TACTICAL SCIENCES TO PROTECT THE U.S. AGRICULTURAL ENTERPRISE

Building Awareness and Developing a Coordinated Strategy

In 2017, the National Institute of Food and Agriculture (NIFA) proposed an initiative to focus attention on protecting the integrity, reliability, and sustainability of the U.S. food and agriculture system. These investments enable research, development, and deployment of science-based tactics that are critically needed by the U.S. agricultural sector to detect pests, diagnose diseases, support regulatory systems, and respond to disasters. This report describes current NIFA investments in tactical sciences and summarizes stakeholder opinions from a recent "Call to Conversation" held on the campus of the University of Maryland at College Park on the topic of biosecurity of food systems and the need to strengthen tactical sciences. The report also creates a draft framework for a coordinated, national effort to better protect our food and agricultural systems from existing and emerging threats.

BACKGROUND

Agriculture and agriculture-related industries contribute over 21 million jobs and approximately $1 trillion to the U.S. gross domestic product (ERS report). Tactical sciences protect the integrity, reliability, and sustainability of the U.S. food and agriculture system from a wide array of known and potential threats from pests and diseases harmful to plants, animals, and/or human health. In the context of the need to feed an estimated global population of over 9 billion by 2050, there is a critical and growing need to strengthen tactical science capabilities and competencies on a scale commensurate with current and future threats to the safety, stability, diversification, and profitability of our nation's food and agricultural systems. Recent examples of threats that illustrate this point are highly pathogenic avian influenza, which resulted in the loss of nearly 50 million chickens and turkeys and an estimated economic loss of more than $3 billion in a single year, and citrus greening, which has caused 23 percent yield losses and an economic impact of at least $1 billion per year.

NIFA INVESTMENTS IN TACTICAL SCIENCES

NIFA's current tactical science portfolio covers three broad functions and consists of multiple small programs distributed across administrative and disciplinary areas (Table 1).

Table 1. NIFA tactical science programs

Function	Programs	Activities
Detection and Diagnostics	National Plant Diagnostic Network National Animal Health Laboratory Network	Surveillance and early detection of high consequence pests and diseases; timely deployment of technologies and human resources to respond, manage and recover from outbreaks
Regulatory Systems Support	Minor Crop Pest Management Food Animal Residue Analysis Database Minor Use Animal Drugs Program	Critical research to inform federal regulations ensuring the safety and diversity of agricultural products
New Tools and Management Strategies for Crop and Animal Production and Protection and recovery	Crop Protection and Pest Management Minor Crop Pest Management Extension Disaster Education Network	Research on effective tools to manage pests and diseases and science-based outreach to help producers respond to local and regional threats

Collectively, these programs offer essential solutions to crop and livestock producers and are critically important to our nation's trade and economic well-being. Through hard work and good planning, and despite small budgets, these programs have contributed to the protection of our nation's food and agricultural systems. However, as the global demand for food production increases, the challenge of ensuring adequate protection of agricultural products from emerging pests and diseases is also increasing. To meet this challenge, the elements that contribute to the success of current tactical science programs need to be leveraged and expanded at a national level. Currently these programs function independently, are limited in scope, are not functionally organized to maximize efficiency and impact, and are not viewed by stakeholders as a unified effort. Significant increases in efficacy, effectiveness, and efficiency may be synergized through greater integration and sharing of technical expertise across program areas. Such an integrative effort would require a high level of communication, coordination and mutual trust building among the various functional areas and programs that comprise the tactical science portfolio. Given the very real threats posed by emerging pests and diseases, NIFA believes that a forward thinking tactical sciences initiative is both timely and necessary to enhance U.S. food, agricultural, and economic security.

GOAL OF THE TACTICAL SCIENCES INITIATIVE

The overall goal of the tactical sciences initiative is to create a coordinated national framework of translational and applied science to protect U.S. plant, animal, and food production systems. This framework will significantly strengthen and expand current investments to close existing gaps in food and agricultural defenses through increased capacity to detect pests and diseases, prevent outbreaks, respond to natural disasters, and support containment and recovery operations. Achievement of these objectives will protect the biosecurity of our nation's food systems, promote U.S. agricultural sustainability and minimize serious disruptions to business and trade. It will also enhance protections for producers, consumers, the food and agricultural system, and the national economy as a whole.

STAKEHOLDER INPUT AND ANALYSIS

On February 15 and 16, 2017, NIFA collaborated with the University of Maryland's College of Agriculture and Natural Resources to convene a "Call to Conversation" on tactical sciences; background information on the conversation is available at https://agnr.umd.edu/tacticalsciences. This two-day interactive workshop was considered a starting point for further discussions that would lead to specific recommendations for meeting the overarching goals of the tactical sciences initiative. Approximately 70 participants were invited to provide diverse producer, industry, regulatory, academic, and federal and state perspectives for both crop and livestock systems. Four facilitated sessions were conducted to solicit input in key areas. Participants were asked to engage in discussions on the strengths and weaknesses of the existing system of protecting the biosecurity of our food systems, highlight areas that need emphasis, and envision an ideal tactical sciences framework that would ensure U.S. agro-security. Session topics and the questions posed to participants were:

Session 1: Emerging trends, threats and/or forces that may influence the security of the American food system enterprise

- *What are economic, political, social, technological, and scientific trends/forces that will impact security of the American food system enterprise in the next 10 years?*

Session 2: Current state of tactical sciences

- *When you consider the tactical sciences efforts to protect and secure the American food system enterprise, what are we doing well?*
- *When you consider the tactical sciences efforts to protect and secure the American food system enterprise, what are we not doing so well?*

Session 3: Strengthening relationships for success in tactical sciences

- *When you consider the working relationship of NIFA, the land-grant university system, the U.S. agriculture enterprise and the other partners who contribute to our success in protecting the U.S. agriculture enterprise, what is working well?*
- *When you consider the working relationship of NIFA, the land-grant university system, the U.S. agriculture enterprise and the other partners who contribute to our success in protecting the U.S agriculture enterprise, what is not working well?*

Session 4: Envisioning success in tactical sciences

- *Imagine an extraordinary working relationship among NIFA, the land-grant universities, the U.S. agriculture enterprise, and other partners in the tactical sciences. What would be the principles and characteristics of that relationship?*
- *Reflecting on the past two days of dialog and reflection on tactical sciences, what is the crossroad this collaborative is at? What would success look like in one year? Four years?*

RESULTS FROM THE FIRST STAKEHOLDER MEETING

Input provided by stakeholders during the four sessions was diverse, complex, and extensive. Therefore, natural language processing techniques were used to create term co-occurrence networks to identify major trends and areas of consensus; see Appendix A for a detailed description of the method used. This approach provides an objective process to create meaningful categories using the stakeholders' own words. Modeling of stakeholder comments resulted in the identification of key terms, which were clustered in relation to one another for a given question, or set of questions asked of stakeholders. Based on the modeling conducted, stakeholder comments fell into primary general clusters, which were further grouped by relevance to each other, resulting in 3-5 major meaningful color-coded clusters (themes) for each analysis. Emphasis is depicted by the size of the circles (nodes) and relationships are depicted by lines (edges) connecting the circles. Topic maps representing stakeholder input on key issues—in response to questions posed—are presented and discussed below. The visualizations, shown below, demonstrate relationships among the key topics and relevant issues discussed during the meeting.

Session 1: Emerging Trends, Threats and/or Forces That May Influence the Security of the American Food System Enterprise

Stakeholders identified several major forces that are likely to impact the security of the U.S. agriculture and food system enterprise in the coming years. A color-coded visualization of stakeholder perception of these forces is presented in Figure 1. The primary forces include:

1) Efforts that are lacking or unaddressed issues that create needs (grey);
2) Costs associated with efforts (purple);
3) Technology (blue) and related political and social aspects (red);
4) Data (light blue); and
5) Persistent and peripheral influences (yellow).

"Lack" was often mentioned in conjunction with "need" (*i.e.,* issues that are unaddressed create needs) and expressed as a dominant theme in many contexts. These include lack of funding, knowledge, awareness, understanding, team mentality, and big-picture thinking by state and federal legislatures. Other forces with broad influence on tactical sciences include communication, information, and role of scientists, research, and Cooperative Extension (Extension).

Costs were also a dominant factor and were presented in the context of regulations, production (vs. demand for cheap food), conducting science, management, and monitoring costs. The potentially uneven distribution of costs between small and large producers and the influence of "big Pharma" were also noted.

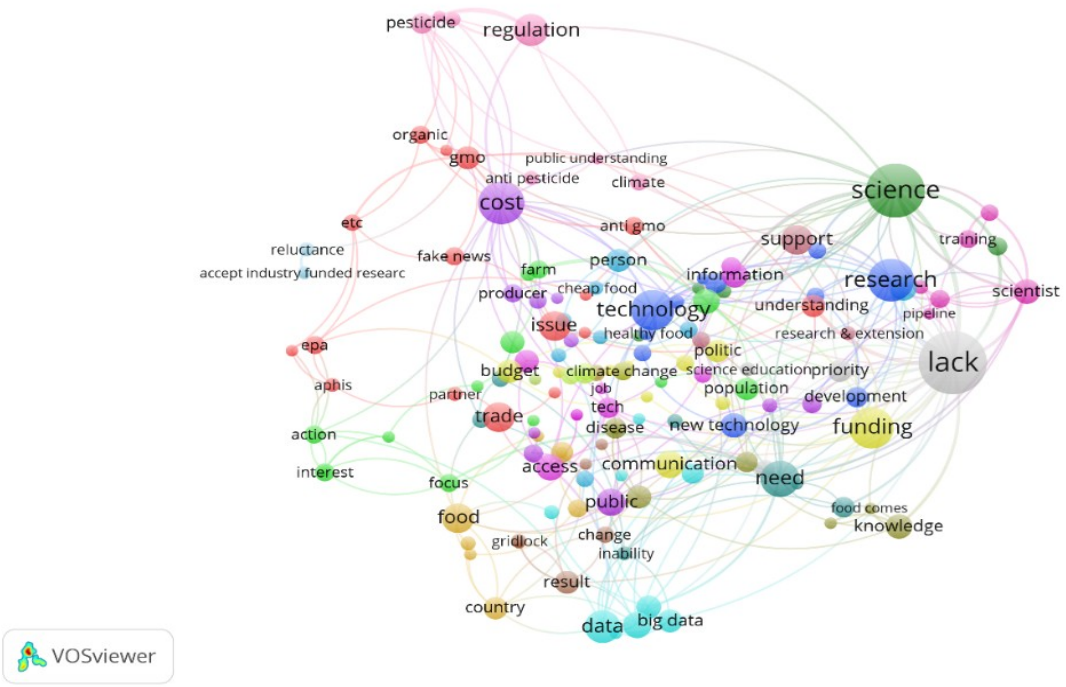

Figure 1. Forces influencing security of the U.S. agriculture and food system enterprise

Advances in science and technology such as big data were identified as significant but underfunded forces. Social forces include scientific literacy and perceptions about technology (*e.g.,* genetically modified organisms, organic foods, pesticides, industry funding) and "fake news". Political and economic forces included trade, budgets, regulations, climate change, and the management of science.

Session 2: Current Efforts to Protect and Secure the American Food System Enterprise

There are several USDA and NIFA tactical science programs that contribute substantially to protecting the U.S. agricultural and food system. A visualization of stakeholder input on the positive aspects of current efforts is presented in Figure 2a. Five core strengths of current tactical science programs were identified:

1) Diagnostic capacity (purple);
2) Collaboration (pink);

3) Networks (blue);
4) Genomics and other data generated by universities (red); and
5) Use of resources and technology in agriculture (yellow).

Diagnostic capacity was clearly viewed as working well with promising new technologies on the horizon. Collaboration and partnerships among industry, states, universities, and laboratories were considered very positive. Existing networks are very effective in both emergency and nonemergency situations. The collection, curation, sharing and use of data are a positive and critical component of protection. Responsible and effective use of limited resources has contributed significantly to successfully averting disasters and facilitating major advances in new diagnostics.

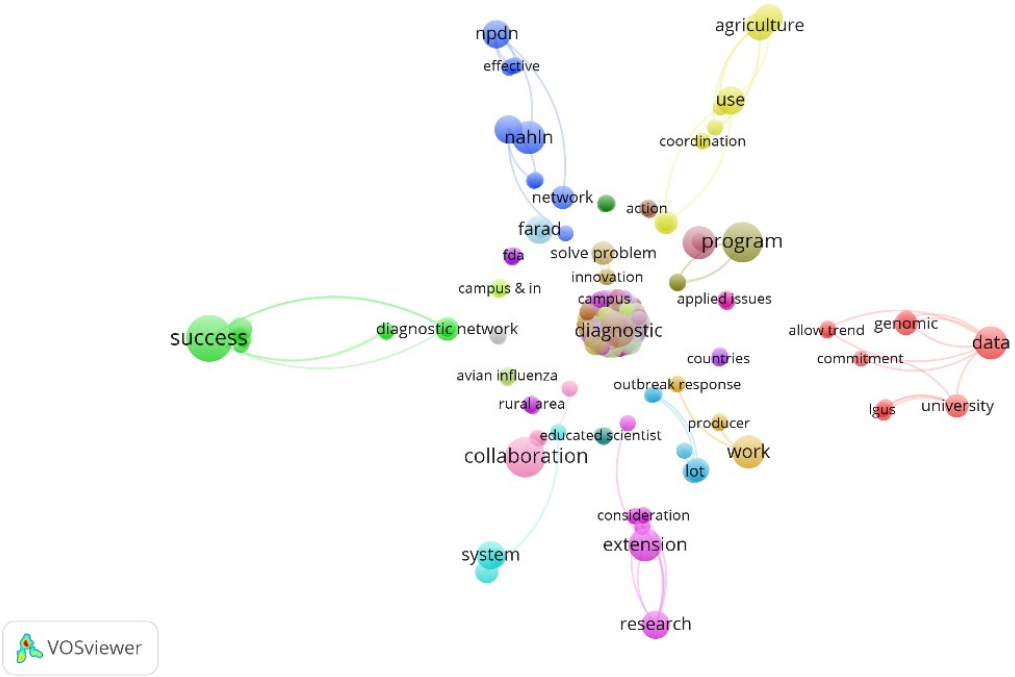

Figure 2a. Core strengths of tactical science programs focused on the protection of the U.S. agriculture and food system enterprise

Workshop participants also opined on what is not working well in current efforts to protect and defending agriculture and its products, and a visualization of this input is presented in Figure 2b. Four core weaknesses of current tactical science programs were identified:

1) Inadequate funding (red);
2) Lack of support, collaboration and public awareness (green);
3) Inadequate communication with the public, industry and Congress (blue, purple); and
4) Inadequate collaboration among federal, state, research, and extension entities (yellow).

Sustainable funding from federal, state, and local sources with increased leveraging of public-private partnerships was the most significant stakeholder concern. The need for both competitive and capacity funding across disciplines, species, and systems was also expressed.

Stakeholders shared concerns about lack of land-grant university support for programming to support local response, multi-state collaboration and long-term research on minor crops. Outside the land-grant system, lack of support for small businesses and new farmers and ranchers was also noted.

Better communication with the public was another major concern. Better federal-state, interagency, and industry communication is also needed. Finally, improved communication about benefits, successes and failures would be valuable.

Improved coordination and balance of research and extension roles is needed, with recognition that extension is sometimes more critical than research. Regardless, both roles need better support.

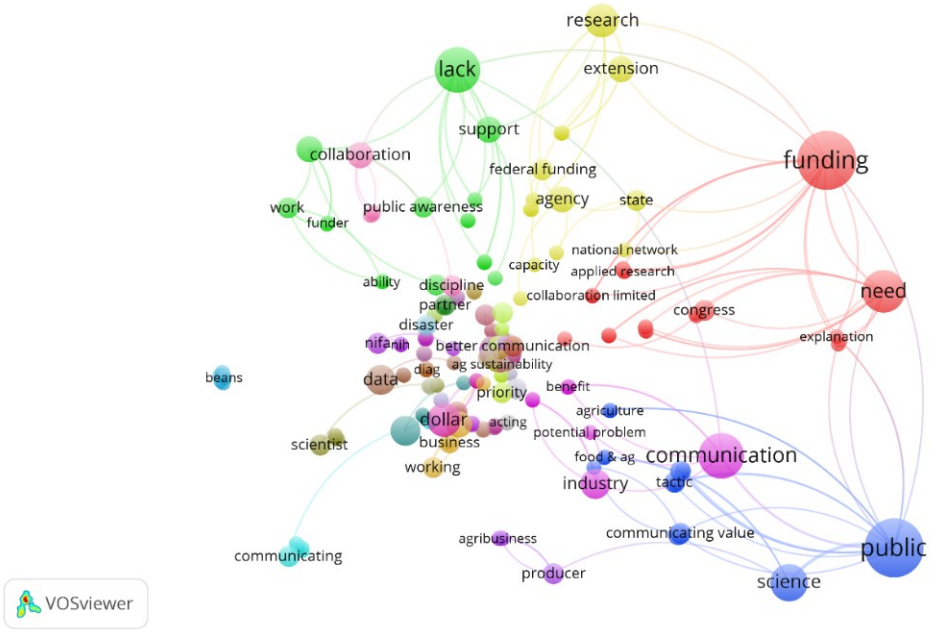

Figure 2b. Core weaknesses of tactical science programs focused on the protection of the U.S. agriculture and food system enterprise

Session 3: Strengthening Relationships for Success in Tactical Sciences

The land-grant university system, commodity groups, federal and state agencies, Congress, and producers, and other entities all play specific and essential roles in protecting the U.S. agriculture enterprise from threats. Factors that currently facilitate strong working relationships among these groups are presented in Figure 3a, these include:

1) Collaboration among congress, industry, and land-grant universities (red);
2) Stakeholders and decision support (green);
3) Extension, education, and local capacity (blue);
4) Working under adverse conditions with land-grant universities (yellow); and
5) Communication and priority setting (brown).

Collaboration is an essential feature of any regional or national initiative. The collaborative relationship among Congress, industry and land-grant universities is working well but needs ongoing care.

Relationships that enable knowledge transfer between people on the ground and the response chain that includes universities, industry, agencies and Congress are needed for effective and timely decisions.

Participation of producer and industry stakeholders in decision making is an important feature of good working relationships. The strong existing links among field stations, land-grant universities, the USDA Agricultural Research Service, the agricultural industry and communities were specifically noted. Meaningful stakeholder engagement and outreach to industry were listed as key activities to improve understanding and meet their needs.

Participants said the land-grant universities play a critical role in educating the next generation of researchers and extension professionals. The need to foster and maintain boots-on-the-ground talent was also noted. There is a need to rediscover extension's capacity for local engagement and education.

Stakeholders recognized that working on complex problems under adverse conditions with limited resources is a challenge. This challenge will likely become greater in the future and participants will need to leverage limited resources while sharing recognition.

The large node at the center of the map the represents the confluence of all the players in the tactical sciences community. Communication and priority setting are key features of their good relationships.

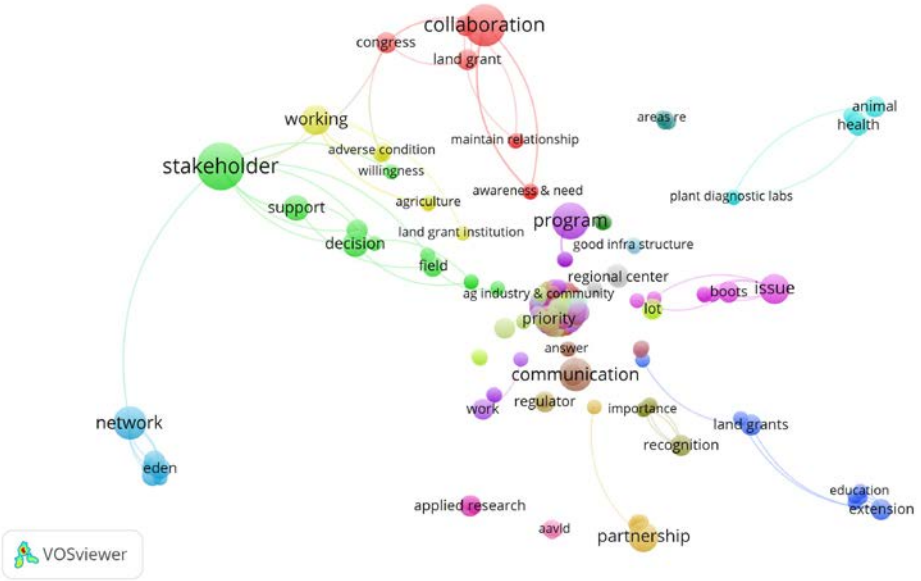

Figure 3a. What is working well with regard to relationships among tactical science stakeholders

In contrast to factors facilitating good working relationships, factors inhibiting strong working relations were also identified and are presented in Figure 3b. The top concerns were:

1) Lack of effective communication;
2) Need to better integrate, prioritize, and use research and Extension; and
3) Improved approach to funding.

Stakeholders noted a pervasive lack of effective communication across all entities: state and federal agencies, the land-grant system, scientific communities, regulators and those affected by regulations, Congress, and the general public. Stakeholders related lack of communication to less trust. The deficiency of effective communication and trust creates obstacles that inhibit collaboration. Better communication outside of perceived silos was identified as an urgent need.

The relationships between research and extension were explored and the need for better integration between the two featured prominently. Participants noted that the value of extension is not adequately recognized and suggested potential ways to re-invent extension with greater engagement.

The current situation is burdened by complicated funding approaches and lack of coordination, and these problems were identified as major obstacles. Stakeholders believed that joint efforts and working as a unified force to attract funding and coordinate program activities are potential solutions. The ability to collaboratively target funds and "brain power" to high priority needs with the highest potential for impact was also noted.

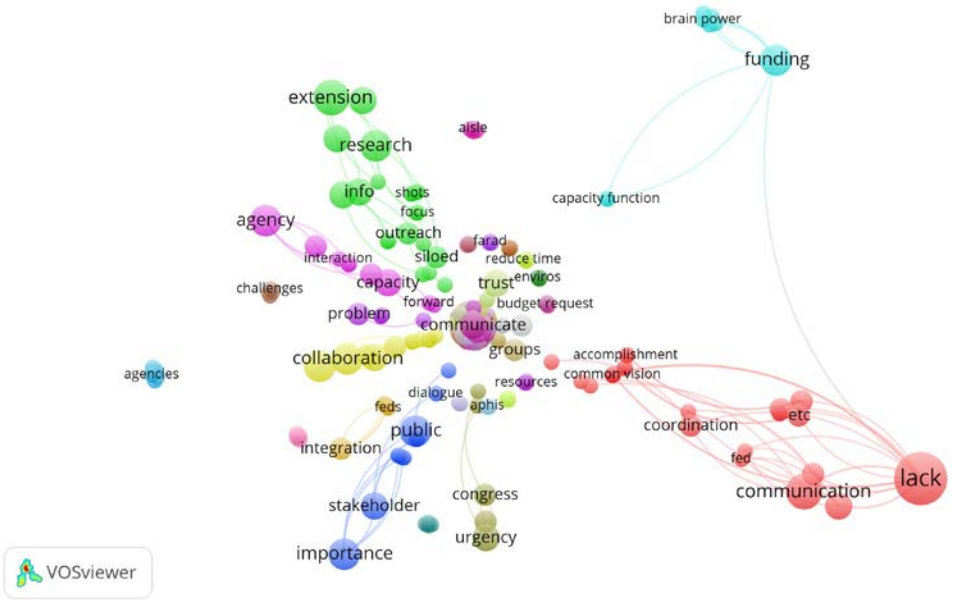

Figure 3b. What is not working well with regard to relationships among tactical science stakeholders

Session 4: Envisioning Success in Tactical Sciences

After reflecting on the influencing forces, current efforts and working relationships, workshop participants were asked to characterize an effort that would ensure security of the U.S. food and agricultural enterprise. Several principles, characteristics and milestones of a successful tactical science strategy were identified and are presented in Figure 4. The key features were:

1) Communication (blue);
2) Trust, resources, and relationships (green);
3) Funding and infrastructure (red);

4) Industry and university research system (yellow);
5) Groups and shared vision (purple); and
6) Science, collaboration, and priority setting (light blue).

Communication featured prominently with extensive linkage to most other elements indicating that communication is an integral component of other factors including trust and a shared vision.

The importance of trust and a shared vision were also emphasized as components of successful collaboration between industry, government, and academia. The concepts of openness, principles and group value were closely related to vision and trust as features that will sustain long term efforts.

Funding and infrastructure were also noted as key components of success. Funding for infrastructure that is integrated with multiple components of the tactical sciences system was clearly a priority. Commitment by all parties was identified as a key element of sustained funding and infrastructure.

Science emerged as a clear component of a successful strategy with strong linkage to communication, collaboration, consumers, change, goals, priorities and problem solving. Finally, the key players include Industry, land-grant research and extension, USDA-APHIS, Congress, producers, and consumers.

In addition to defining the principles and characteristics of a successful working relationship among all partners that would underpin a new tactical sciences strategy, stakeholders identified milestones for the new approach. These projected milestones are presented in Table 2.

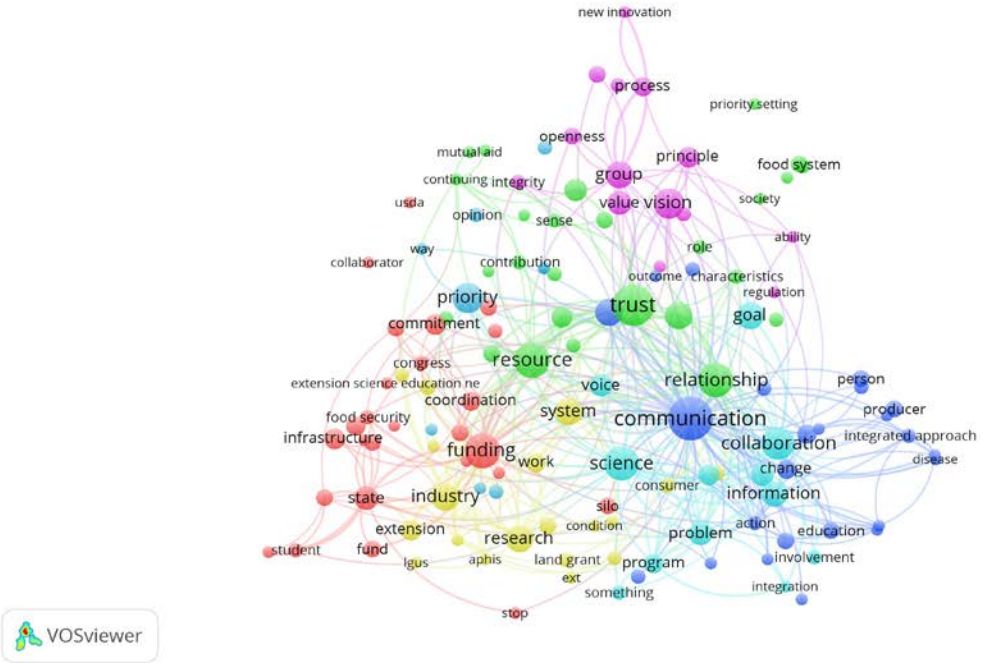

Figure 4. Principles and characteristics of a successful working relationship among NIFA, the land-grant universities, the U.S. agriculture and food system enterprise, and other partners

CONCLUSIONS

There is an urgent need to focus attention on protecting the integrity, reliability, and sustainability of the U.S. food and agricultural system. These investments are essential to support research, development and deployment of science-based tactics needed to address threats from pests, diseases, and natural disasters. The "Call to Conversation" on tactical sciences brought together a broad range of stakeholders and initiated productive discussions about the science needed to protect our complex national food system from numerous threats and vulnerabilities. Participants provided diverse producer, industry, regulatory, academic, federal and state perspectives for both crop and livestock systems. The format encouraged attendees to share their thoughts and reconsider their individual programs and activities as part of a coordinated network serving the entire food system and the entire nation. Many of the existing tactical science programs (Table 1) were recognized for their accomplishments, and the factors supporting their success were noted. Despite these successes, participants agreed that current investments in tactical sciences are not sufficient to address growing challenges posed by emerging threats to our nation's food supply. There was consensus that a major initiative to protect the biosecurity of our nation's food systems by raising the stature and increased support for tactical sciences is timely, necessary, and worthwhile. It was recognized that a significant, sustained effort will be required to increase public recognition, appreciation and support for tactical sciences.

NEXT STEPS

To maintain the momentum generated by the conversation, NIFA will form a working group of key stakeholders to provide recommendations for strengthening the agency's tactical science portfolio. The majority of members will represent the broad array of entities engaged in tactical sciences for the protection of U.S. food and agriculture. NIFA will provide support and serve as a liaison among stakeholders represented by the working group and other federal agencies as needed. This group will:

- Develop a shared VISION of a robust, coordinated framework of tactical science capabilities that will ensure the biosecurity of the U.S. food and agricultural system;
- Identify an ASPIRATIONAL OUTCOME with specific and measurable short, mid-, and long-term goals, to strengthen tactical science capabilities in the United States; and
- Develop a COMMUNICATION STRATEGY that effectively conveys the importance of tactical sciences to relevant audiences.

Ideally, the efforts of this working group will result in a successful, national initiative and facilitate:

- Support and buy-in from all affected stakeholders, with an expanded network of advocates;
- Development of a functional framework for identifying national needs, setting priorities, coordinating efforts, and achieving synergies in tactical sciences;
- Increased investment in tactical sciences from federal and non-federal sources; and
- Enhanced protection of the U.S. food and agricultural system from existing and emerging threats.

Table 2. One-year and four-year milestones for an effective tactical science strategy

Milestones to be accomplished within one year	Milestones to be accomplished within four years
An inclusive tactical science organization/consortia/coalition/collaborative is formed	An efficient working group that routinely evaluates programs and solicits new ideas exists and effective protection, defense, and diversity are achieved
A compelling shared vision/unified message is defined	There is new institutional capacity to inform and respond to threats confronting the security of the U.S. food system
A strategy with measurable outcomes is set (simply repackaging current programs is not acceptable)	Measurable and documented progress toward the goal of building a new system is made
All sectors are behind the new strategy	Networking and collaboration among partners is increased
An action plan is developed through a collective priority setting process in which everyone can see their respective role	Improved infrastructure, increased personnel, and a focused program at the federal and state levels exist to address the safety of our food supply, prevention strategies, reactive abilities, and protocols
Listening sessions, conversations, and dialogues are held among players and with the public	Mechanisms for promoting additional collaboration have been developed and implemented
A communication strategy is developed	Improved public perception and appreciation for agriculture are present
Greater recognition of tactical sciences programs and efforts	Recognition, stature, and perceived value of tactical sciences are enhanced
There is funding for current efforts	A defensible budget with increased funding for tactical sciences exists; congressional funding is distributed equitably to states for priorities established at the local level (decentralized use and prioritization of funds)

APPENDIX A: Empirical Topic Modeling

Analysis of stakeholder input: The analysis provided herein represents a depiction of written and oral comments collected during a two-day meeting from approximately 70 individuals representing universities, professional societies, industry and producer organizations, government agencies, and other entities. The text mining used during topic modeling provides an objective and comprehensive global view of input across all areas discussed and gives the reader a sense of the areas that appear to be of most interest to stakeholders. This method uses the evidence (*i.e.*, the stakeholders' own words) to create meaningful categories, independent of keywords or preconceived designations. These major categories reflect relevance across the plethora of issues covered during the two-day meeting. The resulting visualizations demonstrate relationships among the key topics that were identified. Key topics generated from the analysis were further examined for specificity.

Determining themes, key concepts, and concerns: Natural language processing techniques (Vosviewer, 2017; Centre for Science and Technology Studies, Leiden University, The Netherlands) create term occurrence and co-occurrence networks based on English-language textual data, in this case the stakeholder's written or spoken words. Relevant and non-relevant terms are distinguished algorithmically. This approach produces a term map that visualizes the structure of text by showing the relationships among important terms in the text fields.

Given a collection of text, the main topics or clusters in the collection are identified using a technique called probabilistic latent semantic analysis. Given the main topics, words and phrases that are strongly associated with the topics are then identified. These words and phrases are included in a term map. An important property of the methodology is that it identifies terms that are not only domain-specific but that also have a high discriminatory power within the domain of interest. This is important because terms with a high discriminatory power are essential for visualizing the structure of what was articulated.