced Impacts on Water, Soil, Fertility	X	X	X	Conveyor	X				
Farmers are Solid Stewards of Land	X	X	X	Conveyor	X				
Science drives continuous improvement	X	X	X	Conveyor	X				
Freedom to Operate									
Challenge of Conventional and Organic Farming	X	X	X	X		Conveyor	Conveyor	Conveyor	Conveyor
Inherent Risk of Farming	X	X	X	X	X				
Significant Variable with Significant Restrictions	X	X	X	X	X				
Technological Improvements Alters the Equation	X	X	X	X	X				
Opportunities									
Agbiosciences solves Global Grand Challenges	X	X	X	X		X	X	X	X
Opportunities include Economic, Societal, Human	X	X	X	X		X	X	X	X
Ag is "Cool"			X					Conveyor	Conveyor

Examples of Other Organizations Currently Involved with Key Messages

- GMOs—What they are, and what they are not.
  - GMOAnswers.com
  - Purdue's Science of GMO's: https://ag.purdue.edu/GMOs/pages/scienceofgmos.aspx#.V-Mba5jD-AY
- Agbioscience solves global grand challenges.
  - http://www.scidev.net/sub-saharan-africa/agriculture
  - http://saaesd.ncsu.edu/docs/Impact%20Report.pdf

- Opportunities include economic, societal, human.
    - www.weforum.org/agenda/2016/01/what-are-the-10-biggest-global-challenges
- Ag is "cool."
    - Peterson Farm Brothers: www.petersonfarmbros.com

General Awareness Opportunities

- K–12 students
    - NC Farm Bureau Ag in The Classroom—K–8 Basic understanding of agriculture
    - and agricultural science—Lesson Plans: http://www.ncagintheclassroom.com/
    - NC Department of Public Instruction—Ag education and FFA programs, grades 7-12: www.dpi.state.nc.us/cte/program-areas/agricultural
    - FFA: ncffa.org
    - 4-H: www.ces.ncsu.edu/categories/4-h-youth-development
    - North Carolinians for Home Education: www.nche.com
- Teachers and counselors
    - NC Agriculture Teachers Association: www.ncagteachers.org
    - NC State CALS, Agriculture and Extension Education degree programs help teach and prepare future Extension professionals, as well as ag educators: harvest.cals.ncsu.edu/agscience/about-us/?pageID=1283
    - Kenan Fellows—Teacher enrichment programs focused on science, technology, engineering, and mathematics (STEM), including agriculture exposure: kenanfellows.org/2017-18-fellowships
    - NC STEM Center: www.ncstemcenter.org
    - Center for STEM Education, UNC–Charlotte: cstem.uncc.edu
    - Association of Mathematics Teacher Educators, UNC–Charlotte: cstem.uncc.edu/amte-nc
    - NC Science Teachers Association: www.ncsta.org
    - NC College Counseling Association: nccounselingassociation.org/ncca-divisions/nccca

Research Translation and Delivery Sub Task Force

Introduction

Agriculture has long been one of North Carolina's leading economic engines. Today, agribusiness generates $84 billion in annual economic impact in the state, making it the state's leading economic sector. Within the rapidly changing and highly competitive global marketplace, North Carolina's agriculture and related industries must operate at peak competitive efficiency – and must do so in a uniquely unpredictable production environment affected by such significant and wide-ranging variables as the following:

- Climatic conditions, such as amount of rainfall, amount of sunlight, and temperature extremes
- The emergence of bacterial, fungal, and viral diseases and pathogens that affect the production of crops and livestock
- The control of insects and other pests that affect preharvest and postharvest output
- The control of weeds, including herbicide-resistant weeds, that reduce yield and quality of crops
- Land management, including the retention of soil, the maintenance of optimal soil fertility, and drainage management
- Benefits and risks of embracing agricultural biotechnology innovation (including sensitivity and resistance to environmental stressors such as heat, drought, salinity; dependence on and independence from inputs; risks of accelerated resistance; food safety, human health and nutrition)
- Financial rewards and risks related to market-driven food supply systems (i.e., economically sustainable levels of financial reward to participants in the food chain – farmers, processors, and retailers – while simultaneously providing safe, nutritious, natural-resource-stewarding, and affordable food to consumers)

Those working in agribusiness do, however, have a professional resource in North Carolina to which they turn for advice, analysis, and access to the very latest in applied research – NC State Cooperative Extension. Since its founding in 1887, NC State has been an essential source of leadership and support for NC agriculture. Its land-grant commitment to applying knowledge through Cooperative Extension has put research innovations to work in every county. Through Cooperative Extension, those in agriculture and related industries have access to state-of-the-art research, education, and training – access that introduces new crops, value-added products, and production technologies; improves production and processing efficiency; reduces losses due to environmental, weed, insect, and disease threats; and enhances marketing strategies and management skills.

The NC PSI is envisioned to be a world-class transdisciplinary research center that will help position North Carolina as the global leader in plant sciences education, research, and innovation. However, for this effort to significantly impact North Carolina's agribusinesses, including producers, an effective process through which research is translated and disseminated to the agribusiness community must be in place.

To this end, a Research Translation and Delivery Sub Task Force was formed (Attachment RT&D-A lists sub task force members), composed of industry, nonprofit, Cooperative Extension, and higher-education leaders. The charge of the Research Translation and Delivery Sub Task Force was to help NC State CALS ensure the following:

- The output of NC PSI reaches producers through the Cooperative Extension model.
- The NC PSI receives input from producers, commodity groups, and allied agricultural organizations to help inform and guide the research agenda and other activities that the NC PSI undertakes.

This white paper represents the culmination of the work and findings of the Research Translation and Delivery Sub Task Force and provides recommendations to the NC PSI leadership for developing an effective translational research delivery model.

North Carolina Cooperative Extension Overview and Background

As a land-grant university, NC State has an important obligation to serve the people of North Carolina through Cooperative Extension and outreach. Cooperative Extension serves as a bridge between the campus and the state's communities, transferring groundbreaking research and solutions directly into the hands of millions of North Carolinians.

Cooperative Extension empowers people to make better-informed decisions and improve their lives. That's NC State Cooperative Extension's mission: to create prosperity for North Carolina through programs and partnerships focused on agriculture, food and nutrition, and 4-H youth development.

Cooperative Extension is the largest nonformal educational outreach organization in the 17-campus University of North Carolina (UNC) system, comprising a network unrivaled in terms of access, scope, and value to the state. With a statewide focus on local solutions, Cooperative Extension has established itself as a trusted partner in communities across North Carolina, operating local centers in all 100 NC counties and the Eastern Band of Cherokee.

County centers are staffed by nearly 600 Cooperative Extension professionals, while another 180-plus faculty with Cooperative Extension appointments work on NC State's campus. In fact, 60 percent of the CALS research faculty have Cooperative Extension appointments.

In addition to its extensive network of county centers and on-location services, Cooperative Extension has increasingly implemented a high-tech, high-touch model in recent years, with nearly 200 unique websites serving 5.4 million pages to 2 million users just in 2016.

Regardless of the final outreach and education plan details for the NC PSI, Cooperative Extension will be critical and central to the delivery of NC PSI resources to the market and facilitating an important ongoing dialogue with stakeholders.

Cooperative Extension is a two-way street for faculty-farmer business relationships, facilitating a dialogue to identify market needs, develop research, and deliver solutions. Through Cooperative Extension specialists and county-based agents, emerging issues and challenges in the field are related back to campus research faculty to ensure that Cooperative Extension remains timely, focused, and vital to North Carolina.

In short, Cooperative Extension has a well-established model of working directly with agriculture, commodity groups, and government to better understand market needs throughout

the state and communicate them to campus. It's an ongoing cycle that can be summarized as follows:

- Identify issues and opportunities.
- Facilitate communication and research.
- Deliver research-based solutions through educational programs and outreach.

Research Translation and Delivery Recommendations

Based on the analyses and discussions undertaken, the members of the Research Translation and Delivery Sub Task Force respectfully submit the following recommendations to the NC PSI leadership team for consideration in the development of the NC PSI.

Recommendation 1: Ensure that Cooperative Extension Has a Pivotal Role, from Beginning to End, for Each Project

NC PSI programs and efforts must be designed to encourage collisions of people – including researchers, Cooperative Extension specialists, producers, agribusinesses, and industry – to develop a continuous cycle of feedback so that the research and information developed by the NC PSI is what the consumer wants and needs. These collisions will spark discussions and lead to the ideation of projects that meet real needs. By using the in-place connections with producers and industry representatives that Cooperative Extension has already developed, the NC PSI will have a better understanding of the needs of various constituents. By working intentionally to ensure a continuous feedback loop is in place – gathering input from stakeholders and disseminating information back to them – the NC PSI will not become insulated from real-world problems and issues.

The NC PSI must ensure that researchers are encouraged to pursue and investigate the real-world problems that need to be solved. Creative collisions, facilitated by co-location in the Plant Sciences Building, between basic researchers, producers, and industry will keep the focus on commercial application needs. Early access to research tools in the field will inform basic research projects, linking basic research with on-farm applications. This input will then feed into the research paradigm, setting a new standard for translation of technologies from the bench to the field. Integration of Cooperative Extension at project inception must be intentional. Agents must be brought to campus for meaningful discussions and connections. Outside stakeholders, such as NCDA&CS and the UNC School of Government, should be involved because changes in the law and regulations can affect projects. Project teams need to think systemically from the beginning on how an idea or information can impact society.[18] Every project team must represent meaningful collaboration between Cooperative Extension and researchers on the main campus. The development of a framework that ensures this input and participation is critical. Further, the Cooperative Extension model will need to be adjusted as technologies come online to allow for constant feedback. Because each technology will be different and have different needs per project, it will be important to develop a flexible framework for ad hoc working relationships.

[18] A good example that encapsulates this would be the Komen Foundation, which organizes fund-raisers where cancer survivors meet face to face with cancer researchers. Perhaps the NC PSI could incorporate a similar model, i.e., a fund-raiser where farmers meet face to face with researchers.

It will also be important to receive input from a wide range of stakeholders regarding the greatest opportunities and significant issues that can be addressed through the research agenda. For example, the mergers currently occurring among agbioscience multinationals[19] create an opening for North Carolina to pursue new markets and opportunities, as do monumental shifts in consumer food demand. Ensuring that NC PSI projects are focused on the needs of stakeholders will ensure the greatest impact moving forward.

Recommendation 2: Ensure that Project Teams Represent a Diverse Group of Individuals to Guarantee a Robust Understanding of Needs as well as to be More Encompassing in How Information is Disseminated to Broader Audiences

It will be important to ensure that NC PSI stakeholders are broadly defined and encompass a myriad of different interests. Incorporating stakeholders that represent "oblique angles," which are not always part of a traditional stakeholder and collaborative structure, will enable fresh perspectives and build support for all of agriculture. For example, if food access and human health are important aspects of NC PSI efforts, then local food councils that are developing in many communities need to be viewed as stakeholders. The NC Fresh Produce Safety Task Force is an example of a model that could be emulated. It is interdepartmental, interagency, and includes a variety of outside stakeholder interests.

Recommendation 3: Implement a Formal Process and Create Mechanisms that Ensure that the Capabilities and Capacities that Cooperative Extension Represents are Used and Embraced, Thereby Creating a Culture in which the Role of Cooperative Extension Is Valued

To ensure that stakeholder input drives the NC PSI research agenda and that the knowledge created through projects is effectively disseminated into the field, the NC PSI must create formal processes and mechanisms that mandate a role for Cooperative Extension for every project. Connections between producers and researchers – through Cooperative Extension – are necessary to direct broad research goals toward specific production issues. The model must also ensure that research results are producer-ready by using the research stations. In addition, the model must ensure that Cooperative Extension has the research information to educate producers and to make the necessary connections with commodity groups, grower organizations, and others. For example, the University of Tennessee requires that all research proposals develop defined terms of engagement with research stations and Cooperative Extension. The NC PSI must set similar guidelines and administer the requirements.

This will require a change in NC State's culture, including how Cooperative Extension is viewed by the University Reappointment, Promotion, and Tenure Committee, to ensure that Cooperative Extension is no longer misaligned with promotion. This will also require a shift in mindset on campus to ensure that the value of Cooperative Extension is appreciated at both the college and department levels as well as by the voting faculty.

[19] Agbioscience multinationals include those corporations involved in the agriculture and related agricultural science and value-chain activities.

Attachment RT&D-A: Research Translation and Delivery Sub Task Force Members

Sub Task Force Chair

Richard Bonanno, Associate Dean and Director, NC Cooperative Extension, NC State

Members

- Alan Ayers, Director, State Affairs/Stewardship, Bayer CropScience
- Amy Chilcote, Extension Associate, 4-H, NC Cooperative Extension, NC State
- Debbie Hamrick, Director of Specialty Crops, NC Farm Bureau Federation
- Katie Jennings, Professor and Extension Weed Specialist, Horticultural Science, NC State
- Roland McReynolds, Executive Director, Carolina Farm Stewardship Association
- Justin Moore, Director of Marketing and Communications, NC Cooperative Extension Service, NC State
- Deanna Osmond, Professor and Department Extension Leader, Crop and Soil Sciences, NC State
- Matt Peterson, Director of Federal Research Affairs, NC State
- Bryant Spivey, County Extension Director, Johnston County, NC State
- Sandy Stewart, Director, NC Department of Agriculture and Consumer Services; Research Stations Crop Consultant
- Bob Sutter, Chief Executive Officer, NC Peanut Growers Association
- Dan Weathington, Executive Director, NC Small Grain Growers Association

Workforce Education and Development Sub Task Force

Introduction and Overview

In today's innovation-driven economy, the ultimate competitive factor for economic growth is talent. Industry executives consistently emphasize that their ability to compete in a global economy depends upon access to human capital, including the following:

- World-class researchers who drive new discoveries
- Applied scientists and engineers who help develop new products and processes
- Business strategists, marketers, and financiers who drive new product development into the marketplace
- Technicians who produce and deliver quality products and services

Despite an overwhelming need for innovation in agriculture due to factors such as a growing world population, urbanization, and climate change, the United States faces a predicted agricultural workforce shortfall. According to a report from USDA and supported by analysis from Purdue University, there will be nearly 58,000 job openings in the U.S. food and agriculture industry each year (from 2015 to 2020) for college graduates from across the country.[20] Over this same period, an average of 35,400 new U.S. graduates with degrees in food, agriculture, and natural resources will step in to fill these positions, leaving almost 40 percent of the jobs either unfilled or filled with graduates from other fields.

> "College graduates with expertise in food, agriculture, renewable natural resources, and the environment are essential to our ability to address the U.S. priorities of food security, sustainable energy, and environmental quality. Graduates in these professional specialties not only are expected to provide answers and leadership to meet these growing challenges in the United States, but they also must exert global leadership in providing sustainable food systems, adequate water resources, and renewable energy in a world of population growth and climate change."
>
> *– Purdue University and USDA*

In addition to needing more agriculture professionals, the United States also needs professionals with broader training that integrates agricultural sciences and other science, technology, engineering, and mathematics (STEM) disciplines. Without a larger and better-skilled agricultural workforce, the pace of technological innovation in agriculture may slow, and critical global challenges may not be addressed. The USDA-Purdue University study found that during the five-year period to 2020, 27 percent of the projected job openings will be in STEM-related fields.[21]

What is most concerning about this predicted workforce shortage? The challenges that can effectively be solved through advancements in plant science innovation are occurring at a time

20. U.S. Department of Agriculture. 2015. *Employment Opportunities for College Graduates in Food, Agriculture, Renewable Natural Resources, and the Environment, United States, 2015–2020*. West LaFayette, IN: Purdue University. purdue.edu/usda/employment/.
21. Ibid.

when more individuals are further removed from agriculture in general. Today, most of us do not know, and often do not care, where our food comes from, where the lumber to build our homes originated, nor the source of the fibers in our clothes and furnishings. We don't know if the fuels we consume, the plastics we use, and the paints we apply are petroleum-based or bio-based, nor the original source of their inputs. This distancing from our agricultural heritage is, in part, causing the predicted workforce shortage.

Importance of Workforce Education and Development as a Component of NC PSI's efforts

From its earliest conception, the NC PSI was envisioned as a training ground for the best and brightest students to receive unparalleled experiences in transdisciplinary research and professional development, thereby ensuring their ability to support the growing industry sector in North Carolina. Plant sciences, a component of the broader agbiosciences, is a fundamentally transdisciplinary endeavor, and plant science professionals rely on a range of specialties that necessitates a broad education. Plant breeders, for example, draw upon entomology, plant pathology, agronomy, soil science, and microbiology and need to integrate the tools of genetics, bioinformatics, statistical modeling, and robotics.

Understanding the importance of NC PSI's workforce education and development component, a sub task force was formed (Attachment WE&D-A lists Workforce Education and Development Sub Task Force members), composed of industry and academic leaders, to help guide the planning and development of the NC PSI in regards to undergraduate, graduate, and postgraduate development. The goal of the Workforce Education and Development Sub Task Force was to provide advice and structure for the NC PSI in the following areas:

- Undergraduate recruitment and development
- Graduate development
- Dissemination of knowledge and innovation through postgraduate development for industry practitioners

This white paper represents the culmination of the work and findings of the Workforce Education and Development Sub Task Force and provides recommendations to the NC PSI leadership for developing a transdisciplinary development program that will attract the world's most promising students and professionals. In addition, the Workforce Education and Development Sub Task Force also has taken the opportunity to provide the NC State CALS leadership with recommendations on how CALS can strengthen its undergraduate and graduate workforce development efforts to better meet North Carolina's agbioscience talent needs.

Situational Context

Over a six-month period, members of the NC PSI Workforce Education and Development Sub Task Force undertook the following analyses:

- Employer Survey Analysis (Attachment WE&D-B)
- Employer In-depth Interviews (Attachment WE&D-C)
- Land-Grant University Benchmarking (Attachment WE&D-D)
- Peer Institution Career/Professional Development Activities (Attachment WE&D-E)
- NC State Agbioscience Experiential Learning Opportunities (Attachment WE&D-F).

From these analyses, conversations with NC State faculty and staff, and internal discussions among Workforce Education and Development Sub Task Force members, the following conclusions were developed that summarize the current workforce and professional development efforts within NC State CALS.

Strengths of existing system that can be leveraged by recommended actions:

- Technical preparedness of NC State CALS students is above average when compared with peer institutions.
- Proximity to a diverse industrial base and alumni (presence of "knowledge economy" that is committed to NC State in the region) holds promise for a broad array of internships and other experiential learning opportunities.
- Diversity of academic offerings and majors is unique, driven by the diversity of crops grown in North Carolina.
- NC State CALS Career Office provides significant programs and activities to assist undergraduate students, which can be leveraged by the NC PSI.
- Breadth of other academic institutions in region can also provide significant opportunities for collaborative workforce development efforts to serve the needs of the agbioscience industry in North Carolina.

Weaknesses within existing system that recommended actions should seek to address:

- Professional skills acquired by students during their development are found to be somewhat lacking by industry, driven in part by the lack of consistent opportunities for experiential learning (such as internships and work experience). Analysis found the following:
    - A lack of organized, consistent, CALS-wide effort to foster and create internships
    - A lack of consistent, CALS-wide academic connections with industry – both at graduate and undergraduate levels
    - Unexplored opportunities for connection to alumni base
    - A lack of innovation, commercialization, and entrepreneurial experiences
- Industry also found interpersonal people skills, social skills, communication skills, and emotional intelligence attributes acquired by students during their development to be somewhat lacking (including teamwork, critical thinking, and adaptability).
- An insufficient number of students are currently enrolled within agbioscience degree programs to meet industrial demand. This is in part driven by the following:
    - A lack of knowledge regarding well-paying career opportunities
    - A lack of student population with diverse backgrounds (including racial, ethnic, socio-economic, and geographic diversity)
    - Higher hurdles set for admission to NC State due to increasing competition, which can be particularly inhibiting to students from rural areas interested in ag-related degrees
- There is not enough focus on transdisciplinary programs, research, degrees, and certificates:
    - Perceived lack of a mechanism to ensure that curricula and degrees are relevant to innovation and jobs of the future.

Workforce Education and Development Recommendations

Based on the analyses undertaken, the members of the Workforce Education and Development Sub Task Force respectfully submit the following recommendations to the NC PSI leadership team for consideration in the development of the NC PSI.

1. Hire a Dedicated Professional Development Coordinator

North Carolina's agbioscience employers have made it clear that a technically focused college curriculum alone does not provide the sufficient skills needed for its workforce. Currently, many ag-specific degree programs are viewed as lacking industrial relevancy due to insufficient professional skill development. Some experience and understanding of the world of work are necessary to help college graduates translate their education into practical workplace skills. This demand for college graduates with workplace skills and experience represents a shift in the demands of the external world, demonstrating the pressures a global knowledge-based economy places on talent to be relevant to work.

The National Research Council, in its study *Transforming Agricultural Education for a Changing World* found as follows:

> *…students should master a variety of transferable skills in addition to content knowledge. Employers value those skills at least as much as book learning. Providing students the opportunity to engage in a variety of experiences … helps to make content knowledge come alive while strengthening the so-called soft skills important in the workplace.*[22]

The NC PSI must ensure that the experiences it offers students involved with the initiative provide a strong orientation toward career opportunities and practical applications of their skills in a nonacademic setting. The National Research Council proposes that this orientation includes integrating work experience and exposing students to professional development skills, including the following:

- **Teamwork and Working in Diverse Communities** – Provide students with opportunities to work together, to interact with and depend on people with different backgrounds, and to work on projects that will lead to better results than any student could have obtained alone.
- **Working across Disciplines** – Prepare students to work not only with experts in their own field but with those in other fields to solve common problems.
- **Communication** – Provide students with numerous opportunities to write and speak about a variety of topics to audiences that extend beyond their classmates.
- **Critical Thinking and Analysis** – Provide students with opportunities to engage in real-world systems and to evaluate disparate data, make decisions based on these data, and explain and defend their choices.
- **Ethical Decision Making** – Provide opportunities to weigh contradictory aspects of disparate data and balance competing interests, such as assess the risks and benefits

22. National Research Council, National Academy of Sciences. 2009. *Transforming Agricultural Education for a Changing World*. Washington, DC: National Academies Press. nap.edu/catalog/12602/transforming-agricultural-education-for-a-changing-world

associated with various practices to balance concerns coming from scientific, economic, environmental, and other arenas.

- **Leadership, Management, and Business** – Provide students with opportunities to motivate others; manage complex tasks, teams, and budgets; and develop facilitation, conflict resolution, and basic business-financial skills.
- **Research** – Provide students with the opportunity to contribute to original research, to gain first-hand experience in conducting research, and to participate in laboratory communities.
- **International Experiences** – Expose students to international perspectives through learning-abroad programs and by increasing the international content in coursework.

Oregon State's College of Agricultural Sciences has created the experiential learning coordinator position, who works in close partnership with industry, agencies, and the Career Development Center on establishing and enhancing partnerships relating to internships and careers. The position works to place students in a wide range of experiential learning opportunities through the office's connections with industry, government, and other agbioscience stakeholders.

Similarly, the Workforce Education and Development Sub Task Force recommends the creation of an NC PSI professional development coordinator position that would assume several responsibilities, including the following:

- Undertake an annual survey and interviews with industry to assess workforce needs.
- Develop professional development programs for both undergraduate and graduate students in cooperation with other departmental, college, and university programs.
- Develop an NC PSI Graduate Program Certificate, incorporating transdisciplinary research, innovation, commercialization, and entrepreneurship components.
- Develop business skills integration – a potential model is the 2Blades Masterclass launched in 2015 by the Sainsbury Laboratory.
- Coordinate an internship and cooperative education (co-op) program.

The internship and co-op program merits additional discussion. Within professional degree programs, a long tradition exists of including field experiences as ways to build practitioner skills and facilitate the move from theory to practice. Two of the most common forms of workplace learning are co-op programs and internships. In co-op programs, students alternate periods of paid work with campus study or split their time between the workplace and the campus. An internship provides students with relevant work experience over a shorter, set period.

Both co-op programs and internships are structured and supervised experiential learning opportunities that provide students with practical experience in their chosen fields. Co-op programs and internships illustrate classroom relevance in the professional world. Beneficial for both students and employers, the programs offer career exploration and skills application for students and provide employers with workers who are creative, enthusiastic, and able to assist with projects, and open for mentorship. Transitioning students into full-time employees is also a proven time- and cost-saving recruiting method.

While prevalent in both professional degree programs and engineering programs, co-op programs and internships are not as widespread in ag degree programs. However, experiential education can certainly help students gain the following:

- A deeper understanding of subject matter than is possible through classroom study alone
- The capacity for critical thinking and application of knowledge in complex or ambiguous situations
- The ability to engage in lifelong learning, including learning in the workplace

The hardest part of developing co-op programs and internships is to gain the participation of employers. The NC PSI and CALS needs a coordinated outreach effort to stimulate and implement employer involvement with co-op programs, internships, job shadowing, and other work experience activities for students.

The professional development coordinator will benefit from having a diverse advisory council composed of both industry and academia representatives to guide strategic efforts and initiatives. It is also important to note that a critical component of the professional development coordinator's role will be to work within the existing NC State and CALS workforce development infrastructure, particularly with the Career Services Office, to ensure that effective coordination is realized. This position is not envisioned as duplicating the current efforts of the CALS Career Services Office, but instead as supplementing existing efforts. The specific organizational hierarchy and reporting lines will need to be determined by the NC PSI leadership and launch director as the programs are initiated.

2. Develop Agbioscience Leaders of the Future, which Includes Both Technical Expertise and Experiential Programs and Hands-On Curricula

In addition to the specific efforts described in the previous recommendation, other agbioscience leadership development programs should be developed over time, either by the professional development coordinator for efforts specific to the NC PSI or in partnership with the CALS Career Services Office for initiatives that are in demand by other CALS departments. The Workforce Education and Development Sub Task Force recommends that efforts similar to those identified below be developed:

- Create an industry mentorship program using active researchers, alumni, retirees, and successful entrepreneurs. At least initially, focus on graduate students and faculty. As the program grows, also incorporate juniors and seniors.
- Develop partnerships with other colleges to enable transdisciplinary study. Most industry stakeholders interviewed expressed a desire for NC PSI programs to incorporate greater degrees of business and professional development. CALS has one model degree program in this regard, the master of microbial biotechnology (MMB) program.[23] Another example of such programs includes Rutgers' master of business and science degree (MBS), which is a hybrid degree combining master's level coursework in science or engineering with courses in business and policy. The degree is a combination of master of science (MS) and master of business administration (MBA) degrees. The science courses are taken within a specific concentration in areas such as the life sciences, engineering, mathematics, information technologies, and sustainability. Agbioscience-specific related programs include food science, global agriculture, global food technology and innovation, horticulture and turfgrass science, sustainability, and biotechnology and genomics. All MBS students take a common business core, including finance and accounting, marketing, communication, leadership, and project management. In place of

23. See: harvest.cals.ncsu.edu/master-of-microbial-biotechnology

a thesis, students work in teams and develop a business plan around a technology in their field.
- Create an NC PSI certificate with flexibility of content for fast change – one title but evolving curriculum. The Biomanufacturing Training and Education Center could serve as a model.
- Emphasize exposure to innovation, commercialization, and entrepreneurship.
- Provide funding for graduate assistantships.
- Provide funding for undergraduate research experiences.
- Develop and fund faculty sabbaticals with industry.
- Create an International University Exchange Program. The program would allow for an exchange of students – both into the NC PSI from abroad as well as out of the NC PSI for international studies. Such a program would be modeled after the PhD "sandwich experience," in which students complete one to two years of their degree program and research, work in an international lab for three to 12 months to gain skills and international experience, then come back to their home country to finish their degree. Several countries, including Brazil and Pakistan, offer and fund such programs for their PhD students. It will be critical to identify funding to enable NC State PhD students to take part in the exchange.

As previously indicated, the members of the Workforce Education and Development Sub Task Force did not limit their analysis only to issues that should be addressed by the NC PSI, but also examined broader issues that will need to be addressed by CALS. Based on the analyses undertaken, the members of the Workforce Education and Development Sub Task Force respectfully submit the following recommendations to NC State CALS leadership for consideration in the continued evolution of the college's workforce and career preparedness efforts.

1. Develop a CALS Academic Advisory Board with Sub-Teams for Each System: Plant, Insect, Microbe and Soil; Animal and Ecological; Food, Biochemical and Engineered; and Human and Resource Services

The CALS Academic Advisory Board should focus on career development and curriculum design. Creating sub-teams at the system level will allow for industry's input into transdisciplinary areas of study. It is our opinion that the current process of allowing career development and curriculum design to be managed at the departmental level allows for significant inconsistencies of offerings as well as diminishes effectiveness due to a lack of critical mass.

2. Create Transdisciplinary Areas of Studies

Researchers increasingly recognize the benefits associated with transdisciplinary science in addressing major scientific and technological challenges. Indeed, there is growing acknowledgement that some of the biggest questions in science demand solutions that are beyond the capabilities of any single discipline. The facilitation of transdisciplinary teams of faculty is thus key to advancing progress and innovation in a complex area such as agbioscience. CALS should consider the following suggestions:

- Create new transdisciplinary degrees – the NC PSI could serve as the pathway for a plant science transdisciplinary degree program.
- Allow for greater flexibility for curriculum requirements.
- Encourage multiple minors.

3. Develop New Programs Responsive to Industry of the Future

We recommend that CALS work with the agbioscience industry to determine current or emerging skill sets that are in high-demand, but not currently being met by the existing talent base, and then work to develop specific programs to ensure the necessary skill sets can be found in North Carolina (including regulatory, biotechnology, biologics, and informatics).

4. Position NC State as the World Leader in Agbioscience Leadership Development

Through the creation of a high-profile summer symposium, CALS can become the thought leader in regards to developing industrial talent for the future.

5. Increase Pipeline of Students Interested in the Agbiosciences (Enrolling in CALS)

The first step in creating a greater pipeline of students interested in the agbiosciences is to overcome the industry sector's image problem. Simply put, for most youth, agriculture is not "cool."

While the public perception of agriculture is a challenge beyond the scope of this effort, perception is a factor that influences the perspective of future undergraduate students. Thus, the recommendations found in this report cannot focus solely on programs and initiatives aimed at NC State. Undergraduate agbioscience students enter college after graduating from a K–12 education system. Therefore, one strategy for increasing the number and quality of students is to encourage more students to pursue agbiosciences careers before they reach college.

However, a lack of understanding of the exciting career opportunities available within the agbioscience industry sector is reducing the number of students interested in pursuing agbioscience careers. To help overcome this issue, North Carolina must begin a multifaceted educational campaign to inform the public about agbioscience career opportunities and how these careers will change the world in the coming decades. This educational campaign must be targeted not only at educational providers, such as teachers throughout the K–12 system, administrators, and guidance counselors, but also at the students and their parents, regional leaders, and community thought leaders.

CALS should continue its ongoing significant efforts to increase interest in agriculture and life sciences in children of all ages and their parents, teachers, and guidance counselors. Ultimately, these efforts will encourage more young people to choose ag and life science-related careers:

- Utilizing industry personnel to speak to the opportunities at high schools
- Working with industry to generate additional funding for scholarships
- Focusing on diversity of student interest and enrollment
- Developing summer camps for interested high school students
- Partnering with the National Future Farmers of America organization and trade associations
- Introducing STEM educators through continuing education units (CEUs) to agbioscience educational opportunities and case studies

6. Develop College-level Coordination, Positions, and Programs

Efforts should include the following:

1. Develop coordination and consistency across all departments or at a systems level to deliver professional development and career services.
2. Design and offer career and professional development courses that are required for every student (note some departments already offer such courses):
    a. First course introduced during sophomore year
    b. Second course offered during senior year
3. Develop career ladders for professions related to each department, inclusive of professional development needs.
4. Consider creating an employer relations coordinator position focused on industrial internships as well as research experiences. (Internships and research experiences were included in the responsibilities for the proposed NC PSI professional development coordinator. Coordinating these experiences, however, could easily take up all the available time for the coordinator. A separate position supported by CALS might be needed. In addition, the need for an internship and research experiences coordinator extends collegewide.
    a. Increase number of, as well as coordination of, internships for all students.
    b. Ensure participation by industry.
    c. Establish specific metrics to track success, including specific growth goals.
    d. Provide funding for internships so that students can have the freedom to leave their assistantships to pursue opportunities.
    e. Create a research opportunities job board through which faculty members can post available research positions.
5. Develop more online courses to address skill gaps. These courses could be stand-alone courses or part of certificate programs for graduate students and career professionals.
6. Showcase what CALS is already doing in workforce development. Note that an employer engagement plan exists within CALS Career Services, but more resources are required to implement the plan.
7. Enhance coordination within CALS to be able to engage multiple people from the same companies. CALS needs to approach companies holistically and not just based on individual principal investigator interests and personal contacts. Work on this with Deborah Thompson, Director of Research Partnerships for CALS.
8. Develop and fund faculty sabbaticals with industry partners.

Attachment WE&D-A. Workforce Education and Development Sub Task Force Members

Co-chairs

John Dole, Professor, Horticultural Science and Interim Associate Dean and Director, Academic Programs, CALS, NC State

Paul Rea, Senior Vice President, BASF Crop Protection North America

Members

- Josh Allen, Regional Sales Manager, Coastal AgroBusiness
- Sara Lane, Coordinator, Career Services, CALS, NC State
- Debra Pickett, Manager, Sales and Marketing Effectiveness, BASF Crop Protection
- Bharat Vedak, Retired John Deere executive

Attachment WE&D-B: Employer Survey Analysis

I. Highlights

All respondents rated NC State students as average or above average in both technical and professional skills.

Companies who recruit only within North Carolina rate NC State students as better prepared than other NC schools. NC companies most commonly recruited at NC Agricultural & Technical State University. National companies most commonly recruited at Iowa State, Purdue, and University of Missouri.

NC State students lack the following professional skills:

- Leadership
- Communication
- Presentation

NC State students lack the following technical skills:

- Agronomic and farm experience
- Work, practical, and hands-on experience

The most desired items on student resumes are as follows:

- Work experience
- Internships
- Technical competence in discipline
- Graduate research (graduates, mostly marked by national employers)
- Student leadership (undergraduates)
- GPA (undergraduates)

The most important characteristics for an employee are as follows:

- Ability to work on a team
- Adaptability
- Critical thinking (4.3)

In general, students do not need specific certifications before entering the workforce.

For continuing education, employers prefer their employees receive short trainings (such as conferences and workshops) face-to-face, but longer-term trainings (including university degrees and certificates) through distance education.

Employers expect the following emerging areas to most affect the skills needed in the future:

- Precision agriculture
- Value-added food and health products
- Compliance with and understanding of regulatory affairs
- Bioinformatics
- Biotechnology and gene editing

II. Demographics of responding companies

23 Companies responded with the following characteristics:

Number of Employees:

9 companies with greater than 10,000 employees

4 companies with 1,000 to 10,000 employees

5 companies with 100 to 500 employees

5 companies with less than 100 employees

Annual Gross Sales and Operating Budget:

10 companies with greater than $100 million

8 companies with $10 million $100 million

2 companies with $250,000 to $1 million

1 company with less than $50,000

Business Area (number of companies):

10 – Agricultural, biotech, and/or life sciences R&D

7 – Agricultural chemicals

7 – Plant science and seed development

5 – Agricultural support services

3 – Plant production

3 – Precision agriculture

3 – Agricultural financial services

3 – Animal production

3 – Agricultural machinery and equipment

2 – Agricultural and food packaging

2 – Animal science and breed development

2 – Biofuels and biomass processing

1 – Animal processing

1 – Animal and livestock feed and nutrition products

1 – Human nutrition products

1 – Landscape contractor

1 – Other: Bee care

III. Question summaries

***Employees hired per degree type (number, all companies combined):**

No diploma – 365

High school – 1,374

Vocational training – 175

Two-year or associate's – 253

Bachelor's – 3,633

Master's – 1,239

PhD or equivalent – 274

Postdoctoral – 147

Other – 12

Other informal postgraduate training (workshops, short courses) – 15

*Hiring of degrees lower than a bachelor's degree was primarily by animal and food production and processing companies

**One company, Metabolon, accounted for 40 master's degrees, 75 PhDs, and 75 postdoctoral.

***Two companies, John Deere and Syngenta, accounted for 2,900 bachelor's degrees.

Employees hired from NC State in the last five years per degree type (number, all companies combined):

Two-year and associate's – 10

Bachelor's – 133

Master's – 16

PhD or equivalent – 24

Respondents reporting they actively recruit at NC State:

19 (Of these, four said they did not hire any NC State students in the last five years.)

Reasons respondents report actively recruiting at NC State:

- Considered a strategic ag university (Monsanto).
- Good talents. Need to be more active in recruiting at NC State (Dow).
- We are an NC State spinout. The hires we made were PhDs from the lab that developed our technology (Galaxy Diagnostics).
- It's nearby and has a lot of engineering students (Novozymes).
- We recruit for ag majors, and NC State graduates meet most of our needs (AgCarolina Farm Credit).
- Effective (USDA Natural Resources Conservation Service).

- Great candidates who have a passion for agriculture and who have been prepared to enter the workforce (Carolina Farm Credit).
- NC State students understand and relate to the culture, diversity and demographics of employees (Perdue – Rockingham Plant).
- We are always looking for college-educated new hires in turf and horticulture (Bland Landscaping Co.).
- Our proximity to the school and the quality of hires (Bayer CropScience Division).
- Good applied programs (DuPont Pioneer).

Reasons respondents report they DO NOT actively recruit at NC State:

- Based out of China (Tide).
- We are a nonprofit organization serving the agricultural industry that has minimal opportunity for employment because of our size (NC Association of Soil and Water Conservation Districts).
- All we need at the time is general labor (Pamlico Pecans).
- We are a younger company and are just beginning our plant science research team (LumiGrow).
- We use other methods (Metabolon).

At what other colleges/universities do you recruit?

Local NC Employers (number of companies responding in parentheses):

- NC A&T (3), Appalachian State (2), Mt. Olive (2), Wingate (2), Alamance Community College, Campbell, Duke, Fayetteville State, NC Central, Richmond Community College, Sandhills Community College, UNC, UNC-Pembroke, Virginia Tech, Warren Wilson, Winston-Salem State
- Comments about which schools provide the best graduates:
    - NC State provides the best graduates for our organization.
    - CALS students are better prepared initially but all are developed.

National Employers:

- Iowa State (3), Purdue (3), University of Missouri (3), Clemson (2), Kansas State University (2), Mississippi State (2), Oklahoma State (2), Penn State (2), Texas A&M (2), University of Florida (2), University of Georgia (2), University of Nebraska (2), Abraham Baldwin Agricultural College, Auburn University, BYU-Idaho, College of the Ozarks, Colorado State, Delaware Valley, Florida State, Kansas State, Louisiana State, Michigan State, New Mexico State, North Dakota State, Northwest Missouri State, Ohio State, South Dakota State, Southern Illinois-Carbondale, Southern Utah, UNC, UC-Davis, University of Arkansas, University of Illinois at Urbana-Champaign, University of Minnesota, University of Pennsylvania, University of Missouri, University of Illinois, Utah State, Virginia Tech.
- We recruit on campus at 31 schools and hire interns/new college grads from over 90 schools each year.
- All land-grant universities, individual-dependent, not university-dependent.
- All East Coast agriculture schools.

- Regarding the groups we support as an organization, they recruit at schools that have good environmental undergraduate and graduate programs. NC State is one of them, but there are several others in and out of state.
- Comments about which schools provide the best graduates:
    - NC State and UC-Davis provide a different type of graduate; one is more applied than the other; both are necessary.
    - Auburn University, UNC, Iowa, Nebraska, Penn State, and NC State all provide quality graduates in the various areas we seek candidates.
    - All major universities worldwide. High ranking in terms of hiring and preparation: the University of Minnesota.

What resume experiences make a student applicant stand out for positions requiring an UNDERGRADUATE degree (with number of companies listing each):

21 – Work experiences

18 – Internships

13 – Student leadership

13 – GPA

12 – Technical competence in discipline

8 – Community involvement

8 – Certifications appropriate to the position

6 – Service learning experiences

6 – Documented professional development activities (participating in career services)

6 – Undergraduate research

5 – International experiences (only international employers marked this)

Other – Portfolio for marketing or communications work

What resume experiences make a student applicant stand out for positions requiring a GRADUATE degree (with number of companies listing each):

17 – Work experiences

16 – Technical competence in discipline

15 – Internships

14 – Graduate research (mostly marked by national employers)

11 – Certifications appropriate to the position

9 – International experiences (only international employers marked this)

8 – Community involvement

8 – Student leadership

8 – Grade point average

7 – Documented professional development activities (participating in career services)

6 – Service learning experiences

Other – Leadership qualities, publications, field based R&D

Please select the characteristics of an employee you or your organization considers most important and rank them. (Results are listed from highest ranked to lowest by total number of points from all companies with lowest number being most important. Number in parentheses is average ranking of those marking the characteristic as important.):

50 – Ability to work on a team (2.6)

82 – Adaptability (4.3)

91 – Critical thinking (4.3)

93 – Have a spark (are they passionate about something?) (5.2)

101 – Strong written and oral communications (5.1)

102 – Ability to work independently (5.1)

112 – Readiness – ability to be productive on the job immediately (5.3)

114 – Ability to work across functions (i.e., accounting and engineering) (5.4)

153 – Project management (7.3)

Others:

- Leadership.
- Attitude matters the most. Curiosity. Insight. Engagement. Too many candidates fail to even look at our website before the interview, never mind try to learn something about our business problem and solution. Seems simple enough.
- Personality.
- Ag background or hands on experience usually ranks close to the top.
- High integrity (1), and being accountable to self and others (2).
- Honesty, being on time, good with the public, having a valid driver's license, having a cell phone or can be reached in a timely manner.
- Structured organization (2).
- Integrity, flexibility, and efficiency.
- Ability to understand other cultures, language training.
- Business acumen.

Do student applicants need any specific certifications for their jobs?

Only four “yes” responses:

- NC Association of Soil and Water Conservation Districts: Must be certified to provide consultation for regulatory type functions, such as agriculture waste management experience, pesticide application, engineering and job approval authority of water and soil conservation programs.
- NC Agromedicine Institute (ECU): Certification in an agricultural health or safety-related field (such as industrial hygiene, AgriSafe certified provider, and healthcare licensure).
- Bayer CropScience Division: It is job-dependent.

- Syngenta: Proof of education.

What is your organization's perception of NC State student applicant skills (shows number of companies responding):

Technical Skills:

11 – Above average

8 – Average

Professional Skills:

8 – Above average

12 – Average

What technical skills are NC State students lacking?

- Student-dependent but, in some cases, **farm background.** (Monsanto)
- **Agronomic readiness.** (Helena Chemical)
- Project management, business acumen. (Dow)
- Undergrads need more **work experience**, even internship experience in their field and function of choice. Lab experience is important for lab jobs. Ability to dig into the scientific literature is important. Even on the business side. (Galaxy Diagnostics)
- NC State students that come to us have exceptional technical skills. (AgCarolina Farm Credit)
- **Implementation** of conservation practices such as nutrient and pest management (on farm). (NC Association of Soil and Water Conservation Districts)
- An understanding of metabolism. (Metabolon)
- Real **hands-on experience**; the school farm is excellent for teaching. (Smithfield)
- **Practical.** (Bland Landscaping)
- Knowledge of the regulations associated with the registration of chemicals, traits, and new gene technologies. Bioinformatics (Bayer CropScience Division)
- None. (BASF)

What professional skills are NC State students lacking?

- Student-dependent; often **leadership** seems to be lacking. (Monsanto)
- Ability to relocate and be better at self-awareness. Soft skills are not as good as other universities. (Helena Chemical)
- **Presentation**, **communication,** and team **leadership.** (Dow)
- Understanding the basic principles of business is important. Understanding the basics of job qualifications and valuations is important. Students have a tendency to overvalue their qualifications. Salary and promotions are not awarded based on potential. Another issue I run into with student hires is a reluctance to answer phones and to call or email people for more information. Very odd. How do we teach them to be tenacious within their job scope? (Galaxy Diagnostics)
- Speaking/**presentation** skills. (AgCarolina Farm Credit)
- **Communication.** (NC Association of Soil and Water Conservation Districts)
- Rarely an issue for our needs. (Smithfield)
- Organization. (Bland Landscaping)
- **Leadership** and management skills, time management and project management skills, supervisory skills, and networking capabilities. (Bayer CropScience Division)

- Interview preparation in certain colleges/majors could be improved. Business students tend to be better prepared in this area, students in more technical majors could benefit from focusing on this more. (John Deere)
- Flexibility and ability to work on teams. (DuPont Pioneer)
- Public speaking, **presentation** skills, business. (BASF)

What occupational fields/types of jobs do you currently have trouble finding good candidates for?

- Sales jobs. (Helena Chemical)
- Computational biology and big data analytics. (Dow)
- Lab positions are pretty easy because training is cut and dried. Marketing and business processes is much harder to find good candidates. Marketing candidates should bring portfolios or samples of prior work. (Galaxy Diagnostics)
- Entry-level accounting positions.
- Appraisers. (AgCarolina Farm Credit)
- Soil conservationist. (USDA–NRCS)
- Appraisers. (Carolina Farm Credit)
- Employees need to be certified planners in conservation and have the authority to make decisions. (NC Association of Soil and Water Conservation Districts)
- General labor. (Pamlico Pecans)
- Scientific writing for nonscientists. (LumiGrow)
- Agricultural occupational safety and health. (NC Agromedicine Institute [ECU])
- PhD trained scientists with expertise in metabolism. (Metabolon)
- Feed milling. (Smithfield)
- Experienced team leaders, but we develop them through our PMT (Plant Management Trainee) program. (Perdue – Rockingham Plant)
- Irrigation services.
- Lawn care technicians. (Bland Landscaping Co.)
- Metagenomic and toxicology positions. (Bayer CropScience Division)
- Engineering, specifically electrical, computer, and weld. IT disciplines as well. (John Deere)
- Commercial and engineering roles. Also information systems. (Syngenta)
- Field-related scientists. (DuPont Pioneer)
- Field-based applied research. (BASF)

What type of continuing education do your current, incumbent workers receive (with number of companies listing each)?

22 – Conferences, seminars, workshops, other periodic trainings

12 – University degree (i.e., BS, MS, PhD)

10 – Selected university courses

8 – University certificates (generally 4 to 6 courses)

For the following types of continuing education for your current, incumbent workers, how do they prefer to receive their education (listed with number of companies responding)?

Type of Education	Face-to-Face	Distance Education
Conferences, seminars, workshops, other periodic trainings	20	2
University degree (i.e., BS, MS, PhD)	4	9
Selected university courses	1	12
University certificates (generally four to six courses)	1	10

Is NC State part of your employees' continuing education? Why or why not:

Yes – 13

No – 9

Yes:

- Employee- and topic-dependent. (Monsanto)
- One of our undergrad hires started master's coursework at NC State. It was convenient and cost effective. (Galaxy Diagnostics)
- We have sponsored some master's degrees from NC State. (Novozymes)
- Nutrient management course. (USDA–NRCS)
- NC State is usually part of the program along with other speakers from the industry. (Pamlico Pecans)
- Potentially for postgraduate work. (LumiGrow)
- When topics are available. (NC Agromedicine Institute [ECU])
- Provide excellent help with Mill training. (Smithfield)
- Turf and horticulture. (Bland Landscaping Co.)
- Employees are able to select which school they will attend to continue their education. (John Deere)
- I believe some employees are signed up for courses at the university. (Syngenta)

No:

- Geographic location/distance. (Dow)
- Currently seeking proper programs for our people. (LumiGrow)
- NC State requires face-to-face time. Many of our staff working on an MBA select East Carolina University due to availability of online courses. (AgCarolina Farm Credit)
- Generally, classes are a good distance for many employees. Internal training is provided for many continuing education needs. (Carolina Farm Credit)
- Don't offer the type of certification processes that are needed and often required by government agencies like USDA. (NC Association of Soil and Water Conservation Districts)
- Lack of flexibility on the programs. (DuPont Pioneer)
- Required training is handled in-house. (Bayer CropScience Division)

In your organization or research area, what are the emerging areas of agbioscience-related research that you expect to impact the skills you will require in the next 5 to 10 years and therefore need to be reflected and/or increasingly emphasized in today's educational curriculum?

12 – Precision agriculture

11 – Compliance/understanding of regulatory affairs

8 – Value-added food and health products (mostly NC businesses)

7 – Bioinformatics (mostly large life science companies)

6 – Biomaterials, renewable materials

6 – Produce and food safety technologies

6 – Industrial microbiology, i.e., the manipulation of microbes and metagenomic microbial populations for application to food and biomass production, energy and green chemicals production, and bioremediation of environmental contaminants

5 – Molecular plant improvement, including tissue culture, genetic engineering, and transgenics

3 – Pathogen biosecurity

2 – Biofuels and other bioenergy technologies

1 – Synthetic biology

Other:

- Culture of fastidious microbes
- Product marketing
- LED Lighting whole plant physiology
- Correlation between worker health and food safety
- Metabolomics
- Agronomy (including soils) and crop protection (I/F/H)

What are the emerging skill sets and training needs you view as critical for your current, incumbent workers? These might be areas in which you would like to see certificates, seminars, and/or workshops created and made available:

- Critical thinking and innovation, team leadership, project management. (Dow)
- Large data management, light as a tool for manipulating plant growth. (LumiGrow)
- Regulatory requirements and certifications, patent processes, basic business principles, NSF/USDA grant writing and management, early stage technology commercialization. (Galaxy Diagnostics)
- A leadership development program. (AgCarolina Farm Credit)
- GIS, understanding the implementation of nutrient and pest management on the farm, communication to farmers. (USDA NRCA)
- Job approval authority to make decisions to move plans forward ... e.g., conservation programs for farms. The groups we support experience backlogs because there are not enough people that have authority to move certain plans along. This could include district soil and water supervisors or district soil and water conservation employees. ...

need more opportunities for both parties to do their roles well by getting certifications. (NC Association of Soil and Water Conservation Districts)
- Understanding GAP and how worker health/safety may have an effect on food safety. (NC Agromedicine Institute (ECU)
- Metabolism. (Metabolon)
- Teaching a millennial what an employer expects with regards to their work ethics. (Perdue – Rockingham Plant)
- Managing staff. (Bland Landscaping Co.)
- Genome editing and ISO 9001. (Bayer CropScience Division)
- Data/analytics. (John Deere)
- Biotechnology and bioinformatics seems to be of increasing importance. (Syngenta)
- Remote sensing, bioinformatics, management of large data. (DuPont Pioneer)
- Precision ag, data management, crop protection, agricultural economics, pest resistance management. (BASF)

What are the emerging skill sets and knowledge areas you view as critical to new, less experienced workers/candidates? These would be areas you would like to see emphasized or introduced into current educational curriculum.

- Critical thinking and innovation, presentation skills, project management. (Dow)
- Technology commercialization in small/new companies. (Galaxy Diagnostics)
- More emphasis on soft skill sets. (AgCarolina Farm Credit)
- Communication with farmers. (USDA NRCS)
- Greenhouse management for industrial research. (LumiGrow)
- Understanding GAP and how worker health/safety may have an effect on food safety. (NC Agromedicine Institute [ECU])
- Metabolism. (Metabolon)
- Teaching a millennial what an employer expects with regards to their work ethics. (Perdue – Rockingham Plant)
- Production. (Bland Landscaping Co.)
- Genome editing and bioinformatics analysis and tools. (Bayer CropScience Division)
- Data/analytics. (John Deere)
- Biotechnology and bioinformatics seems to be of increasing importance. (Syngenta)
- Statistics, genetics, pathology, physiology. (DuPont Pioneer)
- Precision ag, data management and analysis, cropping systems, including soils, fertility management and pest management. (BASF)

What are the greatest workforce-related challenges facing your organization's operations in North Carolina?

- Restructuring and consolidation. (Monsanto)
- Excellent supply of highly qualified workers in Research Triangle Park. The challenges for us are on the business side, finding qualified people in diagnostic development, regulatory requirements, and insurance reimbursement in human health. (Galaxy Diagnostics)
- Finding lending staff (loan officers) with an agricultural background. (AgCarolina Farm Credit)
- Courses not being offered and incorporating multiple disciplines into one. (USDA–NRCS)

- Recruiting employees who have a passion for agriculture and a desire to work in the financial field. (Carolina Farm Credit)
- Lack of funding to support critical roles to either maintain the roles currently in place or grow roles so they can benefit more end-users (e.g., rural and urban). A good number of individuals we support are older farmers that aren't savvy on computers. We need face-to-face teaching opportunities at the county level so these individuals don't have to travel far to get the certifications they need. (NC Association of Soil and Water Conservation Districts)
- Apathy among the workforce regarding low-tier general labor. (Pamlico Pecans)
- Finding space to do greenhouse research. (LumiGrow)
- Funding to support work-force expansion. (NC Agromedicine Institute [ECU])
- For college level graduates, it is the sense of entitlement. The education received is on par; the idea that a company owes the new employee something or that a management position is waiting for them. (Smithfield)
- Hiring general labor employees. Finding employees that want to come to work every scheduled day. (Perdue – Rockingham Plant)
- The cost and uncertainty of the H2B program. (Bland Landscaping Co.)
- The impact of external agricultural innovation technology. Knowledge of the Bayer CropScience brand. (Bayer CropScience Division)
- Willingness to relocate outside of North Carolina (or the Southeast in general). (John Deere)
- Greensboro location is not always a first choice for relocating employees; competition for salaries on RTP with pharmaceutical and biotech companies. (Syngenta)
- Far from key production areas. (DuPont Pioneer)
- Finding diverse candidates and highly skilled workforce. (BASF)

Attachment WE&D-C: PSI Employer In-depth Interviews

In-depth interviews were conducted with:

- BASF
- Helena Chemical
- NC Biotechnology Center
- Novozymes
- PrecisionHawk
- Prestage Farms

Key Takeaways:

Strengths of North Carolina's workforce:

- Local universities with broad range of areas of study

Weaknesses and challenges of North Carolina's workforce:

- Lack of willingness to relocate
- Inability to apply academic knowledge to real world
- Lacking skills in
  - Agronomy
  - Sales and marketing
  - Logistics/supply chain
  - Management (MBA)
  - Regulatory science, experience with government
  - Formulation chemists (chemical engineering)
- Need for people with transdisciplinary experience
- Changing ag biotech sector, possibly losing jobs in plant and seed sciences, being more focused on ag chemicals and regulatory affairs
- Lack of diversity
- Hard to find people interested in production agriculture and willing to work

How is NC State doing in addressing workforce needs?

- Well to average. Some areas are good; others need work.

NC State does well with:

- Technical training (especially in plant sciences)

NC State could improve on:

- Soft skills training
  - coachability, willingness to learn
  - understanding of how things work in industry versus academics
  - overcoming entitlement attitude; helping them have appropriate expectations
  - Self-starters (New grads tend to do what they're asked, but nothing more.)
- More collaborative education programs with industry
- More internship participation and availability
- More students willing to relocate
- Focus on specialty crop areas
- Agribusiness, logistics/supply chain in ag (maybe partner with Poole College of Management)
- Training for work in government (such as USDA, Department of Energy)

- Training across disciplines to develop complementary skill sets (such as agronomy and business or agronomy and life sciences)

Curriculum development partnerships:

- No curriculum partnerships reported.
- All companies are open to partnering on curriculum.

Hiring students:

- All companies have an internship program that they use as a full-time hiring pipeline.
- All companies recruit at career fairs.
- Some are open to partnering more on internships/co-ops; others are happy with their current process.

Attachment WE&D-D: Land-Grant University Benchmarking Findings

We sent surveys to 50 universities and all but one (Cal Poly at San Luis Obispo) were land-grant universities. We received 24 responses, which are summarized below.

1. How many students do you typically have in the following degree programs in your college?

Degree	NC State	Average	Low response	High response
Two-year	330	154	35	352
Four-year	2460	2191	884	4258
MS	339	217	28	604
Professional MS (nonthesis)	280	142	10	749
PhD	378	220	46	675

2. What types of interdisciplinary research/academic programs do you have, and of those, which ones do you think are most effective in preparing students for their careers?

Summary: Depending on the definition of interdisciplinary, all universities reported having at least one program and most reported having a number of interdisciplinary programs. In some cases, the programs were limited to majors. Commonly listed interdisciplinary programs and majors include environmental science (which NC State also has), international ag, and food science. Several programs that may be particularly applicable to the NC PSI were agriculture biosecurity, homeland security, global change, community and leadership development, and remote sensing and spatial analysis.

Auburn: Undergraduate: environmental science major, agricultural science major, applied biotechnology major, food science major. The environmental science and food science majors are well established, and both are successful in terms of career placement and opportunities. The other two majors have been developed and are in the final stages of approval within the university. They should be available beginning next year. Interdisciplinary research is somewhat informal in many cases, but we do have to areas that provide some coordination. We have a Water Resources Center that facilitates research collaboration and funding. We have a position as part of the new AU Climate Cluster Hire initiative, so we anticipate some collaboration through that.

Clemson: Plant and environmental sciences: *clemson.edu/cafls/departments/pes* and environmental toxicology programs: *clemson.edu/entox*

Cornell: The following undergraduate majors are interdisciplinary, involving more than one department, and in some cases, more than one college: biological sciences, environmental and sustainability sciences, biology and society, agricultural science, information science, international agriculture and rural development, science of earth systems, and viticulture and enology. All of these majors, except the latter two, have been attracting an increasing number of students in recent years. All of the new majors (inclusive of this list) that have been created in the last 15 years are interdisciplinary. Administration of them works well so long as there is a committee with membership representing all the departments and colleges involved in the major.

Michigan State: MSU has several, and our college is involved (either as the lead administrative unit, partner, or courses) of several. Many are open broader than the college. At the graduate level, examples include:

hrt.msu.edu/pbgp
espp.msu.edu/index.php
eebb.msu.edu

At the undergraduate level, a couple of examples would be:

natsci.msu.edu
bsp.msu.edu

Oklahoma State: Undergraduate program in environmental science, graduate program in international agriculture (master's degree), graduate program in food science (master's and PhD degrees). Job placement is good in all three programs. The undergraduate program in environmental science has some challenges in placing students in their field of interest since some of these jobs prefer or require graduate degrees.

Oregon State: Many of our students will do research in their major for which there is both university and college funds. Specific programs include the "BioResource Research" (BRR) major (agsci.oregonstate.edu/brr/about-brr), which requires students to work with a research mentor and compete an undergraduate thesis.

We also have a sustainability (SUS) major, which offers a minor and double-degree major but not stand-alone major. The SUS program (agsci.oregonstate.edu/sustainabilitydd) can be added when another major is selected and builds upon the student's primary major to develop theory of sustainability within that area of study; it requires some type of experiential learning.

At the graduate level, there are several interdisciplinary programs which are housed at the Graduate School because of this characteristic: gradschool.oregonstate.edu/programs. In addition, there are several programs offering an MAIS, master of arts in interdisciplinary studies.

Penn State: We have many intercollege graduate programs that may qualify for interdisciplinary research/academic programs. Almost all of them are effective in preparing students for careers. These intercollege programs provide unique opportunities for graduate students to explore research problems and potential solutions to address those problems from different disciplinary lenses: agricultural biosecurity (option), bioinformatics and genomics, ecology, environmental pollution control, homeland security (world campus, plant biology, physiology, molecular, cellular, and integrative biosciences, watershed stewardship (option).

Purdue: Natural Resources and Environmental Science:
ag.purdue.edu/nres/Pages/default.aspx

Rutgers: This really depends on how you define interdisciplinary. At one level of analysis, nearly every program at our school is interdisciplinary. For example: food science (chemistry, biology, and engineering); marine science (biology, chemistry, physics); environmental policy institutions and behavior (sociology, anthropology, law, political science). Only biochemistry and entomology are not interdisciplinary.

South Dakota State: Agricultural science, A.S. and B.S. It is very effective for those undergraduate students who do not wish to specialize, including those who may be managing family farming operations.

Texas A&M: We have molecular and environmental plant sciences (MEPS) interdisciplinary MS and PhD degrees that are in a "Biological and Biomedical Sciences" classification of instructional programs code (26.0307).

University of Arizona: The UA runs graduate interdisciplinary programs for the campus. We have an interest in several of these programs. Our faculty are involved in governance of those programs listed with an asterisk:

- Applied biosciences
- Arid lands resource sciences*
- Biomedical engineering
- Cancer biology*
- Cognitive science
- Entomology and insect science*
- Genetics
- Global change*
- Physiological sciences*
- Remote sensing and spatial analysis*
- Statistics*

UConn: We do not have a lot of these in our college. Formal degree programs include environmental science and environmental studies. Environmental studies is new to us (two years old), so it's difficult to assess preparation. The environmental sciences major has been around for 15 years or so, and our students do get placed pretty well out of it.

University of Florida: We have several interdisciplinary programs which include either multiple departments and/or colleges (i.e., plant molecular and cell biology, animal molecular and cell biology, doctor of plant medicine, plant sciences, and interdisciplinary ecology).

University of Georgia: The majority of students focus on a particular major. The potential for interdisciplinary academic program resides in our "Interdisciplinary Certificate Programs" and in our experiential learning requirement, which includes undergraduate research, service learning, and study abroad.

University of Idaho: UI has two university-wide graduate programs (environmental sciences and water resources) that I would consider clearly interdisciplinary. Environmental sciences is housed in the College of Natural Resources, but many of our faculty have graduate students in the program. Water resources is housed in our college, and we also have faculty with graduate students in the program. Both seem to do a good job of developing graduate students for career opportunities.

University of Kentucky: The UK College of Agriculture, Food and Environment (CAFE) has 14 academic departments (ca.uky.edu/deptunits) and offers 19 undergraduate degrees, of which the following are multidisciplinary:

- Agricultural biotechnology (multidisciplinary)
- Community and leadership development (multidisciplinary)
- Equine science and management (multidisciplinary)
- Natural resources and environmental science (multidisciplinary)
- Individualized program in agriculture (IPA)
  Please note: *These are not official degree programs. However, we will work with each student toward building a plan of study that allows them to fully explore these areas.*
    - Entomology (IPA)
    - Modern agronomic crop production (IPA)
    - Sustainable agriculture (IPA)
    - Technical systems management (IPA)

The college also offer 14 graduate degrees.

University of Minnesota: Every College of Food, Agriculture and Natural Resource Sciences graduate program is interdisciplinary in nature and is quite effective in preparing students for their careers. Graduate students have access to a database of professional development activities, and courses identify student learning outcomes.

All undergraduate students are required to complete one interdisciplinary course as part of their major requirements. In addition, there are several interdepartmental majors that are interdisciplinary in nature; these include environmental sciences, policy and management; plant sciences; and food systems. Based on career center graduation survey statistics, six months post-graduation, 92 percent of these graduates are employed in their field or are enrolled in graduate school.

University of Missouri: The most prominent interdisciplinary program for plant biologists on our campus is the Interdisciplinary Plant Group (IPG). The IPG is composed of a broad spectrum of faculty, postdocs, and graduate students from several departments on campus, including plant sciences, biology, biochemistry and computer sciences. The IPG has developed courses that are cross-listed in several departments that attempt to provide broader perspective for plant biology. The Division of Plant Sciences has also developed interdisciplinary ties with other programs in soils and ag engineering. This traditionally has appealed to a different subset of graduate students within the division than those attracted to the IPG. There is a culture of research collaboration within and across these groups that provides unique training for graduate and undergraduate students, and postdocs working with participating faculty members.

University of Nevada: BS programs: rangeland ecology and management; ecohydrology. Combined BS/MS programs: biotechnology. MS/PhD: evolutionary, ecological and conservation biology; cellular and molecular biology; environmental health sciences; hydrological sciences; animal and rangeland sciences (in development); plant sciences (in development).

Most effective in career prep are rangeland ecology and management; biotechnology.

University of Rhode Island: We have three formal undergraduate research fellowship programs in the College – Energy Fellows (web.uri.edu/ceoc/energy-fellows-program), Science

and Engineering Fellows (in collaboration with the College of Engineering – web.uri.edu/cels/science-and-engineering-fellows), Coastal and Environmental Fellows Program (web.uri.edu/coastalfellows). We have found that participation in either one of these fellowship programs or engaging in research in a faculty member's lab provides a significant advantage to those students both in competing for jobs and for admission to graduate/professional school. The Science and Engineering Fellows program is specifically targeting at students from underrepresented backgrounds who might otherwise not choose to apply for an undergraduate research experience.

University of Tennessee: Watershed minor (undergraduate and graduate) and international agriculture and natural resources minor. It is difficult to tell how effective they are preparing students for their careers – we don't track data specifically for assessing minor's effect on students post-graduation.

Virginia Tech: For graduate students, we have a graduate student scholar program that helps prepare students for academic positions. There is also a similar program, not as formal, for extension.

Washington State: This is a very broad question. In brief: interdisciplinary BS degrees (agricultural and food systems, integrated plant sciences, and others) and certificates; undergraduate research opportunities (for-credit courses, funded opportunities), internships, the Center for Transformational Learning and Leadership.

3. Do you have a transdisciplinary center that provides graduate education curriculum/research experiences? If yes, can you provide a website link or a summary of the program?

Summary: Thirteen universities reported not having a transdisciplinary center or program. There was some question as to the difference between interdisciplinary and transdisciplinary. University of Florida reported the most transdisciplinary centers and several (bold) may serve as models for additional centers through the NC PSI:

- Center for Agricultural and Natural Resource Law
- Center for Aquatic and Invasive Plants
- Center for Cooperative Agricultural Programs
- Center for Food Distribution and Retailing
- Center for Landscape Conservation and Ecology
- Center for Leadership
- Center for Nutritional Sciences
- Center for Public Issues Education
- **Center for Remote Sensing**
- Center for Sustainable and Organic Food Systems
- Center for Tropical Agriculture
- Energy Extension Service
- Florida Center for Renewable Chemicals and Fuels
- Florida Sea Grant College
- Herbarium
- **Interdisciplinary Center for Biotechnical Research**
- International Agricultural Trade and Policy Center

- International Programs
- Nature Coast Biological Station
- Straughn IFAS Extension Professional Development Center
- University of Florida Juice and Beverage Center
- **Water Institute**

Cornell: At Cornell, thesis-based graduate education is managed by The Graduate School, rather than the individual colleges. The Graduate School reports that Cornell's graduate field structure is, by design, transdisciplinary. Students are required to develop special committees with faculty representing different disciplinary areas, and students are allowed and encouraged to enroll in courses offered by other colleges within the university. Students can find this information at the following website: gradschool.cornell.edu

Penn State: No. But there are several centers and/or institutes that provide graduate education curriculum/research. Huck Institute of Life Sciences, Environment and Natural Resources Institute.

Purdue: Look at PULSE: purdue.edu/gradschool/pulse

University of Arizona: gidp.arizona.edu.
We also have the Bio5 Institute for Collaborative Research that has graduate students.

University of Florida: We have several centers:
directory.ifas.ufl.edu/Dir/searchdir?pageID=3&pl=02

University of Georgia: We have a few joint BS-MS degree programs, but enrollment in these programs is limited to our high-achieving undergraduates.

University of Kentucky: UK College of Agriculture, Food and Environment is in the planning phase of such a program. The college also has a Research Office, which oversees graduate education and acts as the liaison between graduate students and research programs within the college: research.ca.uky.edu/content/graduate-education

University of Minnesota: College of Food, Agriculture and Natural Resource Sciences (CFANS) Research and Outreach Centers (cfans.umn.edu/research/roc-centers); Other CFANS centers and cooperatives (cfans.umn.edu/research/centers).

University of Nevada: We are working on developing a transdisciplinary program between the chemical engineering program and the biotechnology program. In this program, we cross-train engineering students and biotech students in cellular and molecular biology and process engineering. So far we only have one transdisciplinary lab course, but are working to more closely link the two programs. We also are developing a minor in Native American engagement. This program is aimed at teaching our students how to interact with Native American communities while working in areas related to agriculture and natural resource management.

University of Rhode Island: Most of our graduate students are part of the biological and environmental sciences degree program, in which faculty are free to create specializations that capitalize on current strengths or emerging trends – web.uri.edu/cels-gradprograms/bes. With no fixed curriculum, faculty and graduate students have the flexibility to create novel programs of study that can cross departmental and college boundaries. We also have faculty who

participate in the Interdisciplinary neurosciences program, which is in the early stage of development – web.uri.edu/inp.

Virginia Tech: Yes, the Institute for Critical Technology and Applied Science, which is a university institute, provides such experience for students. We also have several interdisciplinary graduate education programs (interdisciplinary graduation education programs, in thematic areas such as water, obesity, translational plant sciences) funded by colleges and the graduate school that include both education and research experience.

Washington State: I am not sure I understand this question. We have various degree options, and some are more transdisciplinary or provide an option to define a trans-d program than others. We have an NSF Integrative Graduation Education and Research Traineeship (NSPIRE, Nitrogen Systems: Policy-oriented Integrated Research and Education) program that is coming to conclusion. The Center for Transformational Learning and Leadership mentioned above.

4. Have you developed any professional (nonthesis) graduate programs specifically targeted toward producing graduates for industry positions? If yes, can you provide a website link or a summary of the program(s)?

Summary: Most universities referred to their generic professional (nonthesis) master's programs as being industry focused. NC State also has nonthesis masters in most departments and, typically, the graduates primarily go to industry positions. Cornell's master of professional studies program is unusual in that it is a year-long program instead of a two-year program, which is typical. Several universities have an agribusiness professional master's. Rutgers's professional science master's program (master of business and science degree) combines business courses with science, including biotechnology and genomics, food science, geospatial information systems and technology, global agriculture, horticulture and turfgrass science, sustainability. Several other industry-focused degrees are offered by various universities.

Auburn: We have some certificate programs in the college: public horticulture, brewing science, aquaculture professionals
cap.auburn.edu
hort.auburn.edu/programs-of-study/graduate/certificate-in-public-horticulture
humsci.auburn.edu/brewing (human sciences, but has an ag faculty member)

Clemson: We have a packaging science MS degree; that industry hires the grads. More students are taking a food science/nutrition MS degree program to become registered dietitians. We have MFR – master of forest resources – that we graduate about five every two years. These have been around a while; not recently developed.

Cornell: An overview of our professional degree program
at CALS is available here: cals.cornell.edu/mps
Specific fields of study are listed at: cals.cornell.edu/mps/fields-of-study

Michigan State: Several of our units allow graduate students to pursue a nonthesis option. For some students, these may lead to work with industry but not always. Graduate program information can be found at: canr.msu.edu/graduate/graduate_programs

Oklahoma State: Students in both MS and MAG programs go into industry positions – similarly, students in both MS and MAG programs pursue additional doctoral degrees. Many of the MS degree programs include a nonthesis option. The master's of international agriculture program may fit what you are looking for, but these students go into a very broad range of careers: miap.okstate.edu/program-information

Oregon State: Each graduate program has the option of carrying a nonthesis option. Most do. We have several graduate certificates and professional science master's degrees that target the audience you imply here.

Penn State: Not specifically for industry, but we do have an online master of professional science graduate program in community and economic development (CEDEV) offered through World Campus. The CEDEV program provides individuals with the knowledge and skills to work with citizens and leaders to establish and maintain viable communities and community organizations: aese.psu.edu/graduateprograms/cedev

Purdue: I believe the MS-MBA Program in agricultural economics fits best what you may be looking for: agribusiness.purdue.edu/ms-mba-degree

Rutgers: Yes. A number of our programs (food science, for example) have nonthesis (so called "plan B") MS programs. Also, over the last five to seven years, RU-NB (Rutgers University–New Brunswick) has developed a robust professional science master's program (MBS) that combines business courses (taught through the Business School) with science curricular taught in various schools at RU-NB (mbs.rutgers.edu). The following MBS concentrations are either run through or have a substantial connection to our School: biotechnology and genomics, food science, geospatial information systems and technology, global agriculture, horticulture and turfgrass science, sustainability.

South Dakota State: Not formally, but we do have several master's students who work full-time for a (somewhat) local vaccine company. We deliver part of their curriculum by distance. They are in a Plan B master's program that requires a research paper, but not a research-based thesis.

Texas A&M: Information about the master of ag listed above can be found at essm.tamu.edu/academics/graduate/degrees-and-certificates/magr

UConn: alliedhealth.uconn.edu/dietetics/internship.php, sepm.uconn.edu

University of Florida: We have three programs:
MFAS – sfrc.ufl.edu/fish/degreeprograms/graduate
MFRC – sfrc.ufl.edu/forest/degreeprograms/graduate
MAB – fred.ifas.ufl.edu/graduate

University of Georgia: Most recently, our master's in ag business is designed to train graduates for industry. We are also proposing an undergraduate major in food and hospitality management.

University of Idaho: We have tried to initiate some type of program from departments and a college-wide program with a focus on distance. So far, we have not successfully launched anything.

University of Kentucky: We are in the planning phase of such a program.

University of Minnesota: Master's students from any CFANS graduate program may select a Plan B MS, which is the nonthesis/nonresearch academic approach. A typical MS Plan B student has targeted industry as their next step, or they already are in industry and are returning for more education and plan to continue in industry.

University of Missouri: We do not offer any professional (nonthesis) graduate programs specifically targeting graduates for industry positions. However, some of our MS programs (and to a lesser degree PhD programs), in particular the crop, soil, and pest management program area, have traditionally been attractive to students who wish to pursue degrees in industry. The success rates for students entering industry from these programs has been very high over the years.

University of Nevada: Yes, the BS/MS biotechnology program. We are currently working on rebuilding the website. What is currently available is pretty minimal, sorry: unr.edu/degrees/biotechnology/bs-ms.

University of Rhode Island: Yes – we have a master of environmental science and management program –web.uri.edu/cels-gradprograms/mesm, and a medical laboratory science MS program – web.uri.edu/cels-gradprograms/mls

University of Tennessee: The Department of Agricultural Leadership, Education and Communications has an online master's program used in part by county Extension agents seeking a graduate degree.

Virginia Tech: Our online master of agricultural and life sciences program: cals.vt.edu

Washington State: msag.wsu.edu

5. Do you have any specific academic industry relations programs, such as industry advising on curriculum (college or departmental level), partnerships in career services, etc.?

Summary: Most common response appeared to be advisory boards or consultative partnerships of various types. Other responses included career fairs and internships. One NC PSI recommendation would be to develop ways to encourage active participatory industry advisory boards for academic programs and curriculum review and for career development.

Auburn: We don't have industry advising on curriculum. We do have extensive industry contacts, and these are usually maintained at the department level for internships and jobs. The college does offer career fairs.

Clemson: We have a great career fair and use contacts to advise students in our leadership courses. Some units have good industry advisory boards such as Animal Vet Sciences and Food, Nutrition, Packaging Sciences. A few other departments are beginning advisory boards.

Cornell: At this time, most of the liaising between academia and industry happens at the level of unit. For example, our Department of Food Science has a designated industry liaison officer, Dr. Julie Stafford. In addition, several of our academics utilize their advisory councils to provide feedback on curricula. Regarding partnerships in career services:

- To capture an employer perspective, we involved Elanco as a career fair planning partner for the CALS Make Your Mark Career Fair to be held in February 2017.
- As the Office of Academic Programs refined a "Professional Skills Self-Assessment" developed by a subcommittee of the CALS Curriculum Committee, we engaged with employers across industries for feedback on the professional skills that CALS seniors need in order to successfully transition into entry-level employment or graduate study.
- CALS Career Development annually engages employers from various industries in career education programming (workshops, webinars, resume feedback sessions), and in a new career course taught in spring 2016.

Michigan State: We do, but it is department by department. For example, our School of Packaging has a very active advisory board that is primarily made up of industry leaders. Similarly, our departments of forestry and biosystems engineering also have strong advisory boards. In all cases, these boards provide insight on curriculum, research, etc. Many meet two-plus times per year to engage with the unit. We also have exceptionally strong relationships with many different industries as related to career services and their engagement in career fairs, etc.

Oklahoma State: Some departments include industry advisory committees. We do not have an industry advisory committee for our career services/student development area, but that is a great idea. We do not have a formal industry partnership program, but we do have a regular partnership on student development programming with Dow AgroSciences. We are also active participants in the Agriculture Future of America student leadership development program.

Oregon State: The College of Agricultural Sciences' experiential learning coordinator works in close partnership with industry, agencies, and the Career Development Center on establishing and enhancing partnerships relating to internships and careers. As stated above, the Career Development Center has placed assistant directors as liaisons in the colleges.

Penn State: We periodically meet with our key stakeholder groups to enhance both undergraduate and graduate curricula. Each program has its own curriculum advisory groups to provide input and feedback. Examples include – Ag Ed Teachers Advisory Group; Dairy Council. In addition, we also seek input from our Extension Advisory Board regarding updating undergraduate and graduate curriculum. Furthermore, at the undergraduate and graduate level, we periodically review curricula, at least once in five years to revise/revitalize curricula to meet industry needs as well as incorporate current changes occurring in the disciplinary area. Plus, many of our programs are accredited by external organizations; this brings in a whole different level of advisory/stakeholder interaction.

Purdue: Pretty much every academic department, plus Natural Resources and Environmental Science, has some form of industry-relations programs. And of course, the college does (ag.purdue.edu/Pages/dac.aspx).

Rutgers: Three credits of "experience-based education" are required for a BS degree in our school. We support a unit (Student to Professional Internship Network, SPIN (sebsspin.rutgers.edu) that connects students to internship opportunities (during semester or over summer). Rutgers Career Services also supports an internship program for students (careers.rutgers.edu/page.cfm?page_id=281). Individual programs (food science, in particular)

have long-standing relationships that connect students (both undergraduate and graduate) to local internship opportunities at over a dozen food companies (Mondelez, Unilever, Pepsi-Co, etc.).

South Dakota State: We have a college advisory board and some departments have an advisory board. We are required to do a formal program review of each academic program every seven years. Sometimes an industry representative serves on the review team, and sometimes a session is set up in which the review team meets with external stakeholders.

Texas A&M: Departments offering degrees in the plant sciences have industry partners who provide input about employer needs. In addition, departmental staff and advisors help facilitate pathways for students interested in internships and employment in these fields.

University of Arizona: Yes, we have about 50 companies we can contact from the college on curriculum issues at large. In addition, numerous companies are involved at the unit level in internships and so forth.

UConn: Not per se. Our college has an advisory council that contributes in that manner but they do many other things as well.

University of Florida: Many of our departments use an advisory board to provide input on teaching, research and extension programs.

University of Georgia: Not at the college level. Some of our departments seek the advice of industry in designing their curriculum but not necessarily in academic advising.

University of Idaho: Each department and the college have advisory boards that include industry reps. Some boards are more active and utilized than others, depending on the department. My experience with these boards is that, if active, they are more than willing to provide input on curriculum.

University of Kentucky: Most departments have industry/external stakeholder advisory groups which work with the departments to identify and formulate industry- and career-specific courses and programs.

University of Minnesota: A graduate student may select an industry professional (nonfaculty) to serve on their exam committees, as long as the professional can demonstrate they are the expert within the field. University of Minnesota Career Services has many strong partnerships with industry leaders.

We partner closely with industry, public agencies, and nonprofits for our CFANS Alumni Mentor Program.

University of Missouri: For the past two years, we have offered a program for enhancing our grad students' interpersonal skills for jobs in industry.

University of Nevada: Yes, we have worked with the biotech industry to develop curriculum targeted at soft and hard skill development of our biotechnology students. We also work closely with federal and state agencies to ensure undergraduate curricula in the natural resources areas meet federal and state hiring guidelines.

University of Rhode Island: The college and several departments have advisory boards comprised of industry professionals. Our career services liaison works with alumni to connect recent graduates with positions and internships.

University of Tennessee: Yes, some are at departmental level; some are college level.

Virginia Tech: Several of our departments have advisory boards who do provide guidance on career partnerships for students.

Washington State: Yes, see the Center for Transformational Learning and Leadership. CAHNRS also has a board of advisors that is evolving into the "Student Experience Advisory Council." Many departments in CAHNRS have advisory boards that provide input on curricula.

6. What else do your college and departments do that makes your graduates stand out in the job market?

Summary: A broad range of factors were listed, including internships, international experiences, community engagement, leadership experiences, undergraduate research, experiential learning, interview preparation, and service learning. The question for our task force is what we want our students to be known for.

Auburn: Long-time relationships between faculty and industry provide extensive contacts and opportunities for students for internships and jobs. Likewise, regional contacts through extension provide many job and internship opportunities for students.

Clemson: Leadership courses, internships, and undergraduate group research teams called creative inquiry: clemson.edu/academics/programs/creative-inquiry

Cornell: CALS has a long-term goal of increasing the number of undergraduates participating in meaningful international experiences. CALS will most likely experience growth in international engagement through (1) short-term faculty-led courses, independent departmental initiatives; and (2) Our new Global Fellows Program, which supports CALS undergraduate students from any major in pursuit of challenging, professionally focused summer internships that enhance and complement their career goals and academic progress, while enriching their undergraduate experience with diverse cultural and international immersion. In addition, providing engaged learning experiences to our undergraduate and graduate students has been a priority for CALS and Cornell University. Aligning with our land-grant mission, many CALS faculty have structured courses to offer students opportunities to engage in the community. These experiences allow them to enhance traditional classroom education with relevant needs in our communities. At the university level, a new Engaged Cornell office supports such efforts in the colleges, with an annual call for proposals in engaged learning. You can read about the successful programs, many of them in CALS, here: engaged.cornell.edu

Michigan State: At the undergraduate level, several units have moved to include experiential learning as a requirement for a degree. This can be met via internships, study abroad, and independent study or research experiences. The college also supports an undergraduate research program to engage undergrads early in research to help make them more marketable to the work place. We strongly encourage active participation of all (undergrads and grads) in

professional meetings, etc., often providing matching dollars (faculty mentor, department, college, graduate school, and international programs, if applicable) to support their attendance.

Oklahoma State: Here is a link to the College of Agricultural Science and Natural Resources (CASNR) career services webpage: casnr.okstate.edu/career-services. Our careers and student development coordinator utilizes peer mentors (career liaisons) to assist with resume reviews, mock interviews, and other career-related programming. CASNR alumni participate as speakers in many of our programs. We also include a focus on graduate student career preparation. As an example, we host an etiquette dinner for graduate students which includes networking skills students will also need when attending professional conferences. Many of our academic departments have a professional seminar course at undergraduate and/or graduate levels. We partner with departments to include career development curriculum in these courses. Oklahoma State University and CASNR have a very strong commitment to service. This is a visible value on our campus, and I believe it does set our students apart from many others. It provides them with a connection outside of their own self-interest. Student resumes include evidence of this service commitment, and we encourage students to communicate what they have learned through their involvement in service activities.

Oregon State: We offer several opportunities for industry to come to networking events for both careers and internships. We offer a series of panels and workshops, usually with industry partners.

Penn State: Publication/presentation record; Experiences in professional development, including participation in internships, fellowships etc.; laboratory and analytical skills; research and internship/fellowship experiences; fellowships received by NSF, NIH, USDA and other private foundations; experience and success in grant writing; the breadth and depth of graduate courses offered, including dual title degree programs and concentration areas; interdisciplinary nature of their research and application; recognition received for excellence in research, teaching and extension. Examples include teaching awards, research awards, doctoral dissertation awards, etc., at the departmental, college, university, and professional levels; communication and interpersonal skills; completion of Scholarship and Research Integrity (SARI) and Institutional Review Board (IRB) training; opportunity to work with world-class scientists, teachers, and researchers known for their scientific contributions; undergraduate and graduate research grants; undergraduate and graduate level intern and externships; undergraduate and graduate educational study abroad programs.

Rutgers: RU-NB and the School of Agriculture have an aggressive program to involve undergraduates in research opportunities beginning as early as possible: first-year seminars with direct research experiences; living learning communities (Oceanography House); the Aresty Research Center (aresty.rutgers.edu) that connects students to research opportunities; fall and spring research mixers that connect undergrads to research opportunities; the George H. Cook Honors Scholars program that supports over 60 senior honors thesis research projects.

South Dakota State: We sponsor an annual college career fair. We offer sessions in which students have their resumes critiqued. Last fall, we offered an employer panel that was well attended by students. We offer mock interviews for students applying to professional schools. Employers sometimes attend student club meetings or are invited to speak in classes.

Texas A&M: We place a heavy emphasis on high-impact experiences through research, experiential learning, and international experiences. Data suggests that these rich learning experiences make our students more competitive in the job market.

University of Arizona: We have career competencies that are incorporated into the curriculum and we have a number of specialized leadership programs for students that have corporate involvement.

UConn: Our university lagged others in career counseling, and the like, until about four years ago. We now have a very engaged central office that does a great deal to gain internship opportunities for our students, and this has been very good. All of our departments have undergrad courses that address issues of professional development and preparing for careers, but it's very different in each of those units as to how it's handled.

University of Florida: Most of our programs either require or highly suggest professional development courses and/or opportunities, internships, research experience, teaching experience, study abroad, capstone courses, and many opportunities for leadership in clubs or organizations. In addition, CALS has an undergraduate CALS Leadership Institute and 30 to 35 "CALS Ambassadors."

University of Georgia: The single most valuable undergraduate experience is the internship. I am attaching a report that highlights an Association of Public and Land-grant Universities (APLU) survey that examined soft skills and other attributes of preparing students for the workplace.
aplu.org/members/commissions/food-environment-and-renewable-resources/CFERR_Library/comparative-analysis-of-soft-skills-what-is-important-for-new-graduates/file

escop.ncsu.edu/Docs/Josef%20Broder%20Columbus%20Ohio%20Presentation2.pdf

University of Idaho: I would say that there are two things that come to mind. First, our previous graduates are major players in the ag and related industries in Idaho and the Pacific Northwest. I think we have an excellent reputation for providing good graduates, and that is important for our current graduates. Second, several specific faculty in certain departments have excellent industry contacts and make sure those contacts look to University of Idaho as they seek excellent employees.

University of Kentucky: CAFE prepares graduates with the skills, knowledge, and abilities to be competitive in the workforce by providing program offerings, many with research experiences, which are innovative, creative, and challenging. Academic enrichment experiences consisting of faculty mentored internships, research projects, education abroad, or other high value activities are required of all undergraduate students in all CAFE programs. We believe those enrichment experiences help our students tie their academic coursework to real-world applications, and thereby enhances their attractiveness in the job market. Additionally, many of our programs are multidisciplinary and comprehensive, allowing students the opportunity to engage in activities which increase their marketing potential and stand out among peers.

University of Minnesota: CFANS faculty have strong partnerships with public and private organizations. Graduate students are very likely funding through grants from these sources, and during their studies students make valuable connections with them.

We partner closely with our career center to provide significant resources for our undergraduate and graduate students to enhance their career opportunities and prepare for graduate school. Examples include:

- Resume and cover letter development
- Individual career counseling
- Effective interviewing workshops
- Career fairs (two offered annually) along with workshops on preparing for the career fair experience
- Networking workshops
- Mentoring programs
- Online internship and job database
- Career courses (offer academic credit)
- Developing personal statements for graduate program applications
- Admission test preparation

University of Nevada: Our programs have numerous experiential learning opportunities built into the curricula and through internship and internal research opportunities. We also co-sponsor a STEM career fair that is tailored to our students' career paths.

University of Rhode Island: Experiential learning – almost every course we teach is infused with experiential learning – field trips, community service projects, attendance at professional conferences, hands-on activities in the classroom and laboratory, and a shift toward problem-based and active learning in many of our courses. Development of the associated critical thinking and communication skills is valued by employers of our graduates.

University of Tennessee: Experience learning – student internships are highly encouraged and in some majors required, as is undergraduate research. All of the majors have very hands-on laboratory courses. Students are mentored to take leadership positions during college, e.g., office positions in student clubs. Our college provides a number of service learning courses. Some majors require a minor in business or entrepreneurship.

Virginia Tech: Graduate student organizations at both the department and college levels.

Washington State: Degree programs designed with industry input; experiential learning – research and internship experience; job preparation skills (resume, interview, employer panel discussions, etc.); leadership development**.**

7. Does your college have a career services person or office?

Summary:

- Yes, we have a career services person/office: 13
- Yes, we have a career services person in the University office assigned to our college or we partner with the university: 8
- No, we do not have a career services person/office; we rely on university office: 3

Attachment WE&D-E: Benchmarking of Peer Institution Career/Professional Development Activities

We interviewed career directors at three universities:

- Purdue
- Iowa State
- University of Illinois.

Key Takeaways

Includes information from NC State for comparison

Organization of career services offices vary:

- Purdue (2,700 undergrads, does not serve grad students)
    - Main university career center does student counseling
    - College career center handles employer relations (two full-time staff)
    - Each department has a career coordinator who teaches career courses and counsels students
- Iowa State (4,600 undergrads, does very little with 750 grad students)
    - College career center handles student prep and employer relations (two full-time staff)
- University of Illinois (2,700 undergrads, 700 grad students)
    - College career center handles student prep and employer relations (one full-time staff, half-time grad assistant, two part-time student workers)
- NC State (2,800 undergrads including two-year students, 1,000 grad students)
    - College career center handles student prep and employer relations (one full-time staff)

Career/professional development services commonly provided:

- Class and club workshops (all schools)
- Career fair (all schools)
- One-on-one career advising/counseling (all schools)
- Weekly career newsletter (all but Iowa State)

Only the University of Illinois and NC State routinely provide services to graduate students or offer special programming for graduate students.

Career/professional development in the curriculum varies:

- Purdue
    - Every major has a required career/professional development course
- Iowa State
    - Every major has one required career/professional development course
- University of Illinois
    - Two majors have one or two required career/professional development courses
- NC State
    - Two majors have a required career/professional development course

Common ways students are connected to industry:

- Employer talks to clubs and/or classes (all schools)
- Career fair (all schools)
- Pre-career fair networking event(s) (Purdue, Iowa State)

Attachment WE&D-F: NC State Agbioscience Experiential Learning Opportunities

We surveyed faculty coordinators for 16 undergraduate and 15 graduate programs (listed at bottom of document).

Seven undergraduate majors require an internship, co-op, or research experience:

- Biochemistry
- Plant and soil science
- Horticulture
- Turfgrass science
- Plant biology
- Agricultural education
- Extension education.

Most departments track internship, co-op, and research experiences only if the students are receiving course credit for the experience. A few try to gauge participation in these experiences through surveys.

Level of student participation in internship, co-op, and research experiences varies widely by program. Very few programs report participation in co-ops.

About half of the programs report they actively connect students to industry. There are two common ways of doing this:

- Bringing guest speakers into classrooms or club meetings
- Making personal connections through faculty

Undergraduate students most often find employment and research opportunities through the following:

- Connections through faculty/staff
- Internet job postings
- Personal/family connections
- career fair
- Departmental job board
- On-campus recruiting through Career Services
- ePACK job postings.

Graduate students do not often find jobs through Career Services-related means. They most often find employment and research opportunities through the following:

- Connections through faculty/staff
- Internet job postings
- Personal/family connections
- Departmental job board
- Professional meetings

Eight undergrad programs and five graduate programs say they consult with industry in curriculum development. This happens primarily through advisory boards and informal personal connections.

Most industry feedback to programs reports strong technical skills, though two majors report a need for more. A few programs report strong professional skills:

- Extension education

- Agricultural science
- Agricultural education
- Microbiology

Undergraduate programs report problems with professional skills report needs in written communication, among a number of other soft skill areas.

Several graduate programs report students are strong in presentation skills but poor in writing skills.

Advocacy and Resource Development Task Force

Introduction and Overview

The overall charge of the Advocacy and Resource Development Task Force was to help NC State CALS educate stakeholders across North Carolina about the importance of the NC PSI to economic development and job creation and to help develop the resources necessary to ensure its success. Specifically, the Advocacy and Resource Development Task Force (Attachment A&RD-A lists task force members) was charged to engage stakeholders from industry, government, and academia so that collectively they may accomplish the following:

- Advise on NC PSI direction and messaging and help demonstrate the potential impact to North Carolina.
- Develop new advocates, partners, and collaborators.
- Assist in resource development.
- Serve as spokespersons and champions for the NC PSI, NC agriculture, and plant sciences.

The deliverables that are expected from the work of the Advocacy Task Force include the following:

- Identifying key decision makers and stakeholders who should be informed about the NC PSI
- Creating and executing a strategy for effectively educating key decision makers about the importance of the NC PSI, including a timeline for reaching out to these key decision makers
- Developing and executing a strategy to secure the funding to ensure the success of the NC PSI

Advocacy and Resource Development Summary

From the beginning, the Advocacy and Resource Development Task Force chairs confirmed their commitment to the above charge and deliverables, noting that it will be critical to understand the efforts and outcomes of the other three task force groups to support the programmatic efforts being planned. As such, after a series of initial conference calls, the co-chairs ultimately decided to conduct their work in two phases defined below and to reconvene the task force once these proceedings were completed.

Thus, in lieu of presenting a series of recommendations, the Advocacy and Resource Development Task Force respectfully submits a reporting of its activities performed to date:

1) Developed Timeline for Advocacy Task Force Operations

We discussed that, unlike other task forces for the NC PSI who have completed their work in the lead-up to this report, the Advocacy and Resource Development Task Force will foster fund development and partnership development over a longer period, from March 2016 through December 2021.

The task force is pursuing its work in two phases:

Phase I: Capital fund development for the facility, both through advocacy for the bond referendum and through private fund development.
Phase II: Partnership and operating fund development for NC PSI programs and personnel, and continued fundraising for remaining capital needs. Efforts on Phase II would begin once recommendations from the other task forces are reported.

2) Capital Fund Development Activities

At the time this report was published, CALS had successfully raised 90 percent of the capital funds to support the design and construction of the $160.2 million Plant Sciences Building on Centennial Campus (anticipated opening in 2021). Members of the Advocacy and Resource Development Task Force were instrumental in helping raise over $9 million in planning monies for the Plant Sciences Building from 44 commodity groups and agricultural organizations throughout North Carolina. Further, members from this task force wrote letters of support for the proposal to the Golden LEAF Foundation, which ultimately granted an additional $45 million (on top of the $3 million in planning monies previously granted) toward the design and construction of the Plant Sciences Building.

3) Advocacy and Voter Turn-Out Efforts for Connect NC Bond Referendum

The Connect NC Bond Act of 2016 was a $2 billion bond package to support needed statewide capital improvements in education, parks, public safety, recreation, plant sciences, agriculture, and water and sewer infrastructure. The bond was proposed to NC citizens as a voting referendum for the March 15, 2016, primary election. Due in large part to a statewide effort with leadership by the Connect NC team, commodity leadership, NC Farm Bureau, CALS Communications, and NC Cooperative Extension, the Connect NC Bond Referendum passed, thereby providing $85 million for the Plant Sciences Building.

Members of the Advocacy and Resource Development Task Force were active in these statewide efforts in support of the Connect NC Bond in a multitude of ways, but primarily as vocal advocates for the bond within their own respective spheres of influence, focusing on how the bond is good for all of North Carolina – across all 100 counties and the global plant science and agricultural industry – as volunteers on election day in their home districts, and through other opportunities.

Now that the other task forces have weighed in with their recommendations, the Advocacy and Resource Development Task Force stands ready to support the next phase of resource development for the NC PSI.

Attachment A&RD-A: Advocacy and Resource Development Task Force Members

Co-chairs

James Blome, President and Chief Executive Officer (CEO), Bayer CropScience
Lawrence Davenport*, President, J.P. Davenport and Son Inc.
Dan Weathington, Executive Director, NC Small Grain Growers Association
Larry Wooten, President, NC Farm Bureau

Members

- Alan Ayers, Director, State Affairs/Stewardship, Bayer CropScience
- MeeCee Baker, President and Owner, Versant Strategies; Adjunct Professor, NC State
- Dave Corum, President, AgCarolina Farm Credit
- Bill Culpepper, President and CEO, SePRO Corporation
- Peter Daniel, Assistant to the President, NC Farm Bureau
- Doug Edgeton, President and CEO, NC Biotechnology Center
- Mark Fleming, Vice President, Blue Cross and Blue Shield of North Carolina
- Mark Forbes, Senior Vice President, Wells Fargo
- Sharon Hall, Manager, Communications and Industry Relations, BASF Crop Protection
- Vern Hawkins, President, Syngenta Crop Protection North America
- Allen James, Past President, NC Agricultural and Life Sciences Research Foundation; Retired Executive Director, Responsible Industry for a Sound Environment (RISE)
- Kelly McIver, Executive Director, NC Sweet Potato Commission
- Richard Reich, Agricultural Services Assistant Commissioner, NC Department of Agriculture and Consumer Services
- Mark Schmidt, Principal Scientist, John Deere
- Sam Taylor, President, NC Biosciences Organization (NCBIO)

*Mr. Davenport, who has served on the Board of Directors for the Golden LEAF Foundation, resigned from the Advocacy Task Force upon first learning of the CALS proposal to the Golden LEAF Foundation in March 2016.

Reflections and Next Steps

Overview

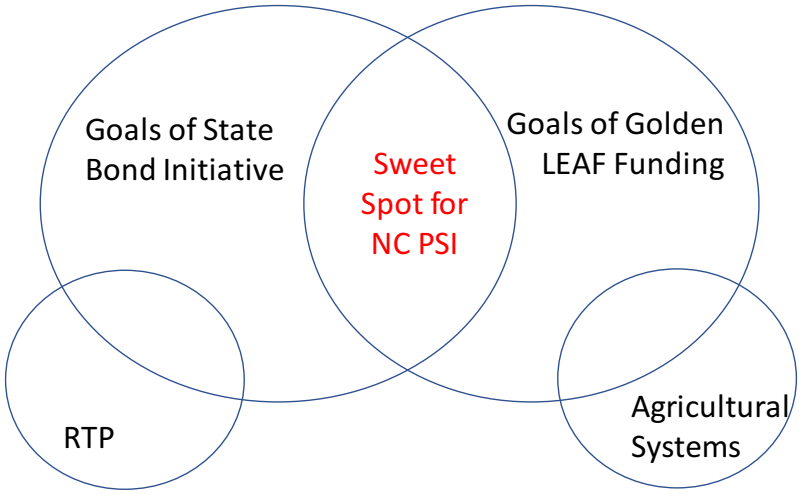
On May 1, 2017, the members of each task force came together to review and discuss the findings and recommendations that had been compiled in this *Task Force Proceedings* (Attachment R&NS-A lists meeting attendees). During this meeting, the members were asked to consider both where there are areas of synergies across the work product of each task force as well as whether there are missing components that require further exploration during implementation planning. The following narrative represents a synopsis of the discussion and provides a series of further thoughts and recommendations to the NC PSI leadership with regards to developing an implementation plan for the NC PSI.

Reflections on Task Force Proceedings

The task force members in attendance recommend that the following topics be further explored and vetted as the NC PSI Implementation Plan is developed:

Institute a focus for the NC PSI that goes beyond simply plant science research to instead examine the broader issues of farm sustainability systems. The members recognized that a plant science institute cannot focus solely on plant research, but instead must examine the entire farm sustainability system. The two primary funding sources, the state bond initiative and the Golden LEAF grant funding, create a natural tension between the competing goals of the NC PSI, representing varying points of view that will need to be resolved as the NC PSI moves forward. In analyzing the Venn diagram in Figure R&NS-1, it will be critical to the success of the NC PSI to be able to meld the various economic drivers to create an institute that can stand as a true benchmark leader for plant sciences research in the world. Developing that dynamic and communicating it effectively will be critical to moving forward with implementation planning and ultimate success.

Figure R&NS-1. Venn Diagram Showing Desired Convergence of Goals ("Sweet Spot") for the NC PSI



This success will entail evolving the current research programs into greater transdisciplinary efforts under the new PSI platforms, while ensuring that they meet the needs of agricultural stakeholders in the state. Noting that the building will not be operational for another five years, it will be important to ensure that the research currently being conducted is integrated into these new concepts and platforms while also ensuring that the research continues to meet the needs of NC producers. One of the caveats for the Golden LEAF Foundation grant is that the NC PSI must have relevancy to the NC farmer, which keeps the initiative's efforts grounded and focused. Overall, it will be critical that there is a seamless integration of existing research with the NC PSI coming online. Current faculty need to be thinking about how to evolve their research into greater transdisciplinary efforts.

Success will require that the NC PSI maintain strengths in both basic and applied research (i.e., solution-based science). It will be important to recognize that not all research will be tied to commercializable products. The NC PSI model will need to be responsive to other projects as well, particularly the work related to farm sustainability systems.

Ensure that the NC PSI serves as a model for how research is pursued and how faculty are evaluated. It will be critical to the success of the NC PSI model that it does not become a new silo on campus or within the NC State CALS, but instead works collaboratively across relevant initiatives and departments and leverages existing resources both internal and external to NC State. It will be important to ensure that the NC PSI does not duplicate existing efforts but instead leverages and connects to all campus resources. The goal must be better connections.

This will require a cultural change on campus. The NC PSI can become a driver of that change by modeling how research is pursued: (1) team-oriented versus principal-investigator-oriented; (2) embedded flexibility to ensure adaptability to the needs of the future; (3) recognition of the important role of industry; and (4) representing a new model for how students are trained. This will require a change in how faculty are evaluated, including recognizing the value of working in teams, working with Cooperative Extension, and working with commercialization endeavors.

A successful model will also require that the planning process turns to developing thinking on what the NC PSI is not. The task forces spent much of their time focused on discussing what the NC PSI is to ensure inclusivity. As implementation planning moves forward, it will be important to also focus on what the NC PSI is not to seek better clarity on the ultimate design of the initiative.

Help to ensure a pipeline of students interested in the plant sciences and agriculture. Student interest across agricultural disciplines has been declining for several years. It will be critical to the future of the NC PSI and the agbioscience industry it supports to ensure there is a pipeline of students interested in the plant sciences. It will therefore be important for the NC PSI to work with 4-H and other stakeholders to reach students throughout the K–12 pipeline. Both the Science Policy and Communications Sub Task Force and the Workforce Education and Development Sub Task Force discussed these needs and have put forth recommendations on how to ensure a pipeline of students. In this effort, it will be important to link the NC PSI to broader CALS efforts to reverse declining student interest.

Have the NC PSI be a trusted source for agriculture and ag-based research and information, both locally and globally. Task force members broadly concurred that the NC PSI should be the voice for the agbiosciences – a source trusted beyond just the campus.

Communicate the NC PSI value proposition to garner understanding and support for the initiative. From its initial conception, the NC PSI was envisioned as bringing solutions to problems through collaborative research. That value proposition is different depending on the stakeholders' specific needs. Thus, a key component of advocacy will be to define the various stakeholders – including students, producers, and industry – and what the NC PSI's value proposition is. It will be important moving forward to institute a segmented approach to communicate the NC PSI value proposition to the various stakeholder groups. This will entail developing a marketing strategy that will better connect and resonate with stakeholders and the public.

Continue to engage advisory groups representing diverse viewpoints to ensure the creation of a solution-based NC PSI operating model. Maintaining advisory groups that represent the many stakeholder points of view will be critical to ensure that unlimited new ideas are generated, vetted, and eventually integrated into a strong and effective NC PSI model. It will be important to continue to engage private, public, and academic stakeholders in the implementation process.

It will also be important to have a process to integrate and harmonize the recommendations contained throughout these proceedings that at times are somewhat divergent. Knitting these recommendations together into a concerted effort will require harmonization of current areas of disagreement.

While much of the activity of the NC PSI will now occur within NC State through the efforts of the NC PSI launch director and CALS administration, members of the various task forces can continue to serve an important role in helping to guide the effort. Every task force has recommended that select members continue to stay involved with the implementation efforts to help ensure that the body of knowledge collected through their efforts not be lost, but instead be conveyed and further formulated as the NC PSI continues to develop and take shape. This will provide the opportunity to cross-pollinate the various efforts to ensure that the NC PSI is meeting the goals and objectives of its diverse stakeholders.

Next Steps

The activities of the coming year and beyond will build firmly on the foundation of the extensive efforts of the task forces. Collectively, these efforts provide a strong framework for the formation of the NC PSI operating model. The thoughtful guidance and insights found within these recommendations will help to ensure that the NC PSI will be truly visionary and successful.

During the summer of 2017, the NC PSI launch director will be hired to serve as the strategic lead for the NC PSI during the nascent prebuilding phase of the effort. We envision that this critical and highly visible role will cultivate powerful relationships within the corporate, academic, and public spheres and act as the public face for the NC PSI in the early stages as he or she works with NC State and CALS administration to develop an implementation plan for the initiative and continues to rally support for the building and program. CALS will also be working internally with faculty to begin to develop projects.

Two advisory groups have been created based on this report – one internal and one external – to help guide the action plan. Assistance will be sought in thinking through priorities based on available resources. An Implementation Task Force will also be formed to help guide the launch director.

Attachment R&NS-A: Joint Meeting Attendees

Task Force Members

- Alan Ayers, Director, State Affairs/Stewardship, Bayer CropScience
- Rodolphe Barrangou, Associate Professor, Food, Bioprocessing and Nutrition Sciences, NC State
- Richard Bonanno, Associate Dean and Director, NC Cooperative Extension, NC State
- Rebecca Boston, Assistant Director, NC Agricultural Research Service; William Neal Reynolds Distinguished Professor of Plant and Microbial Biology, NC State
- Hannah Burrack, Associate Professor and Cooperative Extension Specialist, Entomology and Plant Pathology, NC State
- Richard Campbell, Chief Communications Officer, CALS, NC State
- Amy Chilcote, Extension Associate, 4-H, NC Cooperative Extension, NC State
- Dave Corum, President, AgCarolina Farm Credit
- Nancy Creamer, Professor of Horticultural Science, NC State; Director, Center for Environmental Farming Systems
- John Dole, Interim Associate Dean and Director, Academic Programs, CALS, NC State
- Doug Edgeton, President and CEO, NC Biotechnology Center
- Mark Fleming, Vice President, Blue Cross and Blue Shield of North Carolina
- Amy Grunden, Professor of Microbiology, NC State
- Charles Hall, CEO, NC Soybean Producers Association
- Debbie Hamrick, Director of Specialty Crops, NC Farm Bureau Federation
- Vern Hawkins, President, Syngenta Crop Protection North America
- Allen James, President, NC Agricultural and Life Sciences Research Foundation; Retired Executive Director, Responsible Industry for a Sound Environment (RISE)
- Katie Jennings, Professor and Extension Weed Specialist, Horticulture, NC State
- Richard Kouri, Professor of the Practice, Poole College of Management, NC State
- Jennifer Kuzma, Distinguished Professor of Public and International Affairs; Director, Genetic Engineering and Society Center, NC State
- Sara Lane, Director, Career Services Office, CALS, NC State
- Kelly McIver, Executive Director, NC Sweet Potato Commission
- Roland McReynolds, Executive Director, Carolina Farm Stewardship Association
- Deanna Osmond, Professor and Department Extension Leader, Soil Science, NC State
- Matt Peterson, Director of Federal Research Affairs, NC State
- Paul Rea, Senior Vice President, BASF Crop Protection North America
- Alan Rebar, Vice Chancellor, Office of Research, Innovation and Economic Development (ORIED), NC State
- Richard Reich, Agricultural Services Assistant Commissioner, NC Department of Agriculture and Consumer Services
- Mark Schmidt, Principal Scientist, John Deere
- Kelly Sexton, Assistant Vice Chancellor, Office of Technology Commercialization and New Ventures, NC State
- Bryant Spivey, County Extension Director, Johnston County, NC State
- Sandy Stewart, Director, NC Department of Agriculture and Consumer Services Research Stations
- Bob Sutter, CEO, NC Peanut Growers Association
- Deborah Thompson, Director of Research Partnerships, CALS, NC State
- Dan Weathington, Executive Director, NC Carolina Small Grain Growers Association

Other Attendees

- Bob Aimutis, Global Director of External Innovation, Cargill, Inc.
- Tom Christensen, CEO, Ag TechInventures
- Frank Grainger, President, Fair Products, Inc.
- Brenda Summers, Director of Communications and Operations, NC Biosciences Organization (NCBIO)
- Rich Linton, Dean, CALS, NC State
- Steve Lommel, Associate Dean for Research, CALS; Director, NC Agricultural Research Service (NCARS), NC State
- Heather Daughtridge, Associate Director, Corporate and Foundation Relations, NC State
- Genevieve Garland, Director of Research Operations, ORIED, NC State
- Thomas Manshack, Assistant Director of Development, NCARS, NC State
- Catherine Maxwell, Director of Development, NCARS, NC State
- Lorena McLaren, Executive Director, University Development, NC State
- Geoff Bock, Project Manager, NC PSI, CALS, NC State
- Deborah Cummings, Senior Director and Principal, TEConomy Partners, LLC
- Simon Tripp, Senior Director and Principal, TEConomy Partners, LLC

Compiled by TEConomy Partners, LLC