FY 2020 Annual Report of Accomplishments and Results

Minnesota
University of Minnesota
Minnesota Agricultural Experiment Station UNIVERSITY OF MINNESOTA Driven to Discover® UNIVERSITY OF MINNESOTA EXTENSION

I. Report Overview

The NIFA reviewer will refer to the executive summary submitted in your FY 2020 Plan of Work located in the Institutional Profile. Use this space to provide updates if needed.

1. Executive Summary (Optional)

This report highlights the accomplishments of the University of Minnesota's Agricultural Experiment Station (MAES) and Extension in 2020. Impacts achieved by the University of Minnesota (UMN) have made a difference in addressing nine critical issues identified, as outlined for NIFA in 2019. Extension reports on impacts related to these critical issues made by its four program centers — Agriculture, Food and Natural Resources; Community Vitality; Youth Development; and Family Development. Extension's Regional Sustainable Development Partnerships (RSDP) connects Extension to local stakeholders for most of those critical issues and manages the work of Clean Energy Resource Teams. MAES describes research within its five partner colleges that is making a difference related to these critical issues. In many cases, MAES research informs Extension programming. Of the 37 impacts described in 2020, 11 describe impacts achieved jointly by Hatch and Smith-Lever programs.

Critical Role of NIFA Capacity Funding in 2020

Two things shaped much of the activity, conversation and direction of NIFA-funded programs and projects at the UMN in 2020:

- First, when Governor Walz announced Minnesota's stay-at-home order on March 23, researchers and Extension quickly adapted to an ever-changing landscape as the COVID-19 virus quickly spread across Minnesota, the U.S. and the world.
- Second, George Floyd, a 46-year-old African American man, was killed while in Minneapolis police custody on May 25. Weeks of civil unrest and protests followed, with many people taking time to reflect, learn and grow. Minnesota spent the summer under a microscope, with protests, violence, and personal and political reckoning. This local, national and international event spawned increased focus on race and racism at the University of Minnesota. Extension mobilized a new council to examine Extension's gaps and opportunities with regard to diversity and inclusion. MAES-supported colleges worked closely with the University's Office of Equity and Diversity to offer support, improve their college level programming and find ways to spotlight researchers doing great work in the community.

We highlight these 2020 events because it is clear that USDA-NIFA capacity funding provided the UMN with fundamental annual support that allowed researchers and Extension specialists to adapt, coordinate and respond to the needs of Minnesota. Many of the impacts featured within this report reflect these changing priorities and the mobility that was required to adjust to the changing needs of our state and University.

Extension. Summary of 2020 Activities. In 2020, Extension reached over a half-million adults and youth in educational programming. Online access was particularly important in 2020, and Minnesotans came to Extension's website 1,612,604 times to find needed information. With its ongoing commitment to reach underserved audiences, several program areas achieved parity in programming. Twenty-one percent of Minnesotans are now black, indigenous and people of color and 12.4 percent of Greater Minnesotans are people of color. Five program areas are near or beyond parity in programming:

- 40 percent of family resiliency program participants were Minnesotans of color.
- 38 percent of health and nutrition participants were Minnesotans of color.
- 19.8 percent of leadership and civic engagement participants were people of color.
- 15 percent of youth development participants were Minnesotans of color. Importantly, 56 percent of newly recruited "First Generation" 4-H'ers were youth of color.
- 11.2 percent of community economics participants were Minnesotans of color.

As described in some Extension impacts, pivoting Extension programming to online formats was a critical element of success in 2020. Extension hosted more than 5,250 events in 2020, most of which were migrated to online formats in order to adhere to directives from our governor and our college president about keeping Minnesotans safe. Extension trained and supported volunteers who committed 257,970 hours of service to Minnesota's youth, natural resources and communities. The independent sector values these contributions at $7,016,784.

MAES. Summary of 2020 Activities

This report summarizes the effort and results related to over 350 research projects conducted by more than 250 principal investigators (PIs) at five University of Minnesota colleges: College of Food, Agricultural and Natural Resource Sciences (CFANS), College of Biological Sciences (CBS), College of Veterinary Medicine (CVM), College of Education and Human Development (CEHD), and the College of Design (CDES). While the research efforts are reported under program areas, the majority of this research is broad-based and interdisciplinary and has impacts on multiple critical issues.

Though Hatch funding accounts for less than 10 percent of the annual funds for MAES research, we have reported on outcomes from all projects connected to PIs who receive non-discretionary funding. NIFA non-discretionary funds support general-use infrastructure, including greenhouses and research fields, ensuring that researchers have what they need to start projects and generate impacts and outcomes. They also provide critical funding for staffing that allows us to leverage and match other external funding sources. Notably, these funds are used to assist early-career faculty as they start research programs. Without these funds, there would be less applied research, less real-world application of research, and less integration of Extension and research.

Preview of 2020 Impacts - Research and Extension

NIFA funding provides core support for critical University education and research that is making a difference in Minnesota. In 2020, MAES and Extension programs are able to report 37 significant impacts, which are previewed below:

Critical Issue	Impact Headline	Multi-state or Integrated
#1 Crop, Plant and Food Development and Production	1. Drone technologies and resistant varieties show promise in the fight against soybean aphids.	Integrated Multi-state
	2. Extension is making the Food Safety Modernization Act regulation work, creating safe local fruit and vegetable production on Minnesota's farms.	Extension Multi-state
	3. UMN researchers help realize and harness the power of GE crops.	Research
	4. Grape growers shape the craft of cold climate grape growing with University of Minnesota expertise.	Integrated Multi-state
	5. Research helps enhance pea protein functionality for industry applications.	Research

	6. Extension trains cottage food entrepreneurs, assuring that food products are safe, legal and ready to support local economies.	Extension Multi-state
	7. Extension creates a culture of soil management on Minnesota farms through annual conferences.	Integrated Multi-state
	8. Minnesota farms manage pesticides safely with pesticide safety and environmental education.	Extension Multi-state
	9. Minority farmer partnerships provide value for farms, research and education.	Integrated Multi-state
#2 Integrated Animal Systems	10. Selective dry cow therapy program is a win-win-win for the dairy industry.	Integrated Multi-state
	11. Pig microbiome discoveries show promise for the swine industry.	Research
	12. AmE-711 honey bee cell line is a powerful tool for bee research.	Research
#3 Water Resources and Quality	13. New decision-tool helps prioritize AIS management.	Integrated
	14. Study shows effect of AIS on Minnesota walleye.	Research
	15. Model drainage system with multiple frameworks shows promise for reducing nutrient runoff.	Integrated
#4 Natural Resource Management	16. Spatial imagery tools help identify oak wilt at the forest system level.	Research
	17. Minnesotans document urban biodiversity while they cope with COVID-19 restrictions.	Extension Multi-state
	18. Citizen scientists document over 25,000 bees to fulfill the promise of the “Bee Atlas.”	Integrated

	19. Extension uses media to promote "smart gardens."	Integrated Multi-state
	20. Extension mobilizes 69,789 hours of volunteer service to create a greener Minnesota.	Integrated Multi-state
	21. CWD research leads to collaborative efforts across disciplines and jurisdictions.	Integrated Multi-state
#5 Sustainable Energy and the Bioeconomy	22. Anaerobic digester pilot system shows promise for turning food waste into renewable energy.	Research
	23. Extension's Clean Energy Resource Teams projects spurred Minnesota to conserve 62.7 billion BTUs in energy savings and renewable energy offsets in 2020.	Extension
#6 Health and Nutrition	24. New toolkit app helps first responders deal with burnout and compassion fatigue.	Research
	25. Health and nutrition education shapes healthy behaviors.	Extension Multi-state
	26. Mice study shows long-term effects of CBD use during pregnancy.	Research
	27. University of Minnesota research helps in development of face masks.	Research
	28. EFNEP and SNAP-ED Health and Nutrition Education creates nutrition and lifestyle changes.	Extension Multi-state
#7 Resilient Communities and Economies	29. Multidisciplinary team explores COVID-19's effect on food supply chain.	Integrated Multi-state
	30. Extension helps farmers and landowners reach fair and profitable rental agreements.	Extension Multi-state
	31. Extension programs facilitate leadership quality and quantity in rural communities.	Extension Multi-state

	32. Multidisciplinary research leads to an online community focused on designing for culturally enriched communities.	Research
	33. Extension applied research and education inform community and economic development decisions, expanding "community capitals" in Minnesota.	Extension Multi-state
#8 Building Strong, Resilient Families	34. Parentopia platform helps parents and educators during COVID-19.	Research
#9 Youth Development	35. Growing North Minneapolis program engages students and communities around food and food systems.	Integrated
	36. 4-H programs inspired STEM career interest among Minnesota's youth, even during quarantine.	Extension Multi-state
	37. Youth turn attention and action to serving their community in tough times.	Extension Multi-state

II. Merit and Scientific Peer Review Processes

The NIFA reviewer will refer to your 2020 Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Process	Updates ONLY
1. The Merit Review Process	**MAES Update:** Following the merit review process laid out in the 2020 plan of work, MAES supported researchers were evaluated for promotion/tenure within their partner college in accordance with University policy (https://policy.umn.edu/hr/tenure). As the primary receiver of MAES funds, we provide updated CFANS tenure track data annually: As of March 2021, CFANS has 183 tenured faculty and 41 non-tenured. Of those, 131 are full professors with tenure, 52 are associate professors with tenure and 41 are assistant professors. In 2020, eight assistant professors were promoted from assistant to associate professor. Additionally, four faculty were promoted from associate professor to full professor. **Extension Update:** Following the merit review process outlined in the 2020 plan of work, twelve educators were promoted in 2020.
2. The Scientific Peer Review Process	**See Plan of Work**

III. Stakeholder Input

The NIFA reviewer will refer to your 2020 Plan of Work. Use this space to provide updates as needed or activities that you would like to bring to NIFA's attention.

Stakeholder Input Aspects	Updates ONLY
1. Actions taken to seek stakeholder input that encouraged their participation with a brief explanation	**See Plan of Work**
2. Methods to identify individuals and groups and brief explanation.	**See Plan of Work**
3. Methods for collecting stakeholder input and brief explanation.	**See Plan of Work**
4. A Statement of how the input will be considered and brief explanation of what you learned from your stakeholders.	**EXTENSION UPDATES:** County Investments: In Minnesota, counties negotiate contracts with Extension that give them access to educators who deliver local programming from any of Extension's four Centers. This year, county leaders were concerned initially when the University pivoted to online learning in order to follow the governor's work-from-home order and keep staff and program participants safe. This concern abated over time. Ultimately, negotiated contracts showed that a majority of counties maintained or increased their fiscal investment in Extension programming. While 25 of Minnesota's 87 counties decreased their Extension investment, 47 increased their investment. Fifteen maintained existing program levels. Overall, county investment in Extension programming increased by .2 percent, demonstrating that local leaders continue to value Extension's expertise and impacts.

	State and local advisory committees are key contacts for Extension leaders. Regional Sustainable Development Partnerships (RSDP): In 2020, regional boards, work groups and idea generators coordinated by RSDP influenced Extension priorities, especially related to five critical issues. ● *Crop, Plant and Food Development and Production:* Sustainable agriculture and food systems work groups in five regions weighed priorities and opportunities and then tapped University teams for sustainability projects. As a result, a multilingual project team worked with a cooperative to identify new markets for immigrant-owned organic produce. A market assessment for halal and kosher meat markets identified untapped opportunities for Minnesota farmers to expand markets for food production. A USDA grant supported work with sugar beet farmers to research the viability of winter camelina within sugar beet rotations, quantify the economics of this new system, and spur supply chain connections. Finally, a market access program helped Minnesota's garlic farmers reach more markets. ● *Resilient communities and economies:* Regional boards used stakeholder input to inform 58 community projects. In Southwest Minnesota, a UMN-developed guide informed communities as they refurbished formerly vacant small-town buildings into valuable community spaces. Landscape architecture students and faculty designed outdoor classrooms for tribal partners to use during the pandemic. Finally, the Mille Lacs Band of Ojibwe developed a strategic plan for an agricultural learning and therapeutic ranch in collaboration with UMN colleges and units. ● *Natural Resource Management* and *Water Resources and Quality:* RSDP boards supported 30 community-driven natural resources projects. A new partnership with the Lake of the Woods Keep it Clean Committee is addressing the environmental impact of a dramatic increase in ice fishing. Another project built a regional market for cultivating climate-smart tree seedlings from local farms and nurseries. A market and feasibility project is supporting the development of a National Loon Center in Crosslake, Minn. ● *Sustainable Energy:* Regional steering committees guide CERTs work and serve as the clean energy workgroup. There is a monthly statewide CERTs webinar for all regional steering committee members to gather and exchange ideas from regions and inform programming as a whole, as well as quarterly meetings for each regional steering committee to meet about regional priorities and projects. Other stakeholder engagement outcomes A host of critical partners inform and support Extension programming.

- *Health and Nutrition* and *Building Strong, Healthy Families:* When the COVID-19 global pandemic led to stay-at-home orders, Minnesota's Governor Walz created a food security task force. Extension's Center for Family Development was tapped to lead the effort to bring hunger prevention professionals together to create a rapid response team addressing food insecurity. The team also participated in statewide boards, networks and committees to focus on school and childcare nutrition.
- *Youth Development:* County investments in 4-H and youth development programming were largely maintained (see above). Concerns about losing 4-H programs for out-of-school summer activities were addressed with a redoubled effort to provide impactful online engagement.
- *Integrated Animal Systems:* Minnesota's livestock producers are well represented by Minnesota associations, and Extension has deep relationships with these associations so that Extension education and research aligns itself with all other resources that can solve producers' problems. This includes the Minnesota Pork Producers Association, the Minnesota State Poultry Association, the Midwest Dairy Association and more. In 2020, collaboration with these groups addressed concerns for developing and implementing safety protocols that assured consumer safety and retained trust in the industries and their products during COVID-19.

MAES. As described in the 2020 Plan of Work, MAES-supported researchers and research centers have processes in place to effectively gather input from a variety of stakeholders. A few 2020 examples of how this feedback is used are noted below:

1. **Diverse Grower Advisory Board helps guide research and outreach with minority farmers:** A team of researchers working with immigrant farmers received critical input into fine-tuning research questions and methodologies and outreach strategies from a nine-member advisory board including Appalachian, Hmong, urban and refugee farmers. (Outcome #9).
2. **Stakeholders inspire new online aquatic invasive species (AIS) decision tool:** Early meetings between AIS stakeholders and UMN experts identified the need for a decision tool that would help managers on the ground determine the best ways to control AIS with limited people and funds. In short, they needed to not only know where AIS are, but also where they are most likely to go next. (Outcome #13).
3. **Stakeholders seek innovative ways to deal with waste**: An anaerobic digester developed by UMN researchers that handled pig manure inspired a collaboration with Twin Cities-based food bank Second Harvest Heartland. The research team was tasked with developing a system that could help with the 1,500 tons of food waste the food bank discards annually. (Outcome #22).

IV. Critical Issues Table of Contents

No.	Critical Issues in order of appearance in Table V. Activities and Accomplishments
1.	Crop, Plant and Food Development and Production
2.	Integrated Animal Systems
3.	Water Resources and Quality
4.	Natural Resource Management
5.	Sustainable Energy and the Bioeconomy
6.	Health and Nutrition
7.	Resilient Communities and Economies
8.	Building Strong, Resilient Families
9.	Youth Development

V. Activities and Accomplishments

Please provide information for activities that represent the best work of your institution(s). In your outcome or impact statement, please include the following elements (in any order): 1) the issue and its significance (e.g. who cares and why); 2) a brief description of key activities undertaken to achieve the goals and objectives; 3) changes in knowledge, behavior, or condition resulting from the project or program's activities; 4) who benefited and how. Please weave supporting data into the narrative.

No.	Project or Program Title Type of Impact	Outcome/Impact Statement	Critical Issue
1.	**Drone technologies and resistant varieties show promise in the fight against soybean aphids.** ● Integrated Impact ● Multi-state	**The Issue:** The soybean aphid is the most significant insect pest of soybean production, especially in Minnesota. The number of soybean acres treated with broad-spectrum insecticides has increased dramatically since the invasion of the soybean aphid in 2000, which threatens the economic and environmental sustainability of soybean production. Growers need more economically and environmentally efficient options to protect their yield. **Key Activities:** Since 2016, the Minnesota Invasive Plants and Pests Center has helped fund a team of research and Extension soybean specialists to explore two ways to help Minnesota soybean farmers: ● Developing Aphid-Resistant Soybeans: Pest-resistant crop varieties offer one alternative to heavy insecticide use. At least nine soybean aphid-resistance genes have been identified, but few of today's commercially available resistant varieties are suitable for Minnesota. UMN researchers are thus looking to close that gap for local growers by developing a selection of early maturing soybean aphid-resistant lines appropriate for Minnesota. They are using the USDA Soybean Germplasm Collection, which has become an important reservoir of genetic diversity, to zero in on soybean lines that contain soybean aphid-resistance genes called Rag — 'resistant to Aphis glycines.' These Rag genes will then serve as building blocks for breeding aphid-resistant lines in Minnesota. ● Using Drone Technology to Help with Pest Scouting: The time-intensive nature of traditional pest scouting has led some growers to bypass it, applying broad-spectrum insecticides preventively regardless of aphid density. Fortunately, unmanned aerial vehicles (UAVs) show promise as a more convenient option for estimating pest damage and insect counts across a field. Previous research had shown spectral reflectance of soybean canopies caused by aphid-induced stress could be detected from ground-based sensors; however, it remained unknown whether these changes could	**#1 Crop, Plant and Food Development and Production**

		also be detected from UAV-based sensors. The team set up small-plot trials where cages were used to manipulate aphid populations. Additional open-field trials were then conducted, where insecticides were used to create a gradient of aphid pressure. Whole-plant soybean aphid densities were recorded along with UAV-based multispectral imagery. Simple linear regressions were used in determining whether UAV-based multispectral reflectance was associated with aphid populations. **Results:** To date, one soybean line with aphid resistance has been developed and commercialized with Viking Seeds in Albert Lea, Minn. (Viking 0.0654AT). Nine additional lines are in advanced stages of testing. However, concerns persist that aphids could quickly adapt to resistance in the plant. Thus, the team is also exploring 'stacking' of multiple resistance genes to create a stronger, more robust resistance and also expanding their work to include food-type soybean germplasm. Drone trial findings showed near-infrared reflectance decreased with increasing soybean aphid populations in caged trials when cumulative aphid days surpassed the economic injury level, and in open-field trials when soybean aphid populations were above the economic threshold (250 aphids per plant and/or over 80 percent of plants infested). These findings provide the first documentation of soybean aphid-induced stress being detected from UAV-based multispectral imagery and advance the use of UAVs for remote scouting of soybean aphid and other field crop pests. The team is now working with UMN Extension to incorporate their findings into a patent-pending tool for decision-making about insecticide applications for soybean aphid to a broadly applicable, satellite-based platform. This tool could then help prioritize fields for ground- or drone-based scouting, or even enable decision making for individual fields. **Who Benefited and How:** Soybeans make up 30 percent of Minnesota's total agricultural exports and remain the state's top export commodity. In addition, the state ranked third in the nation for soybean production as of 2019. This research directly serves the agricultural community of Minnesota by advancing the development of aphid-resistant soybean cultivars and improving remote sensing technologies to locate damaging levels of soybean aphids. The resulting decreases in insecticide inputs will reduce adverse	

		economic and environmental impacts of soybean aphid management and will be especially beneficial economically to organic producers who have few options for aphid management.	
2.	**Extension is making the Food Safety Modernization Act regulation work — creating safe local fruit and vegetable production on Minnesota's farms.** ● Extension Impact ● Multi-state	**The Issue:** While the consumption of fruits and vegetables is universally viewed as a trend toward healthier living, improper handling of produce can result in foodborne illness outbreaks. Contamination can occur at any point within the farm-to-fork continuum, including poor on-farm agricultural practices. The 2011 Food Safety Modernization Act Produce Safety Rule focuses on prevention, especially targeting significant on-farm risk factors. The rule outlines mitigation strategies that reduce the potential for foodborne illness associated with on-farm handling practices. The law relies on regulatory agencies and Extension programs to help farmers navigate the nuances and determine which parts of the rule apply to their farms. **Key Activities:** Extension's Produce Safety Rule (PSF) education program trains Minnesota growers about the Produce Safety Rule using a team of trained Extension educators, farmers and regulators. The training uses FDA-approved standardized curriculum. Educators encourage all produce farmers to take the course so that they understand PSF requirements, including those whose farms are excluded or qualify for exemption. By understanding requirements, farmers are prepared to manage on-farm food safety, address customer questions, anticipate challenges in scaling-up and explore new market opportunities. In 2020, UMN Extension offered five full-day Food Safety Modernization Act workshops for 102 participants. **Results**: Farmers across the spectrum were able to act in accordance with the Produce Safety Rules after participating in the program, including 38 percent planning a required on-farm food safety plan. In a follow-up evaluation, 95 percent of farmers were confident they understood what was required for their operations, and 85 percent understood the difference between mandatory inspections and voluntary audits. Importantly, 87 percent believed that on-farm produce safety practices were important, and 82 percent were confident they now knew how to manage the potential risk of bacteria, viruses and parasites. This program is an expansion of Extension's offerings that protect Minnesota food systems from foodborne illnesses. In addition to the Product Safety Rule program, Extension managed the Serve it Up Safely Renewal Courses, certifying participants in Minnesota's restaurants, child care settings and other institutions. In	**#1 Crop, Plant and Food Development and Production**

		Minnesota, there are more than 35,000 certified food protection managers, and they oversee many more food handlers. **Who Benefited and How:** Proper compliance with relevant food safety practices leads to safe food products. Consumers can feel more confident in the food system as it reduces outbreaks of foodborne illness. A safely regulated and supported industry allows growers to access local markets such as wholesale distributors, grocery stores, schools, and other institutions that require food safety training and food safety plans. Helping growers understand federal regulation also builds trust in government as they come to understand the purpose of the law and the best way to comply.	
3.	**UMN researchers help realize and harness the power of GE crops.** ● Research Impact	**The Issue:** The ability to alter DNA sequences in living cells makes possible detailed functional analysis of genes and genetic pathways. In plants, targeted genome modification has applications ranging from understanding plant gene function to developing crops with new traits of value. Being able to modify DNA in living cells is revolutionizing the life sciences. **Key Activities:** Members of the University's Center for Genome Engineering have long led the charge in developing new, powerful genome modification technologies. The center's work involves gene therapy, gene discovery and precision gene editing using UMN-developed TALEN® (transcription activator-like effector nucleases) and techniques such as CRISPR-Cas9. More recently a second research center, Center for Precision Plant Genomics (CPPG), was added, which focuses on developing tools and technologies to aid in developing GE crops. One key initiative of the CPPG is to develop a simple biocontainment strategy to prevent gene flow into, or out of, GE crops. Their novel approach is to engineer Synthetic Genetic Incapabilities (SGIs) between GE organisms and their non-modified counterparts that prevent gene flow bi-directionally by utilizing a recently developed CRISPR tool for controlling which genes are turned on in a cell. **Results:** In 2012, Science named TALEN® as one of 2012's top scientific breakthroughs. It has been licensed to several companies including Calyxt, a startup company that uses TALEN® for precision targeting of existing genes within a plant's genome, thus allowing scientists to select desired characteristics, accelerating	**#1 Crop, Plant and Food Development and Production**

		breeding in a fraction of the time. The first TALEN® developed crop, a high-oleic soybean, entered Midwest fields in 2018 and was planted on over 72,000 acres in 2020. Researchers at the CPPG also recently developed an alternative method for genetically modifying legume species that is efficient and doesn't require technical skills such as traditional tissue culture. The latter opens up the door for small agricultural firms to get involved with developing GE crops and has been successfully applied to achieve expedited genetic transformation in soybean plants. As GE organisms continue to gain market share and be applied to more and more applications, the ability to limit unintended spread of transgenes into wild organisms is critical. Notably, researchers with the CPPG are not only involved in developing Engineered Genetic Incompatibilities to prevent unwanted spread of transgenes from GMO crops but are also involved in studies related to using GE to control invasive species. Currently, they are testing their technique in model monocot and dicot plants for transgene containment but have plans to move into crops in the near future. **Who Benefited and How:** The telltale sign of any transformational technology is how quickly researchers apply it to their own scientific problems. By that standard, CRISPR (whose developers received the 2020 Nobel Prize in Chemistry) ranks among the most powerful additions to biology's tool kit in the past half century. CRISPR, and other gene-editing tools like TALEN®, allow scientists to alter an organism's genome with unprecedented precision. Both easy to use and inexpensive, it has the potential to put powerful genetic-modification capabilities into the hands of small agricultural firms, rather than big agribusinesses. Proponents say it is less biologically disruptive than traditional plant-breeding techniques practiced for thousands of years. With gene editing, scientists are simply using science to accelerate the process and develop crops that have the best, most desirable traits possible — and unlike GMOS, contain no foreign DNA in the final product — while also considering the long-term implications of their work.	
4.	**Grape growers shape the craft of cold-climate grape growing with University of Minnesota expertise.**	**The Issue:** Minnesota's climate presents unique challenges for growing grapes, such as extreme temperatures and limited growing seasons. Research-based practices support high-quality grape production that can survive the cold weather and resist disease.	**#1 Crop, Plant and Food Development**

	● Integrated Impact ● Multi-state	**Key Activities:** In 2020, a series of five webinars on cold climate grape growing practices was held in conjunction with the University of Wisconsin Extension. Seminars were attended by 343 live participants and received 1,163 views on YouTube afterwards. The series covered which tasks to do at key points in the growing season. The series was formatted so that an educational presentation on a timely topic was followed by answering grower questions, helping growers be better prepared for the next stage of the season. **Results:** One hundred percent of participants reported that the quality and timing of the information helped them make key decisions during the growing season and 91 percent changed or will change practices as a result of something they learned through the webinar series. **Who Benefited and How:** Minnesota's wine industry generated $80.3 million dollars in economic activity and supported more than 10,500 jobs in 2016 (Brigid and Gartner, 2016). There are over 80 wineries that support that economic development. Successful grape growing supports an important economic sector and the desire for more local goods.	**and Production**
5.	**Research helps enhance pea protein functionality for industry applications.** ● Research Impact	**The Issue:** As the demand for plant proteins continues to grow, there is a need to develop alternative sources of protein other than soy protein, which is limited by being sourced from a GMO crop and a "Big Eight" allergen. Yellow field peas have similar agricultural benefits and protein profiles as soybean but are non-GMO and of low allergenicity. While soy protein has undergone decades of research to optimize extraction and processing conditions and evaluate structural and functional properties, pea protein is less researched. **Key Activities:** Currently, pea protein is mass produced in a way that can alter its native structure, thus reducing its functionality in food applications. In order to make pea protein competitive with soy protein, there is a need to optimize both the conditions used for pea protein extractions and for functionalization, to produce pea protein isolates (PPI) with high protein purity, preserved structural, and enhanced functional properties. Additionally, the scalability of optimized extraction methods must be evaluated to determine industrial feasibility.	**#1 Crop, Plant and Food Development and Production**

		Researchers at the UMN Plant Protein Innovation Center tested two protein extraction protocols (alkaline solubilization with isoelectric precipitation and a salt solubilization coupled with membrane filtration) to optimize pea protein extraction conditions to maximize protein purity and yield. They then characterized the impact of the two "bench-top" extraction methods on the pea protein structure and functionality. They then conducted a pilot scale study to evaluate the impact of a larger-scale production on the protein's structure, functionality, nutritional quality and flavor. In addition, the team used cold plasma treatment to improve the pea protein functionality, which resulted in enhanced emulsification and gelation properties. **Results:** Overall, this study demonstrated successful optimization and scalability of two pea protein extraction methods: alkaline solubilization with isoelectric precipitation and salt solubilization coupled with membrane filtration. Both optimized bench-top methods achieved high protein purity and yield, while using relatively non-denaturing conditions. Scaled-up extractions achieved similar protein purity to the bench-top counterparts. Compared to commercially available PPI, the scaled-up PPIs had superior solubility at pH 3.4 (suitable for acidic beverage application) and superior gelation and emulsification properties. While there were slight differences in structural and functional properties between bench-top and scaled-up PPIs, compared to commercially available PPIs, scaled up PPIs were less denatured, resulting in superior functionality that should be advantageous to industry. Cold plasma treatment further enhanced emulsification and gelation properties of the produced pea protein isolates, surpassing commercial soy protein isolates. This study is significant in demonstrating that PPI, with superior functionality to commercially available PPI, as well as commercially available soy protein isolate, can be produced on a large scale through both the traditional pH extraction and the novel salt extraction coupled with membrane filtration. Functionalization of the protein via cold plasma and Maillard-induced glycations has been successful. A patent related to these process discoveries — Method for Producing Functional Pea Protein 63/107,797 — has been applied for. **Who Benefited and How:** The global protein ingredient market was valued at $38 billion in 2019 and is expected to grow at a rate of 9.1 percent from 2020 to 2027. Protein ingredients have gained prominence in the food industry because of escalating consumer awareness and demand for healthy foods. In general,	

		consumers want more protein in their diet, sustainably sourced. Accordingly, food industries are interested in commercializing products formulated with ingredients derived from environmentally sustainable crops. From a sustainable agriculture perspective, adding peas to crop rotations enhances the structure, nutrient content and levels of organic matter in the soil, increasing the yields of subsequent crops. From a manufacturer's, and subsequently consumer's perspective, pea proteins are not as yet allergenic, nor genetically modified. In order to meet both consumer demand and desired eating experience, the expansion of options and functionality of protein ingredients is essential for product development and manufacturing.	
6.	**Extension trains cottage food entrepreneurs, assuring that food products are safe, legal and ready to support local economies.** ● Extension Impact ● Multi-state	**The Issue:** It is estimated that the cottage food industry could contribute more than $22 million annually to Minnesota's economy if all registered producers achieved maximum allowable sales. These revenues would have a local economic impact and diversify household earnings. Since 2015, Minnesotans have been allowed to sell shelf-stable foods made in homes under the Cottage Food Production law. The law allows small producers to produce homemade foods for niche markets in unlicensed home kitchens. Cottage foods can be sold from home, farmers markets, farm stands or at community events. Registration with the Minnesota Department of Agriculture is required after completing a food safety training course offered only by Extension. **Key Activities:** UMN Extension offers the *Cottage Food: Keep it safe! Keep it legal!* curriculum to allow cottage food producers to meet training requirements. UMN Extension is the only training provider for producers who register for "tier 2" sales of $5,000 - $18,000 per year. The training assures that producers know how to properly produce, package, label, store and transport products, and stresses protecting public health. In 2020, Extension trained 374 producers. **Results:** Based on what they learned, 63 percent agreed that they were ready to change their practices in alignment with safety and the law. Thus, Extension prepared 235 new entrepreneurs who can now legally create businesses that sell local foods. These businesses can diversify economies in households and communities. **Who Benefited and How:** Local producers are more likely than national firms to buy local. If all registered producers achieve maximum allowable sales, they will increase their personal finances while supporting	**#1 Crop, Plant and Food Development and Production**

		their local economies. By being trained in prevention, these registered cottage food producers are reducing incidents of foodborne illness, thus protecting public health.	
7.	**Extension creates a culture of soil management on Minnesota farms through annual conferences.** ● Integrated Impact ● Multi-state	**The Issue:** Soil management on farms is critical to improving soil resources and water quality. Conventional tillage practices remove more than 70 percent of crop residue. That leads to eroding soils and the loss of soil nutrients such as phosphorus and nitrogen. When those nutrients migrate to rivers and lakes, water quality suffers. Farmers can reduce these losses by keeping soil covered for most of the year with crop residue or "cover crops." These practices provide economic benefits to farmers because no-till, strip till, and cover crop practices allow at least 30 percent of crop residue to remain on the field, which improves soil quality, nutrient retention and long-term soil productivity. **Key Activities:** Since 2008, Extension has conducted an annual conservation tillage conference to educate the farming community about conservation tillage practices and research. The conference presents information on conservation tillage techniques and other soil management practices that help farmers realize full benefits. In 2014, other positive soil health practices were introduced to the agenda, including cover crops, crop rotation, and adding livestock to the fields. In 2020, the conference was renamed the "Soil Management Summit." Over 200 people attended the virtual conference from across Minnesota and elsewhere. The Soil Management Summit included presentations based on Hatch-funded research projects. **Results:** Program evaluation charted the impacts of the conference from learning gains to longitudinal changes in practice that lead to soil health and increased profitability. Overall, 87 percent of attendees from past conferences reported they had used information from previous conferences in their work. This has the potential to impact over 36,695 acres of farmland managed by farmers who participated and 303,000 acres of farmland with practices informed by consultants who attended the conference. **Who Benefited and How:** Soil health management systems contribute to higher water and air quality while they increase food security. Producers who apply soil health practices report greater economic returns due to reduced fuel, machinery, labor and fertilizer costs. Benefits are also realized through better water infiltration and reduced soil crusting, which increases crop productivity. Leaving soil covered results in less	**#1 Crop, Plant and Food Development and Production** **#3 Water Resources and Quality**

		erosion. Nutrients remain on the field rather than being washed or blown away. This improves soil resiliency and creates consistent yields for producers over time. The people of Minnesota benefit from conservation tillage and cover crops. Reduced soil erosion results in better long-term soil quality and improved water quality. This reduces water treatment costs and lake and retention basin dredging costs, while increasing recreational values and improving aesthetic values. Better water quality also results in improved aquatic species habitat due to reductions in sediment and nutrient loading and reduced eutrophication.	
8.	**Minnesota farms manage pesticides safely with Pesticide Safety and Environmental Education.** ● Extension Impact ● Multi-state	**The Issue:** Farmers must navigate their need to control pests that reduce crop yields with the harm that can be done when pesticides are not managed safely. Responsible management of pests and pesticides is essential to public health, safety and environmental protection. Proper management affects water quality, waste management, endangered and threatened species, food safety, pollinator protection, control of invasive species, land and building use policies, and more. Proper pesticide safety education also minimizes the harm of pesticides to people and the environment. **Key Activities:** Pesticide Safety and Environmental Education (PSEE) at University of Minnesota Extension provides statewide education and leadership for pesticide safety. PSEE provides education for Minnesota's 17,000 certified farmers and other agricultural producers. Extension is also the educational provider for more than 11,000 occupational and professional licensed and certified applicators in natural resources, agriculture, horticulture, public health, and other industries and business sectors. Applicators renew their certification by attending workshops every three years. In 2020, 54 private pesticide recertification workshops were held for 1,686 people. Another 37 commercial/non-commercial workshops were held for 2,765 people, including 26 Licensed Pesticide Application Training workshops specifically for Ornamental and Turf applicators and 1,531 people who needed bi-annual recertification. Finally, Extension conducted six field crop workshops for 892 people. **Results:** In July 2020, Extension sent surveys to 1,000 people who attended private pesticide workshops. The longitudinal survey confirmed that training resulted in safer practices and protections. Participants: ● followed recommended laundering procedures (51 percent). ● made appropriate pest management decisions (54 percent).	**#1 Crop, Plant and Food Development and Production**

		● used information about transportation, storage and emergencies to make pest management decisions about farming operations (29 percent). ● said that the invasive species information helped them comply with laws and regulations to a great extent (29 percent). **Who Benefited and How:** Proper training for pesticide applicators creates greater safety for the general public by minimizing unnecessary pesticide use and contributing to safer food, cleaner water and a healthier environment.	
9.	**Minority farmer partnerships provide value for farms, research and education.** ● Integrated Impact ● Multi-state	**The Issue:** Farmers in the U.S. are becoming a more diverse population, especially those in vegetable production. Immigrant and minority farmers often face particular challenges of land tenure and not having access to high-quality farmland, which exacerbates their struggles with the challenge that all farmers have of how to manage tradeoffs that balance crop production with ecological sustainability. **Key Activities:** Vegetable farmers typically grow many different vegetables, some of which are planted and harvested during the spring and fall, leaving bare, unused soil during the summer. Cover crops grown during this bare period could provide benefits to soil structure and nutrient status; inhibit weed growth during the long, hot days of summer; and protect soil from intense summer storms that are typical in the Upper Midwest. With the ultimate goal of developing more sustainable food production systems, UMN researchers explored plant-soil-microbe relationships driving soil fertility in organic systems. To do this, they developed a farmer-driven project to investigate the role summer cover crops can play in enhancement of soil nutrients and overall health when grown for short periods of time. Significantly, they partnered with a variety of immigrant farmer grower groups for on-farm studies and shared their soil health information directly with producers. **Results:** Results showed increases in soil nitrogen (N) following the use of a variety of cover crops, especially hairy vetch. However, Minnesota's variable climate decreases the potential of legume cover crops to deliver N compared to more temperate states — thus highlighting the need for increased winter tolerance for cover crop legumes as well as improved understanding of the soil microbes that associate with those legumes and	**#1 Crop, Plant and Food Development and Production**

		promote nitrogen cycling. Research results were shared via Extension programming and meetings, including twice at the Emerging Farmers Conference and at the Great Lakes Indigenous Farming Conference, and have reached approximately 2,000 farmers over the last five years. The farmers have responded well to the team's hands-on approach that provides realistic practices for them to implement. Their success is further evidenced by the team having over $1.5 million in continued funding for this work via USDA-SARE and NRCS-CIG programs. A 30-page curriculum handbook titled *Soil Health & Nutrient Management for Immigrant Farmers* was developed. This resource is designed to be culturally appropriate for immigrant growers and uses approachable language and technical concepts. The handbook is intended to serve as both a stand-alone resource for introductory soil science and soil fertility concepts, as well as a teaching tool that can be used in classrooms or one-on-one interactions. This work has allowed the team to deepen their relationships and establish trust with the farmers. Increased collaboration between the UMN, immigrant farming organizations, and indigenous farming groups has led to additional grants and collaborative projects aimed at strengthening the farmers' operations and access to markets. The research team has also benefited from the expertise of a nine-member Grower Advisory Board including individuals and organizations representing Appalachian, Hmong, urban and refugee farmers. The Board has provided critical input into fine-tuning research questions and methodologies and outreach strategies. **Who Benefited and How:** Today's community food systems, including school and community gardens, horticultural therapy programs, and urban agriculture education NGOs, are richly complex. Working within these systems, staff and students will help individuals from a range of backgrounds combine their strengths to achieve the common goal of food production. Extending advanced soil science concepts would allow both beginning and seasoned farmers to enhance soil quality and productivity of their organic systems. Partnerships like this provide the opportunity for researchers and students to work alongside farmers to answer questions and help them maximize productivity and improve agricultural sustainability of their farms. The combination of collaboration, trust and long-term relationship building has yielded significant results and helped guide community instructors as they work with increasingly diverse populations.	

10.	**Selective dry cow therapy program is a win-win-win for the dairy industry.** ● Integrated Impact ● Multi-state	**The Issue:** Dairy cows have a two-month 'dry period' when they are not milked, allowing time for the cow and her udder to rest and regenerate between lactation cycles. During this period, the udder is especially vulnerable to infection by bacteria, causing mastitis. Mastitis remains one of the most significant diseases of dairy cattle. Historically, to deal with this threat, dairy farmers have used blanket dry cow therapy (BDCT) which involves infusing long-acting antibiotics into the mammary gland of all of their cows at dry off, to cure existing infections during the period between lactation cycles, regardless of they have contracted an infection. This not only increases costs for farmers but leads to increased antibiotic use. **Key Activities:** Over the past five years, UMN researchers in the College of Veterinary Medicine are spearheading a project that selects cows for dry cow therapy. Selective dry cow therapy (SDCT) is an approach whereby only those cows or quarters with a known or suspected intramammary infection are treated with antibiotics at dry off. The team compared two SDCT approaches (Culture-based or Algorithm-based) against BDCT in a multi-herd, multi-state clinical trial. They collected data on 1.) reduction in antibiotic use at dry off, 2.) intramammary infection dynamics during the dry period, and 3.) subsequent lactation performance, including clinical mastitis risk, milk yield and somatic cell count (SCC) in the first 120 days in milk. The findings were incorporated into Extension guidance for dairy teams, and Extension provided online guidance to dairy farmers that was informed by this research. **Results:** Results showed the two SDCT approaches each reduced antibiotic use at dry off by an average of 55 percent, while causing no negative impacts on intramammary infection dynamics during the dry period or future lactation health and performance. Roughly 1/3 of all antibiotics used in the dairy industry are used for dry cow therapy, and by using this SDCT method farmers can significantly reduce their usage. An economic analysis showed an estimated positive economic return with either SDCT program. Specifically, the average cost savings for producers employing SDCT was $2.13 per cow with the culture-guided system and $7.83 per cow using the algorithm method. If a single herd of 1,000 cows was tested with the algorithm	**#2 Integrated Animal Systems**

		method, nearly $8,000 would be saved in one year. An app is now available that allows producers to estimate the economic savings they may get if they adopt SDCT on their farm. While not all farms are good candidates for SDCT, having this as an option is still beneficial for many farms. The research team has worked closely with UMN Extension dairy educators to develop recommendations for farms and has partnered with the Minnesota Dairy Herd Improvement Association (DHIA) to roll out the program. The DHIA is providing dairy farmers with information on the SDCT program and individual farm level reports on which dairy cows are at high or low risk for infection to guide antibiotic treatment decisions at dry off. This latter partnership will reach approximately 50 percent of Minnesota dairy farmers. By examining historical DHIA records (April/May, 2020), the team determined that approximately 60 percent of Minnesota dairy farms on a regular DHIA SCC testing program are potential candidates for adopting SDCT. Within these herds, about 10,043 cows would be eligible to avoid being treated with antibiotics at dry off in April and May (2020) alone. Similar programs are being rolled out by project collaborators at Cornell University to dairy producers in New York State. **Who Benefited and How:** As of 2019, Minnesota ranks seventh for the most dairy cows in the nation and it is important for the dairy industry to remain a viable and healthy agricultural sector of the state. Over the last few decades, advances in treating and preventing mastitis (including use of teat sealants and availability of rapid tests) mean that BDCT is no longer necessary for many herds. Adopting SDCT can result in ensuring animal health, production and wellbeing, and improved economic sustainability for U.S. dairy producers, while significantly reducing antimicrobial use on U.S. dairy farms — an issue that is increasingly causing public concern. In short, it is a win-win-win for the dairy industry.	
11.	**Pig microbiome discoveries show promise for swine industry.** ● Research Impact	**The Issue:** The trillions of microbes that inhabit the gastrointestinal tract of mammals, the gut microbiome, play indispensable roles in energy harvest, nutrient synthesis and gut health. Although these issues have been well-known in the animal science field, microbiome work in swine production systems is still in its infancy. **Key Activities:** The microbiome in the gut or respiratory tract provides a protective layer against infectious diseases in swine. Thus, with microbiome research, researchers can determine how novel feed additives and management interventions work, by either enhancing the abundance of microbes that promote health	**#2 Integrated Animal Systems**

		and/or displacing those that cause disease. Even though microbiome research in swine production systems has shown an altered microbiome in poor performing or sick pigs, we need more studies that better characterize the systematic changes in microbiome diversity over time (from birth to after weaning) to predict health and performance outcomes. A team of UMN researchers hypothesized that increased sanitation level in maternal environments affects development of piglet fecal and nasal microbiomes, and physiological performance. The team conducted their study at the West Central Research and Outreach Center, where six sows were allocated to two treatment groups: farrowing stalls cleaned with or without disinfectant. Swabs were collected from stall floors, drinkers and feeders, and from sows' vaginal, rectal, oral and udder surfaces at day 109 of gestation and the day before farrowing. They also collected fecal and nasal swabs from piglets at days: 0 (within 24 hours of birth), 7, 14, and 21 postpartum. Nine piglets were then selected from each sow (n = 27/treatment) for microbiome analyses. **Results:** Although environmental microbiomes were different between disinfected and not disinfected stalls after cleaning, they detected no compositional differences among any disinfected or not disinfected sow samples. However, at day 0, not disinfected piglets compared with disinfected piglets exhibited higher gut and nasal bacterial diversity. Not disinfected piglets also displayed greater nasal bacterial diversity at 0 but also at day 21 (weaning), and different gut and nasal microbiome compositions across all time-points, including higher abundance of potentially probiotic gut bacteria (Lactobacillus). However, disinfected piglets exhibited higher average birth and weaning weights compared to not disinfected piglets. These results show that sanitation level during farrowing persistently alters swine microbiomes and growth performance. Because of the multiple environmental, nutritional and health factors influencing the pig's microbiome, determining which factors are most important in shaping this microbiome early in life is key to devising microbiome-based interventions. Ultimately, discoveries like this will allow producers to manipulate the pig's microbiome through nutritional and environmental interventions and ultimately will improve performance and health.	

		Who Benefited and How: Minnesota is home to over 3,000 pig farms and ranks second in the nation for both the number of pigs raised and pig value. In 2013, Minnesota pig farmers marketed 14 million pigs and the Minnesota pork industry generated $7.28 billion in economic activity. Knowledge of the diversity of the swine microbiome can provide a novel, alternative perspective on the biological process that affects some of the most important issues in swine production systems. Regular "microbiome snapshots" along the most critical stages of pig growth (e.g., pre- and post-weaning), can predict health and potential pathogen threats for disease by early identification of bacteria in slow-growing pigs or those that are at most risk of infection. This would allow producers to make early decisions on therapeutic or dietary interventions to enhance performance and health.	
12.	**AmE-711 honey bee cell line is a powerful tool for bee research.** ● Research Impact	**The Issue:** Colony collapse disorder (CDD) is a threat to the survival of honey bees and could significantly disrupt agricultural production. CCD research into how pathogens and toxic compounds affect honey bees is a rapidly expanding field. However, this research is limited by the lack of in vitro cultures composed of honey bee cells. Instead, researchers must use valuable whole organisms (bees) or colonies, limiting the progress and studies that can happen. **Key Activities:** To address this limitation, UMN researchers at the Bee Lab and the Department of Entomology set out to develop a honey bee cell line that would support continuous culturing of the insect cells in order to develop a powerful tool to explore the process of infection and the negative impact pathogens may have on honey bee biology and health. In 2013, the team reported they had successfully established a cell line (AmE-711) with potential application for studies aimed at honey bee development, genetics, pathogenesis, transgenesis and toxicology. AmE-711 was established from embryonic tissues, and is characterized as adherent, fibroblast-type cells. Cells from the line are mainly diploid by karyology — similar to honey bee workers in nature. Most importantly, the cell line is continuous, meaning the cells remain viable and replicate for over 50 generations, translating to more than a year of culture in the lab. As a demonstration of the utility of the line, the team conducted experiments to show AmE-711 cells are susceptible to infection with the emerging fungal pathogen, Nosema ceranae, and honey bee viruses, which are contributing factors to honey bee decline.	**#2 Integrated Animal Systems**

		Results: Since its release, the Apis mellifera-derived AmE-711 cell line has served as a powerful tool for studies of host-pathogen interactions and toxicology in honeybees at the University. Notably, in 2015 the line crashed, possibly because of virus infection, but has since been recovered from liquid nitrogen stocks and adapted for growth using a commercially available medium. It is now licensed to other Universities, public institutes and private companies as the only continuous honey bee cell line available for research and experimental testing. **Who Benefited and How:** Through their pollination services, honey bees serve an essential role in sustaining the nutrition, health, and shelter of humans and other animals. Unfortunately, many factors commonly found throughout the U.S. can detract from honey bee health. To better understand the interaction between intracellular pathogens and honey bee cells, we need tools that allow examination of infection at fine resolution and under controlled, aseptic conditions. One such tool is cell culture, which has been instrumental to advances in medicine, including better understanding the effects of cancer, viruses, toxins, genes, radiation, nutrition and developing vaccines. With the AmE-711 cell line, a new door into honey bee research has been opened and there is huge potential for developments that can help us better understand why bees are dying and how we can help protect them.	
13.	**New decision-tool helps prioritize AIS management.** ● Integrated Impact	**The Issue:** Minnesota aquatic invasive species (AIS) managers are tasked with preventing the spread of many AIS moving through a highly complex and interconnected waterways system, often with limited resources. A data-driven approach to identify and prioritize waterbodies of high risk of invasion is needed to help inform effective and efficient control programs throughout the state and, in time, the region. **Key Activities:** Early meetings between stakeholders and the team at the University's Minnesota Aquatic Invasive Species Research Center (MAISRC) identified a large number of needs as the state works to control AIS. One of these needs seemed to tie all of the issues together: Minnesota needs a decision tool that would help managers on the ground determine the best ways to control AIS with limited people and funds. In short, they needed to not only know where AIS are but also where they are most likely to go next. Minnesota's water system includes over 10,000 lakes with thousands of rivers and streams interconnecting them. Hundreds of these are already infested by AIS and thousands more are at risk of infestation. The state is also home to over 800,000 registered boats. Armed with over 1.6 million data points of reported boater	**#3 Water Resources and Quality**

		movements, the Minnesota Department of Natural Resources infested waters list, and complex networks of natural water connectivity, an interdisciplinary team set out to determine which Minnesota lakes are most at risk and thus should be prioritized at the local and state level. They ultimately created two models: 1.) Introduction Risk for Surveillance and 2.) Prioritizing Watercraft Inspections. The former uses a Bayesian modeling approach to predict the likelihood a lake will be infested with zebra mussels or starry stonewort. The latter uses a GAMS-CPLEX optimization approach to rank lakes within a county that should be prioritized for watercraft inspection efforts and provides a figure that displays the optimal balance of inspection resources. **Results:** In November 2020, after five years of development and thousands of simulations to test accuracy, these models moved into an online dashboard: aisexplorer.umn.edu. The AIS Explorer allows local and state managers to optimize their limited resources by accessing science-based recommendations about where to focus surveillance efforts and which lakes inspectors should be placed at for the best effect. Ranked inspection lists can be generated and exported for zebra mussels, starry stonewort, Eurasian watermilfoil, spiny water flea and any combination thereof. The models are able to forecast eight years into the future and are updated weekly with new data to account for new infestations and changing risk dynamics. Feedback from training workshops with county managers has been positive with many planning to incorporate AIS Explorer into their work stream. While currently focused on county and statewide AIS work, the team is working with additional stakeholders to incorporate data that will not only improve the current models' accuracy but could help with region wide AIS management decisions. Significantly, while built for managers, stakeholders across the board can learn and gain insights from it. **Who Benefited and How:** Minnesota is home to hundreds of AIS-infested waters and thousands more that need protection. Millions of dollars are spent annually on AIS activities but with such a broad waterway system a decision-making tool was needed to help prioritize time, people and funds. This project showcases how quantitative risk modeling, implemented in specialist software, can be directly linked with operational decision-making in biosecurity, and connect field work conducted by regional authorities with cutting edge	

		science in a timely manner. The AIS Explorer supports stakeholder engagement and smart use of data for rapid detection and response to biosecurity threats in a practical and cost-effective way.	
14.	**Study shows effect of AIS on Minnesota walleye.** • Research Impact	**The Issue:** Hundreds of Minnesota lakes are infested with zebra mussels or spiny water flea, two aquatic invasive species (AIS) that have a significant impact on lake ecosystems. Researchers know both species reduce a lake's zooplankton — an important food source for young walleye — but there is limited research on how that translates up the food chain to larger species, including Minnesota's favorite, walleye. **Key Activities:** Researchers at the Minnesota Aquatic Invasive Species Research Center focused on studying nine large Minnesota lakes that are destinations for walleye anglers: Lake of the Woods, Rainy, Kabetogama, Vermillion, Red, Cass, Winnibigoshish, Leech and Mille Lacs. All, except for Red Lake, were at varying stages and combinations of invasion from spiny water flea and/or zebra mussel, with Mille Lacs being infested by both at the time of the study. Armed with decades of data from the Minnesota Department of Natural Resources (DNR), the researchers used fishery sampling information to explore the lengths of 50,012 walleye and 176,983 yellow perch. In the early years, none of the lakes were invaded by zebra mussel or spiny water flea, thus providing an excellent source of data to show how these invasions affected the fish. **Results:** In their first year of life, the walleyes were 12 percent smaller in the presence of spiny water fleas and 14 percent smaller in the presence of zebra mussels as compared to walleye in uninvaded lakes. Growth of young walleyes in Mille Lacs Lake was particularly stunted. Slower growth makes it more difficult for baby walleye to survive over winter. Significantly, this study is one of the few to show effects of AIS on high-level fish such as walleye, but more research is needed to determine if zooplankton causes this decrease. Notably, yellow perch, which rely more heavily on high levels of zooplankton in lakes, did not show the same decrease in size. Other causes could include increased water clarity and temperature in the presence of AIS reducing walleyes preferred habitat, a possibility that has spawned several additional collaborative studies.	**#3 Water Resources and Quality**

		Who Benefited and How: In Minnesota, walleye is king! As the state's official fish, management and stocking of this vital Minnesota native has been a key issue for the DNR for decades. It is not only a favorite of anglers but is also a cornerstone of the northern Minnesota tourism industry. Because of its popularity as a game and food fish, the walleye now occupies about 1,700 lakes totaling 2 million acres, and 100 warm-water streams totaling 3,000 miles, and accounts for about one third of Minnesota's annual fish harvest. Each spring the DNR hatches millions of walleye eggs and releases tens of thousands of tiny fry and fingerlings into Minnesota lakes as part of their walleye management and stocking program. This massive effort costs more than $3.5 million per year. Quantifying how AIS are disrupting the walleye food web will allow managers to set realistic goals and implement policies that could improve the fisheries in the long term.	
15.	**Model drainage system with multiple frameworks shows promise for reducing nutrient runoff.** ● Integrated Impact	**The Issue:** Agricultural production is intensifying to meet the increased demands on food security, availability and accessibility caused by global population growth. Climate and land use changes place stress on land and water resources. Opportunities for sustainable intensification of agricultural production, including water management strategies, have never been greater. **Key Activities:** Researchers at the Southwest Research and Outreach Center in Lamberton, Minn., wanted to understand the individual and cumulative impacts of multiple, integrated best practices on water quantity and water quality in order to meet nutrient load reduction goals. In particular, researchers were interested in evaluating the response of in-field, edge-of-field and beyond-the-field/in-stream management practices on water quantity and water quality for a small watershed and upscale these results to watershed scale. The team used unique research infrastructure situated in the Cottonwood River Watershed (CRWS) at the Southwest Research and Outreach Center to achieve this goal. The site included a series of components consisting of modular bioreactors, constructed wetlands, managed ditches and cover cropping strategies to assess in-field tile drainage and surface runoff. In addition to the field research, data from the experimental site was coupled with actual on-farm management data from farms in the CRWS that were enrolled in the Minnesota Agricultural Water Quality Certification Program (MAWQCP). Data collection and monitoring took place over a three-year period, 2017-2019.	**#3 Water Resources and Quality**

		Results: Data for the experimental site supported that structural practices like bioreactors, constructed wetlands and managed ditches can have a positive effect on water quality through reduced nutrient loss (nitrogen and phosphorus) and can increase temporary water storage on the landscape. During the three-year experiment, ditch management using a minimally invasive low-grade weir resulted in, on average, 57 percent less flow than the unmanaged ditch. Similarly, on an annual basis, the managed ditch exhibited an average 67 percent reduction in nitrogen (N) load and a 27 percent reduction in dissolved reactive phosphorus (DRP) load. During the experiment, nutrient reduction varied by type of constructed wetland, but all types reduced nutrient losses. Constructed wetland management resulted in a range of 54 to 60 percent reduction in N load and a range of 44 to 50 percent reduction in DRP load. Performance of corncob/woodchip modular bioreactors (MB) varied by treatment type, but all types reduced nutrient losses. Nitrate load was reduced by 14 percent when the MB consisted of corncobs and wood chips only. When a supplemental carbon source was added to MBs, the nitrate load reduction increased to 31 percent. Finally, when supplemental carbon and heat were added to MBs, the nitrate load reduction increased to 42 percent. **Who Benefited and How:** In much of the Midwest, including Minnesota, land use is dominated by row crop agriculture with the extensive use of artificial subsurface drainage systems and maintained ditches to manage soil water conditions. Excess water in the system can affect soil properties and plant growth and development. In order to make meaningful strides at mitigating and improving the impact of agricultural runoff on the environment, a multi-scale approach (in field, edge-of-field, beyond-field/in-stream) is needed and projects like this represent a significant step forward for agriculture.	
16.	**Spatial imagery tools help identify oak wilt at the forest system level.** ● Research Impact	**The Issue:** Oak wilt fungus infected over 266,000 oak trees between 2007 and 2016 in Minnesota, making it the second greatest invasive pathogen threat to the state behind Dutch elm disease. The fungus is found in more than a quarter of all Minnesota counties. Because the fungus spreads primarily by the tree's roots, oak wilt can be difficult to detect. Monitoring forest health by foot has been expensive and time-consuming. But new technology like satellite imaging and spectral technology can analyze a tree's vitals even before it shows physical signs of sickness. **Key Activities:** One of the key challenges of detecting oak wilt is how similar the symptomatic bronze or brown wilting leaves can look to signs of drought stress and other diseases. Finding infected trees in a large	**#4 Natural Resource Management**

		plot of forest land can be like searching for a needle in a haystack, especially when wilting is in its more subtle early stages. Using handheld devices, drones and airborne hyperspectral sensors, UMN researchers in collaboration with the University of Wisconsin and University of Nebraska and with the help of NASA pilots have been capturing the photons — packets of energy — reflecting off forest canopies. This light contains information about the species of tree, its physiological condition and health, and stress it is under. **Results:** Using hyperspectral image data, the team can now identify oaks from other tree species with 95 percent accuracy and differentiate between healthy and trees infected with oak wilt with 84 percent accuracy. The team also determined some best practices for using hyperspectral technology in this way, including identifying: the most important wavelengths to identify oak species, red oaks, and diseased red oaks; several multispectral indices associated with physiological decline that can detect differences between healthy and diseased trees; and the best time of year to conduct similar research (August). The wavelengths identified are also among the most important wavelengths for disease detection within PLS-DA models, showing a convergence of the methods. This study highlights how hyperspectral models can differentiate oak wilt from other causes of tree decline, and that detection is correlated with biological mechanisms of oak wilt infection and disease progression. It has also shown how, within a canopy, symptom heterogeneity can reduce detection, but that symptomatic leaves and tree canopies are suitable for highly accurate diagnosis. The team's next step, aimed at lowering cost, will be to test protocols that can use satellites or drones instead of manned flights for canopy detection. **Who Benefited and How:** Oaks make up nearly 30 percent of our North American forests and are one of the most important tree lineages in North America and the Northern Hemisphere. Not only do oaks store and filter carbon out of the atmosphere, oak trees are essential in preventing run-off, preserving habitat, and even fostering the economy through the export of lumber. Homeowners and municipalities are spending millions of dollars annually to treat, remove, and replant oak trees. An effective strategy for limiting the spread of invasive forest pathogens like oak wilt is to find and remove diseased trees before the infection	

		spreads to nearby trees. By using hyperspectral imagery to identify oak wilt in forest land, researchers are on their way to helping forest managers identify the best places to treat before the disease can spread throughout the system.	
17.	**Minnesotans document urban biodiversity while they cope with COVID-19 restrictions.** ● Extension Impact ● Multi-state	**The issue:** Governor Tim Walz issued a stay-at-home order beginning March 27, 2020, to reduce the spread of COVID-19. In 2020, Minnesotans were challenged to stay active and occupied in and near their homes as a result of the stay-at-home order. Time spent outdoors in nature has health benefits, including reducing stress and increasing cardiovascular health. **Key activities.** Soon after Governor Walz issued Minnesota's stay-at-home order, Extension shared ideas online for being active in the safe outdoors. Extension also invited all Minnesotans to participate in the City Nature Challenge to record and share observations of urban biodiversity. Using the iNaturalist app https://www.inaturalist.org/, Minnesotans in 11 counties helped to document urban biodiversity and built their awareness of nature within their urban areas while finding healthy outlets to cope with the stress and fear of COVID-19. This event was quickly converted to virtual training, virtual marketing and independent participation. Seven events were held on Zoom and Facebook Live to prepare volunteers. More than 530 Minnesotans provided identifications and observations of more species (815) than any previous year within the designated boundaries. **Results:** When compared to other cities in our biome, including the much larger metro areas of New York City and Chicago, Minnesota had the highest number of observers and identifiers and the second highest number of species reported. Even better, the gold standard of the event is the number of observations that make it to "Research Grade," e.g., high enough quality to be used for future conservation biology research. Minnesota observers achieved the highest in its biome at 57 percent of observations. **Who Benefited and How:** Participants benefited by learning about the urban ecology and finding productive outlets for their time during the isolated and frightening first months of COVID. As noted, future conservation biology research will have access to the observations made by Minnesotans.	**#4 Natural Resource Management**
18.	**Citizen scientists document over 25,000**	**The Issue:** Bees play a critical role in pollination and wild plant growth. Pollination also supports food supplies for both humans and animals. They build homes for insects and animals and play a critical role in	**#4**

	bees to fulfill the promise of the "Bee Atlas." ● Integrated Impact	every aspect of the ecosystem. Historically, records show 23 species of bumble bees in Minnesota; however, for most species we do not know their current presence in the state. For some species, we do not know even if they can still be found in Minnesota. Quantitative surveys are needed to document the status of Minnesota bumble bees, not only to tell us which bumble bees are where, but also which bumble bee species are decreasing in abundance. The state is too large for Minnesota's handful of bee biologists to reach. By mobilizing volunteers to document bumble bee sightings statewide, science can document how bumble bees are faring in Minnesota. **Key Activities:** The Minnesota Bee Atlas was a citizen science research project implemented from 2015-2020. It relied on volunteers to document and learn more about the distribution and diversity of native bees in Minnesota. Volunteers submitted photos of bees to iNaturalist, adopted roadside survey routes to capture, identify and release bumble bees, and monitored nesting blocks for stem-nesting bees. All resulting data became publicly available. In addition to recording the presence of bee species, the information collected by volunteers was used to create web pages for each bee species that included pictures, descriptions, maps of where in the state bees were found nesting and other details. For this collaborative project, Extension reached more than 3,500 citizen scientists of all ages through events like volunteer training, webinars and pollinator festivals. **Results:** Bee Atlas volunteers documented over 25,000 bees across three protocol areas. In contrast to common research practices, two of the three protocol areas involved non-lethal methods. Over the first three field seasons, volunteers observed almost 400 bee blocks. The blocks attracted stem-nesting bees that would normally build nests in old plant stems or other cavities. Volunteers reported when new nests were built and what materials bees used. Three species set records for being the first observed in Minnesota: Osmia georgica, Megachile inimica and Megachile frugalis. A nest structure for Megachile frugalis was documented for the first time. Bee Atlas volunteers also documented B. affinis or the rusty patched bumble bee, which is federally listed as endangered. These observations expanded the known range of the species and will help the U.S. Fish and Wildlife Service determine management plans. **Who Benefited and How:** It will take many people taking small actions to reverse the declines seen in bumble bee populations. The preservation of Minnesota's bee population supports the quality of life for	**Natural Resource Management**

		every Minnesotan who relies on Minnesota's ecosystem. Volunteer participants who supported documentation became more knowledgeable about the plight of bees in Minnesota and how they can be part of conservation. The data that Bee Atlas volunteers collected can now be viewed by the general public as part of the Bell Museum's Biodiversity Atlas, which is a part of Minnesota's official natural history museum. The data is available to researchers and the general public. Better information on bees native to the state can help both scientists and the public protect them and their habitat.	
19.	**Extension uses media to promote "smart gardens."** ● Integrated Impact ● Multi-state	**The Issue:** Gardening is a popular pastime in the United States. Lawn and garden activities are at an all-time high, with 77 percent of all U.S. households participating in at least some related activity in Minnesota in 2017 (National Garden Survey, 2018). The horticulture industry has an economic impact of $3.5 billion to our Minnesota economy (MNLA, 2014). Changes with the COVID-19 pandemic increased that interest. A 2020 independent survey found that 91 percent of respondents spent the same or more time gardening in 2020 and 86 percent of respondents (n=1200) reported planning to garden the same amount or more in 2021. (Axiom Marketing, Gardening Survey November 18, 2020). **Key Activities:** Minneapolis-based WCCO Radio contacted Extension in 2013 to host a weekly live gardening show called Smart Gardens in their Saturday morning line-up. During each Smart Gardens show, listeners call or text questions to be answered by one of three Extension horticulture experts. The 60-minute show's question-and-answer format provides science-based answers to as many listeners' questions as possible (average 21-25 questions per show, 1,100 per year) in the on-air time (41-44 minutes) between commercials, news and weather. The WCCO Smart Gardens radio show is regularly recorded and available as podcasts on the WCCO website and also on the Extension Yard and Garden homepage. **Results:** An online survey was open to listeners from May 2019 to September 2020 to learn about the impact of the Smart Garden show. When asked about changes made since listening to the show, 56 percent of respondents reported adopting environmentally important practices such as pollinator gardens, less chemical use, better lawn care, water conservation and removing invasive plants. Nineteen percent reported paying more attention to the timing of yard and garden care, and 13 percent added plants they heard recommended on the show.	**#4 Natural Resource Management**

		Who Benefited and How: Better gardening practices help to maintain soil health, reduce the use of pesticides and create pollinator-friendly habitats. These benefits in health and environment accrue well beyond the gardeners who benefit from the physical and emotional health benefits of gardening. During the COVID-19 pandemic, interest in gardening grew exponentially as people sought to grow their own food and enjoy a productive past-time.	
20.	**Extension mobilizes 69,789 hours of volunteer service to create a greener Minnesota.** ● Integrated Impact ● Multi-state	**The Issue:** Community volunteers, acting as citizen scientists, are uniquely situated to collaborate with local organizations and groups, know and address local opportunities, and engage and educate people in their communities. With proper education, they can teach research-informed horticulture practices, manage invasive species, protect pollinators, promote best practices in gardening, promote the use of sustainable techniques for growing local food, teach ways to create resilient landscapes that adapt to climate change, and create access to plants and green space for community health and wellbeing. **Key Activities:** The Master Gardener program mobilizes willing Minnesotans, providing them with comprehensive training so that they can share gardening best practices in neighborhoods and communities with confidence and competence. The goal is to create healthy landscapes, healthy foods and healthy lives. Master Gardeners complete a course taught by University faculty and Extension educators. Upon completing the course, they contribute time to teach research-based horticulture practices in their communities. In 2020, the Master Gardener program offered 799 educational events for 25,346 participants. **Results:** In 2020, 2,558 volunteers provided 69,789 hours of service across Minnesota. Among the benefits they brought to communities are these: ● County programs worked with 95 community gardens, 35 school-based gardens, and 17 Habitat for Humanity projects and homes. ● Groups donated 9,974 pounds of produce to food banks and pantries. ● Master Gardeners maintained or installed 16 rain gardens for 6,425 square footage and installed or maintained 39 pollinator gardens for 19,558 square footage. **Who Benefited and How:** Better gardening practices help to maintain soil health, reduce the use of pesticides and create pollinator-friendly habitats. These benefits in health and environment accrue well	**#4 Natural Resource Management**

		beyond the gardeners who benefit from the physical and emotional health benefits of gardening. During the COVID-19 pandemic, interest in gardening grew exponentially as people sought to grow their own food and enjoy a productive past-time.	
21.	**CWD research leads to collaborative efforts across disciplines and jurisdictions.** ● Integrated Impact ● Multi-state	**The Issue:** Chronic Wasting Disease (CWD) is a highly transmissible disease that affects cervids. The disease is 100 percent fatal, and it can take months for infected animals to show symptoms while, in the meantime, they spread the disease by shedding prions into the environment which can remain infectious for years, putting other animals at risk. Limited knowledge about CWD's movement through the environment inhibits prediction of CWD transmission and risk in Minnesota and beyond. **Key Activities:** Over the last two years, researchers at the UMN have been working with several Minnesota agencies to facilitate surveillance and enhance our understanding of the risk for CWD spreading — a key concern for Minnesota legislators. In Minnesota, these partners include the Minnesota Department of Natural Resources (DNR), Minnesota Board of Animal Health (BAH), Minnesota Department of Agriculture, Minnesota Pollution Control Agency, several tribal natural resources agencies around the state and Extension specialists. **Results:** One significant result of this effort is the creation of the Minnesota Center for Prion Research and Outreach (MNPRO), which has brought together an interdisciplinary team of researchers from across the University to share knowledge and insights related to CWD management strategies amongst themselves, stakeholders, other researchers and the public. Center collaborators are developing new CWD diagnostic tools, education and outreach materials focused on reaching Minnesota's diverse hunting communities, and novel studies to explore various risks to humans and other animals posed by CWD. One noted difficulty with CWD management elsewhere in the U.S. and Canada has been the difficulty in bringing together all the diverse voices and stakeholders. MNPRO's effectiveness is built on coordinated communication that respects social values of diverse communities affected, collaborations in community-centered science and the engagement of influential federal and state policymakers. UMN researchers working on CWD diagnostic efforts and education have already connected with more than 7,000 members of the public via in person and virtual outreach, despite a global pandemic. Notably, this effort is also in	**#4 Natural Resource Management**

		coordination with a new multi-state research project that will help align research and management across jurisdictions. Another significant outcome of MNPRO's research effort is the development of novel CWD diagnostic tools. Thanks to funding from the Minnesota legislature and the Minnesota Agricultural Experiment Station, the MNPRO research team has successfully developed technologies capable of identifying CWD-positive animals in less than 24 hours and using field-deployable equipment. In early March of 2021, MNPRO researchers worked with the Minnesota DNR to successfully test a field deployable CWD test in southern Minnesota, where CWD is circulating in wild white-tailed deer. This achievement was made possible by a transdisciplinary research effort at the University of Minnesota. **Who Benefited and How:** Since 2002, over 90,000 wild deer have been tested for CWD in Minnesota, with the first positive test appearing in 2010. It now has a foothold in southeastern Minnesota and is threatening the state's billion-dollar hunting industry. The DNR conducts intense, concentrated surveillance in areas around known positives (both within a captive cervid farm or near our neighboring states' borders) for a minimum of three years after an infection is discovered to ensure the disease has not transferred to wild deer in Minnesota, following our State's CWD response plan. Additionally, cervid farmers across the state are part of the BAH's management program that includes mandatory CWD testing. However, as CWD becomes more prevalent, concerns grow about it crossing over and affecting other animals and even humans. Comprehensive research and collaboration across stakeholder groups, states and jurisdictions is as essential to the management plan as developing novel prion detection methods and understanding the complicated ecological factors in the spread of CWD.	
22.	**Anaerobic digester pilot system shows promise for turning food waste into renewable energy.** ● Research Impact	**The Issue:** The United States is the global leader in food waste, with Americans discarding nearly 40 million tons of food every year with most of it going to landfills. Anaerobic digesters show real promise in helping to deal with excessive food waste while also creating new renewable energy resources. **Key Activities:** Unlike traditional composting, which takes place aerobically and only captures solid nutrients allowing methane and carbon dioxide to escape into the environment, anaerobic digesters use a system of airtight tanks containing communities of microbes to break down organic waste. As the microbes "digest" the waste, they create a mixture of methane and carbon dioxide, known as "biogas," which can be collected	**#5 Sustainable Energy and the Bioeconomy**

		to use as a fuel. The microbes also produce heat and leave behind solid matter rich in nutrients like nitrogen, phosphorus and potassium that is ideal for use as a fertilizer and other soil amendments. Previously, UMN researchers developed an anaerobic digester that handled another kind of waste — pig manure — but Twin Cities-based food bank Second Harvest Heartland was interested in seeing if such a system could help with the 1,500 tons of food waste, they discard to the tune of $200,000 annually. To make the process suitable for application at Second Harvest, the research team refined the initial design so it would work with a variable waste stream, with a minimal need for water, and with a bio-electrochemical system that removes adverse odors. They also did an economic analysis to determine whether a digester would make dollars-and-cents sense for Second Harvest, which aims to put every extra penny into helping allay hunger and reduce food waste. **Results:** With funding from the MnDRIVE Bioremediation program, UMN researchers set up a pilot scale anaerobic digester in the parking lot of Second Harvest's Brooklyn Park facility. The system included connecting a first-stage solid-state digester and second-stage liquid digester and it ran for months. Preliminary economic analysis of the data shows the digester will offset over 70 percent of the heat and power needed to run the Brooklyn Park location. Additionally, food-waste loading for the two-stage system increased by 33.3 percent compared to the conventional one-stage dry digester system. **Who Benefited and How:** Spoiled food, manure, sewage — while many just see items to dispose, UMN scientists see the potential to turn organic waste into heat, energy and fertilizer and in doing so, create a greener economy in Minnesota. Anaerobic digesters are popping up in more and more locations throughout the state, including wastewater treatment facilities, farms and food waste facilities. They show real promise to not only create renewable resources, such as renewable natural gas — thus reducing costs and increasing profits for the facilities — but they also reduce the amount of greenhouse gases in the atmosphere.	
23.	**Extension's Clean Energy Resource Teams projects spurred Minnesota to conserve**	**The Issue:** Minnesota's energy efficiency and renewable energy goals were stated and signed into law in 2007 with Minnesota's Next Generation Energy Act, which established a statewide energy conservation goal of 1.5 percent of annual retail electric and natural gas sales. Minnesota has set greenhouse gas emissions	**#5 Sustainable Energy and**

	62.7 billion BTUs in energy savings and renewable energy offsets in 2020. ● Extension Impact	reduction goals to achieve by 2030 and is tracking behind on meeting these goals in every sector except electric generation. **Key Activities:** The Clean Energy Resource Team (CERTs) is spurring Minnesota governmental units, small businesses, farmers and utilities to take action to contribute to Minnesota's clean energy goals, with an emphasis on ensuring that underserved communities are part of this work. CERTs facilitated partnerships, funded seed grants, hosted learning and networking opportunities, created educational guides and decision tools, shared project models for replication, and provided technical assistance that advanced clean energy projects. In 2020, CERTs awarded a total of $140,000 in seed grant funds to support 35 local efficiency, renewable energy, electric vehicle and battery storage projects in communities across the state. CERTs' Extension programming was delivered through 329 public education events and meetings and presentations sponsored by partners. CERTs' most popular resource, The Clean Energy Job Board, hosted 305 postings. CERTs published 111 new stories to illustrate what is possible, to allow peer learning and to inspire readers to take action. Stories were distributed through the Minnesota Energy Stories email newsletter digest, reaching more than 14,000 Minnesotans. CERTs also tested and implemented new models for scaling up sustainable energy impact. **Results:** As a result, CERTs achieved 62.7 billion BTUs in annual energy savings or renewable energy offsets in 2020, enough to power 1.8 million LED light bulbs annually. This savings was the result of the following energy saving projects resulting from CERTs programs: ● Twenty solar installations within the jurisdictions of two counties, two cities and one township following SolSmart certification. *Savings: 23 billion BTUs* ● Two community solar garden subscriptions by a city and a county and on-site solar by a city (two systems) and a school district (one system). *Savings: 20 billion BTUs* ● Distribution of more than 30,000 energy saving items such as light bulbs and showerheads with nine partnering utilities to clients of 24 food shelves, residents of five manufactured home parks, nine seniors' homes and others. *Savings: 6.6 billion BTUs*	**the Bioeconomy**

		• Three farms, three businesses and one school completed two energy efficiency and seven solar projects with clean energy financing and grants. *Savings: 6.6 billion BTUs* • The remaining energy savings and offsets achieved in 2020 were from changes such as energy efficiency upgrades in businesses and multi-family housing, weatherization of manufactured homes, and cities using electric vehicles in fleets. **Who Benefited and How:** Businesses, residents, communities and jurisdictions that implement clean energy projects (see above) benefit by saving on operating costs. They also benefit from being seen as clean energy leaders. As BTUs are saved, utilities meet energy savings and renewable energy goals and are exposed to innovative approaches. Low-income communities begin to have their cost burden reduced for income spent on energy and are included in energy decisions from which their voice has been excluded historically.	
24.	**New toolkit app helps first responders deal with burnout and compassion fatigue.** • Research Impact	**The Issue:** Disaster-responder EMT, police, fire, MRC and other personnel are essential in the work of protecting, saving, and promoting the health and lives of people in crises. However, they are a high-risk group for burnout and compassion fatigue. **Key Activities:** In 2012, UMN providers and researchers from the School of Public Health, Academic Health Center (Office of Emergency Preparedness), and Department of Family Social Science partnered with colleagues at the Minnesota Department of Health to develop an innovative self-care app for emergency responders in the field. In 2018, they then worked closely with colleagues from police, fire, EMT and MRC organizations to improve its usability. In early 2020, they again refined the app as a simplified in-the-field tool for first responders engaged in responding to the COVID-19 epidemic. **Results:** The First Responder Toolkit app is available for free to first responders throughout the U.S. and has been downloaded in all 50 states. The app aids those deployed to emergency response events in maintaining their own physical, emotional and social wellbeing. It provides checklists for before, during and after deployments to help responders attend to daily needs, maintain important relationships, reflect on experiences and more. Moving forward, the team will further develop the toolkit to include enhanced features that fit individual user needs. The app will also, with users' consent, collect anonymous data to help researchers better	**#6 Health and Nutrition**

		understand the extent and impact of mental health and wellness issues in their fields, and to discover and advance better ways to address these issues. **Who Benefited and How:** Emergency event responders have among the world's most important jobs, but also some of the most taxing. Preventing, mitigating and promoting recovery from compassion fatigue is essential for the health and wellbeing of first responders, and for the people they serve. Compassion fatigue can lead to greater risks of missing important cues or questions, working ineffectively in teams, conducting poor documentation, and making medical errors. The simple design of the First Responder Toolkit provides highly stressed responders with an efficient way to consider their personal wellbeing at the present moment and then monitor it.	
25.	**Health and Nutrition Education Shapes Healthy Behaviors.** ● Extension Impact ● Multi-state	**The Issue:** In April 2020, almost 452,000 Minnesota residents applied for unemployment benefits, representing approximately 14 percent of the state's labor force. Communities of color were hardest hit. As a result of job loss and reduced incomes, almost 37 percent of Minnesotans reported some level of food insecurity in 2020, with a significantly higher proportion of food insecurity experienced by communities of color (Wilder, 2020). Issues of food insecurity and food access are systemic and need systemic efforts to adequately prevent and reduce how many Minnesotans families and children struggle with access to and consumption of healthy food. **Key Activities:** Extension Health and Nutrition programs engage a variety of efforts aimed at creating changes in local policy, systems and environment to address food insecurity, food access, obesity prevention and diet-related chronic disease prevention. Three key initiatives include: 1.) addressing food waste through social marketing; 2.) increasing access to high-quality nutrition education to reach more limited income participants; and 3.) addressing equity in encouraging food systems change. The social marketing campaign utilized 17 billboards in 11 cities and grocery cart ads in two grocery stores to increase awareness of the importance of reducing food waste and how food waste depletes budgets. Nutrition education efforts used a self-directed website to feature healthy eating tips, physical activity ideas and recipes. To address equity, a series of eight two-day in-person workshops helped local leaders gain practical tools and partnerships that help people work together on equity issues successfully.	**#6 Health and Nutrition**

		In 2020, the total number of partners who engaged with policy, systems and environment changes was 476. Professionals, organizations and policy makers created 362 changes in local systems, reaching a total of 150,520 Minnesotans. **Results:** Of those participating in equity workshops, 73 percent reported that their skills in engaging online participants through virtual technology had improved. Shortly after receiving the training, 11 percent said they had already used a method they had learned. To measure the impact of the food waste campaign, 307 teen and adult direct education participants answered evaluation questions on social marketing as part of the overall SNAP-Ed evaluation survey. Regression analysis results showed that those who saw the ads tended to agree more with the statement that "wasting food costs me a lot of money" compared to those who hadn't seen the ads. In other words, the food waste campaign increased the awareness of the cost of wasting food. **Who Benefited and How:** Low-income consumers benefit from knowledge about food waste and nutrition as their purchasing power increases and health benefits accrue. Taxpayers and the general public benefit as policies decrease the cost of health and decrease the environmental harms of food waste.	
26.	**Mice study shows long-term effects of CBD use during pregnancy.** ● Research Impact	**The Issue:** Use of cannabidiol (CBD), the major non-psychoactive compound in cannabis, is on the rise across the United States. Pregnant women in particular may view CBD as more "natural" than other remedies for concerns such as nausea and pain, but the consequences of use for the developing fetus are unknown. **Key Activities:** Previously, federal regulations prevented the study of cannabinoids and other illicit drugs, which made it difficult or even impossible to study the effects of these types of compounds. Notably, the FDA advises against the use of CBD, tetrahydrocannabinol, and marijuana during pregnancy or while breastfeeding, yet marijuana use during pregnancy is on the rise, likely because of perceived limited risks and changing social norms. A team of researchers at the UMN set out to close knowledge gaps related to long-term CBD safety and impacts by conducting a first-of-its-kind lab study on mice. The team began by using a human-relevant dose that is typical in adults purchasing CBD over the counter for a variety of ailments. Next, they treated	**#6 Health and Nutrition**

		pregnant mice daily throughout pregnancy and lactation until they weaned the pups. They studied the offspring who were abstinent into adulthood (equivalent to 20-year-old humans) with no additional CBD. In these perinatally exposed adults they looked for persistent behavioral and molecular impacts of CBD. Specifically, the team investigated mice memory function and anxiety behavior along DNA methylation, an important mechanism known as an epigenetic mark in both rodents and humans that helps control gene activity. CBD's effects on gene activity markers were examined throughout the genome in two brain regions important for memory, mood and cognition. **Results:** Maternal CBD treatment shifted gene regulatory marks (DNA methylation) at hundreds of genes in the brains of adult female offspring who were exposed to CBD in the womb and during early life. The results showed long-lasting changes to adult cognitive (thinking) and affective (feeling) behavior, despite not being exposed to CBD since they were infants. The team also found increased anxiety and improved memory performance in adult female offspring, while males were unaffected. CBD exposure also shifted gene regulatory marks that affect the formation of new neurons and synapses, communication between neurons, and diseases like autism spectrum disorder, epilepsy, and substance use disorder. Scientists already know that epigenetic marks are involved in memory and mood, but this study is the first to show that CBD can affect these marks. While CBD may have beneficial effects in adults, these initial findings encourage caution regarding women using CBD in large doses during pregnancy and nursing, as compounds like CBD and THC can easily cross the placenta and be in breastmilk. Next, the team plans to broaden this research by exploring CBD's impact on mice's adolescent development. **Who Benefited and How:** Analysts predict the CBD industry will be worth over $20 billion by 2022. CBD presents the U.S. with unique potential in public health and business, and a good deal of political, medical and legal confusion. Amongst this confusion there is an opportunity for public research to step in and fill some knowledge gaps. This study shows the impact of CBD during development and uncovered effects on the brain and behavior and will help provide better guidance for women, health care providers and regulators, and provide a roadmap for future research.	

27.	**University of Minnesota research helps in development of face masks.** ● Research Impact	**The Issue:** Face masks have been a part of our lives for nearly a year, and health officials say they're the simplest way to help prevent the spread of the coronavirus. Like many aspects of the COVID-19 pandemic, needs and requirements for face masks and other personal protective equipment (PPE) and who needs them have transformed over the last year. **Key Activities**: Early in the pandemic, concerns about N95 respirator shortages dominated the headlines around the world and there was an immediate need for safe alternatives that could also be quickly and effectively mass produced. But as supply chains stabilized, UMN researchers could focus on developing masks that not only block the virus but effectively kill it on contact. ● MNmask: In spring 2020, the need for N95 masks skyrocketed as concerns grew about shortages for medical workers. To address this issue, a multidisciplinary team of UMN designers, engineers and scientists joined forces to develop face masks that could be used during the pandemic to help protect frontline health care workers in crisis situations should N95 respirators not be available. ● LOG3Mask: Another UMN team was interested in improving the overall effectiveness of PPE equipment, like face masks, in order to not only help stop the spread of COVID-19 but also ensure future viruses would not require the extreme measures used to control the spread of COVID-19. **Results** ● MNmask: In May 2020 — six weeks from essential concept to production — and after rigorous testing, the team released three MNmask designs: a single-use, foldable mask (Style 1), a reusable anesthesia mask with an attached disposable filter (Style 2), and a simple-to-prepare single-use general-purpose face mask (Style 3). They produced over 6,000 of Style 1 and provided them to M Health Fairview health care workers. Over 50,000 of Style 3 were packaged over a five-day period for use across the University. The designs were also made available to license at no-cost. ● LOG3Mask: While designed and produced by UMN start-up company Claros Technologies, the LOG3Mask was created using antiviral coating technology developed by UMN researchers and tested and validated at UMN labs. When imparted onto fabrics and other textiles, ZioShield technology inactivates over 99.9 percent of viruses within 10 minutes of contact. It also provides higher particle filtration efficiency than surgical masks by blocking over 95 percent of small and large particles. Claros Technologies' LOG3Mask not only kills the virus but also blocks viral droplets	**#6 Health and Nutrition**

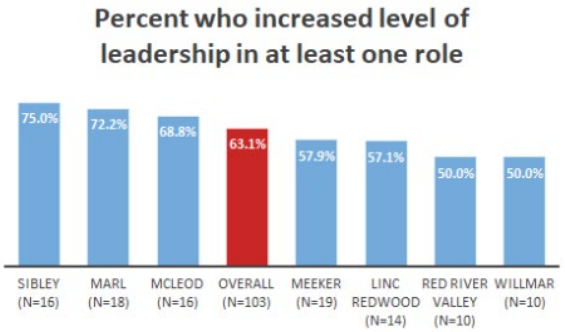
		from reaching the wearer and the wearer's droplets from other people. The Center for Disease Control recently provided funding to Claros to help scale up production of the LOG3Mask. **Who Benefited and How:** The Department of Health and Human Services estimated that the U.S. will need 3.5 billion masks throughout the COVID-19 pandemic. An economic analysis using U.S. data found increasing universal masking by 15 percent could prevent the need for lockdowns and reduce associated losses of up to $1 trillion or about 5 percent of gross domestic product. University researchers responded to the immediate need for safer and more effective mask and PPE options for health care workers and have helped to develop novel ways to protect not only medical workers but the public from COVID-19 and future pandemics.	
28.	**EFNEP and SNAP-ED Health and Nutrition Education creates nutrition and lifestyle changes.** ● Extension Impact ● Multi-state	**The Issue:** In Minnesota, according to the CDC state profile, 36.5 percent of adults and 15.8 percent of toddlers are overweight, and 27.6 percent of adults and 12.2 percent of children are obese. Nearly 1/4 of Minnesotan adults report eating less than one vegetable a day and almost 40 percent report eating less than one fruit serving a day. Diet-related illnesses are higher in limited income communities and communities of color. According to the Minnesota State Legislature, health care costs for those with diabetes and hypertension are 2.5-3 times higher than health care costs of other Minnesotans. Culturally tailored nutrition education, including education about the elements of a healthy diet, cooking skills and how to shop for healthy food on a limited budget can contribute to improved diet and decreased risk for diet-related chronic disease. **Key Activities:** Extension health and nutrition programs continued to implement two major federal USDA grants: SNAP-Ed and EFNEP. Both programs reach limited income audiences in Minnesota; provide research-based education about healthy eating and physical activity; and promote policy, systems and environment changes to reduce disparities in food access and diet-related chronic disease. In addition to core education, educators engage in innovative programming; for example, children's gardening programs, training community members to deliver nutrition education, nutrition programming for childcare providers and farm-to-school initiatives. **Results**: Pre-post surveys assessing knowledge gain and behavior change show evidence that nutrition and lifestyle programming resulted in healthier food and lifestyle choices. For example:	**#6 Health and Nutrition**

		● 60 percent of youth improved their physical activity practices. ● 50 percent of youth improved their ability to prepare simple, nutritious and affordable foods. ● 48 percent of adults showed improvement in one or more food resource management practices, i.e., planning meals, comparing prices or using grocery lists. ● 22 percent of adults met all recommended practices in food security after the educational series. ● 58 percent of adults met all recommended practices in diet quality after the educational series. **Who Benefited and How:** The goal of nutrition education programs is to prevent and reduce poor health, especially among populations with food insecurity. Children in households with improving nutrition will enjoy improved health and habits that may last. Additional benefits, however, accrue to the general public when health care costs are reduced, and educational outcomes improve. As households make better use of food dollars, the financial benefits for the household increase the value of public subsidies while reducing reliance as financial habits evolve.	
29.	**Multidisciplinary team explores COVID-19's effect on food supply chain.** ● Integrated Impact ● Multi-state	**The Issue:** The COVID-19 pandemic has disrupted food supply chains in the U.S. It is essential for our food system to provide adequate nourishment to the people and support the livelihood of people who supply food. Yet, we witnessed empty shelves in supermarkets, food rotting in fields, economic hardship of farmers and restaurateurs, and workers exposing themselves to health risks to supply us with food. **Key Activities:** A multidisciplinary team of researchers and Extension specialists from five universities have partnered to generate science-based knowledge and resources to enhance preparedness of the U.S. food supply chains for future disruptions. The team will: 1.) Assess the impact of COVID-19 on farm and food supply chains; 2.) Understand capacities and structural vulnerabilities of regional food systems to support their population needs; 3.) Develop strategies to mitigate current and future disruptions; and 4.) Develop and host training programs to support local and regional supply chain participants. Research will take place in three food and farm regions — the Upper Midwest, Southern Florida and Southern California — which are distinct in sociodemographic, climate and agri-food systems, and should therefore be able to serve as benchmarks for the nation. In addition, the team will deploy two surveys to collect quantitative data on both the supply chain side and the consumer side regarding how behaviors, barriers, opportunities and needs changed during the pandemic.	**#7 Resilient Communities and Economies**

		Results: Throughout the two-year project period, researchers will collaborate with farmers and business leaders representing all segments of the food supply chain, including producers, processors, wholesalers, retailers, food service providers and food banks, to survey those affected by the pandemic; explore behavioral change among consumers; quantify capacity of regional food systems; model changes in the way food flows within and between regions; interview community and business leaders to identify innovative responses to the pandemic; and develop training toolkits for university Cooperative Extension and other professionals positioned to assist food and farm business owners. A key component of this project involves exploring how smaller, regional food systems have the potential to augment mainstream supply chains to help meet the nation's food needs. This approach has the added benefit of helping to ensure the economic security of small and mid-scale operations that are vital to the overall wellbeing of U.S. rural communities, the economy and the environment. To date, the team has presented one of four webinars they plan to hold over the two-year project, has developed a website to share their findings and has released a supply chain survey for which they have received over 300 responses to date from the Upper Midwest region alone. The nationwide survey was modified from a previous statewide survey by the University of Florida IFAS Extension at the start of the pandemic to target businesses along the food supply chain. Notably, the results of this regional survey helped to guide decision making at local, state and federal levels regarding what aid to provide to various entities. **Who Benefited and How:** The goals of the U.S. food system are to provide adequate nourishment to the populace and to support the livelihood of people who supply food. Visible disruptions of the flow of safe and appropriate food to end consumers during the COVID-19 pandemic call for an urgent, renewed look at the resilience of the U.S. food system. In the short term, this work will increase our collective understanding of COVID-19 impacts on our food system, capacities of regional foodsheds, structure of regional food flows, and how people obtain (or become unable to obtain) food during "normal" times and times of disruption. In the long term, this work will help stakeholders make informed decisions about their practices to prepare for future disruptions and show an increased capacity of Cooperative Extension and other professionals to	

		facilitate food system changes. Ultimately, this work aims to help our food systems navigate future disruptions more deftly.	
30.	**Extension helps farmers and landowners reach fair and profitable rental agreements.** ● Extension Impact ● Multi-state	**The Issue:** Farmland rental rates have increased dramatically in Minnesota as commodity prices have reached record levels since 2008. As a result, farm renters and owners are searching for answers to questions about fair and profitable rental agreements. The number one question received by Minnesota's Extension Farm Information Line relates to farmland rental rates, and agricultural business management educators report an average of three questions daily from landowners, farmers, bankers and agricultural professionals about farmland rental rates. **Key Activities:** To address the demand for information, Extension's agricultural business management team offers education that assists farmers and landlords as they negotiate fair and profitable farmland rental agreements. The program helps participants consider 2020 production costs, use data about current cash rental rates from third-party sources, and consider data about land values and commodity market trends. In 2020, a total of 1,188 farm and ranch family members, landlords and agricultural professionals attended one of 50 workshops. **Results:** Participants reported that they farmed or rented an average of 478 acres, so we estimate a total of 567,864 acres of farmland were affected by the learning outcomes of the program. This represents approximately 3.9 percent of corn and soybean acres planted in 2019 in Minnesota. The total financial impact of this program effort is estimated at $113,572,800, based on average rental rates for 2019 by county of participant. This financial impact is based on participants from 70 of Minnesota's 87 counties attending one of the workshops. **Who Benefited and How:** Both farmers and renters benefit from a fair and profitable rental agreement because it assures fair profitability. Based on the average size of farms reported (478 acres), we can assume that benefits are accruing to small- and medium-sized farms that preserve residents in rural places who support local economies and quality of life.	**#7 Resilient Communities and Economies**

31.	**Extension programs assure leadership quality and quantity in rural communities.** ● Extension Impact ● Multi-state	**The Issue:** Extension educator Ben Winchester has examined the demand for community leadership in Minnesota. He considered the number of board and elected positions needed by government and nonprofits in Greater Minnesota and estimated that one in every 34 rural Minnesotans must serve in a leadership position. In comparison, one in every 143 urban residents must serve. Leadership energy is tied to a community's ability to bring economic and civic vitality to communities. **What has been done:** Community leadership programs at University of Minnesota Extension actively encourage rural residents to serve or commit more to leading in their communities. Long-term learning cohorts strengthen leadership skills, grow confidence, and facilitate connections among community members who can learn and act together. Minnesota's community leadership model emphasizes personal development, navigating relationships, thinking critically and acting strategically to solve problems. In 2020, Extension worked long-term with 25 leadership and civic engagement cohorts. Twelve educated emerging leaders for cities or counties; six were focused on diversity, inclusion and addressing racism; four were focused on regional or statewide and rural leadership; two were focused on leadership topics in these difficult times; and one was a cohort for new tourism leaders. **Results:** Extension examined leadership role changes among participants of seven city/county-focused leadership programs. Of participants who responded to both pre- and post-cohort program surveys, 63.1 percent (65 of 103) increased their level of involvement in at least one organizational role — either a new role, an increase from *inactive* to *active* or *leader* roles, or an increase from *active* to *leader* role. In addition, 52 alumni from cohorts that ended before 2020 responded to an online survey, saying they had taken on a	**#7 Resilient Communities and Economies**

		new role in their communities since completion of the program. The impact, then, is that Extension helped to fill 117 leadership roles in rural Minnesota. Beyond the quantity of leadership resulting from the program, 67.5 percent of participants reported that they had applied skills from the program to make tangible improvements or address public problems in their communities *to a great extent* (16.9 percent) or a *moderate extent* (50.6 percent). An additional 21.7 percent said they'd applied skills *to a slight extent*. **Who Benefited and How:** Leadership programs build the leadership capacity, skills and knowledge of individual participants. A 2017 assessment of a leadership program reported to NIFA last year found that leadership education provided economic benefits to communities as well, with participants receiving salary increases and making connections that led to economic value. Meanwhile, the community benefited from additional volunteer hours, increased local spending, and the development of new community events. 	
32.	**Multidisciplinary research leads to an online community focused on designing for culturally enriched communities.** ● Research Impact	**The Issue:** As the pandemic's disproportionate impact on communities of color and the global call for racial justice demonstrated, securing Minnesota's and the nation's prosperous future is inextricably linked to identifying and addressing systems of exclusion. Minnesota consistently ranks among the top 10 states in the country in terms of quality of life. Yet, the state experiences some of the widest health, income, and educational disparities between people of color and whites. **Key Activities:** Given that eliminating disparities cannot be accomplished by one discipline or sector alone, UMN researchers in the College of Design set out to develop a multidisciplinary/multi-sectoral effort that brings together knowledge and insights from design along with health, sociology, geography, education, politics, business and public policy.	**#7 Resilient Communities and Economies**

		Interviews were conducted with elected officials, planners and policymakers from 20 communities/municipalities around Minnesota with an aim of identifying design best practices and challenges to creating Culturally Enriched Communities (CEC). **Results:** In January 2020, CEC website was launched to more effectively and widely disseminate best practices for how to use design in building a more equitable and just world. Since its launch, the website has had over 13,000 visitors, and has been shared through the digital platforms of municipalities, businesses, and organizations featured and used in teaching and research across institutions. When the pandemic hit, the CEC platform was used to feature design interventions to COVID-19 from around the world, along with information on vulnerable populations that could benefit from attention. And then in May 2020, following George Floyd's killing in Minneapolis, the team created Landscapes of Hope, a research project undertaken in the Twin Cities that documented the stories of over 200 buildings impacted by the riots, elaborating on how the design of the built environment can pave the way for social and racial justice. These help position Minnesota as a role model for eliminating disparities and creating vibrant and economically sustainable futures. **Who Benefited and How:** This research explores how the built environment can be used to create Culturally Enriched Communities, healthy and connected communities in which everyone can thrive. The premise is that there can be no social justice without design justice — that is, designs that support and nourish the wellbeing of all. Design is thereby added as another avenue for rebuilding communities and strengthening the economic and cultural vitality of cities and neighborhoods.	
33.	**Extension applied research and education informs community and economic development decisions, expanding "community capitals" in Minnesota.**	**The Issue:** Every community has assets that can be tapped or leveraged for community and economic development impact. For example, relationships in communities provide helping systems. Connections to financial institutions allow for financial investments that make a difference. "Working together, these characteristics and resources develop a synergy that allows a community to grow and prosper. The process of identifying and linking resources takes effort, but the result can dramatically improve the economics of a community (Wichter-Zoia, 2013)." The community capitals framework maps community resources that	**#7 Resilient Communities and Economies**

	● Extension Impact ● Multi-state	must be nurtured and leveraged. The seven community capitals are financial, built, social, human, cultural, natural, and political. **Key Activities:** Extension applied research helps communities understand and manage local assets and opportunities. Economic impact analysis, for example, defines how local economies and sectors interact. Business retention programs and retail analysis programs help economic developers know and grow their local businesses. Applied research is coupled with facilitated conversations that help communities plan together, using research-based information rather than fears or assumptions to guide planning. In 2020, Extension delivered 130 applied research reports to communities. **Results:** Follow-up surveys and interviews highlighted 83 positive effects that Extension research and education left in communities, according to community leaders who engaged with 29 offerings. (We've excluded human capital, which consistently results from Extension education.) ● 25 offerings produced social capital impacts (e.g., multiple community groups and organizations deciding to work together; stronger connections between community members and community leaders). ● 21 offerings produced civic impacts (e.g., large mobilization of volunteers; new leadership roles for participants). ● 17 produced cultural impacts (e.g., starting a minority coalition for businesses and organizations in the region). ● 11 produced financial impacts (e.g., creating local grants programs to fund projects). ● 6 produced built capital impacts (e.g., restoring a playground and mobilizing people to increase broadband access). ● 3 produced natural capital impacts (e.g., building trails). **Who Benefited and How:** Extension education and applied research for communities helps local decision-makers make more sound decisions, which benefits all local residents who live in communities. Examples of sectors and groups assisted by community economics research include the tourism industry, retail businesses, Main Street businesses, economic development groups and more. Sound economic decisions help towns retain jobs, grow local wealth, and improve quality of life.	

34.	**Parentopia platform helps parents and educators during COVID-19.** ● Research Impact	**The Issue:** During the COVID-19 shutdown, parents, teachers and education staff across the state and country had to adapt quickly to online technology options. One concern was students and parents would feel disconnected from their communities as the shutdown lengthened and that educators would struggle to keep up with the technology requirements. **Key Activities:** Throughout Minnesota, school districts offer parents and young children (birth to five years) two-hour weekly sessions in which they learn with other dyads, then separate into classes of parents or children. Continuous enrollment in the Early Childhood Family Education (ECFE) program during early childhood years offers a context that promotes group identity and community. A group of UMN researchers was interested in exploring the role technology can play in enhancing and prolonging the experience parents have with their weekly face-to-face contacts. Originally launched in 2017, the Parentopia Project involves the design of a web-based application that complements parent learning and engagement through Minnesota's ECFE program. As a closed platform, Parentopia.org can promote both class specific and site-wide discussion, private messaging, and general program information. In more recent years, the platform has expanded to additional school districts and enabled research with parents and staff to design technology as a hybrid for face-to-face interactions. Research has also identified the specific learning benefits to parents meeting in consistent groups and forming networks rich in social capital. Parentopia is a way for parents to continue those connections. **Results:** As a result of the need to move learning online during COVID-19, the Parentopia team provided support to school districts on using the platform as a basis for completely online engagement. Their existing relationships also gave them access to parents and staff as they transitioned to online learning. A survey in spring 2020 resulted in a qualitative database used to identify the challenges, barriers, supports and emotional connections in family educators' ability to adapt and use technology. Parent surveys also identified the value of using Parentopia and other technologies as schools scrambled to continue early childhood education.	**#8 Building Strong, Resilient Families**

		In 2020, the Parentopia Project reached approximately 1,800 parents and staff members. In September 2020, research on Parentopia and on technology attitudes and experiences was incorporated into an educator workshop done in collaboration with the Minnesota Association for Family and Early Education. Key topics for the workshop included becoming adaptive experts, addressing equity and access, and maintaining relationships. More than 125 participants attended. A website of resources was created and serves to model ways to engage learners before, during and after internet-based training. **Who Benefited and How:** Early Childhood Family Education (ECFE) is a parenting education program that provides programming and services for families of small children. Parent and family engagement is crucial to a young learner's development and provides a foundation for future school success and lifelong learning. The internet holds genuine possibilities for helping parents find new communities and forge connections with those who can provide support. Research has validated that strengthening parents' social capital is constructive to their parenting and to their learning. Through the Parentopia Platform and other technology tools, UMN researchers are positively impacting ECFE program engagement, feelings of community connectivity, social support and social capital, and parenting and child outcomes and facets of platform design that complement face-to-face learning. In addition, the team's extensive research into technology incorporation has been incorporated into valuable professional development trainings for early childhood educators across the state.	
35.	**Growing North Minneapolis Program engages students and communities around food and food systems.** ● Integrated Impact	**The Issue:** Today's youth are tomorrow's change agents, and ultimately the leaders who will innovate on food-energy-water (FEW) issues for a healthy earth and healthy communities. Interdisciplinary collaboration and problem solving on FEW issues must be mirrored in formal and informal education, and inclusive of traditionally under-represented youth, educators and communities in order to use their unique experiences and insights. **Key Activities:** Growing North Minneapolis is a community-driven program which aims to build food, environmental, social and cognitive justice through sustainable urban growing and greening. Learning and career development are experiential and contextualized in real-world experiences related to the FEW nexus. Urban youth, predominantly of color and low socioeconomic status, are hired through a local workforce	**#9 Youth Development**

		development program, and work together with UMN undergraduates and North Minneapolis community mentors to form intergenerational communities of practice. The program has two primary components 1.) Community members work with science teachers at North High School to bring agriculture, food and natural resources curriculum directly into the classroom and 2.) Step-Up youth work together with community mentors and UMN undergraduate students to care for Northside community gardens where they grow food to distribute throughout the community and sell to markets. **Results:** During the 2019-2020 school year, 35 North High students took part in the program, which led to the creation of a hydroponic system and that produced 30 bins of leafy greens and lettuce for the school cafeteria. Along with UMN student and Master Gardener volunteers, the student team also worked over 100 hours to design a medicinal, healing garden for the school's courtyard. As for the summer internship program, Growing North Minneapolis supported 10 Step-Up youth interns, nine North Leader interns, six undergraduate interns and eight community mentors in urban agriculture and environmental internships. Over the 2020 summer season, they cared for 17 community garden sites and attended farmers markets weekly. Their efforts yielded over 1,200 pounds of fresh produce, half of which went to the farmers markets. Despite the challenges of COVID-19, the team sold over 250 pieces of produce with sales totaling over $600. The other half (600 pounds) went to program meals, participants, local community members and local food shelves. Qualitative data showed additional positive effects of the internship experience across participants. Thematic analyses revealed youth growth in the areas of self-direction, leadership, persistence and collaboration/teamwork skills. All youth reported growth in their work ethic, felt better prepared for a future job and showed appreciation for a more hands-on approach than in their previous school learning experiences. They especially enjoyed doing work that contributed to their community and beyond. Undergraduate intern mentors reported growth in the areas of youth work, community work and urban agriculture work. All mentors particularly elaborated on their growth in the area of working across differences, in which they hadn't had many opportunities to do so prior.	

		Who Benefited and How: Communities of color and low-socioeconomic status are disproportionately impacted by food, energy and water insecurity, but these communities have been historically left out of environmental movements and policymaking. Community-based education programs are a valuable tool to reach under-represented youth because it contextualizes learning by addressing real-world issues in socioculturally relevant ways. The Growing North project engages multicultural students in North Minneapolis who gain valuable employment skills and learn about agriculture, food, and food systems in hands-on and experiential ways that benefit their community.	
36.	**4-H programs inspired STEM career interest among Minnesota's youth, even during quarantine.** ● Extension Impact ● Multi-state	**The Issue:** Scholarship about out-of-school time notes that vocational identity is established in middle and high school. "…(A)iding youth in career exploration and decision-making may be an important goal. Recent research shows that youth who are indecisive about their career plans have significantly lower wages in adulthood." (Staff, Harris, Sabates, & Briddell, 2010.) Further research demonstrates that youth maintain interest in youth development programs when they can build real-world skills through hands-on learning. **Key Activities:** COVID restrictions required 4-H Youth Development programs to make a complex "pivot" in delivery. Minnesota 4-H responded with weekly online content that engaged new and existing 4-H'ers. Ultimately, 4-H involved 9,100 youth in more than 400 virtual programs and distributed more than 11,000 learning kits to help youth explore hands-on learning away from the computer screen. 4-H also hosted virtual learning showcases that engaged 6,188 youth and 2,520 volunteers. Programming included successful offerings that helped youth explore STEM careers. For example, youth competed in a Science of Agriculture Challenge program, where youth created a solution to an agriculture-related issue. 4-H also offered weekly hands-on agronomy learning sessions to experience the value of agriculture. Another series featured engineers at NASA's Jet Propulsion Laboratory. Farah Alibay, a flight system engineer, Rich Rieber (lead mobility systems engineer), and Hallie Abarca (operations and systems engineer) helped 600 Minnesota youth explore the world of NASA. The goal was to feature youth STEM career options and encourage youth to imagine themselves in those roles. **Results:** Program evaluations demonstrated that online learning and challenges to explore topics away from the screens resulted in enhanced interest in STEM careers.	**#9 Youth Development**

		• Nine out of 10 participants in the Science of Agriculture Challenge program reported they gained a greater understanding of agricultural science. • Among agronomy learning participants, 95 percent were more interested in agricultural science and seven out of 10 participants said they would like a career in agricultural science. • 90 percent of participants in the NASA engineer series were more interested in engineering and 85 percent said they would like to pursue a STEM-related career. **Who Benefited and How:** As noted, youth who begin to shape an identity around career interests ultimately benefit by pursuing education to achieve goals and ultimately increase lifetime earnings. These outcomes also benefit local and national economies. Labor market changes, technological innovation, globalization and the decline of unions makes it difficult to manage a labor force for those with limited education or career development. Youth programming that nurtures interest in career learning ultimately creates a more nimble and responsive labor force for modern economies.	
37.	**Youth turn attention and action to serving their community in tough times.** • Extension Impact • Multi-state	**The Issue:** Evaluations of service-learning programs have shown that service-learning can play a role in meeting the challenge to "foster youth's civic engagement and participation in free and democratic societies." Successful service-learning projects provide young people with meaningful experiences as active citizens and by giving young people the knowledge and skills they need to identify community issues and respond. **Key Activities:** In April of 2020, *True Leaders in Service* engaged youth in service within communities, counties, tribal nations and states. Minnesota's 4-H State Ambassadors encouraged youth and adults to pledge to complete a community service project. They challenged youth to identify community needs and try to make a difference. **Results:** An annual evaluation of 4-H youth across Minnesota showed 57 percent of 4-H youth volunteered in their community in 2020. 4-H'ers made and distributed thousands of masks to health care workers and others in need. They also provided care and companionship to elderly residents isolated in long-term care and assisted living facilities. 4-H clubs wrote letters, created videos, brought animals to windows and colored pictures for residents. Youth also made and distributed blankets and scarves and organized neighborhood food drives.	**#9 Youth Development**

		Who Benefited and How: Service-learning benefitted youth themselves, giving them a sense of efficacy in a time of grief and loss. Community members also directly benefited from the resources and encouragement provided by youth during the pandemic. The goal of service and leadership programming in 4-H is to help youth see themselves as active citizens capable of making a difference in communities. Therefore, these impacts will ultimately serve communities where youth eventually live and work.	