2018 University of Minnesota Combined Research and Extension Annual Report of Accomplishments and Results

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I. Report Overview

1. Executive Summary

This report highlights the accomplishments of the University of Minnesota's Agricultural Experiment Station (MAES) and Extension in 2018. Twelve planned programs organize our report on activities, outcomes and impacts.

While the planned programs remain unchanged from the 2017 POW and report, we have changed the order of programs. This was done to spotlight work and impacts related to farm profitability, a current national imperative and key initiative of both research and extension at the U of M. They are numbered in their new order below with their former placement noted for clarity.

1. Global Food Security and Hunger - no change
2. Agricultural Business Management - Previously #12
3. Horticulture - Previously #11
4. Youth Development - Previously #9
5. Natural Resource Management - Previously #10
6. Community Vitality and Public Finance - Previously #7
7. Sustainable Energy - Previously #2
8. Building Strong, Healthy Families - No change
9. Health and Nutrition - Previously #4
10. Food Safety - Previously #5
11. Water Resources - Previously #6
12. Climate Change - Previously #3

Extension reports on programs and initiatives as defined by structured program areas. MAES describes its research on topics related to those planned programs. In many cases, MAES research informs Extension programming. Of the 46 impacts reported in 2018, 16 describe impacts achieved jointly by Hatch and Smith-Lever programs.

MAES. Summary of 2018 Activities
This report summarizes the effort and results of 405 research projects conducted by 297 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 programs areas.

The University of Minnesota (U of M) consistently ranks among the nations' top ten public research Universities. In U of M FY2018 (July 1, 2017- June 30, 2018), external research funding reached an all-time high for the University. For this report, we tracked 468 peer-reviewed journals, 42 patents filed, 16 patents issued, and three U of M start-up companies that all have a direct tie to researchers and/or

research projects represented in this report.

Though Hatch funding accounts for only 7 percent of the annual funds for research, we have reported on outcomes from all projects connected to PIs receiving non-discretionary funding. NIFA non-discretionary funds support general-use infrastructure, including greenhouses and research fields, to ensure researchers have the basic requirements to start projects and generate impacts and outcomes. They also provide critical funding for staffing that ultimately allows us to leverage and match other external funding sources. Notably, these funds are also used to assist early career faculty as they are starting up their research programs. Without these funds, there would be less applied research, less real-world application of research, and less integration of extension and research work.

This year saw the completion of several long-term MAES-supported research projects and researchers branching out into new territory based on previous discoveries or new interests. Researchers also continue to increase their focus on underserved audiences within the state including seniors, minorities and low-income individuals. In 2018, 86 projects (up from 74 in 2017) had components tied to underserved populations in Minnesota and around the world. Industry needs and key investments from the Minnesota State Legislature were also influential in shaping research plans and topics throughout the year

New Opportunities for Community and Stakeholder Engagement
University administrators and researchers are constantly looking for new ways to engage with stakeholders and the public to ensure meaningful research is being conducted and shared.

- **Bell Museum -** 2018 saw a huge change to the St. Paul campus with the addition of the Bell Museum, which opened to the public on June 14, 2018. The new Museum sits directly across the street from the St. Paul campus fields and features picture windows looking out over the fields and campus. University researchers have taken part in Bell Museum events, including "Meet the Scientist," allowing them to share their work directly with a new audience. Notably, University research has also made its way into Bell Museum exhibits including the current exhibit titled "Weather to Climate: Our Changing World," which localizes the potential impact of climate change (Climate Change Outcome #3).
- **Agricultural Research, Education, Extension, and Technology Transfer Program (AGREETT) -** AGREETT is providing a key opportunity to gather stakeholder feedback on the most important issues. The program includes an advisory panel made up of industry representatives, University leaders and Minnesota Department of Agriculture experts who have worked together to assess needs across the state and region.
- **Working with Tribal Communities -** To better engage with tribal communities in and around Minnesota, University and MAES/CFANS leadership took part in several meetings and events with Tribal leaders. In particular, they discussed the University's research related to manoomin (wild rice). Research efforts in this area include work on breeding, health, water quality, history and social dimensions. Another example of long-term collaborative research with tribal communities related to diabetes is highlighted in this report (Health and Nutrition Outcome #5).

Power of Collaborative and Interdisciplinary Research
Collaboration, both internally and externally, is a key tool used to broaden the scope and impact of University research.

- **Minnesota's Discovery, Research, and InnoVation Economy (MnDRIVE) -** MnDRIVE continues to be a key driver of collaborative research across the University. During the U of M FY2018, researchers involved in MnDRIVE work disclosed 74 inventions for patents or licensing and received more than $55 million in funding, of which $3.9 million came from business and industry. Several of the impacts featured

in this report include work tied to either current or previous MnDRIVE projects including work on developing new technologies for food safety and work on developing robotics and remote sensing technology for the apple industry. Notably, the latter began as a MnDRIVE collaboration between researchers in the College of Science and Engineering and apple experts in CFANS before receiving a NIFA grant in 2015 to continue refining their work (Horticulture Outcome #5).

- **Hatch Multistate and MFR -** In FY18 University researchers were involved in 60 Hatch Multistate/MFR funded projects. Four of these collaborative projects No: W6, No. NC1029, No. NC-1197 and No. S1056 are highlighted in our 2018 impact statements (Global Food Security and Hunger Outcomes #4, #5 and #8 and Food Safety Outcome #2).
- **G.E.M.S, the Agroinformatics Alliance -** The Agroinformatics Alliance has provided MAES leadership and University researchers with an excellent way to engage with other AES, regional private sector partners and farm organizations to advance a collaborative strategy to harness the power of big data for improving crop productivity, environmental, outcomes, quality policy and farm profitability. To date, this effort has facilitated 11 case studies--six focused on collaboration and five focused on actionable outcomes.

Research highlights for 2018 include:

- An analysis of the economic impact of the 2015 Avian Flu Outbreak revealed it cost U.S. turkey producers $225 million; $207 million of which was due to lost exports (Agricultural Business Management Outcome #3).
- The famous Honeycrisp apple cracked the list of the top five apple varieties produced in the U.S. for the first time in 2018 (Horticulture Outcome #6).
- A new microwave-assisted pyrolysis reactor was developed which has the potential to increase biodiesel yield up to 10 percent (Sustainable Energy Outcome #1).
- Thanks in large part to collaboration with U of M aquatic invasive species experts; the Minnehaha Creek Watershed District received a state grant to decrease levels of common carp throughout the watershed. Notably, they are continuing the U of M collaboration by using Carp Solutions, a U of M start-up company, to handle carp removal over the next three years (Water Resources Outcome #3).
- Long-term research on the value of snow fences, and Extension collaborating with the Minnesota Department of Transportation (MnDOT), has led to safer roads in rural Minnesota. With MnDOT reporting a 40 percent reduction in accident severity in areas where snow fences have been added (Climate Change Outcome #3).

Extension: Summary of 2018 activities

Though non-discretionary NIFA funding provides 14.4 percent of Extension's annual funds, U of M reports on outcomes of all program activities because of the critical nature of that funding. NIFA funds assure that centralized services are available to over 430 educators, specialists and coordinators who bring research-informed education to critical decisions made by Minnesotans. This includes human resources, accounting, communications, information technology and bricks-and-mortar offices across Minnesota, where 65 percent of Extension faculty and staff work.

Service levels: In 2018, Extension delivered programming to over 840,000 Minnesotans. This includes participants of planned programs described here, as well as Farmer Lender Mediation programs and outreach from Regional Sustainable Development Partnerships. Extension strives to describe unduplicated counts in reporting direct contacts, referring to contact that has likely resulted in changes in action or condition. However, program teams also reported over 3.5 million indirect contacts from casual learners who connected to critical information via extension.umn.edu, social media, marketing or outreach.

Extension mobilizes volunteers across Minnesota, giving them the capacity to teach others, serve communities, and protect Minnesota's land, water, children, families and communities. Extension volunteers provided more than 1,267,469 hours of service in 2018, the equivalent of 609 full-time staff.

According to the Independent Sector, this service can be valued at $34,956,790. Strong volunteer training and support programs are provided by Extension's youth development team, the Master Gardener program (Horticulture), the Master Naturalist program (Natural Resource Management), and Regional Sustainable Development Partnerships.

Addressing farm profitability: The University of Minnesota Extension strives to be relevant and responsive to critical issues, especially for Minnesota's 73,200 farms. To address profitability in the vulnerable dairy industry, Extension specialist Joleen Hadrich is finding ways to combine animal health, production and farm financial data to help dairy farmers create more profitable and sustainable operations. To support the most at-risk farms, the Agricultural Business Management team established a farm financial counseling center in 2017 to respond to financial stress among producers. This free and completely confidential service mobilized a team of Extension farm financial analysts, making them available to farmers experiencing financial stress. Analysts help participating farmers understand their financial situation, explore options, and identify alternatives to cope with the current agricultural climate. This responsive service complements programming in Global Food Security and Agricultural Business Management, which increases agricultural profitability. This year we've reported four of our direct impacts to farm profitability resulting from lower cost management of weeds and nitrogen, marketing groups, estate planning, and new product development.

Outreach to underserved audiences:
Five of the 12 planned programs reported parity or near-parity in reaching underserved audiences. That is, the number of persons of color reached by these programs mirrors the percentage of Minnesotans of color in that region of the state. Residents of color compose 19.6 percent of Minnesota's total population, but percentages vary across Greater Minnesota where much of Extension's work happens -- from 9.3 percent in West Central Minnesota to 16.2 percent in Northwest. In the Twin Cities, 27.2 percent of residents are persons of color.

Below are examples of programs that work at or near parity through targeted outreach:

- Health and Nutrition: Program teams reported fourteen 2018 initiatives that engage persons of color. Educators collaborate with organizations that Minnesotans in poverty already trust -- both in their communities and through cultural affiliation. As a result, 41 percent of participants were people of color.
- Building Healthy, Strong Families: Program team reported 20 targeted initiatives, and 36 percent of participants were Minnesotans of color.
- Horticulture: The Master Gardener program reported that 20 percent of its participants are people of color. Its highest percentages were in teaching youth (27 percent), educational service projects (26 percent) and county-specific projects (34 percent). Extension is involved in planning and presenting education at the Emerging Farmers' Conference for immigrant and minority farmers. Language interpretation is provided in six languages for this conference.
- Youth Development: As a result of intentional efforts to train volunteers and coordinators to engage new populations -- called "the Minnesota 4-H First Generation" initiative -- 19 percent of participants were youth of color in 2018.
- Natural Resources Management: 13 percent of Greater Minnesotan participants were persons of color, especially through collaboration with the Prairie Island Indian community.

Multi-state engagement: All planned programs report collaboration with Extension in other states, especially with contiguous states that share land and water issues. Nine of 12 planned programs engage with eXtension. Online learning has opened up offerings to learners across the country. Youth development programs are engaged in multi-state program evaluation. Extension's associate deans meet regularly with counterparts in Ohio, Michigan, Purdue, Illinois, Wisconsin, Iowa, Missouri, North Dakota, South Dakota, Nebraska and Kansas. Joint projects and positions, funding for new initiatives, and collective metrics for outputs and outcomes result from multi-state collaboration.

Staff expertise: In 2018, 138 highly specialized Extension educators (122.3 FTE) delivered planned programs described in this report. In county offices, 25 (23.5 FTE) local educators delivered programming and 202 (182.65 FTE) program coordinators supported 4-H, Nutrition Education and Master Gardener programs. Partnerships with six academic affiliates assure funding or partial funding for 89 faculty (36 FTE).

Merit review: Since 2018, an academic promotion process has been in place to monitor and reward educator performance and scholarship. In 2018, 11 regional educators and one county educator were promoted after rigorous peer review of scholarship, teaching and program leadership, as described in "Merit Review Processes." With its emphasis on applying a practical lens to research, Extension educators and specialists contributed to 190 peer-reviewed publications in 2018.

County and regional stakeholder relationships: Extension offers a memorandum of understanding to each of Minnesota's 87 counties so that local educators can develop, deliver and evaluate county-based programs that align with local priorities. This county system works alongside Extension's regional system, which is funded with federal and state dollars. In 2018, county investment increased by 5.93 percent over 2017. Of Minnesota's 87 counties, 74 increased their investment in Extension programming. Regional Sustainable Development Partnership boards across the state managed additional stakeholder engagement, bringing together 267 community partners and 130 University partners for 128 community-driven projects across Minnesota. The projects addressed issues ranging from water quality, to local foods and supply chains, to clean energy and sustainable tourism.

Total Actual Amount of professional FTEs/SYs for this State

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	267.7	0.0	329.5	0.0
Actual	245.3	0.0	476.1	0.0

II. Merit Review Process

1. The Merit Review Process that was Employed for this year

- Internal University Panel
- Combined External and Internal University Panel
- Combined External and Internal University External Non-University Panel
- Expert Peer Review

2. Brief Explanation

MAES. Merit and Peer Review Process
Merit Review
The merit review of research faculty supported by MAES funding occurs within each of the five partner colleges. The process follows standards established by the University for promotion and tenure (https://policy.umn.edu/hr/tenure). As the University's policy state, "A well-designed promotion and tenure system ensures that considerations of academic quality will be the basis for academic personnel decisions, and thus provides the foundation for academic excellence. "

This policy is essential to the protection of academic freedom and to the promotion of excellence within the University. Notably, it includes an evaluation of research quality and impact in addition to teaching and service.

Criteria for Conferral of Indefinite Tenure

The award of indefinite tenure is based on achievements that demonstrate the effectiveness of the individual for continued significant contributions to the mission of the Department, College and University (See Appendix A. Section 7.11 of Faculty Tenure). The primary criteria are demonstrated effectiveness in teaching (which includes extension) and professional distinction and demonstrated production in research/scholarship. Faculty are encouraged to demonstrate inquiry, creativity, attention to questions of diversity, and innovation through interdisciplinary and intercultural scholarship and teaching. Collaboration, interaction and education across a wide range of diverse ethnic and cultural perspectives contribute to the breadth and quality of academic work and represents a core value of the University of Minnesota.

Faculty Probation

To give the University ample opportunity to determine the qualifications of those faculty members whom it is considering for regular appointments with indefinite tenure, the maximum period of probationary service of a faculty member is normally six academic years, whether consecutive or not.

Department Annual Appraisals and Procedures

Each probationary faculty member is appraised annually. Beginning with the first year of the probationary period, the probationary faculty member has the responsibility for gathering performance data relevant to the criteria for tenure for the probationary file. The final tenure/promotion file is inclusive of data from these probationary files.

Each department has a promotion and tenure committee. The committee votes on each probationary faculty member every year. Voting is by secret ballot with yes, no or abstain choices in each of the following categories: 1) continuation of the appointment; 2) the individual is ready for consideration of tenure; and, 3) the individual is ready for consideration of promotion.

Award of Indefinite Tenure - CFANS

When a probationary faculty member is in their sixth or decision year, or when they ask to be put forward for tenure, the following steps ensue:

1. The department Promotion and Tenure Committee review the dossier and vote on a tenure recommendation. The voting process is conducted by secret ballot and the committee prepares a written recommendation. The department head is normally a voting member of the committee and also writes a recommendation.
2. CFANS Collegiate Advisory Promotion and Tenure Committee (P&TC) review the dossier and vote on a tenure recommendation. The voting process is conducted by secret ballot and the committee prepares a written recommendation to the dean of the college.
3. The dean reviews the recommendations of the P&TC and writes his/her own recommendation, which is then forwarded, to the executive vice president for academic affairs and provost.
4. The executive vice president for academic affairs and provost has the final authority to make recommendations on tenure and promotion to the Board of Regents. The executive vice president for academic affairs and provost presents his or her final recommendations to the Board of Regents for its decision whether to confer indefinite tenure and/or to approve promotion.

CFANS Tenure Track

As of March 2019, CFANS has 193 tenured faculty and 50 non-tenured (all 50 non-tenured faculty were hired in 2012 or later). Of those, 143 are full professor with tenure, 50 are associate professors with tenure and 50 are assistant professors. In 2018, five assistant professors within in CFANS were promoted from assistant to associate professor (on average it took 5.5 years to attain tenure). Additionally, four faculty were promoted from associate professor to full professor.

Project Review

The merit review process by which research projects are selected for MAES funding is also under the

direction of the deans of the five MAES partner colleges as members of the MAES deans' council. The process varies somewhat by college.
In CEHD, for example, in the Department of Family Social Science, all tenured and tenure-track faculty are offered the opportunity to prepare a proposal for MAES funding. The total amount of AES funding for research projects is shared between all approved MAES projects, which must undergo peer review.
In CFANS the review process primarily takes place at the department level with the assistance and oversight of MAES administration and leadership. A minimum of three reviewers is required for each project (two internal and one external to the department). The reviewers fill out a project proposal review form and submit it to the PD and department head for revisions. Once approved at the department level, proposed projects are sent on to MAES for approval by the MAES Deputy Director before being sent to NIFA for review via the REEport system.

Extension continues to manage its academic promotion process for educators working in local and regional offices, as well as specialists working in the Extension college. In 2018, 11 regional Extension educators were promoted and one local (e.g., county) educator was promoted. Each was promoted after a rigorous review of educational outcomes, scholarship and outreach to communities. After review of the promotion process in 2016, a revised plan provides Extension faculty with greater clarity about the promotion process, and supports educators with examples of past promotion dossiers that align with expectations. Criteria for promotion was clarified, indicators for success were added, and an appeal process was described. Language is standardized across two sets of guidelines.

To assist educators through the rigorous promotion process, the dean's office coordinates peer learning groups and recruits mentors who have successfully navigated the promotion process to support those new to the process.

Reviewers consider seven criteria for promotion within Extension's merit review system: 1) program leadership; 2) Extension teaching; 3) program management; 4) scholarship; 5) technical assistance; 6) engagement; and, 7) service. These seven criteria are weighted differently for Extension educators with rank (regional educators) and Extension educators without rank (local or county educators). Candidates choose their primary emphasis and focus on that in their promotion dossier. Candidate dossiers are reviewed by peers in Minnesota and colleagues in other states who share their programmatic discipline. Responsibility for the Extension promotion decision rests with the dean of Extension, based on recommendations from a promotion review committee, center associate deans and Extension's senior associate dean.

Promotion is neither automatic nor routine, and the decision is made without regard to race, color, creed, religion, national origin, sex, age, marital status, disability, public assistance status, veteran status or sexual orientation. Promotion is awarded to recognize the level of the academic professional's contributions to the mission of Extension and the University, as well as to their professional field. Although tenure is not granted at U of M Extension, there are clear expectations that academic professionals will be recognized for attaining a higher academic rank.

III. Stakeholder Input

1. Actions taken to seek stakeholder input that encouraged their participation

- Targeted invitation to traditional stakeholder groups
- Targeted invitation to non-traditional stakeholder groups
- Targeted invitation to traditional stakeholder individuals
- Targeted invitation to non-traditional stakeholder individuals

- Survey of traditional stakeholder groups
- Survey of traditional stakeholder individuals
- Survey specifically with non-traditional groups
- Survey specifically with non-traditional individuals
- Other (One-on-one interactions)

Brief explanation.

MAES. The five colleges that receive MAES funding define the research priorities. Their decisions are guided by stakeholder input gathered through each college's research advisory committees. Feedback is also gathered from stakeholder groups on specific research areas.

Besides the formal processes in place to identify stakeholders and gather input, other strategies are in place to elicit input for research decisions, such as the requirements for stakeholder input to be included in each proposal for Rapid Agricultural Response Fund research project funding and for Small Grains Initiative research project funds. MAES manages both of these funds. Other research related committees bring stakeholders to the table for input and decision-making, such as the Agronomic Variety Review Committee, which meets yearly under the leadership of the MAES deputy-director.

Each Research and Outreach Center (ROC) has an advisory committee, which reflects the composition and interests of the local area. Also, at the ROCs, there are other specific stakeholder groups advising on particular programs. For example, the Southwest ROC has a program guided by an Advisory Committee of conventional and organic farmers, researchers and educators. Research advisory boards also exist in several academic departments in CFANS.

CEHD maintains a formal Dean's Advisory Council, as well as an innovations Council focusing on issues of research, discovery and application. The college strives to mirror its commitment to diversity in these groups, which draws from a number of community groups.

The nature of research requires that MAES maintain contact with stakeholder groups and use their input to shape the research agenda of the University. Many researchers volunteer to serve on national review panels so they can better understand issues and priorities at the national level.

Extension. Over 650 local stakeholders serve on county Extension committees in Minnesota's 87 counties, and Extension's dean and director convenes more than 20 Minnesotans to serve on Extension's Citizens' Advisory Committee. County committees review, promote and support county-based programs and determine which investments should be made at the local level. Regional directors recruit committee members from a broad spectrum of local interests.

The Citizens' Advisory Committee is a network of citizens who believe in the mission and values of Extension, reflect the diversity of Minnesota's communities and are willing to advise Extension administration at the big picture level. Members serve a three-year term, and are encouraged to provide honest, constructive input for continuous improvement while building support for Extension.

At the programmatic level, educators seek local and statewide partners with expertise and connections that reach Minnesotans. These partners are equal to Extension, providing guidance as Extension chooses issues to address and program strategies that can make a difference.

In 2018, Regional Sustainable Development Partnerships (RSDP) managed and solicited direct

stakeholder input through community boards, work groups, community input sessions, social media sites, webinars, public seminars and outreach events, and surveys. This outreach informed activities of 13 of the 15 federal programs outlined in this report. The Partnerships' governing boards are composed of community members (75 percent) and University staff (25 percent) who met throughout 2018 in each region of the state. Work groups set regional priorities and presented ideas. Newsletters, webinars, public seminars and research reports delivered updates to leaders, policy makers, students, farmers, business people, media, local government jurisdictions and community members.

Specific events that encouraged stakeholder participation in 2018 included Deep Winter Greenhouse open houses and workshops, an annual Local Foods College webinar series, presentations at Association of Minnesota Counties district meetings, a survey of garlic growers in the Upper Midwest, a traveling "We Are Water Minnesota" exhibit, a Salsa Fest event celebrating agri-tourism and connections to Minnesota-grown agriculture, a design process for a new Southwest Minnesota Hmong Community Center, public showcases in central and southwest Minnesota, and an annual survey of RSDP board and work group members across the state.

2(A). A brief statement of the process that was used by the recipient institution to identify individuals and groups stakeholders and to collect input from them

1. Method to identify individuals and groups

- Use Advisory Committees
- Use Internal Focus Groups
- Use External Focus Groups
- Open Listening Sessions
- Needs Assessments
- Use Surveys

Brief explanation.

MAES maintains ongoing relationships with the main agricultural and natural resource stakeholder groups formally by inviting them to take part in advisory groups, and informally, through contact with individual researchers in their research areas. Stakeholders are identified by their connection to the relevant research area.

Extension. County Extension Committees and Citizens' Advisory Committees are drawn from groups of leaders, volunteers and program participants. They are identified as candidates because they have knowledge or experience with Extension, an interest in the future of Extension education and outreach, and are willing to commit the time required. Extension calls for nominations and memberships and recruits viable participants.

Program partners are chosen based on their ability to earn and keep the trust of the audiences that Extension reaches through programs. Program partners can make access to educational resources easier and more efficient as Extension remains part of a seamless system of community and industry support to farmers, communities, families, youth and businesses.

Opportunities for programmatic feedback comes through partnerships with community agencies and individuals with connections to local issues and people. Structured program evaluations provide Extension with input from partners and program participants. Regular meetings with collaborators assure that Extension stays responsive to stakeholder concerns.

Regional Sustainable Development Partnerships (RSDP) board members and staff reach out to communities, constituents and organizations to develop priorities for each region of the state. One venue that collects the public's ideas is the RSDP Idea Brief form. Community members are encouraged to call or email their RSDP regional executive director to discuss their idea. Regional executive directors work with community members to help them develop ideas into a full project proposal for RSDP and University of Minnesota consideration. Ideas can be submitted online.

When priorities are identified, RSDP brings together stakeholders with key involvement in prioritized issues. Deep Winter Greenhouse open houses and workshops, garlic workshops and Southwest Hmong Community Center meetings are examples of events that solicited key stakeholder involvement.

A Statewide Coordinating Committee leads the Partnerships' efforts. This statewide committee represents a breadth of interests that can attract individuals and groups to the discussion, including University Colleges, regional staff, regional board members, project partners, and other interested parties.

RSDP board and work group members serve as local ambassadors across the state, sharing opportunities and making local contacts at community meetings, events, and gathering spaces throughout Greater Minnesota.

RSDP actively encourages new and underserved audiences to share their ideas. Each regional RSDP has a Diversity Action Plan that articulates the Partnerships' intention to attract diversity to the RSDP board, work groups, and project partnerships.

2(B). A brief statement of the process that was used by the recipient institution to identify individuals and groups who are stakeholders and to collect input from them

1. Methods for collecting Stakeholder Input

- Meeting with traditional Stakeholder groups
- Survey of traditional Stakeholder groups
- Meeting with traditional Stakeholder individuals
- Survey of traditional Stakeholder individuals
- Meeting with the general public (open meeting advertised to all)
- Meeting specifically with non-traditional groups
- Survey specifically with non-traditional groups
- Meeting specifically with non-traditional individuals
- Survey specifically with non-traditional individuals
- Meeting with invited selected individuals from the general public
- Survey of selected individuals from the general public

Brief explanation.

MAES. While the majority of stakeholder input is collected through advisory committees and informal researcher contacts and events, there are other more formal opportunities for collecting this input including events where industry and stakeholder input is strategically sought. One such example is the Allen D. Leman Swine Conference, an annual educational event for the global swine industry. Each year hundreds of participants from over 20 countries attend.

Extension. County Extension Committees and Citizens' Advisory Committee meetings are held at

regular intervals throughout the year, and include programmatic as well as administrative updates. Committees engage in discussions that result in decisions about Memorandums of Understanding, program investments, recognition of quality programming, and advocacy for Extension to other public bodies such as the state legislature.

Program leaders collect input from collaborating partners. They use regular meetings to discuss mutual goals and formal evaluation processes to examine program success and concerns.

RSDP Idea Brief forms are available to the public through Extension's website. They are distributed at community events, meetings and conferences. They are promoted through social media, print materials, and among community volunteers. Through personal and professional networks, community members who volunteer on RSDP work groups and boards connect local ideas and projects to the University of Minnesota, especially Extension. This connects Extension to the pulse of local communities across Minnesota. RSDP uses its website, social media networks and newsletter email list to communicate regularly with all University staff, community members and groups throughout the state. RSDP also intentionally reaches diverse audiences, with intentional outreach guided by regional diversity and inclusion action plans.

3. A statement of how the input will be considered

- In the Budget Process
- To Identify Emerging Issues
- Redirect Extension Programs
- Redirect Research Programs
- In the Staff Hiring Process
- In the Action Plans
- To Set Priorities

Brief explanation.

MAES research funds have been redirected toward high priority areas, interdisciplinary and cross-species research and on the development of breakthrough technologies based on feedback from stakeholders in recent years. A key example of this is the research and extension work being conducted on invasive species at two research centers at the University--the Minnesota Aquatic Invasive Species Research Center and the Minnesota Invasive Terrestrial Plants and Pests Center.

MAES and Extension. As of February 2019, 21 faculty and Extension educators have been hired to focus on issues that include clean water, crop and livestock productivity, microbial science, soil fertility, agricultural technology, pest resistance and climate change. These hires are part of the state-funded initiative called Agricultural Research, Education, Extension, and Technology Transfer Program (AGREETT). AGREETT hires and priorities are chosen by an advisory panel including industry representatives, University leaders and MDA experts working together to determine the most important challenges facing agriculture and therefore what experts to hire.

Extension. County advisory committees direct the type of Extension programming that is targeted to counties. Memorandums of understanding determine which Extension programs will deliver county-based service addressing critical issues and program specializations to the county. County advisory committees also provide feedback to local programs and staff.

In 2018, Extension's Citizens' Advisory Committee provided direct feedback about Extension communications projects. The committee reviewed the newly constructed Extension website to consider usability and relevance to stakeholders. Reviews of Source Magazine helped communications determine forms and formats that better reach today's Greater Minnesota audiences.

Program partners provide input about when, where and how programs will be delivered. On the continuum of partner relationships, program collaborators can serve to host programs, recruit participants, act as trained trainers, delivering Extension content, or co-create programs or events in order to build on the expertise of both organizations.

RSDP work groups set programming priorities for regions in the areas of sustainable agriculture and food systems, natural resources, clean energy and resilient communities. Annual action-planning brings together stakeholders across each region to set project priorities. Programmatic changes are made with input from surveys. Priorities, established in response to stakeholder input, drive where staff time is spent and seed funding is allocated. Priorities are also brought to Extension and other University entities for response. Here are a few examples of responses.

- A statewide survey of over 200 rural grocery stores resulted in the development of produce handling toolkits and development of a backhauling project to provide a new niche for rural grocery stores.
- RSDP created a new crops marketing position in response to local farmers' expressed need to develop supply chain connections necessary to bring new crops to the market.
- Farmers' concerns about the short growing season and energy conversation led to a statewide initiative to conduct pilot research and outreach and prototype Deep Winter Greenhouses in Minnesota.
- Board members expressed interest in water issues, so RSDP brought on a Conservation Corps member to support regional natural resources work groups. The We Are Water MN exhibit hosted community conversations about Minnesotans' relationship with water.

Brief Explanation of what you learned from your Stakeholders

MAES. Stakeholder input has led to an increased focus on interdisciplinary solutions and finding ways for researchers to interact and develop solutions across departments, colleges and even campuses. The development of new, and increased investment in, research centers that can take a broader interdisciplinary view of key research concerns, like invasive pests, is a direct result of stakeholder input.

In 2018, two key pieces of input from stakeholder groups led to a major shift for research programs and policies within CFANS: 1) The American Malting Barley Association recently decided to stop testing new six-row barley breeding lines due to the lack of interest in utilizing six-row barley varieties. This led to the University's six-row barley breeding program being discontinued in favor of further establishing a two-row program; and, 2) Feedback from American Indian tribal nations, bands and communities in relation to University research on manoomin (wild rice) has led to hiring of a tribal national to help oversee and provide feedback on University policy, research and engagement with tribal communities in relation to wild rice.

Extension

Input about communications revealed interest in a number of resources, pointing to a need to share information about Extension's work using numerous platforms and media.

Stakeholder assessment processes reveal strong interest in strengthening local food systems. Community members want to support local economies and safeguard natural resources through

sustainable tourism initiatives, workforce attraction, attention to water quality issues and clean energy initiatives.

Stakeholders also express a strong commitment to engaging with diverse communities, leading to adaptations in outreach.

Community groups are thinking about the future and want to partner with the University of Minnesota to create it. These community efforts create perfect partnerships for Extension, which can deliver education, training and applied research that informs these actions and makes them more successful.

IV. Expenditure Summary

1. Total Actual Formula dollars Allocated (prepopulated from C-REEMS)			
Extension		Research	
Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
{No Data Entered}	{No Data Entered}	{No Data Entered}	{No Data Entered}

2. Totaled Actual dollars from Planned Programs Inputs				
	Extension		Research	
	Smith-Lever 3b & 3c	1890 Extension	Hatch	Evans-Allen
Actual Formula	10479704	0	6006379	0
Actual Matching	26833527	0	35045595	0
Actual All Other	27677961	0	48338222	0
Total Actual Expended	64991192	0	89390196	0

3. Amount of Above Actual Formula Dollars Expended which comes from Carryover funds from previous				
Carryover	0	0	0	0

V. Planned Program Table of Content

V(A). Planned Program (Summary)

Program # 1

1. Name of the Planned Program

Global Food Security and Hunger

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
201	Plant Genome, Genetics, and Genetic Mechanisms	5%		10%	
204	Plant Product Quality and Utility (Preharvest)	5%		5%	
205	Plant Management Systems	15%		5%	
206	Basic Plant Biology	5%		5%	
211	Insects, Mites, and Other Arthropods Affecting Plants	5%		10%	
212	Pathogens and Nematodes Affecting Plants	5%		10%	
213	Weeds Affecting Plants	5%		5%	
216	Integrated Pest Management Systems	5%		5%	
301	Reproductive Performance of Animals	5%		5%	
302	Nutrient Utilization in Animals	5%		5%	
304	Animal Genome	5%		5%	
305	Animal Physiological Processes	5%		5%	
306	Environmental Stress in Animals	5%		5%	
307	Animal Management Systems	5%		5%	
311	Animal Diseases	5%		5%	
315	Animal Welfare/Well-Being and Protection	15%		10%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	37.7	0.0	110.2	0.0
Actual Paid	26.9	0.0	188.1	0.0
Actual Volunteer	0.4	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
1102062	0	2893049	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
2608442	0	14918186	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
1364317	0	21510521	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

MAES. Research related to Global Food Security and Hunger includes a broad range of efforts to support the viability and success of Minnesota's crop and animal production systems. Highlights for 2018 include:

- Researchers have developed eight potential vaccine candidates for highly pathogenic avian influenza. They have successfully concluded primarily tests and, in 2019, they will test the vaccine candidates in animals.
- Researchers compared the genetics of 1960s Holstein (housed at the West Central Research and Outreach Center in Morris, MN) to modern dairy cows. Results showed contemporary Holsteins have a less robust immune system. They will use this information to help identify and select genes for improved immunity from the 1960s Holsteins that can be incorporated into gene assisted selection programs to enhance immune performance of contemporary cows.
- A multistate project on porcine reproductive and respiratory syndrome (PRRS) looked at seven years of PRRS incidence data to describe temporal patterns of PRRS outbreaks on farms in five states. Results showed a difference in PRRS seasonality among states. Previous descriptions of PRRS seasonality only held up in three of the five states (Minnesota, North Carolina and Nebraska). But for Iowa and Illinois, they detected seasonal peaks every six months. These results show epidemic patterns are not homogeneous across the U.S. and highlight the need for coordination of alternative control strategies in various regions.
- Researchers are developing oral alternatives to antibiotics that commercial turkey farms can use to maintain both growth performance and health in their birds. This work will help assist turkey farmers who may struggle with the phase out of antibiotic rations for poultry.
- Research on DNA fingerprints revealed the rate of genetic gain for complex traits, like yield, is potentially doubled through targeted recombination, which is the ability to induce or select for chromosomal recombinations precisely where a breeder would want recombination to occur. Researchers found this doubling of predicted gain is possible not only in maize but also self-pollinated species such as wheat and soybean.
- Researchers are using hyperspectral imaging to identify soybean diseases residing in soil, such as sudden death syndrome and brown stem rot, before the naked eye can detect them. And, therefore, possibly in time for farmers to take action before it is too late. Pilot studies are underway.
- A camera-tracking system was piloted that allows researchers to record real-time plant traits at different locations in the experimental field. This technology enables plant breeders to collect lodging data, which will help improve lodging resistance of cereals. During the pilot study the camera system captured lodging in approximately 15 minutes, saving hours of time compared to measuring it manually.

Extension. In 2018, key programming addressed threats to food production and farm profitability. Impacts include increased farm profitability through effective management of nitrogen and soybean cyst nematode.

In addition, new Pork Supply Plan workshops are helping producers maintain continuity of business in the event of outbreaks of swine diseases. Ten "Strategic Farming --- Growing Soybeans that Out-compete Weeds" workshops were presented across Minnesota to help agricultural professionals develop a better understanding of weed biology, non-chemical weed control tactics and herbicide-resistance. Impacts showed that professionals developed more robust weed management programs for the long-term. Also, the Global Foods team developed a new online application that facilitates early detection and reporting of the Invasive Brown Marmorated Stink Bug. Work continued to reduce the spread of Palmer Amaranth throughout the state.

As markets and consumer choices change, Extension is helping producers explore additional market opportunities. Education about organic swine production was more broadly disseminated in 2018 after its development in 2017. Programming reached 58 producers, researchers and stakeholders to discuss best management practices for organic swine production.

2. Brief description of the target audience

The Global Foods team manages multi-state initiatives in order to efficiently deliver education relevant to producers in Minnesota and contiguous states. The four-state dairy nutrition and management conference is a collaborative effort of Iowa State University, the University of Illinois, and the University of Wisconsin. Moo University represents a collaboration of five states (South Dakota, Minnesota, Iowa, North Dakota and Nebraska) and representatives from the dairy industry with complementary expertise and knowledge of dairy production and management for sustainable dairy along the Interstate 29 border. Finally, Minnesota and North Dakota share four specialist positions in crops and livestock to support Extension in our contiguous states.

Primary audiences are producers of livestock, commodity crops and small farms. Targeted workshops reach producers with particular issues in protecting crops or livestock or growing markets for specific crops or livestock. In 2018, new options came available online to reach more producers efficiently --for example, a "Healthy Horse App". Moreover, the Carver County Dairy Expo attracted Spanish-language dairy workers to learn about calf care, dairy labor management and mastitis in dairy cattle.

MAES. Target audiences for research include crop and livestock producers, industry representatives, veterinarians, local legislatures and fellow researchers and scientists.

3. How was eXtension used?

A number of specialists responded to Ask an Expert questions.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	397809	1746610	2773	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	16

Patents listed

Patents Filed
GEMSTOOLS: 87/569,234 - 8/15/2017; GEMSHARE: 87/569,231 - 8/15/2017; G.E.M.S.: 87/569,229 - 8/15/2017; Low Fiber Pennycress Meal and Methods of Making: 62/559,122 - 9/15/2017; Systems and Breeding Methods for Pest Control: 62/581,220 - 11/3/2017; Low Glucosinolate Pennycress Meal and Methods of Making: 62/619,360 - 1/19/2018; Plants Having Increased Oil Capacity: PCT/US2018/015536 - 1/26/2018; Plants Having Increased Oil Quality: 62/629,387 - 2/12/2018; Lang-MN: 201800165 - 3/8/2018 3003652 - 4/27/2018; Engineering of Humanized Dopamine Neurons by Genetic Complementation: 2016344152 - 5/2/2018; Biocontainment/Biocontrol System and Methods: 15/775,164 - 5/10/2018; Biocontainment/Biocontrol System and Methods: BR112018009515-0 - 5/10/2018; Programmable Transcription Factors and Methods: PCT/US2018/031950 - 5/10/2018; Biocontainment/Biocontrol System and Methods: 2016353057 - 5/11/2018; Engineering of Humanized Dopamine Neurons by Genetic Complementation: 2016800748787 - 6/20/2018

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	91	149	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of Extension publications and presentations.

Year	Actual
2018	500

Output #2

Output Measure

- Number of Extension learning opportunities.

Year	Actual
2018	500

Output #3

Output Measure

- Number of new crop germplasm released to the public.

Year	Actual
2018	4

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Percentage of Extension program participants that significantly change one or more practice as a result of attending classes and conference sessions intended to improve participant practices.
2	Number of changes in condition reported each year.
3	Number of acres affected by new livestock and crop production to increase production, efficiency, or conservation.
4	Research will support a more sustainable, diverse and resilient food system (Measure: number of new or improved innovations developed for food enterprises. Measure: number of new diagnostic systems analyzing plant and animal pests and diseases)
5	Development of new crop varieties will help Minnesota growers improve profitability
6	Research will provide information to support strategies to control animal diseases.
7	Nitrogen Smart training increased farm profitability while reducing nitrogen lost to the environment by 551,740 pounds.
8	Minnesota soybean cyst nematode (SCN) sampling and education resulted in increased yields that could be valued as high as $5 million for Minnesota farmers.

Outcome #1

1. Outcome Measures

Percentage of Extension program participants that significantly change one or more practice as a result of attending classes and conference sessions intended to improve participant practices.

Not Reporting on this Outcome Measure

Outcome #2

1. Outcome Measures

Number of changes in condition reported each year.

Not Reporting on this Outcome Measure

Outcome #3

1. Outcome Measures

Number of acres affected by new livestock and crop production to increase production, efficiency, or conservation.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	473922

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The profits and production of soybean farms are increasingly threatened by weed populations that become resistant to multiple herbicide groups. The number of weed species with resistance to herbicides has risen dramatically in recent years. As a result, more time and money is spent on weed control. Farmers face the likelihood of lower yields and profits unless changes in weed management are implemented.

What has been done

From January to March of 2018, educators presented ten programs called "Growing Soybeans that Out-Compete Weeds" across Minnesota for 541 people. This increased the reach of programs piloted in 2017. The goal was to help farmers and agricultural professionals develop a better understanding of weed biology, non-chemical weed control tactics and herbicide-resistance, and to develop effective and more robust weed management programs for the long-term.

Results
Participants reported an increase in commitments to change practices from before to after the workshop. The greatest increases were shown in: using more than one effective herbicide to control key weed species (62 percent); using more than one crop technology or conventional herbicide for weed management (58 percent); including planting date as a consideration in weed management (43 percent); and utilizing mechanical or cultural control tactics for weed control (41 percent). Of participants, 76 percent were crop producers with a total of 453,921 acres. Other participants who were not crop producers but consulted for producers provided advice on the management of 20,001 or more acres.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
213	Weeds Affecting Plants

Outcome #4

1. Outcome Measures

Research will support a more sustainable, diverse and resilient food system (Measure: number of new or improved innovations developed for food enterprises. Measure: number of new diagnostic systems analyzing plant and animal pests and diseases)

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Pork production has an estimated $23.5 billion gross output and respiratory diseases can affect up to 50 percent of the herd. Despite this, advances in enhancing diagnostic capacity for porcine

respiratory disease complex (PRDC) remain stagnant.

What has been done
Maxim Cheeran and JP Wang, along with their colleagues have developed a portable handheld platform that detects veterinary pathogens in clinical samples. They standardized a giant magnetoresistance-based (GMR) immunoassay as a wash-free single step protocol that integrates seamlessly into the handheld GMR-biosensor platform to detect swine influenza.

Results
Six nasal swab samples were tested using the one-step GMR assay and compared with standard lab-based ELISA. The results of this preliminary trial showed complete congruence of the wash-free GMR assay with ELISA for Influenza A Virus (IAV). In addition, they found the wash-free IAV GMR test could detect as low as 250 (TCID50) infectious viral particles per ml of clinical sample with real-time signals developing within four minutes. Furthermore, the testing kit consisting of the GMR chip and the reagent mixture could cost as low as $3/test.

To multiplex the GMR platform, a PRRSV and Mycoplasma hyopneumoniae detection system using the same method is being developed, which would enable the diagnosis of all three PRDC pathogens simultaneously leading to huge economic implications for the pork industry.

4. Associated Knowledge Areas

KA Code	Knowledge Area
307	Animal Management Systems
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection

Outcome #5

1. Outcome Measures

Development of new crop varieties will help Minnesota growers improve profitability

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	300

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Most of Minnesota's 27 million acres of farmland are dedicated to summer annuals which leads to unprotected land for a good portion of the year. This not only leads to nutrient depletion but also means Minnesota farmland is not as productive as it could be.

What has been done
The Forever Green Initiative employs cutting-edge research focused on developing cover cropping and perennial plant systems that keep the land covered 365-days-a-year. By bringing together a team of experts in breeding, genetics, agronomics and product commercialization the initiative plans to successfully domesticate new crops over the course of a decade--a concept only made possible by breakthroughs is plant sciences over the last several decades.

One such crop is field pennycress, an annual crop that overwinters and can be seeded after corn or soybeans are harvested in the fall making it an easy addition to a corn-soybean rotation. Beyond soil protection, field pennycress produces high-value oil and protein meal from unused fertilizer and water that would otherwise be wasted and helps suppress weeds.

Results
University researchers have already made improvements related to seed size, oil content and shatter resistance along with successfully mapping the pennycress genome. The most productive lines in the program produce 40 percent oil by weight, with a composition that could be converted to biodiesel, aviation fuel or other industrial products. The first U of M variety is scheduled for public release in 2021.

Researchers estimate that adding pennycress as a winter crop has the potential to add up to an extra $300 of profit per acre for soybean growers. In 2018, 7.74 million acres of soybean were harvested in Minnesota, at $300 per acre the potential value add is over $2.3 billion.

4. Associated Knowledge Areas

KA Code	Knowledge Area
201	Plant Genome, Genetics, and Genetic Mechanisms
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems
206	Basic Plant Biology

Outcome #6

1. Outcome Measures

Research will provide information to support strategies to control animal diseases.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Research has shown dairy cows alter their eating behavior prior to showing symptoms of disease and a majority of them die or leave the herd during the first 40 days after calving. Identifying animals at risk before they become severely ill could reduce farm dairy mortality, thus improving profitability while also improving overall animal wellbeing.

What has been done
Marcia Endres and her collaborators have conducted studies with over 300 dairy farms in Minnesota, Wisconsin, Iowa and South Dakota to help improve the use of new technologies and investigate best management practices in the dairy industry. While exploring the effects of different bedding materials, barn ventilation systems or a new piece of technology, these researchers are also looking for clues to see if a cow is healthy and comfortable. This includes evaluating prevalence of hock injuries and lameness, seeing how cows are grooming or pushing each other, and testing manure for stress hormones.

Results
In a recent validation study, they showed that an ear-tag accelerometer (i.e. fitbit) accurately recorded eating and rumination behavior of grazing dairy cattle. This research shows the potential of this type of technology to help identity animals at risk. Producers can pay closer attention to cows that had a change in behavior, and take steps to help them, consequently improving their health and wellbeing.

A reduction in on-farm mortality for dairy cattle from the current 6 percent to 3 percent would result in an estimated economic benefit of over $500 million while also helping to improve public opinion of the dairy industry.

4. Associated Knowledge Areas

KA Code	Knowledge Area
306	Environmental Stress in Animals
307	Animal Management Systems
311	Animal Diseases
315	Animal Welfare/Well-Being and Protection

Outcome #7

1. Outcome Measures

Nitrogen Smart training increased farm profitability while reducing nitrogen lost to the environment by 551,740 pounds.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	551740

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Nitrogen is absorbed in large amounts by Minnesota crops. It is the major nutrient supplied in a fertilizer program. Nitrogen in soil exists in several forms, and conversion from one form to another can be complex. There is general agreement that voluntary best management practices are an economically sound choice and that, if used, they can minimize nitrogen loss to the environment and maximize utilization by the crop.

What has been done
Nitrogen Smart training programs for producers presented the fundamentals for maximizing economic return on nitrogen investments while minimizing nitrogen losses. Between 2016 and 2018, Extension held 36 events for 756 people across Minnesota. Participants received "Nitrogen Smart" certification that lasts for three years. Updated research regarding appropriate nitrogen levels has influenced established best practices.

Results
A follow-up survey examined program impacts of 756 participants who managed 423,695 acres, finding that 34 percent reduced their nitrogen rate by an average of 30 pounds per acre. This translates into savings of $5,067 per attendee; 17 percent changed from an all-fall application to all spring, which resulted in an estimated increase of 355,816 bushel of corn or $13,512 per farmer who made the change. Over 11 percent stopped using fall Urea, which converted an estimated 27,587 acres of land. This extrapolates to a reduction of 551,740 pounds of nitrogen lost to the environment.

4. Associated Knowledge Areas

KA Code	Knowledge Area

205 Plant Management Systems

Outcome #8

1. Outcome Measures

Minnesota soybean cyst nematode (SCN) sampling and education resulted in increased yields that could be valued as high as $5 million for Minnesota farmers.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	5000000

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The soybean cyst nematode (SCN) is the most yield-limiting pathogen of soybeans, responsible for annual yield losses of more than 100 million bushels in the North Central U.S. SCN may be present long before producers are aware that fields are at risk because above-ground systems may not be overt. While Extension, agronomists, and other agricultural professionals stress the importance of monitoring and managing SCN, many producers remain unaware of the threat SCN poses, and of how essential monitoring population densities is to maintaining crop productivity.

What has been done
In 2018, with funding from the Minnesota Soybean Research and Promotion Council, Extension developed the Minnesota SCN sampling and education program to increase awareness of the threat of SCN and to encourage SCN sample collection. Presentations reached 861 people with information about SCN and how best to manage it. Free sampling kits were provided at these presentations, including 2,500 sample collection bags. While farmers were responsible for sample collection and shipping, costs associated with sample analysis and education were covered by check-off funds.

Results
A total of 363 samples were submitted for analysis in 2018. Of these, 50.4 percent tested positive for SCN and 44.8 percent of these had egg densities at which yield loss could result even with planting an SCN resistant variety; 6.6 percent had densities so high that planting soybeans is not recommended. After learning this, 47 percent planned to plant a soybean variety with SCN resistance and 29 percent planned to plant a different crop. Participants represented 43,774 acres.

Collaborative research in recent years has resulted in the discovery of SCN resistant soybean lines and potential novel genes (including Rhg1) that are now used in screening new varieties for SCN resistance. Additionally, research has shown that when SCN is present at moderate densities, SCN-resistant varieties can improve soybean yield by up to 40 percent. Using Minnesota's average field size of 160 acres, the value of SCN management after detection could be as high as $29,120 per field. Given that 183 positive samples were identified, the value of the program could be higher than $5 million.

4. Associated Knowledge Areas

KA Code	Knowledge Area
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems
211	Insects, Mites, and Other Arthropods Affecting Plants
212	Pathogens and Nematodes Affecting Plants

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Economy
- Public Policy changes
- Other (Industry Needs/Feedback)

Brief Explanation

Food production was again impacted by weather events, low commodity prices and shrinking markets due to new international tariffs, weed resistance and the spread of invasive species.

MAES. Breeding work on six-row barley is in the process of being discontinued in favor of further establishing a two-row barley breeding program. This is because the American Malting Barley Association recently decided to stop testing new six-row barley breeding lines due to the lack of interest in utilizing six-row barley varieties.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Post-event evaluation happens across most Global Foods Extension programs to examine whether education is resulting in action change in the agriculture industry.

- Evaluation of organic dairy days showed that 80 percent of attendees indicated they would take information home and implement it on 64 total farms.
- Evaluation of the Carver Dairy Expo indicated that 64 percent of previous attendants had made a change in their operation, affecting 30,000 head of cattle.
- Evaluation of the Women in Dairy workshop showed that 72 percent would make changes in practice. Minnesota County Feedlot Officers reported that they would be better able to work with farmers on nutrient manager plans.
- Evaluations of Pesticide Applicator Recertification Workshops, hosting 3,943

attendees, showed that 96 percent were going to read pesticide labels before buying and utilize U of M research-based information in pest management.

- Pork Quality Assurance certifications affected over 5.2 million pigs, and Transport Quality Assurance affected over 233,355 pigs, and Pork Quality Assurance Advisor certifications affected over 980,600 pigs.
- Finally results from the Conservation Tillage conference showed that 19 percent established cover crops after harvest and 19 percent evaluated the soil health of their fields. This likely affected 44,500 acres of land.

MAES. Publication of peer-reviewed papers and success in obtaining external grants are typical measures of evaluating the quality of basic and applied research. The projects reported in this planned program led to the publication of 149 peer-reviewed journal articles during FY18.

Non-NIFA research funds and grants leveraged by PIs in this program include: Qualitech Corporation, USDA-AFRI CAPs, USDA-ARS, Small Grains Initiative, Rapid Agricultural Response Fund, MnDRIVE Global Food Ventures, Minnesota Department of Agriculture and the Minnesota Turkey Growers Association.

Key Items of Evaluation

- Evaluation of organic dairy days showed that 80 percent of attendees indicated they would take information home and implement new practices on 64 total farms.
- Evaluation of the Carver Dairy Expo indicated that 64 percent of previous attendants had made a change in their operation, affecting 30,000 head of cattle.
- Evaluation of the Women in Dairy workshop showed that 72 percent would make changes in practice. Minnesota County Feedlot Officers reported that they would be better able to work with farmers on nutrient manager plans.
- Evaluations of Pesticide Applicator Recertification Workshops, hosting 3,943 attendees, showed that 96 percent were going to read pesticide labels before buying, and would utilize U of M research-based information in pest management.
- Pork Quality Assurance certifications affected over 5.2 million pigs, and Transport Quality Assurance affected over 233,355 pigs, and Pork Quality Assurance Advisor certifications affected over 980,600 pigs.
- Finally, results from the Conservation Tillage Conference showed that 19 percent established cover crops after harvest and 19 percent evaluated the soil health of their fields. This likely affected 44,500 acres of land.

V(A). Planned Program (Summary)

Program # 2

1. Name of the Planned Program

Agricultural Business Management

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
601	Economics of Agricultural Production and Farm Management	20%		50%	
602	Business Management, Finance, and Taxation	20%		10%	
603	Market Economics	20%		20%	
604	Marketing and Distribution Practices	20%		5%	
610	Domestic Policy Analysis	20%		15%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	8.4	0.0	11.5	0.0
Actual Paid	20.8	0.0	12.5	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
856479	0	178551	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
2642987	0	715984	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
1457674	0	1651949	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Extension. In 2018, the Agricultural Business Management (ABM) team designed new programs to address current issues in farm management. With the change of the tax law to go into effect in 2019, the ABM team responded with a webinar that reached 810 learners. The webinar addressed the new legislation and IRS guidance issued since the printing of the textbook for the 2017 tax schools. In a multi-state effort, staff provided leadership for the Land Grant University Tax Education Foundation which plans, writes and publishes the "National Income Tax Workbook" that is used to teach workshops in more than 30 states for over 29,000 tax professionals.

Niche markets are a growing segment of agriculture life in Minnesota. At the Annual Emerging Farmers' Conference, ABM educators taught a breakout session that addressed the economics of high tunnels for immigrant and Native American producers.

Economic issues continue to hit farmers hard. As farmers battle low commodity prices, unpredictable weather and labor shortages, education from Extension helps them gain a better grasp on their farm finances. A team of Extension farm financial analysts was assembled, tapping retired experts from areas like banking and farm business management education to provide financial counseling to farmers experiencing financial stress. These analysts are helping participating farmers understand their financial situation, explore options, and find alternatives that alleviate the financial stress caused by the current agricultural climate.

Programming also helps aging baby boomers develop a plan to successfully transfer their farm to the next generation and understand changing tax laws. Finally, the team helps farmers optimize potential profits by marketing more effectively and negotiating fair land rent fees.

MAES. Agricultural Business Management research focuses on exploring the economic side of small, medium and large farm operations and how domestic and international policies can affect the agricultural industry. 2018 highlights include:

- University economists developed a novel model for forecasting 10-year dairy policy costs that was used by the USDA Chief Economist's office as they developed the 2018 Farm Bill. The model provides daily updates that the Chief Economist's staff can pull directly into an Excel-based policy analysis tool thus providing them with the most recent estimates of the current year's policy costs and benefits.
- University researchers have been exploring hemp and how it genetically differs from marijuana for over a decade. And, since the 2014 Farm Bill, have been heavily involved in Minnesota-based pilot studies exploring best practices related to growth, cultivation and marketing. In 2018, Minnesota had 51 pilot participants and grew 710 acres of industrial hemp. With the inclusion of hemp in the 2018 Farm Bill, this information will prove vital in assisting Minnesota farmers grow this cash crop in today's market including the possibility of double cropping hemp and winter grain.
- Farm level data was used to identify specific management traits that influence farm financial success. Grain marketing-with an emphasis on post harvest contracts-are used more frequently by financially successful farms (top 20 percent compared to lowest 20 percent measured by the adjusted net farm income ratio). Having adequate financial resources when starting a farm was found to play a factor in the overall success of the farm over time with most of the top 20 percent of farms receiving help from family members when starting their operation. This information will be used to extend Extension programming.

2. Brief description of the target audience

Target audiences for Ag Business Management programs include:

- Minnesota's farmers who are facing life or business transitions

- Farm business management associations
- Agricultural leaders
- Other agricultural professionals (e.g., crop consultants)
- Farm business management educators
- State and federal policy makers
- In 2018, one effort reached immigrant and Native American farmers.

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	6778	73008	7	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	5	11	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of educational events.

Year	Actual
2018	151

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Percentage of participants that change one or more business management practice as a result of attending an Agricultural and Business Management workshop or conference session.
2	Dollar amount of profitability increased as a result of agricultural business decisions made after receiving Extension information.
3	Economists will study the economic impact of disease outbreaks and develop recommendations for new policies that will help protect producers (reported as the cost of the outbreak).

Outcome #1

1. Outcome Measures

Percentage of participants that change one or more business management practice as a result of attending an Agricultural and Business Management workshop or conference session.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	64

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
In 2017, the average age of principal farm operators was 56.6 years. The business and personal assets of those who produce the world's food supply need to be protected as owners move into retirement and pass the business on to the next generation.

What has been done
Seven workshops -- Farm Transition and Estate Planning: Create Your Farm Legacy -- were held across Minnesota in 2018. Programs assisted farm and ranch families with farm business transfer and personal estate planning, equipping them with knowledge to develop and implement a transition and personal estate plan.

Results
Of workshop evaluation respondents, 74 percent said they did not have an up-to-date estate plan at the time of the workshop. Eighty-five percent of respondents did not have an up-to-date transition plan. In a six-month follow-up evaluation, 64 percent of those respondents had begun developing or updating their estate plan and 60 percent had begun developing or updating their transition plan.

4. Associated Knowledge Areas

KA Code	Knowledge Area
602	Business Management, Finance, and Taxation

Outcome #2

1. Outcome Measures

Dollar amount of profitability increased as a result of agricultural business decisions made after receiving Extension information.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	336168

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
About 90,000 land owners and dairy farmers produce food in Minnesota. These producers make difficult management decisions that respond to market forces, public policy shifts and personal life circumstances. Focused education and research from Extension can inform those decisions. In 2018, these market forces include continued low prices, the effects of proposed international tariffs, fluctuating rental value for farmland, and severe weather.

What has been done
Extension organized southern Minnesota marketing groups of farmers who agree to work together over an extended period of time to market the agricultural products they produce.

Results
Marketing groups were found to add an average of 5 cents per year for corn and 24 cents for soybeans on 450 acres each crop. With average corn yields of 175 bushels/acre and soybean yields of 50 bushels/acre, the annual impact for each farm would be $3,938 for corn and $5,400 for soybeans. Averaging these benefits, we can estimate that the 72 people who participated in the four marketing groups benefited from the program with $336,168 in enhanced income.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
602	Business Management, Finance, and Taxation
603	Market Economics
604	Marketing and Distribution Practices

Outcome #3

1. Outcome Measures

Economists will study the economic impact of disease outbreaks and develop recommendations for new policies that will help protect producers (reported as the cost of the outbreak).

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	225000000

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Minnesota ranks number one in turkey production, and Minnesota turkey farmers raise between 44 million and 46 million birds annually. Each year these birds generate more than $600 million in income for farmers, processors and other related industries. In 2015 Avian Flu spread to nearly 50 million birds nationwide and led to a major economic downturn in the country's turkey production.

What has been done
Metin Çakir and his team conducted first-of-its-kind research on Avian Flu outbreaks in the U.S. and recently published "The Economic Impacts of the 2015 Avian Influenza Outbreak on the U.S. Turkey Industry and the Loss Mitigating Role of Free Trade Agreements." This research develops a partial equilibrium model of the U.S. meat and poultry industry to simulate the impact of HPAI outbreak on the turkey industry. The model depicts farm and retail stages of the vertical supply chain for each of the sectors of the industry. In the case of turkeys, the model disaggregates the farm level production between the production in Minnesota and other states allowing researchers to analyze supply changes in Minnesota's turkey industry along with the potential changes in supply and demand for turkey in the rest of the United States.

Results
Using a partial equilibrium model of the meat and poultry industry they found the cost of the outbreak to U.S. turkey producers was $225 million; $207 million of which was because of a loss in exports. Of the $225 million, $101 million is borne by the producers in Minnesota and $124 million is borne by the producers in other states outside Minnesota.

However, it could have been worse if not for implementation of regional bans by trading partners who have negotiated free trade agreements with the U.S. Their results show that for every percentage point of additional exports, U.S. turkey producers avoided a loss of about $6 million.

This study provides vital information to help evaluate and update policies that will keep the industry from crashing in the event of another outbreak.

4. Associated Knowledge Areas

KA Code	Knowledge Area
601	Economics of Agricultural Production and Farm Management
603	Market Economics
604	Marketing and Distribution Practices
610	Domestic Policy Analysis

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Public Policy changes
- Populations changes (immigration, new cultural groupings, etc.)

Brief Explanation

New tax laws and changing demographics affected educational content.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

The Agriculture Business Management team conducts surveys of participants and then six-month follow ups to determine whether information in courses resulted in changed behavior. Results show that 93 - 100 percent of the time, respondents changed farm and business practices using information from Extension. Changed practices included decisions made about farm financial management, materials for employee handbooks, and changes in business culture and farm vision. Moreover, direct changes in marketing resulted in $336,168 in enhanced income as a result of Extension education.

MAES. Publication of peer-reviewed papers and success in obtaining external grants are typical measures of evaluating the quality of basic and applied research. The projects reported in this planned program led to the publication of 11 peer-reviewed journal articles during FY18.

Non-NIFA research funds and grants leveraged by PIs in this program include: Rapid Agricultural Response Fund - Avian Influenza and the Midwest Dairy Association.

Key Items of Evaluation

Results show that 93 - 100 percent of the time, respondents changed farm and business practices using information from Extension. Changed practices included decisions made about farm financial management, materials for employee handbooks, and changes in business culture and farm vision. Moreover, direct changes in marketing resulted in $336,168 in enhanced income as a result of Extension education.

V(A). Planned Program (Summary)

Program # 3

1. Name of the Planned Program

Horticulture

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
102	Soil, Plant, Water, Nutrient Relationships	15%		10%	
132	Weather and Climate	15%		10%	
201	Plant Genome, Genetics, and Genetic Mechanisms	15%		20%	
204	Plant Product Quality and Utility (Preharvest)	15%		20%	
205	Plant Management Systems	15%		20%	
211	Insects, Mites, and Other Arthropods Affecting Plants	15%		10%	
213	Weeds Affecting Plants	10%		10%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	14.4	0.0	37.5	0.0
Actual Paid	20.6	0.0	62.0	0.0
Actual Volunteer	67.8	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
858447	0	45934	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
2210770	0	4157688	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
1432176	0	6426448	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

MAES supports horticultural research for fruit, vegetables and ornamental plants and turfgrasses. Research in these areas includes breeding new plant and crop varieties, exploring new management practices and technologies and studying pests and disease affecting the horticultural industry. 2018 highlights include:

- Researchers developed a technique to measure root respiration utilizing a novel oxygen sensor. This discovery will help increase containerized food production, reduce inputs, increase understanding of how high temperature impacts plant growth and will help develop new heat tolerant varieties.
- A study revealed Chewings fescues and strong creeping red fescues are better able to thrive under low light quality conditions. This information will be used to develop a high throughput phenotyping methodology that can be executed by other turfgrass breeders.
- A study on the transmission of Tomato mosaic virus found a farm where one variety of commercially purchased tomato seed was the source of the virus. Of the 100 seeds tested, 85 percent were infected. This study highlights the need for farmers to disinfect even commercially purchased seed.
- The RosBREED2 project led to the discovery of a new resistance gene for rose black spot, Rdr4.
- Comparative research plots were developed to determine if grit weeding within raspberry rows provides effective in-row weed control. After one year, grit weeding was found to be more cost-effective than hand weeding with little difference in plot growth of raspberries.
- The study found that queen bees with poor-brood patterns significantly improved after being placed in a good-brood colony after 21 days. These results show poor brood pattern is not sufficient alone to judge queen bee quality and that colony environment may play a role.

Extension. In 2018, horticulture programs broadened the program reach by expanding the number of platforms where it offered education. The team created new offerings through online courses, videos demonstrating best horticultural practices, podcasts, and new newsletters targeted to fruit and vegetable growers. Meanwhile, the teams have continued an educational emphasis on issues related to creating and nurturing habitats that support pollinators. Master Gardener volunteers, the Bee Squad, and horticulture educators undertook large scale efforts to address pollinator well-being.

2. Brief description of the target audience

Extension programming targets:

- fresh market producers, the processing industry, nurseries and garden centers, and landscape professionals;

- consumers of horticultural information for yards, gardens and landscapes;
- community-based initiatives mobilize schools, neighborhoods and non-profit organizations to create and maintain green spaces; and,
- community volunteers who can educate and act to keep yards, gardens and green spaces healthy.

In 2018, 20 percent of Master Gardener volunteer education efforts reached people of color. The highest percentages were in teaching youth (27 percent), educational service projects (26 percent) and county-specific projects (34 percent).

Extension educators are very involved in planning and presentation for the Emerging Farmers Conference (formerly the Immigrant and Minority Farmers Conference). The conference advances the success and sustainability of farmers who traditionally face barriers to education and resources necessary to build profitable agricultural businesses, including immigrant farmers and farmers of color. Language interpretation is provided in six languages at the conference.

MAES. Target audiences include: plant breeders, biochemists, geneticists, farmers and processors of speciality crops, florists, garden centers owners, turf and golf course managers. Government agencies involved with maintaining turf and floral landscapes. And the general public.

3. How was eXtension used?

Educators and volunteers respond to questions and Ask An Expert submissions

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	186029	1736	48324	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	17

Patents listed
Patents Issued
SWEETANGO: 1814896 - 8/23/2017; RAVE: 5324968 - 10/31/2017; SWEETANGO: 262069 - 11/7/2017; RAVE: 1336664 - 12/27/2017; SWEETANGO (design): IR1281280 - 2/17/2018; FIRST KISS: 5444144 - 4/10/2018; SWEETANGO: 591251 - 4/14/2018; Grape Variety, MN 1211 (Marquette): 48924 - 4/23/2018; FIRESIDE: 5493741 - 6/12/2018

Patents Filed
FIRESIDE: 87/514,453 - 7/3/2017; SWEETANGO: 2017-013078 - 8/9/2017
MN 1955 Apple: 17-3169 - 9/26/2017; MN 1955 Apple: 2017/2540 - 10/10/2017
MN 1955 Apple: 10/17/2017; Physocarpus 20130543: 15/732,958 - 1/16/2018; Itasca: 18-9376 - 1/26/2018; Physocarpus 20130543: 18-9377 - 1/30/2018

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	18	32	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of workshops, classes and seminars that provide information to professionals in the commercial horticulture industry.

Year	Actual
2018	1736

Output #2

Output Measure

- Number of new fruit, vegetable and ornamental plant varieties sent for additional testing outside the University.

Year	Actual
2018	7

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Percentage of Horticulture program participants that changed one or more horticulture practice as a result of attending Extension events.
2	Research will support new horticultural crops' growth.
3	Number of volunteer hours committed to providing Master Gardener training and expertise in order to create and improve Minnesota's green spaces.
4	Percentage of beekeepers who participate in programs who self-report they've changed their beekeeping practices to better support the bee population.
5	Collaborative research will lead to new tools to help specialty crop growers make better decisions regarding labor and sales. (Reported as the percent accuracy achieved by the new tool).
6	U of M apple breeding will lead to increased consumer choice and increased revenues for apple growers (reported as the number of Honeycrisp apple produced in 2018).

Outcome #1

1. Outcome Measures

Percentage of Horticulture program participants that changed one or more horticulture practice as a result of attending Extension events.

Not Reporting on this Outcome Measure

Outcome #2

1. Outcome Measures

Research will support new horticultural crops' growth.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	4

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The U.S. floriculture industry is strong. The value of sales of floriculture crops exceeds $5 billion (wholesale) annually, a significant contribution to farm income. Chrysanthemums, or mums, are a staple in fall gardens but research and breeding efforts are vital to help keep floricultural crops sales strong in the 21st century.

What has been done
The University's mum breeding program is one of the oldest public sector breeding programs in the world and the only one in North America. Trend-setting breeding endeavors, coupled with the program's germplasm base and genetic resources, continue to bring a wide range of colors and shapes of proven hardy mums to northern gardens.

In recent years, the University's floral research has garnered international respect and led to the development of a collaborative chrysanthemum-breeding program with the Chungnam Provincial Agricultural Research and Extension Services in South Korea. The program also has cooperative breeding efforts in China. Neil Anderson and his team have collected wild mum species in Alaska to add to the University's germplasm collection. Additionally, scientists from Asia can study at the

University of Minnesota and bring new breeding techniques back to their countries.

Results
Four new chrysanthemum cultivars were released to the world market in 2018, including "Cushion Ball", a new spreading type bred for the Asian markets-particularly South Korea, "White Centerpiece" as a new color for the "Centerpiece" series and two ground cover cultivars.

In total, the program has released over 100 cold-hardy chrysanthemums. Garden chrysanthemums are now the #1 herbaceous perennial ($114.305 million wholesale in 2013), which is partly because of the University's development of the famous Mammoth series.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
201	Plant Genome, Genetics, and Genetic Mechanisms
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

Outcome #3

1. Outcome Measures

Number of volunteer hours committed to providing Master Gardener training and expertise in order to create and improve Minnesota's green spaces.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	141114

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Gardens and green space in communities and homes promote healthy landscapes, healthy foods and healthier lives. While green spaces are gaining popularity in American culture, the skills to create and sustain green spaces are no longer a fundamental skill acquired in homes and schools. Trained volunteers can fill that gap and strengthen skills in landscape management among community members.

What has been done
Extension recruits and trains Master Gardeners in every corner of the state. Master Gardeners teach and act, with University research-based information, to bring horticulture projects to communities. These volunteers strengthen community bonds, support healthy choices, and promote healthier plants for more livable communities. The activities of Master Gardeners benefit community gardens, schools, youth programs, environmental education programs, food banks and farmers markets, to name a few.

Results
In 2018, 2,404 volunteers provided 141,114 hours of service across Minnesota. They reported the following benefits to communities: 36 local programs nurtured 247 community gardens; 24 groups nurtured 82 school-based gardens; eight local programs assisted with Habitat for 27 Humanity projects/homes. Groups donated 114,598 pounds of produce to food banks and pantries. Eleven groups maintained or installed 29 rain gardens, and 27 groups installed or maintained 51 pollinator gardens.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
132	Weather and Climate
205	Plant Management Systems
211	Insects, Mites, and Other Arthropods Affecting Plants
213	Weeds Affecting Plants

Outcome #4

1. Outcome Measures

Percentage of beekeepers who participate in programs who self-report they've changed their beekeeping practices to better support the bee population.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	97

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The recent decline in the health and number of insect pollinators such as bees, butterflies, and moths is cause for concern given their importance in supporting a healthy food system and plant and animal diversity. Community engagement and public education about this issue is necessary to enable pollinators and our ecosystem to thrive.

What has been done
In 2017, Extension developed the Flowers for Pollinators toolkit to assist volunteers who lead efforts to increase the number of pollinator-friendly landscapes. Since then, 387 Master Gardeners from 58 counties were trained to use the tool kits. They delivered 181 pollinator events in 2018. Also in 2017 and 2018, an educational tool was developed to help people assess how pollinator-friendly their landscapes were. The goal was to raise people's awareness about the plight of pollinators. A total of 1,384 responses were received from 2/3 of Minnesota's counties.

Results
Evaluation results showed that 97 percent plan to make changes to gardening practices based on what they learned. A follow up survey showed that 24 percent had made changes to a great extent and 60 percent had somewhat made changes. Behavior changes identified included: left stems in my garden for stem nesting bees (69 percent), paid attention to having something blooming consistently for bees (62 percent), and added more pollinator-friendly plants to gardens (64 percent). In a follow up survey to those who took the pollinator friendly landscape assessment, almost 80 percent reported changing practices somewhat to very much after they took the assessment.

4. Associated Knowledge Areas

KA Code	Knowledge Area
205	Plant Management Systems
211	Insects, Mites, and Other Arthropods Affecting Plants

Outcome #5

1. Outcome Measures

Collaborative research will lead to new tools to help specialty crop growers make better decisions regarding labor and sales. (Reported as the percent accuracy achieved by the new tool).

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	95

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Specialty crop growers rely on manual labor for fruit picking, inspecting, data collecting and other labor-intensive tasks. The less structured environments inherent with specialty crops systems have made automation more difficult but the increasing cost and decreased availability of seasonal workers makes such advances increasing important.

What has been done
Ibrahim Volkan Isler and U of M apple experts James Luby and Cindy Tong have teamed up to develop technology that will focus on two tasks: counting apples in an orchard and measuring their diameter. Counting apples accurately can be difficult, even for humans, due to variations in skin color, inconsistent light conditions and obstructions of fruits by leaves, branches and other fruit.

Results
The team developed deep learning and image geometry based methods to accurately analyze the visual imagery. This new approach resulted in 95.56 to 97.83 percent yield accuracies. Other technologies, including a robotic arm to help with picking, are in development.

A start-up company called Farm Vision Technologies was launched in 2017 with an aim of integrating this and other technology into farms to help farmers monitor count, size and health of their plants. Ultimately, this technology will help farmers make decisions regarding labor and sales far in advance, directly improving their revenue and reducing their costs.

4. Associated Knowledge Areas

KA Code	Knowledge Area
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

Outcome #6

1. Outcome Measures

U of M apple breeding will lead to increased consumer choice and increased revenues for apple growers (reported as the number of Honeycrisp apple produced in 2018).

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual

2018 23500000

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Back in 1996, approximately two-thirds of the apples sold in the U.S. were Golden Delicious or Red Delicious. Neither is known for its outstanding texture or flavor, and neither inspires much enthusiasm today. Today, consumers and growers are reaping the benefits of advances in apple breeding.

What has been done
The University of Minnesota has one of only three University-based apple-breeding programs in the United States. Originally, Minnesota's climate was thought to be unsuitable for the cultivation of apples but over a century of breeding has led to 27 varieties being released since the breeding and evaluation program began in 1878. Eighteen of those 27 are still available today, including the famous Honeycrisp.

Results
Honeycrisp apple, released by U of M apple breeders Jim Luby and David Bedford in 1991, has become a nationwide success story. In 2018, for the first time, Honeycrisp apple made the US Apple Associations' top five list. Coming in at number five in 2018, they expect it to continue to climb up the ranks as production in 2017 included 19.3 million units but jumped to 23.5 million in 2018. Notably, despite its high production numbers, Honeycrisp can command as much as twice the price of traditional apple varieties.

Honeycrisp progeny are also fetching premium prices and consumer enthusiasm--the launch of First Kiss, the Minnesota grown version of the early ripening cultivar MN55, led to a sellout after five days at the Minnesota State Fair, even at $3 an apple. Additionally, Star Tribune restaurant critic, Rick Nelson, named it as the best new food of the fair!

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
201	Plant Genome, Genetics, and Genetic Mechanisms
204	Plant Product Quality and Utility (Preharvest)
205	Plant Management Systems

V(H). Planned Program (External Factors)

External factors which affected outcomes
- Other (none)

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Evaluation of horticulture programs measure the confidence and competence of volunteers and growers to deliver education and practice effective growing techniques. Evaluations have shown a 65 percent increase in using information about plants.

With this information, Extension volunteers are effectively creating community change. As reported in outcomes, local Master Gardener groups are using volunteer hours to create and monitor community and school gardens, create landscapes for Habitat for Humanity projects, donate fresh food to food shelves, install rain gardens, and maintain pollinator gardens. Moreover, targeted efforts to create more pollinator-friendly landscapes resulted in significant new attention to gardens that support pollinators, with 97 percent of participants making gardening changes.

MAES. Publication of peer-reviewed papers and success in obtaining external grants are typical measures of evaluating the quality of basic and applied research. The projects reported in this planned program led to the publication of 32 peer-reviewed journal articles during FY18.

Non-NIFA research funds and grants leveraged by PIs in this program include: National Science Foundation, MnDRIVE Robotics, USDA-CAP, USDA-SCRI, USDA-ARS, USDA-OREI, Legislative-Citizen Commission on Minnesota Resources and the Minnesota Invasive Terrestrial Plants and Pests Center.

Additionally, apple breeders Jim Luby and David Bedford were issued numerous patents: RAVE (#5324968), FIRST KISS (#5444144), RAVE (#1336664), SWEETANGO (design) (#IR1281280), SWEETANGO (#591251), SWEETANGO (#1814896), SWEETANGO (#262069). A new patent was also issued for Marquette grape: Grape Variety, MN 1211 (Marquette) (#48924). A new patent was issued for a landscape plant: FIRESIDE (#5493741).

And a University startup company was launched with direct ties to the research reported in this planned program: Farm Vision Technologies.

Key Items of Evaluation

In 2018, 2,404 volunteers provided 141,114 hours of service across Minnesota. They reported the following benefits to communities: 36 local programs nurtured 247 community gardens; 24 groups nurtured 82 school-based gardens; eight local programs assisted with Habitat for 27 Humanity projects/homes. Groups donated 114,598 pounds of produce to food banks and pantries. Eleven groups maintained or install 29 rain gardens, and 27 groups installed or maintained 51 pollinator gardens.

Moreover, trained beekeepers are making changes to gardening practices that are better protecting bees. In a follow-up survey to those who took the pollinator-friendly landscape assessment, 80 percent reported changing practices somewhat or very much.

V(A). Planned Program (Summary)

Program # 4

1. Name of the Planned Program

Youth Development

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
805	Community Institutions, Health, and Social Services	25%		60%	
806	Youth Development	75%		40%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	42.6	0.0	0.0	0.0
Actual Paid	40.9	0.0	6.5	0.0
Actual Volunteer	520.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
1975874	0	171091	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
4055685	0	593380	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
9180520	0	532690	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

4-H programs continue to focus youth development education and activities on three pillars:

1. Science, technology, engineering and math, including the science of agriculture
2. Citizenship and leadership
3. Animal science

While focusing on these disciplines, 4-H actively adapts its programs to address programmatic gaps. There are young people in Minnesota who need engagement from programs like 4-H, including youth of color, indigenous young people, LGBTQ youth, youth from low income families, and recent immigrants. In 2018, efforts focused on equipping volunteers, federations and other 4-H decision-makers in learning more about outreach work for new audiences. Training and tools were piloted to assess the best way to engage the 4-H system and make systems change.

An important step was to listen to new participants through evaluative efforts. A new member Follow-Along study, completed in 2018 (see "evaluation"), allowed 4-H to gain information from new members throughout the program cycle. Information was fed back into the system so that changes could be made. Internal communications shared outreach success stories with all 4-H staff, with case studies describing successful ways that staff engaged new populations of youth. These stories create a common language and vision across the 4-H system for what engagement looks like.

In 2018, youth development educators reached 4,267 youth workers through 108 online and in-person staff development opportunities. Core training supported quality youth development practice with trainings such as: Culturally Responsive Youth Work Matters; Leadership Matters; and Youth Work Matters.

MAES supported research related to youth development focuses on educating and empowering today's youth. In 2018, all the research projects mapped to this program included elements focused on minorities and other underserved populations in Minnesota. 2018 highlights include:

- A study of the effectiveness of Ramsey County's truancy intervention programs revealed two key issues requiring further study and possible policy changes: 1) The interventions did not improve the attendance of students in the program after one year compared to students in Hennepin County; and, 2) Students of color were more likely to have their absences coded as "unexcused" which led to them disproportionately being referred to the program compared to white students. Further analysis is needed but PIs stressed the need for program analysis to look at the long-term effects, as short-term decreases in absenteeism may be misleading.
- A researcher conducting a study on Hmong student achievement made appearances on the Hmong TV Network and Dr. Chai Lee's Talking Education Radio Show where he discussed children's learning styles and parental expectations.
- Research on the achievement gap showed that active learning--things like working in groups and taking part in classroom discussions--can help close the achievement gap. This knowledge gain will provide valuable information toward designing better classroom experiences for all students.
- The U Connect program, a collaborative project including partners from Minnesota, Tennessee and Kentucky, realized short-term improvements regarding students receiving support to become more confident in their skills and abilities to achieve academic success.
- Researchers used human resource data from the Minnesota Department of Education and student score data to examine the distribution of teacher quality in parts of Minnesota and to devise tools for improving the selection of teachers.
- A study of the role of mentoring in youth development included a survey conducted at the Minnesota State Fair. Results showed that while parents and caregivers see value in connecting their children with supportive adults, they have little experience doing it.

2. Brief description of the target audience

The target market for 4-H clubs is youth. Through intentional engagement, Extension has lifted

involvement by youth of color in Minnesota to 19 percent. Minnesota's population of youth of color is around 21 percent. With 19 percent, Minnesota is close to parity.

Of the 65,779 youth served in Minnesota, 31,877 (48 percent) are 4-H club members.

MAES. Target audiences include educators, policymakers and individuals developing youth programs or otherwise working directly with youth.

3. How was eXtension used?

Nine staff used eXtension. One staff was a contributor as a web manager for 4-H.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	11677	0	65779	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	3	3	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of educational offerings delivered for youth-serving organizations through both face-to-face and on-line offerings.

Year	Actual

2018	108

Output #2

Output Measure

- Percentage of parents of youth participants who report being satisfied with their first year of participating in 4-H programming, thus making long-term engagement more feasible.

Year	Actual
2018	79

Output #3

Output Measure

- Number of lead adult volunteers in 4-H clubs will be trained to work with Minnesota's young people who participate in 4-H program activities.

Year	Actual
2018	10042

Output #4

Output Measure

- Number of 4-H program clubs that use a validated assessment tool to guide quality improvement efforts.

Year	Actual
2018	46

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Youth participating in 4-H Youth Development who go on to higher education.
2	Youth participating in 4-H Youth Development who are prepared with 21st century learning skills; e.g., communicating effectively, building connections, making positive choices, and making contributions to their community.)
3	Adult participants in educational offerings who report that they increased their understanding and knowledge of a given youth development topic.

Outcome #1

1. Outcome Measures

Youth participating in 4-H Youth Development who go on to higher education.

Not Reporting on this Outcome Measure

Outcome #2

1. Outcome Measures

Youth participating in 4-H Youth Development who are prepared with 21st century learning skills; e.g., communicating effectively, building connections, making positive choices, and making contributions to their community.)

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	87

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Research has shown that experiences that create "21st century skills" are ones that cause youth to enjoy learning, make decisions for themselves, and try new things. Leading opportunities give youth a chance to solve problems in a group, design something new, and take part in a service project. These learning benefits are connected, by research, to important life skills.

What has been done
Youth work across Minnesota engages youth in activities that create these 21st century skills. Youth across Minnesota were asked to respond to an outcome survey describing their experiences in learning and leading in 4-H in the past year.

Results
The quantitative outcome above is an average of findings. Evaluations demonstrate that: 92 percent of youth said they learned more about a project in 4-H; 90 percent helped to solve a problem; 94 percent used communication skills; 89 percent solved problems in a group; 79 percent designed something new; and 78 percent took part in a community service project.

4. Associated Knowledge Areas

KA Code	Knowledge Area
806	Youth Development

Outcome #3

1. Outcome Measures

Adult participants in educational offerings who report that they increased their understanding and knowledge of a given youth development topic.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	97

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Quality youth development practice and quality youth engagement are not an accident. Education and training about research-informed practices can provide greater intentional youth development practices in settings where youth are learning and finding relationships with adults.

What has been done
Specific training for youth workers prepared them to use best practices in youth work. Quality orientation for 4-H volunteers assured that they are ready to provide quality 4-H programming to Minnesota's youth.

Results
Quantitative outcome is an average of findings. Evaluation of youth worker training found that 96 percent agree or strongly agree they have a deeper understanding of a youth development topic after taking part in the training. Of the 1,074 volunteers who completed orientation training, 96.9 percent said they have a better understanding of the mission of Minnesota 4-H; 96.6 percent said they had a better understanding of the relationship between 4-H and the University of Minnesota; 97.7 percent said they learned more about the role of a 4-H volunteer; 98.4 percent said they know the stewardship and risk management practices for 4-H youth and volunteers; 98.4 percent agreed they know where to access resources to support their volunteer roles.

4. Associated Knowledge Areas

KA Code	Knowledge Area
805	Community Institutions, Health, and Social Services
806	Youth Development

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Other (Data reliability)

Brief Explanation

We are no longer collecting data on college enrollment. The data site proved to be unreliable.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

In 2018, four program evaluations informed the future direction of youth development programs and demonstrated program success.

- A **First Member Survey** collected feedback from parents of first year 4-H members. Data is used to better meet the needs of new members in the future. We know from research that highest 4-H club dropout rates happen in the first year.
- The **First Generation Follow-Along Study** is an action research project targeting first year families to learn about their experience in 4-H and inform changes based on results. Evaluators surveyed new parents three times throughout the program year to learn about their experiences with the program. Parents described their most recent experiences and offered specific feedback to make the program easier to navigate.
- The **Learn and Lead Impact Study** surveyed youth across Minnesota, determining whether their experience in 4-H had given them opportunities to develop 21st century skills in learning and leading.
- The **North Central Region Volunteer Impact Study** is a 12-state study of volunteers in the 4-H program. The purpose is to document and quantify the impact that volunteers have on 4-H Youth Development Programs in the 12 states of the North Central Region. The survey is being conducted by 4-H Volunteer Specialists in these states as part of a multi-state effort to document the impact of volunteering.

MAES. Publication of peer-reviewed papers and success in obtaining external grants are typical measures of evaluating the quality of basic and applied research. The projects reported in this planned program led to the publication of three peer-reviewed journal articles during FY18.

Key Items of Evaluation

Impact studies have shown that 4-H youth learned to enjoy learning, make decisions, try new things, solve problems, design something new, and take part in a service project. These changes are known, through research, to develop "21st century skills" in youth. Both youth and volunteers value the relationships that 4-H creates between youth and caring

adults, and 92 percent of volunteers in a 12-state study said that volunteering with 4-H ultimately results in creating stronger communities.

V(A). Planned Program (Summary)

Program # 5

1. Name of the Planned Program

Natural Resource Management

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
123	Management and Sustainability of Forest Resources	10%		20%	
124	Urban Forestry	10%		10%	
125	Agroforestry	10%		15%	
133	Pollution Prevention and Mitigation	10%		10%	
134	Outdoor Recreation	10%		10%	
136	Conservation of Biological Diversity	10%		20%	
307	Animal Management Systems	0%		5%	
605	Natural Resource and Environmental Economics	15%		10%	
903	Communication, Education, and Information Delivery	25%		0%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	12.4	0.0	12.9	0.0
Actual Paid	18.8	0.0	49.4	0.0
Actual Volunteer	0.6	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
909344	0	468848	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
2259380	0	2586045	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
1017558	0	4624258	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

MAES. Research in this program area focuses on protecting the diversity of Minnesota's forests, wildlife and native plants as environmental conditions continue to shift in the state. 2018 highlights include:

- A new study found habitat fragmentation of landscapes and habitat loss could put wildlife species at risk of extinction by promoting disease outbreaks. These findings run counter to predictions from previous disease transmission models.
- Researchers developed a new model-based estimator of population abundance that can monitor wildlife populations. They used the model to estimate trends in Minnesota moose population size overtime and showed moose declined from 2009 to 2015 before stabilizing in more recent years.
- A survey of Minnesota's logging business owners' awareness and needs related to invasive forest plants found respondents were somewhat (48 percent) or slightly (40 percent) knowledgeable about invasive forest plants. Of the 15 invasive forest plants included in the survey, approximately half of the respondents could identify three of the species: buckthorn, reed canary grass and honeysuckle, and 89 percent could identify thistle.
- A study looking at the spread rate of various invasive insects found, in the global analysis, voltinism was the most significant predictor of spread rates. Insects with more than one generation per year spread faster than those with one or fewer generations.
- For the first time in nearly 200 years, bison are roaming over 200 acres of oak savannah at the Cedar Creek Ecosystem Science Reserve. Researchers released 32 bison as part of the ongoing effort to restore the oak savannah ecosystem inside the reserve. For the next three years, the bison will roam and graze on grasses that are completing with the oak trees.
- Researchers in the BioTechnology Institute are developing a sustainable method to remove toxic metals, such as arsenic, from contaminated soil using plants paired with a soil microbe that incorporates the toxins into the plant tissue. Plants can then be harvested and burned to collect the metal instead of the much more costly methods of removing soil and storing it long term.
- An equine study on forage preference found teff is more suitable for horses with low-energy demands or horses prone to metabolic concerns. On the other hand, alfalfa and perennial ryegrass have the capability of meeting nutritional requirements of horses with elevated nutritional needs.

Extension continues to train and coordinate citizen science volunteers who make a difference in natural resources management. Programming also equips teachers to incorporate citizen science into school curriculum, and shares best practices with other organizations. In Outcomes, we have featured the impact citizen scientists have in identifying forest pests and managing privately owned forests.

In 2018, Extension hosted the second CitSciMN Symposium in partnership with the Science Museum of Minnesota. It drew people from 42 affiliate organizations, including K-12 and higher education institutions, nonprofit organizations, and state, city, county and federal agencies. The event was a success, and 83 percent agreed or strongly agreed that they had a deeper understanding of citizen science as a result of the event and 89 percent agreed or strongly agreed that they would recommend the event to others.

New efforts are addressing new threats to forestland. A new, research-informed citizen science field method was developed and was piloted in May of 2018. This method engages Minnesota volunteers and landowners in collecting data to measure the impact of deer on forest understory vegetation.

2. Brief description of the target audience

MAES research and Extension programs reach: 1) Concerned citizens and volunteers who are willing to be trained and serve in a variety of roles as citizen teachers and scientists; 2) Minnesota professionals from within Extension, the Minnesota Department of Natural Resources, Soil and Water Conservation Districts, US Fish and Wildlife Services, Health and Human Services Departments and Environmental Sciences; 3) the public schools and others involved in environmental science education programs; and, 4) Youth on the White Earth Reservation in Northwest Minnesota, when funding allows.

To expand its target in 2018, a natural resource management Extension educator co-led a tour with the Environmental Program Manager at the Prairie Island Indian community to get to know the Mdewakanton Dakota Sioux community and to see hands-on native ways for effective management of invasive species. One-third of participants were people of color and/or indigenous. As a result of this and other outreach efforts, 13 percent of participants in natural resource management programs were people of color.

3. How was eXtension used?

Extension educators responded to Ask an Expert questions.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	13492	612380	466	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	2

Patents listed
Patents Issued
Cultivated Agarwood: IDP000047082 - 7/27/2017

Patents Filed
Biomarker for Predicting Equine Gait and Methods of Use Thereof: 62/658,809 - 4/17/2018

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	16	67	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of Master Naturalists trained and supported in Minnesota.

Year	Actual
2018	892

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of hours that volunteers and others involved in programs commit to exploring and conserving the environment, and to teaching others about the environment and environmental stewardship.
2	Number of acres influenced each year by citizens who, through exploration, conservation and education, influence environmental conditions.
3	Forest modeling will provide insights that will assist forest managers make decisions regarding timber harvesting (reported as the number of models developed).

Outcome #1

1. Outcome Measures

Number of hours that volunteers and others involved in programs commit to exploring and conserving the environment, and to teaching others about the environment and environmental stewardship.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1255

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Invasive forest pests in Minnesota include the emerald ash borer, gypsy moth, Asian longhorned beetle, Japanese barberry and Oriental bittersweet. Landowners and other concerned citizens can act as monitors and detectors to identify and eradicate forest pests early.

What has been done
The Minnesota Forest Pest First Detector program was designed to identify the occurrence of invasive forest pests in Minnesota, including emerald ash borer, gypsy moth, Asian longhorned beetle, Japanese barberry and Oriental bittersweet. Between 2015 and 2018, thirteen workshops were held across Minnesota for 263 people.

Results
The number of volunteer hours above represents commitments from all Master Naturalists. Forest Pest First Detectors said that they would use new knowledge from Extension to actively look for emerald ash borer and its symptoms after the class (88 percent). This is a 45 percent increase from those doing it before the class. There was a 57 percent increase in those who said they would look for Asian longhorned beetles and their symptoms. There was a 51 percent increase in those who said that they would look for Oriental bittersweet.

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources
124	Urban Forestry

125	Agroforestry
133	Pollution Prevention and Mitigation
134	Outdoor Recreation
136	Conservation of Biological Diversity
605	Natural Resource and Environmental Economics
903	Communication, Education, and Information Delivery

Outcome #2

1. Outcome Measures

Number of acres influenced each year by citizens who, through exploration, conservation and education, influence environmental conditions.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	6817

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Of the 17.4 million acres of Minnesota woodlands, 37 percent are privately owned. These owners harvest the forest for wood and other assets, and are solely responsible for preserving forest health. Stakeholder assessment tells Extension that woodland owners want to preserve the health of their land now and into the future. Still, from land ownership challenges to climate change, successful woodland management has become complex.

What has been done
Master Woodland Owners was launched in southeastern Minnesota in 2016 and will expand to the Brainerd area in 2018. The cohort's purpose is to help woodland owners articulate their hopes and dreams for their forested lands, learn about related stewardship practices, and connect with forestry professionals to support effective management. The program takes an in-depth look at topics such as: harvesting for forest health, recreation and wildlife, the logging industry, invasive plants, long-range planning, multi-generational properties and estate issues.

Results
One hundred fourteen woodland landowners in central and northeastern Minnesota participated in four Master Woodland Owner programs in 2018, reaching 6,817 acres of Minnesota's woodlands.

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources
136	Conservation of Biological Diversity
903	Communication, Education, and Information Delivery

Outcome #3

1. Outcome Measures

Forest modeling will provide insights that will assist forest managers make decisions regarding timber harvesting (reported as the number of models developed).

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	10

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The forest management situation in Minnesota is intrinsically complex, involving approximately 17.1 million acres of forestland. Forests are part of a multi-faceted natural resources system, with long timber production periods and important environmental values. In managing Minnesota forests much is at stake, so it is critical to integrate and balance well the ecological, social and economic objectives.

What has been done
In 1994, the Minnesota Environmental Quality Board commissioned a Generic Environmental Impact Statement (GEIS), which assessed the environmental and related impacts of three levels of statewide timber harvesting intensity. The study, which University researchers led, developed recommendations to mitigate impacts identified in the assessment, many of which are still in use.

Since the GEIS, Howard Hoganson and his research team have continued their breakthrough modeling work that was a cornerstone of the GEIS. They have since led detailed analyses to support the current forest plans for both the Chippewa and Superior National Forests in Minnesota, expanding modeling methods spatially to recognize important site-level conditions important for wildlife, while also still addressing the economics of timber production--including aspen.

Results

Using and expanding the current U of M forest management modeling system, the team looked in more detail at the aspen resource in Minnesota, focusing on tradeoff information involving aspen harvesting and sustaining some older aspen critical for ecosystem services. Ten scenarios were modeled, with applications using a downward-sloping demand curve to recognize that when less old aspen is present on the landscape, its marginal value is likely higher. These comparisons provided specific insight on the Minnesota situation related to ecological objectives and how detailed timber harvest scheduling can be improved to better recognize environmental values when making site-specific stand-level decisions.

This work highlights that although the forest management situation in Minnesota is complex, careful and detailed analysis can be especially helpful for forest management organizations in Minnesota and beyond to untangle these complex systems and make better decisions.

4. Associated Knowledge Areas

KA Code	Knowledge Area
123	Management and Sustainability of Forest Resources
136	Conservation of Biological Diversity
605	Natural Resource and Environmental Economics

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Other (none)

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Evaluation of Master Naturalist programs monitor whether volunteers feel ready and able to act in their communities -- either to monitor and address problems with invasive species, to better manage the land they own, or to train others in community settings.

In 2018, programs demonstrated that they were recruiting a significant number of people who have the ability and confidence to make a difference in natural habitats. The program mobilized several hundred people who now monitor forests for invasive forest pests, and prepared woodland owners to manage 6,817 acres of Minnesota forest land.

MAES. Publication of peer-reviewed papers and success in obtaining external grants are typical measures of evaluating the quality of basic and applied research. The projects reported in this planned program led to the publication of 67 peer-reviewed journal articles during FY18.

Non-NIFA funds and grants leveraged by PIs in this program include: Minnesota Legislative and Citizens Commission on Natural Resources, National Science Foundation, the Minnesota Environmental and Natural Resources Trust Fund and the Minnesota Department of Natural Resources.

Additionally, Forest Isbell was listed in the 2018 Highly Cited Researchers list published by Clarivate Analytics. And Robert Blanchette was issued a patent: Cultivated Agarwood (#IDP000047082).

Key Items of Evaluation

In 2018, programs demonstrated that they were recruiting a significant number of people who have the ability and confidence to make a difference in natural habitats. The program mobilized several hundred people who now monitor forests for invasive forest pests, and prepared woodland owners to manage 6,817 acres of Minnesota forest land.

V(A). Planned Program (Summary)

Program # 6

1. Name of the Planned Program

Community Vitality and Public Finance

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
602	Business Management, Finance, and Taxation	20%		10%	
608	Community Resource Planning and Development	40%		10%	
611	Foreign Policy and Programs	0%		20%	
803	Sociological and Technological Change Affecting Individuals, Families, and Communities	40%		50%	
804	Human Environmental Issues Concerning Apparel, Textiles, and Residential and Commercial Structures	0%		10%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	29.7	0.0	5.4	0.0
Actual Paid	26.0	0.0	5.3	0.0
Actual Volunteer	3.9	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
1055125	0	184402	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
2866761	0	616742	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
975500	0	303760	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Extension. Community Vitality programs at Extension continued to address civic and economic change, encouraging communities to use research and education as they choose their future, especially in rural communities challenged to thrive in changing times. In 2018, 37 long-term community cohorts strengthened leadership skills and local planning. An average of 66.1 of leadership cohort participants increased the level of leadership they provided to their communities. Communities are using applied research in economics to decide on priority projects, tell their stories to stakeholders, increase support for local businesses and initiatives, and help businesses plan for the future.

New efforts are helping communities shape workforce recruitment efforts, address business succession issues as baby boomers retire, and include Minnesota's growing minority population in community leadership.

MAES. Research related to community vitality and public finance includes projects focused on the impact of publicly supported programs and built environments. A particular focus is placed on assisting rural communities in Minnesota, and internationally, be more prosperous and stable. 2018 highlights include:

- A new project started with Minneapolis Public Housing to improve integrated pest management in multifamily housing and collaborative projects are in the works with stakeholders with direct impact in evaluating dispersal prevention techniques.
- The Joint Retail Assistance Program, which focuses on retail revitalization in rural Minnesota, was featured as part of the annual U of M Driven to Discover Campaign.

2. Brief description of the target audience

In 2018, new partnerships with the Economic Development Administration in Chicago and local partners were developed to expand community and economic development programming for Latino and Native American communities. Moreover, some leadership education cohorts are intentionally engaging informal leaders from minority and immigrant communities into community leadership discussions. New staff will come on board in 2019 who will direct programming that engages Latino and Native American communities.

Community Vitality and Public Finance programs reach out to ten primary audiences: As noted in "outputs", Extension hosted 37 community cohorts. Those cohorts helped communities accomplish specific goals:

• Eleven cohorts were conducted for Minnesota counties that want to create stronger ties and a vision for communities in their county.
• Nine cohorts brought people together to create a vision or strengthen leadership in a town or city.
• Nine cohorts brought people together from across a region or the state to learn about leadership, civic engagement, or economic development.
• Three cohorts were focused on the protection of a watershed, river or lake.
• Three focused on the future leadership of Extension or higher education.
• Two focused on community health.

3. How was eXtension used?

Educators in the Extension Center for Community Vitality participated in, collaborated with, and led eXtension activities, including:

• leadership for the eXtension educational technology group until it was suspended in mid 2018.
• leadership for the Enhancing Rural Capacity Community of Practice.
• participation in the Impact Collaborative in October of 2018,
• participation in communities of practice and collaborated to launch an online course in 2019.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	12000	105383	20	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	6	3	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of community cohort groups convened to develop leadership skills, create civic connections, or strengthen the local economy.

Year	Actual
2018	37

Output #2

Output Measure

- Number of workshops and other structured gatherings that provided communities with increased skills, knowledge and behaviors related to community leadership, civic engagement, economic development or tourism.

Year	Actual
2018	524

Output #3

Output Measure

- Number of community-based applied research studies regarding (for example) retail trade, business retention and expansion, economic impact, tourism development or social capital.

Year	Actual
2018	141

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Number of participants who increased their leadership intensity or involvement in at least one role.
2	Percentage of program alumni who report in follow-up surveys that the program helped make public meetings, planning sessions, or committees more effective.
3	Number of community or economic development decisions that were influenced by applied research or education.
4	Number of positive effects on "capitals" that are essential to the vitality of communities (including human, social, civic, financial, built, health, cultural, and natural) that were stimulated by applied research or education in communities.
5	Researchers will develop B3 tools and programs that will help test and determine the impact of design in new and renovated publicly funded buildings in Minnesota. (Reported as the number of buildings using the tools).

Outcome #1

1. Outcome Measures

Number of participants who increased their leadership intensity or involvement in at least one role.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	150

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Extension researcher Ben Winchester has examined the demand for community leadership. He considered the number of board and elected positions needed by government and nonprofits in Greater Minnesota, and estimates that one in every 34 rural Minnesotans must serve in a leadership position. In comparison, one in every 143 urban residents must serve. According to the Blandin Foundation Rural Pulse survey, 41 percent of rural residents say that they have served in a leadership role. This constitutes a significant 12 percent decline since 2013 study findings.

What has been done
Leadership and civic engagement programs at University of Minnesota Extension offer communities the opportunity to sponsor leadership education programs. Through Extension-led programs, sponsors actively encourage participants to serve or to commit more to leadership in their communities. In 2018, 27 of the 37 cohort programs (described in outputs) focused on growing leadership and civic engagement.

Results
During 2018, leadership role change data were collected with 227 participants in ten cohort programs. Of the participants, 150 of the 227 participants (66.1 percent) increased their level of involvement in at least one of their organizational roles--either a new role or an increase from inactive to active or leader roles. The outcomes varied by cohort group, with three cohorts creating leadership growth among 80 percent or more of their participants.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development
803	Sociological and Technological Change Affecting Individuals, Families, and

Communities

Outcome #2

1. Outcome Measures

Percentage of program alumni who report in follow-up surveys that the program helped make public meetings, planning sessions, or committees more effective.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	100

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Before a community event is a success or an economic development strategy is implemented, community meetings take place. That makes leading productive and civil community meetings critical to successful democratic process. It is not practical or affordable for communities to hire professional facilitators for every community meeting. That means that knowledge of effective facilitation and civic engagement is an essential skill for local leaders.

What has been done
Extension leadership and civic engagement educators make teaching skilled facilitation a priority as they educate community leaders. The goal is to help emerging and existing leaders understand that good meetings are critical, to pass along practical tools for success, and to make skilled facilitation a habit.

Results
100 percent of 107 program alumni surveyed after graduation from a leadership cohort reported that the program helped them make meetings, planning sessions, or committees more productive, at least "to a slight extent." The vast majority (84.1 percent) reported that the cohort program helped them "to a moderate or great extent." As a result, community decisions are being made more productively with effective civic engagement processes.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development
803	Sociological and Technological Change Affecting Individuals, Families, and

Communities

Outcome #3

1. Outcome Measures

Number of community or economic development decisions that were influenced by applied research or education.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	6

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Economic development and public finance decisions, especially in rural areas with few resources and few professional staff, may be based on assumptions, fears and antiquated information. Applied economics research from University of Minnesota Extension explains local economies and their dynamics so that community leaders act on solid information as they invest critical resources in the local economy.

What has been done
The community economics team uses demonstrated research methods to analyze economies and inform local decisions. Examples of applied research provided in this evaluation include: 1) economic impact analysis; 2) business retention and expansion, 3) visitor profiles; 4) rural business succession strategies.

Results
Of seven communities surveyed who received economic research in 2018, six (86 percent) community stakeholders agreed that the program influenced community or economic development decisions. Communities reported that: 1) their community had moved forward with all priority projects discussed; 2) their community had used the report to communicate the impact of their programs to stakeholders and legislators; 3) the reports influenced the scale and size of the economic development project they chose; 4) the program created more support for local arts; 5) the report helped them make the case for additional funds; 6) the education inspired the community to host a series of workshops about business succession for business owners nearing retirement.

4. Associated Knowledge Areas

KA Code	Knowledge Area
602	Business Management, Finance, and Taxation
608	Community Resource Planning and Development
803	Sociological and Technological Change Affecting Individuals, Families, and Communities

Outcome #4

1. Outcome Measures

Number of positive effects on "capitals" that are essential to the vitality of communities (including human, social, civic, financial, built, health, cultural, and natural) that were stimulated by applied research or education in communities.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	48

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
"Capitals" are community assets that can be leveraged to keep towns vital and prosperous. As described by Flora and Flora, community capitals include human capital, social capital, civic and political capital, financial capital, cultural capital, health, and natural environment. Community development programs are in a position to create connections that help communities grow their capitals.

What has been done
Community-based Extension education and applied research helps communities examine critical questions and mobilize residents to act. Examples include business retention and expansion, economic impact assessment, leadership and civic engagement, and resident recruitment initiatives.

Results
Follow up surveys and interviews in 12 communities where Extension worked in 2018 highlighted 48 long-lasting effects on community capitals. (Human capital assessments were excluded because knowledge gains are assumed.) Twelve of these highlighted new community networks working together; 10 highlighted stronger civic action; 6 featured new financial assets; 4 featured new cultural events or assets; 3 described new built constructions, and 4 described newly

protected natural environments.

4. Associated Knowledge Areas

KA Code	Knowledge Area
602	Business Management, Finance, and Taxation
608	Community Resource Planning and Development
803	Sociological and Technological Change Affecting Individuals, Families, and Communities

Outcome #5

1. Outcome Measures

Researchers will develop B3 tools and programs that will help test and determine the impact of design in new and renovated publicly funded buildings in Minnesota. (Reported as the number of buildings using the tools).

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	46

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
According to the Environmental Protection Agency, the average American spends 87 percent of their time indoors. How we feel about our built environments can affect overall health, mood, performance and retention.

What has been done
Abimbola Asojo, Denise Guerin, Carin Martin and their team developed the sustainable post-occupancy evaluation survey (SPOES), a self-administered and internet-based questionnaire that provides a quantitative analysis of occupants' satisfaction. Specifically, they identified 12 indoor environmental quality (IEQ) categories that contribute to overall occupant wellbeing in Minnesota B3 buildings. The IEQ categories include overall lighting conditions, cleaning and maintenance, furnishings, technology, view conditions, privacy, function, appearance, indoor air quality, vibration and movement, acoustic quality and thermal conditions.

Results

Overall, SPOES provides a quantitative analysis of occupants' satisfaction and helps direct attention to both successful areas and areas that need improvement. By prioritizing the problem areas identified by SPOES, business owners and facility managers are empowered to make changes that enhance occupant satisfaction, health and wellbeing and reduce recruiting and training expenses.

To date, 55 SPOES reports exist for 46 buildings in Minnesota (including the new Minnesota Senate Building) and the research team has been approached by architecture firms to conduct pre- and post-occupancy evaluation for their buildings to help them better engage building occupants and bring employee health and wellbeing to the forefront of their practices.

4. Associated Knowledge Areas

KA Code	Knowledge Area
608	Community Resource Planning and Development
803	Sociological and Technological Change Affecting Individuals, Families, and Communities
804	Human Environmental Issues Concerning Apparel, Textiles, and Residential and Commercial Structures

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Other (None)

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

To evaluate the impact of community vitality programming, Extension routinely surveys and interviews individuals and community stakeholders who are part of Extension programs. Pre and post-analysis of participation in community leadership are routine with cohort programs. Surveys of alumni examine how past participants are using Extension education and applied research in their community work. Post-program surveys help us understand the degree to which applied research makes a difference in community decisions.

For communities who are interested in a deeper understanding of their initiatives, Extension conducts ripple effect mapping events in communities. This method draws from community capitals research (Flora, et. al., 2008). A structured format helps communities share what happened as a result of programs and networks created by Extension. Information about outcomes is coded to understand what kind of capital these effects bring to communities -- human, social, political, civic, natural resource, cultural, financial or built.

In 2018, an evaluation of ten leadership programs showed that 66.1 percent of participants

have increased the amount of leadership they are providing in communities. Six of seven communities surveyed agreed that applied research had influenced community or economic development decisions.

MAES. Publication of peer-reviewed papers and success in obtaining external grants are typical measures of evaluating the quality of basic and applied research. The projects reported in this planned program led to the publication of three peer-reviewed journal articles during FY18.

Key Items of Evaluation

In 2018, an evaluation of ten leadership programs showed that 66.1 percent of participants have increased the amount of leadership they are providing in communities. Six of seven communities surveyed agreed that applied research had influenced community or economic development decisions.

V(A). Planned Program (Summary)

Program # 7

1. Name of the Planned Program

Sustainable Energy

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
131	Alternative Uses of Land	10%		15%	
401	Structures, Facilities, and General Purpose Farm Supplies	10%		10%	
402	Engineering Systems and Equipment	5%		25%	
503	Quality Maintenance in Storing and Marketing Food Products	5%		5%	
511	New and Improved Non-Food Products and Processes	5%		15%	
601	Economics of Agricultural Production and Farm Management	5%		5%	
604	Marketing and Distribution Practices	5%		5%	
605	Natural Resource and Environmental Economics	5%		5%	
607	Consumer Economics	5%		5%	
608	Community Resource Planning and Development	5%		0%	
610	Domestic Policy Analysis	5%		5%	
803	Sociological and Technological Change Affecting Individuals, Families, and Communities	5%		5%	
805	Community Institutions and Social Services	5%		0%	
901	Program and Project Design, and Statistics	5%		0%	
903	Communication, Education, and Information Delivery	20%		0%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890

Plan	8.1	0.0	49.8	0.0
Actual Paid	19.7	0.0	31.1	0.0
Actual Volunteer	0.9	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
607313	0	299132	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
2121437	0	2090719	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
1464266	0	3046438	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Extension. Sustainable Energy programming at U of M Extension is primarily carried out through the Clean Energy Resource Team (CERTs). CERTs are a statewide partnership with a shared mission to connect individuals and their communities to the resources they need to identify and implement community-based clean energy projects. CERTs activities in Extension are carried out with the following partners: University of Minnesota Regional Sustainable Development Partnerships, The Great Plains Institute, Southwest Regional Development Commission, and the Minnesota Department of Commerce and its Division of Energy Resources.

In 2018, CERTs demonstrated the significance of its work over time by publishing 70 new stories to its Minnesota Energy Stories blog. These stories included case studies about CERTs seed grant projects, highlights of successful projects, interviews with business owners who made changes to energy consumption with CERTs intervention, and summaries of tours and events that focused on clean energy options. Continuing its work in public education, CERTs hosted 21 events to highlight energy-savings opportunities through workshops, tours, and forums. Additionally, CERTs connected with Minnesotans directly through 262 outreach activities, including meetings with community-based organizations, hosting tables at events. CERTs oversaw the use of $100,000 awarded to seed grants for 30 local clean energy projects. CERTs piloted new campaigns and tested out new models for scaling up sustainable energy impacts.

Overall, CERTs programming is now saving and offsetting 45.8 billion BTUs of energy annually. This is equivalent to powering 1.3 million LED light bulbs for an entire year.

MAES. In addition to discovering novel forms of bioenergy, research on sustainable energy is providing a better understanding of how we can use renewable energy sources and technologies in ways that are both economically and environmentally friendly. 2018 highlights include:

- Terpolymers of L-Lactic Acid, Delta Valero lactone and Organosolve lignin were successfully polymerized in ring-opening polymerization reactions, resulting in lignin-containing polymers with good flexibility, decreased UV transmission and low water transition rate.

• Researchers provided genome sequences and transcriptional profiles of two green algae to the National Center for Biotechnology Information.
• Researchers developed a chemical method to extract phytate as a valuable chemical from corn ethanol co-products. The team is receiving inquiries from companies all around the world that are interested in licensing this innovation.
• A study looked for ways to help swine producers decrease their environmental footprint, and found that heat lamps in breed-to-wean barns and ventilation systems across all three phases of pork production were the most significant users of energy. Focusing on improving efficiency of these electrical loads should provide producers with opportunities to improve their environmental footprint and also increase profitability.

• A study of the potential of microalgae (MAE) as pig feed found that pigs fed one percent, five percent or 10 percent MAE diets weighed 2.6 to 3.3 pounds more than pigs fed the control diet at the end of the nursery period. Additionally, mortality in pigs fed MAE was lower. This study shows the potential of MAE diets to support growth and health of nursery pigs but more research is needed to identify ideal microalgae species and microalgae co-products.
• New solar panels installed at the West Central Research and Outreach Center at Morris serve a duel-purpose. While power generation is the solar panels' main purpose, they were strategically placed 8 to 10-feet above ground surface in order to provide shade for 30 to 40 cows at each of two structures. With the addition of these panels, the dairy is at 80 percent of its goal to be a net-zero operation.

2. Brief description of the target audience

Extension programming through Clean Energy Resource Teams is delivered in seven regions spanning the state of Minnesota. CERTs focuses its work with the following audiences: governmental units (cities, counties, schools, tribal nations), utilities, small businesses, farmers, and underserved communities.

MAES research reaches agriculture and natural resources industry representatives, biotechnology company representatives, policymakers, state and federal agency representatives, private citizens and entrepreneurs.

3. How was eXtension used?

CERTs is using eXtension as a go-to resource. Staff go to eXtension to research farm energy resources. This research informs presentations for public and state-funded research and projects. eXtension increases the team's knowledge about specific energy-efficient farm technologies. Content in eXtension helps CERTs staff discern which Extension programs in other states are the "authority" on given subjects. eXtension also helps substantiate best practices and verify vendor claims.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	9215	91780	49	45

2. Number of Patent Applications Submitted (Standard Research Output)
Patent Applications Submitted

Year:	2018
Actual:	6

Patents listed
Patents Issued
Coatings Containing Polymer Modified Enzyme for Stable Self-cleaning of Organic Stains: 6353106 - 6/15/2018

Patent Filed
Bioactive Materials: 15/810,700 - 11/13/2017; Bioactive Materials: 15/810,713 - 11/13/2017; Electrochemical Removal of Sulfide Species and Phosphorus Species: 15/814,889 - 11/16/2017; Compositions Including Lignin and Methods for Making the Same: 62/645,940 - 3/21/2018; Coatings Containing Polymer Modified Enzyme for Stable Self-cleaning of Organic Stains: 2018-107935 - 6/5/2018

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	0	28	28

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Seed grant dollars will provide opportunity and support for clean energy projects to occur in Minnesota communities.

Year	Actual
2018	100000

Output #2

Output Measure

- Workshops, tours and forums will provide unbiased information regarding energy efficiency and renewable energy to target audiences.

Year	Actual
2018	21

Output #3

Output Measure

- Subscribed members to the CERTs list serve will receive regular communication and education about clean energy resources in Minnesota.

Year	Actual

2018 14300

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Research will investigate and help develop novel sources of bioenergy.
2	Number of participants who report they are likely to take action in their homes, businesses and communities for energy efficiency and renewable energy
3	Number of BTUs (in billions) saved as the result of annual energy savings, either through energy efficiency or by offsetting current energy sources with renewable energy
4	Research will lead to the development of new and improved forms of renewable, biodegradable plastics (reported as the percent of lignin content used in new product).

Outcome #1

1. Outcome Measures

Research will investigate and help develop novel sources of bioenergy.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Bioenergy is a valuable alternative to fossil energy. Despite decades' efforts, commercial production of bioenergy is facing many barriers, including issues with biomass production and logistics, bio-conversion processes and bio-refining processes.

What has been done
Microwave-assisted pyrolysis (MAP) is a new thermochemical process that converts biomass and recycled wastes to bio-oil and fuels. Specifically, MAP maximizes yields by recovering methyl ester from biodiesel vacuum distillation bottoms (VDBs). Compared with the conventional electrical heating pyrolysis, MAP is more rapid, efficient, selective, controllable and flexible. However, biodiesel distillation, the most significant and primary purification process, produces a waste stream of VDBs that represents approximately 5 to 15 percent of the crude biodiesel.

Roger Ruan and his team developed a MAP reactor with a fixed-bed microwave susceptor silicon carbide catalyst that absorbs microwave radiation and quickly achieves a high temperature allowing rapid heating of VDBs, and attaining targeted catalytic reforming while avoiding unwanted dimerization and derivatization.

Results
This new MAP technology recovers valuable methyl esters from VDBs, solving the waste formation problem by recovering a significant amount (approximately 85 percent wt/wt) of the VDBs as a transparent bio-oil composed mostly of methyl esters.

Testing shows the bio-oil can be blended back into the initial distillate stream and that it passes all ASTM D6751 tests required for commercial biodiesel. The process is easily integrated into existing biodiesel processes and can increase biodiesel yield up to 10 percent, resulting in more biodiesel sold than low grade heating fuel. Estimated net economic value of the system is $1.4

million per year with a payback period of about 2 years for a 10 million gallon biodiesel plant.

4. Associated Knowledge Areas

KA Code	Knowledge Area
131	Alternative Uses of Land
402	Engineering Systems and Equipment
511	New and Improved Non-Food Products and Processes
601	Economics of Agricultural Production and Farm Management
605	Natural Resource and Environmental Economics

Outcome #2

1. Outcome Measures

Number of participants who report they are likely to take action in their homes, businesses and communities for energy efficiency and renewable energy

Not Reporting on this Outcome Measure

Outcome #3

1. Outcome Measures

Number of BTUs (in billions) saved as the result of annual energy savings, either through energy efficiency or by offsetting current energy sources with renewable energy

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	45819

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Minnesota's energy supply is not as clean, efficient, reliable and affordable as it could be. In 2015, Minnesotans spent $19 billion and consumed a total of 1,770 trillion BTUs of energy (electricity, natural gas, petroleum products, coal and biomass) to supply energy needs. Energy use spreads across four main sectors: transportation (25 percent of total use), residential (21 percent); commercial (20 percent) and industrial (34 percent).

What has been done
CERTs works with Minnesota communities to connect them to resources, research-based information, and networks that advance clean energy projects. The goal is to help Minnesota meet energy efficiency and renewable energy goals, many of which were signed into law in 2007 with Minnesota's Next Generation Energy Act. The law requires Minnesota utilities to produce 25 percent of energy using renewable resources by 2025 and established a statewide energy conservation goal of 1.5 percent of annual retail electric and natural gas sales.

Results
In 2018, a total of $45.8 billion BTUs in annual energy savings or renewable energy has offset by CERTs programs. This includes the following results: 1) 28 businesses completed energy efficiency and solar projects (16.6 billion BTUs); 2) referred governmental units to resources for clean energy projects, so that six cities, one county, and one school completed projects (13.8 billion BTUs); 3) promoted efficiency and solar programming for utilities, including engagement of businesses, tribal nations, multi-family housing, and low-income senior housing (13.1 billion BTUs). The remaining energy savings achieved in 2018 were from farmers adopting solar energy, energy efficiency at rural groceries, and leveraging programs like Minnesota Technical Assistance Program and Minnesota GreenCorps to assist local governments with energy efficiency projects.

4. Associated Knowledge Areas

KA Code	Knowledge Area
402	Engineering Systems and Equipment
503	Quality Maintenance in Storing and Marketing Food Products
511	New and Improved Non-Food Products and Processes
604	Marketing and Distribution Practices
605	Natural Resource and Environmental Economics
607	Consumer Economics
608	Community Resource Planning and Development
805	Community Institutions and Social Services

Outcome #4

1. Outcome Measures

Research will lead to the development of new and improved forms of renewable, biodegradable plastics (reported as the percent of lignin content used in new product).

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	85

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Lignin-based plastics are eco-friendly alternatives to traditional petroleum-based plastics. However, even the best current lignin-based plastics, and especially their mechanical properties, leave much room for improvement.

What has been done
Previous formulations are limited in the amount of lignin that can be incorporated into the final plastic. These materials exhibit significant deterioration in properties with lignin content higher than 35-40 percent.

Simo Sarkanen and his team have developed new generations of lignin-based plastics using processes that can be easily scaled to industrial volumes. For the first time, innovative lignin plastics with very high lignin content exhibit properties comparable or even superior to conventional polystyrene and polyethylene plastics.

Results
The high-lignin-content plastics and polymeric materials show promising tensile strengths (>50 MPa) with formulations using 85-100 percent lignin levels. Not only are these plastics stronger than previous lignin-based plastics, but they add value to the bio-refining and pulp industries that produce lignin as a byproduct and most often burn it for its fuel value.

This technology offers a route to realizing significant commercial value from lignin in the form of a new renewable, biodegradable plastic. It is generally recognized that the profitable conversion of lignocellulosic polysaccharides to liquid fuels and organic chemicals depends on the successful valorization of the lignin in the starting plant materials (including wood).

4. Associated Knowledge Areas

KA Code	Knowledge Area
131	Alternative Uses of Land
402	Engineering Systems and Equipment
511	New and Improved Non-Food Products and Processes
605	Natural Resource and Environmental Economics

V(H). Planned Program (External Factors)

External factors which affected outcomes
- Other (none)

Brief Explanation

V(I). Planned Program (Evaluation Studies)

Evaluation Results

The CERTs evaluation plan tracks the intentions and follow through of those who are educated by or receive seed grants or assistance from the CERTs program. CERTs quantifies total BTUs of energy saved annually through campaigns, technical assistance, utility support, and seed grants. In 2018, total number of BTUs saved or offset is 45.8 billion. This energy conservation is enough to heat 574 Minnesota homes or power electricity for 1,465 homes annually. This energy-savings amount is the result of 2,620 new household or institutional (business, government, utility, and farm) changes that significantly save or offset energy use.

MAES. Publication of peer-reviewed papers and success in obtaining external grants are typical measures of evaluating the quality of basic and applied research. The projects reported in this planned program led to the publication of 28 peer-reviewed journal articles during FY18.

Non-NIFA research funds and grants leveraged by PIs in this program include: Minnesota Department of Agriculture, MnDRIVE Environment and the National Science Foundation.

Additionally, Ping Wang was issued a patent: Coatings Containing Polymer Modified Enzyme for Stable Self-cleaning of Organic Stains (#6353106).

Key Items of Evaluation

In 2018, total number of BTUs saved or offset is 45.8 billion. This energy conservation is enough to heat 574 Minnesota homes or power electricity for 1,465 homes annually. This energy-savings amount is the result of 2,620 new household or institutional (business, government, utility, and farm) changes that significantly save or offset energy use.

V(A). Planned Program (Summary)

Program # 8

1. Name of the Planned Program

Building Healthy, Strong Families

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
801	Individual and Family Resource Management	45%		20%	
802	Human Development and Family Well-Being	45%		20%	
803	Sociological and Technological Change Affecting Individuals, Families, and Communities	0%		30%	
805	Community Institutions and Social Services	0%		20%	
806	Youth Development	10%		10%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	26.2	0.0	9.0	0.0
Actual Paid	26.4	0.0	5.5	0.0
Actual Volunteer	3.2	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
989248	0	48629	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
2459026	0	613649	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
4815589	0	173033	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

MAES. 2018 research related to building healthy, strong families continued to focus on underserved populations and how new technologies are changing family dynamics and parenting. Some specific projects also address how finances can positively and negatively affect family dynamics. 2018 highlights include:

- A ten-year study of more than 2,000 students in at the University of Arizona led to the identification of some traits that help determine if someone will be good with money after they graduate. Specifically, financial self-sufficiency was the most important trait identified which can be increased through education and training.
- A three-part training module based on research findings on parents with disabilities in the child welfare system was developed and made available for social workers, child welfare workers, foster care parents and others through the Center for Advanced Studies of Child Welfare.
- Research on the role African American grandmothers feel they play in their grandchildren's lives revealed they are very focused on activities to ensure school success and a desire to dispel negative views of African American families. Notably, they also identified their personal legacies as being tied to their grandchildren more than their adult children regardless of the level of success of the latter.
- A study on elder family financial exploitation (EFFE) included work on a new database that includes a sample of 28 family members from 23 different family systems. Results reinforce the complexity of EFFE including that there are often multiple perpetrators and multiple victims within a family system. Additionally, the consequences of EFFE often go beyond financial impact to affect health and wellbeing of direct and secondary victims.

Extension. In 2018, family development educators continued to focus on strategies to increase access to education that addresses current challenges in family life. For example, the team continued to increase their capacity to deliver online learning, expanding educator's knowledge about effective online program delivery. The team launched the third and final online course in a series of educational events about overindulgence, targeted to parents who are most likely to have access to online learning. Over 1,000 participants have taken at least one overindulgence course, reaching local, state, national and international audiences. The team will be launching a four-hour online program about co-parenting, and will continue to offer the Financial Education Certificate online to help build the knowledge and confidence of practitioners who can use financial literacy education to improve the capacity of low-income clients.

To provide better access to education among Minnesotans of color, the family development team creates formal partnerships with organizations that already reach audiences in need of support. In 2018, U of M

Extension and the Consulate of Mexico in St. Paul signed a second Memorandum of Understanding to continue to provide financial education to participants of Mexican ancestry. In five months, 46 two-hour workshops reached 763 participants in 25 rural counties. The team collaborated with tribal schools to provide financial education to American Indian Youth. As described in outcomes, a growing partnership with the Department of Corrections is bringing parent education to incarcerated fathers. This is a small sampling of a wide variety of partnerships that help us reach Minnesota's diverse families.

2. Brief description of the target audience

In 2018, 36 percent of participants in family development programs were Minnesotans of color. This is the result of intentional outreach to Latino communities, Native American communities, African immigrants, Koran immigrants, Hmong parents, incarcerated fathers, and more. Building Strong, Healthy Families programs serve professionals in collaborating agencies such as mental health services, parent educators, schools, courts, family service agencies, health care settings, organizations and businesses. Youth and money programs reach adolescents moving into independent living directly or through their educational resources. Family development programs are highly effective in attracting low-income, minority and immigrant families through partnerships with trusted community organizations.

3. How was eXtension used?

- Staff attended monthly meetings to create an RFP for the Impact Collaborative Summit. They identified Extension mental health professionals, created a national Extension survey and identified virtual bridge webinars.
- Staff attended the Behavioral Health Impact Collaborative in Indianapolis. The Summit helped Extension professionals turn an idea into a project or program with measurable impact.
- Staff worked with the he Military Families Learning Network.
- Staff were members of the Financial Security for All community of practice.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	12747	210464	416	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total

Actual	32	12	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of professionals trained to educate and support families.

Year	Actual
2018	7793

Output #2

Output Measure

- Number of workshops and classes held -- face-to-face or online.

Year	Actual
2018	586

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Professionals who work with parents and families will improve their skills. (Outcome expressed as a percentage of participants who report improving skills, or the significance level showing meaningful change in skills, depending on the evaluations methods used.)
2	Parents will improve their parenting practices. (Outcome is the significance level at which parents demonstrated they made meaningful change in behavior.)
3	Divorcing or unmarried parents will improve their co-parenting relationships in ways that are known to be effective in supporting positive child outcomes. (Outcomes expressed as percentage of participants who report improved communication, planning or resource sharing.)
4	Individuals, families and employees who participate in Resource Management programming will report they have used the knowledge and materials provided by the program to change behaviors related to targeted financial management goals. (Outcome is the significance level demonstrating that parents are making meaningful change in financial condition.)
5	Research will provide information and guidance to educators and school administrators that will help lower the achievement gap in the state.
6	Researchers will develop technology tools that will enhance learning and connectedness from existing parenting classes for both parents and staff (Reported as the number of parents and staff reached by new tools).

Outcome #1

1. Outcome Measures

Professionals who work with parents and families will improve their skills. (Outcome expressed as a percentage of participants who report improving skills, or the significance level showing meaningful change in skills, depending on the evaluations methods used.)

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	39

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Minnesota is losing 2,000 affordable rental options annually. Lack of affordable housing exasperates poverty because home ownership is a key way for families to increase wealth. Home ownership is a major cause of wealth disparities based on race. Successful home ownership is built on a healthy trajectory that includes successful renting, which is more difficult when rent is not affordable. Renting can be a challenge for those who have never rented before, had a previous challenging rental experience, or face barriers stemming from previous life situations.

What has been done
Social service providers can deliver information about renting in a timely way to low-income families, increasing their knowledge and the likelihood they will have a successful rental history, leading eventually to home ownership. The RentWise program helps local social service providers easily deliver quality education about renting with lesson plans, participant resources and more. Workshops train agency staff who use the RentWise curriculum in conjunction with other needed services. Culture and language-adapted workshops are delivered to Latino families.

Results
39 percent of professionals who were trained to deliver Rentwise programming reported they improved their skills in delivering renter education, and their ability to teach tenant education. Data was based on evaluation data from 99 participant surveys. A total of 37 local agencies were trained to conduct RentWise programs in 2018, affecting renters in neighborhoods and communities across Minnesota.

4. Associated Knowledge Areas

KA Code	Knowledge Area

801	Individual and Family Resource Management
802	Human Development and Family Well-Being
805	Community Institutions and Social Services

Outcome #2

1. Outcome Measures

Parents will improve their parenting practices. (Outcome is the significance level at which parents demonstrated they made meaningful change in behavior.)

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	45

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Fathers matter to children, and this is true even when fathers are incarcerated. In the U.S., as many as 10 million children have experienced parental incarceration and 2.7 million children have one or both parents currently incarcerated. Families with an incarcerated family member are significantly more likely to experience poverty and homelessness. Father involvement is a key protective factor for children, and imprisonment can detrimentally affect the role men play in their children's lives. This negative impact on fathers and parenting increases risk factors for already vulnerable children and their families.

What has been done
To support fathers in their efforts to be the best dads they can be, five U of M Extension educators enrolled 121 fathers across three correctional facilities in Minnesota through a parent education contract operated by the Minnesota Department of Corrections in 2018. Sixty percent were non-white. The 121 program participants were fathers to 327 children, and 91 of these fathers will be released by 2020. They participated in 12 parent education sessions, two hours each; 63 percent finished the course.

Results
From before the class to after, fathers significantly improved their knowledge and skills regarding the following items: 1) I know how to: discipline my child without hitting or spanking; set clear limits for my child; keep my child healthy and safe; handle everyday challenges like sleep, toileting, food, dislikes, etc. 2) I am aware: of how children change; of how my relationships impact my child's development. 3) I do things with and for my child to help him learn. 4) I can get

my child to cooperate without yelling. 5) I make time to play or talk with my child. Results were statistically significant. (Quantitative outcome is the percentage that experienced statistical significance.)

4. Associated Knowledge Areas

KA Code	Knowledge Area
802	Human Development and Family Well-Being
806	Youth Development

Outcome #3

1. Outcome Measures

Divorcing or unmarried parents will improve their co-parenting relationships in ways that are known to be effective in supporting positive child outcomes. (Outcomes expressed as percentage of participants who report improved communication, planning or resource sharing.)

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	84

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Though divorce rates are declining, 26 percent of children currently live with a single parent (Pew Research Center). Divorce and separation contribute, along with other adverse childhood experiences, to poor health outcomes such as depression and suicide attempts (Dube, et.al.). Co-parenting positively relates to parenting and child adjustment (Feinberg). For low-income families, supporting co-parenting after relationship dissolution is associated with increased father involvement, which buffers against the negative effects of...dissolution (Dush et. al.).

What has been done
Parents Forever has been a vital parent education program for Minnesota's parents since 1994. The program reaches parents through referrals from court systems concerned about the effects of contentious divorce situations on children. The program is offered online and in person with trained trainers available in multiple community settings.

Results
Participants (n=1,771) responded to five questions assessing improvements after taking the class: 93 percent reported using one of the co-parenting strategies they learned about (e.g.,

developing a co-parenting plan); 86 percent reported encouraging their child to spend time with the other parent; 98 percent reported they never or seldom talk badly about or "put down" the other parent in front of the children; 55 percent reported they never or seldom experienced conflict with the child's other parent that children observed; and 89 percent reported they sometimes to very often feel they have cooperated effectively in co-parenting with the other parent. (Quantitative outcome is an average of findings.)

4. Associated Knowledge Areas

KA Code	Knowledge Area
802	Human Development and Family Well-Being
806	Youth Development

Outcome #4

1. Outcome Measures

Individuals, families and employees who participate in Resource Management programming will report they have used the knowledge and materials provided by the program to change behaviors related to targeted financial management goals. (Outcome is the significance level demonstrating that parents are making meaningful change in financial condition.)

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	73

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
One in 20 Minnesotans identify as Hispanic--the fastest growing ethnic minority group in Minnesota. New Hispanic residents are often unsure how to navigate local economic and education systems. Still, they have American dreams -- to support their children, work, get out of debt and even start a business. Among Mexican-Americans in Minnesota, 76 percent work over 35 hours a week, yet median annual earnings hover around $30,400. Given access to education and opportunity, these families and their children will thrive and continue to contribute.

What has been done
An agreement between the Consulate of Mexico in St. Paul and University of Minnesota Extension includes funding for a financial education and family asset protection reference desk. The agreement, the first between the Consulate and the University of Minnesota, is now in its second year. The goal is to protect and empower Mexican nationals living abroad. Experienced

bilingual educators offer classes or one-on-one sessions depending on the needs of the individual or family.

Results
Based on evaluation data from 490 participants who attended the education series, participants reported significant improvement in their confidence in 13 areas related to protecting personal and family assets; 73 percent improved their skills at the highest variable. The most significant gains were made regarding: 1) confidence in ways to manage or prevent debt; 2) identifying scams and frauds and where to find help; 3) looking for financial, legal or education resources in the community; 4) organizing important papers; 5) opening and managing a checking, savings account or certificate of deposit; 6) sharing information with others; 7) interpreting a credit score; 8) building, improving and maintaining good credit; and, 9) identifying the benefits of post-secondary education.

4. Associated Knowledge Areas

KA Code	Knowledge Area
801	Individual and Family Resource Management
802	Human Development and Family Well-Being

Outcome #5

1. Outcome Measures

Research will provide information and guidance to educators and school administrators that will help lower the achievement gap in the state.

Not Reporting on this Outcome Measure

Outcome #6

1. Outcome Measures

Researchers will develop technology tools that will enhance learning and connectedness from existing parenting classes for both parents and staff (Reported as the number of parents and staff reached by new tools).

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	450

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Despite a range of supports to parents and families, the single asset most report lacking, and one that could have a positive impact on parenting, is a felt connectedness to their communities. Technology has the potential to enhance and prolong the experience parents have with their weekly early childhood family education (ECFE) courses and potentially provide a community connection.

What has been done
Susan Walker and her team developed the Parentopia platform collaboratively with staff and parents. The closed technology platform provides parents with additional secure and private ways to connect with other parents and staff outside of class hours. The platform includes discussion, messaging, photo sharing and a program calendar for continued conversation, program information and opportunities for learning. Pilot testing revealed the need for the platform to be streamlined and more mobile friendly. The current version was launched in March 2017.

Results
By the end of the yearlong pilot program in four ECFE sites, staff and parents reported enjoying having the platform available. Parents like easy ways to get program information, connecting with others and learning more about their children's learning. Staff like having an easy outlet to reach parents. Hybridizing ECFE reveals a huge shift in the program culture that for 40 years has been face to face only. Another sign of the cultural shift was the request to continue the project by staff and parents.

As of 2018, the Parentopia platform has expanded to five sites in the St. Paul school district, and three additional school districts in Minnesota to reach over 450 parents and staff. Research continues to examine technology implementation needs and platform use benefits to learning and social capital.

4. Associated Knowledge Areas

KA Code	Knowledge Area
802	Human Development and Family Well-Being
803	Sociological and Technological Change Affecting Individuals, Families, and Communities
805	Community Institutions and Social Services

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Natural Disasters (drought, weather extremes, etc.)
- Public Policy changes
- Other (Impact reporting)

Brief Explanation

• A continued high frequency of natural disasters created higher demand for time invested in disaster recovery financial resources.
• The current immigration climate was an external factor that influenced outcomes,

creating the impetus for the class delivered for the Mexican Consulate about keeping papers safe. Participants were extraordinarily interested in this information. The Latino Financial Literacy Team created a bilingual resource and lesson plan to meet this need.

MAES. A planned research outcome (#5) was not reported on due to research related to lowering the achievement gap being moved to the Youth Development Program in 2016. Brief highlights related to this work are provided in the Youth Development activity section.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

In 2018, Extension piloted a first iteration of the Department of Corrections father-focused parent education course, using a series of pre-post surveys and session evaluations. Findings from the evaluation and the reflections of educators led to a revision of curriculum and evaluation tools. We also conducted a simple outcome evaluation for Latino Financial Literacy programs. The Parents Forever program continues to have two levels of evaluation, post-course and a six month follow up. We are still planning to launch a replication study of the online course to compare outcomes for those who received no parent education to a sample who went through the program. This more rigorous level of evaluation answers a call in peer-reviewed literature for more rigorous evaluation of divorce education programs.

Evaluation of all of the programs are finding statistical significance in levels of confidence and knowledge of appropriate parenting and financial management.

MAES. Publication of peer-reviewed papers and success in obtaining external grants are typical measures of evaluating the quality of basic and applied research. The projects reported in this planned program led to the publication of 12 peer-reviewed journal articles during FY18.

Key Items of Evaluation

Evaluation of all of the programs are finding statistical significance in levels of confidence and knowledge of appropriate parenting and financial management.

V(A). Planned Program (Summary)

Program # 9

1. Name of the Planned Program

Health and Nutrition

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
501	New and Improved Food Processing Technologies	15%		10%	
701	Nutrient Composition of Food	15%		10%	
703	Nutrition Education and Behavior	15%		20%	
704	Nutrition and Hunger in the Population	15%		10%	
721	Insects and Other Pests Affecting Humans	15%		10%	
722	Zoonotic Diseases and Parasites Affecting Humans	15%		20%	
724	Healthy Lifestyle	10%		20%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	9.6	0.0	32.0	0.0
Actual Paid	16.5	0.0	28.1	0.0
Actual Volunteer	6.3	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
614083	0	683482	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1795597	0	2929336	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
4639175	0	1573751	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

In 2018, health and nutrition programs continued to expand efforts to promote positive health outcomes for families and to prevent negative outcomes of unhealthy behaviors such as obesity and malnutrition. To strengthen skills, health and nutrition direct education is continually testing and adapting its program for new audiences. For example, nutrition education curriculum was revised for English Language Learners. This curriculum will be piloted in 2019. New research indicated a need for more physical activity for Somali women, so the team developed a culturally-based video and disseminated it for use in agencies and at home.

Health and nutrition teams are also becoming more adept at leading social marketing campaigns. One partnership with Save the Food is developing a food waste marketing campaign that will be implemented in 2019. A collaboration with three Minnesota communities and the Robert Wood Johnson Foundation is implementing initiatives to develop and support a culture of health.

Among its efforts to train professionals and providers is the Smarter Lunchrooms campaign. Extension trained nearly 70 providers who will provide technical assistance to schools who can create smarter lunchroom strategies for healthy school lunch programs. Train-the-trainer programs are critical to SNAP-Ed program, so that we can foster networks that help to meet the demand.

Continued efforts to foster coalitions and networks that can change local policy and systems have resulted in stronger networks and greater involvement. New analysis is monitoring those networks and looking for success.

MAES. Research reported under this program focuses on improving the mental and physical health of Minnesotans. A particular focus is placed on identifying and overcoming barriers pertaining to children making more nutritious food choices and the health and wellbeing of the state's growing number of seniors. 2018 highlights include:

- A NIFA-supported biochemist assisted scientists at the Hormel Institute in identifying a biomarker for the early diagnosis of aggressive breast cancer. They have completed a mice study and a pilot human clinical trial is underway.
- Researchers compared 25,000 switches for genes common to 131 mammal species, including primates and humans. Four percent of the switches displayed a clear pattern--the longer the mammal's lifespan, the more strongly these switches exhibited a particular feature of DNA that helps it resist wear and tear. Targeting these genes could lead to ways to control them as we age.
- A study on vegetable liking of 9 to 12-year-old children from low-income families found that over 50

percent of children who had tried a vegetable (of the 35 studied) considered it acceptable. Corn was the most liked vegetable, closely followed by potatoes, lettuce and carrots. Artichoke had the lowest mean liking, followed by onion and beets. Overall, the study found children liked a wide variety of vegetables, which offers counter evidence to the commonly held perception that children dislike vegetables.

- Researchers at the Wearable Technology Lab have designed a patient controlled dynamic therapeutic compression tension garment. This novel garment provides patients with independent control of compression and offers hands-free power switching for constant pressure.
- The Third Annual Conference on Native American Nutrition was attended by 577 people, from 38 states, Washington DC and American Samoa; four Canadian provinces, and New Zealand and Ecuador. Fifty-six percent of registrants stated a Native American affiliation, representing over 100 tribes across the Americas.
- Several animal studies were conducted looking at the effect of different wheat (red, white, whole, refined, etc.) on reducing colon cancer risk. The results strongly show that the color of wheat, not the state of refinement, influences colon cancer risk and, specifically, that red wheat, the type used in making breads, reduces colon cancer risk.
- Researchers from the CDES and CEHD are collaborating to bring museum exhibits to people living in senior care facilities via virtual reality experiences. Research has previously shown residents living in senior care facilities feel happier, more relaxed and more positive when using virtual reality.

2. Brief description of the target audience

Targeted outreach helps the Health and Nutrition Extension team reach Minnesotans with great diversity in need, culture and life situations. EFNEP programs serve 80 percent participants of color, and hire peer-professional staff with an intentional focus on working with diverse, vulnerable communities. In 2018, the team reported 14 specific efforts to reach new and diverse families, food insecure families, the Somali community, Latinx families, Hmong families, low-income fathers, trial communities, and more. As a result of these and other efforts, 41 percent of those served are from Minnesota's communities of color. For maximum impact, Extension directs its educational programs to:

- parents and other caregivers of low-income children
- situations where more than one organization collaborates to bring SNAP-Ed classes to eligible audiences in the community
- communities that present opportunities for impacting systems, environments, and policies so that SNAP-Ed participants have every opportunity to put into practice what they learn in classes.

MAES research target audiences also include:

- Food industry.
- Health professionals including dietitians, nurses, and physicians.
- Researchers concerned with the diet, nutrition, and human health fields.
- Senior care facility staff.
- The public.

3. How was eXtension used?

Health and nutrition staff worked with eXtension in the following ways:

- They participated in the "building racial equity" initiative within the Cooperative Extension work group.
- They attended the Impact Collaborative Summit in October.
- They participated in webinars from eXtension.
- They presented a webinar as part of the Healthy Food Choices offering in the Schools Community of

Practice.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	7871	88250	10292	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year: 2018
Actual: 11

Patents listed

Patents Issued
Compositions and Methods for Transplantation of Colon Microbiota: 2012225305 - 9/21/2017; Protective Garments and Methods of Making: EP 2 958 446 - 1/18/2018; Stitched Stretch Sensor: 9885621 - 2/6/2018; Compositions and Methods for Transplantation of Colon Microbiota: 9968638 - 5/15/2018

Patents Filed
Composition and Methods for C. Difficile Treatment: 2018-567792 - 7/3/2017; Composition and Methods for C. Difficile Treatment: PCT/US2017/040591 - 7/3/2017; Freeze Dried Fecal Microbiota for Use in Fecal Microbial Transplantation: 15/837,834 - 12/11/2017; Stitched Stretch Sensor: 15/888,562 - 2/5/2018; Smart Fabrics Incorporating Low Transition Temperature Materials: 62/635,268 - 2/26/2018; Active Tension Control via Elastically-Induced, Passive Circuit: 62/635,285 - 2/26/2018; Smart Fabric: 15/905,372 - 2/26/2018; Polylactose, a Prebiotic Dietary Fiber: 62/692,206 - 6/29/2018

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	7	52	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of workshops/classes or educational presentations taught.

Year	Actual
2018	1985

Output #2

Output Measure

- Number of organizations represented in community networks.

Year	Actual
2018	423

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Percentage of participants who report knowledge change related to human nutrition knowledge.
2	Number of changes made by professionals, organizations and policy makers related to practices, organizational culture and policies that promote food literacy, active living and healthy food access.
3	Percentage of program participants who use research-based information from Extension to improve their intake of healthful foods and engagement in physical activity.
4	Research will support families, children and youth understanding of healthy food choices.
5	Collaborative research and community engagement will led to positive health outcomes for American Indian communities.
6	Research will lead to the development of human food products that have a positive impact on health (reported as the number of new projects developed).

Outcome #1

1. Outcome Measures

Percentage of participants who report knowledge change related to human nutrition knowledge.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	36

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Early childhood is a critical time that sets the stage for a lifetime of health and nutrition behaviors. Children with diets rich in whole grains have higher rates of improved health. Child care providers can play an important role in providing foods rich in whole grains to children, both setting the stage for later eating habits and establishing long-term health.

What has been done
Early childhood professionals were offered a Cooking with Whole Grains online course, with certification available through Child Care Aware. The course teaches professionals how to read labels for whole grains, shop for whole grains on a budget, prepare whole grain foods children will eat, and introduce whole grains to families. The course was reviewed by the Minnesota Department of Education and the course was approved by the Minnesota Center for Professional Development for two hours of continuing education.

Results
An average of 36.3 percent of participants reported an improvement in knowledge based on answers to pre and post-tests to monitor knowledge about a myriad of subjects covering whole grains. It should be noted that 52 percent of participants already knew this information and so had no change from pre to post-test, but 36.3 percent increased their knowledge.

4. Associated Knowledge Areas

KA Code	Knowledge Area
701	Nutrient Composition of Food
703	Nutrition Education and Behavior

Outcome #2

1. Outcome Measures

Number of changes made by professionals, organizations and policy makers related to practices, organizational culture and policies that promote food literacy, active living and healthy food access.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	328

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The 2017 MN Department of Health state health assessment makes clear that health equity in Minnesota depends on changing policies, systems and environments that shape health behaviors. For example, the lifespan of people living in higher income areas of the Twin Cities can be more than 13 years longer than people living in low income areas. Working-age adults living in households earning less than $35,000 a year are 2.5 times as likely to report having diabetes as those with higher incomes. And a decline in grocery stores in "food desserts" affect access to healthy foods.

What has been done
In 2018, Extension supported 120 coalitions, wellness committees and food networks as they implemented food charter strategies. Extension guided the networks as they enhanced local and regional food access. The largest such network, Metro Food Access Network, is currently led and supported by SNAP-Ed educators and Health and Nutrition Extension educators. Extension also supports a workplace wellness position in Anoka county.

Results
328 policy, systems and environment changes were made. They included 40 changes in workplaces. For example, workplaces implemented guidelines for healthy potlucks or created flexible break schedules for physical activity (3,577 people reached). Five schools adopted farm-to-school initiatives as part of their policy platform.

4. Associated Knowledge Areas

KA Code	Knowledge Area
703	Nutrition Education and Behavior
704	Nutrition and Hunger in the Population

724 Healthy Lifestyle

Outcome #3

1. Outcome Measures

Percentage of program participants who use research-based information from Extension to improve their intake of healthful foods and engagement in physical activity.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	58

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
According to the Minnesota Department of Health, 28.4 percent of adults in Minnesota were obese in 2017, an increase from 27.8 percent in 2016. Social determinants of health indicate that some groups in specific areas are more at risk of poor nutrition and increased risk of obesity because they are located in food deserts. The MDH statewide health assessment made it clear that Minnesota communities of color are at greater risk of experiencing health disparities. For example, 40.9 percent of American Indians were obese in 2017, compared to 26.7 percent of white Minnesotans.

What has been done
In Minnesota, EFNEP operates in the Twin Cities metro area. The program targets immigrant families and Native American communities. Nutrition educators work in a diverse array of community sites already trusted and utilized by those communities. Nutrition and lifestyle classes are conducted in several languages in these community and home visit settings. In 2018, 80 percent of EFNEP participants were from communities of color.

Results
In a study of EFNEP participants (both children and adults), using the 24-hour dietary recall tool before the class series and after, 58 percent chose healthier foods, used safe food handling practices, increased physical activity, improved ability to prepare nutritious food, gained skills to be more food secure, showed improvement in one or more food resource management practice, or engaged in more nutrition practices such as reading nutrition labels and using food safety practices.

4. Associated Knowledge Areas

KA Code	Knowledge Area
703	Nutrition Education and Behavior
704	Nutrition and Hunger in the Population
724	Healthy Lifestyle

Outcome #4

1. Outcome Measures

Research will support families, children and youth understanding of healthy food choices.

Not Reporting on this Outcome Measure

Outcome #5

1. Outcome Measures

Collaborative research and community engagement will led to positive health outcomes for American Indian communities.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Diabetes is one of the most widespread chronic diseases in the United States. In affects over 7 percent of the population and disproportionately affects racial and ethnic minorities. American Indians (AI) are the hardest hit, with prevalence rates exceeding 50 percent in some tribes.

What has been done
Efforts to-date to respond to this epidemic in AI communities have been largely unsuccessful, as most research and care is conventionally positioned in reservation contexts and designed/administered through top-down, professionally led frames that do not reach AIs who live in urban areas.

Tai Mendenhall and his team collaborated with healthcare providers in St. Paul to partner with AI community elders in the Twin Cities. Over several years, they designed and launched a

University/Community partnership called the Family Education Diabetes Series (FEDS). FEDS purposively combines Western knowledge regarding disease processes and management with Native worldviews of the Medicine Wheel and "Walking in Balance."

Results
Mendenhall and his team conducted talking circles with AI participants, wherein foci addressed included the roles of biomedical and behavioral research in health, the importance of collaborative public engagement, and the establishment of community trust. Ultimately, AI elders involved in the FEDS project maintained that researchers should not compare findings discovered with the intervention group to any kind of control/waitlist group (so as to facilitate more broad and inclusive participation in the FEDS).

Quantitative findings, assessed through a series of single-group repeated measures assays, show consistent improvements and/or maintenance of improvements-achieved in AI participants across physiological outcomes (random blood sugar, blood pressure and body-mass-index) and disease management measures (self-care and knowledge about diabetes). Qualitative findings also noted other behavior changes, including gaining or maintaining sobriety in adults, and youth becoming "health messengers" for their peers and the broader community.

4. Associated Knowledge Areas

KA Code	Knowledge Area
703	Nutrition Education and Behavior
704	Nutrition and Hunger in the Population
722	Zoonotic Diseases and Parasites Affecting Humans
724	Healthy Lifestyle

Outcome #6

1. Outcome Measures

Research will lead to the development of human food products that have a positive impact on health (reported as the number of new projects developed).

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Most Americans don't get enough fiber in their diets. Prebiotic dietary fibers have been shown to enhance digestive health, benefit the immune system, help with blood sugar control and aid in mineral absorption.

What has been done
Tonya Schoenfuss and her team have shown that the polymerization of lactose with an acid catalyst and glucose creates a soluble fiber, which they call polylactose. This novel dietary fiber can be easily ground and shows great promise as a prebiotic additive to human food products or as a supplement. As it uses lower-value dairy whey streams, polylactose also provides both economic and environmental opportunities by commoditizing a product that is otherwise of low value.

To realize this potential, polylactose must be evaluated to determine if it has prebiotic activity when consumed and if it benefits human and animal health. The FDA provides guidelines for products labeled as a dietary fiber--the first of which is animal feeding trials to determine if it has prebiotic activity in an animal model.

Results
A rat study demonstrated polylactose-fed animals had slightly improved glucose control, significantly decreased epididymal fat and had increased large intestine fermentation when compared to all other tested groups. But most significantly, liver lipid concentration of polylactose fed rats was equivalent to the normal fat control rats. Comparatively, polydextrose and fructooligosaccharides fed rats had significantly higher lipid levels than controls.

Polylactose is highly fermentable and has a profoundly positive effect on the colonic microflora. Preclinical rat studies showed significantly reduced body fat, lowered plasma leptin concentrations, improved blood glucose control and reduced fatty liver at a dietary concentration where the other prebiotics tested were not as effective.

4. Associated Knowledge Areas

KA Code	Knowledge Area
501	New and Improved Food Processing Technologies
701	Nutrient Composition of Food
704	Nutrition and Hunger in the Population

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Economy
- Appropriations changes
- Public Policy changes
- Government Regulations
- Competing Public priorities
- Competing Programmatic Challenges
- Populations changes (immigration, new cultural groupings, etc.)
- Other (Impact reporting)

Brief Explanation

MAES. The research knowledge/action outcome related to encouraging healthy food choices (#4) was not reported on this year in favor of impacts that describe a change in condition. Brief highlights related to this work are provided in the activity section.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

EFNEP programs use a 24-hour dietary recall measure that is prescribed by EFNEP federal funding. However, this evaluation has been adapted to use touch-based, iPad apps for easier use and data upload. Evaluators are creating Hmong, Somali and Karen versions of the app to serve frequent participants. This app helps the team collect better data because participants are better able to understand the questions.

In SNAP-Ed, pre-post participant surveys examine behavior change, and local policy changes are also tracked. Behavior change focuses on fruit and vegetable consumption, whole grain consumption and physical activity for the most widely used programs, primarily in school-based settings.

Behavior change studies have found that when schools offer healthier lunchroom meals, student's fruit and vegetable consumption grows to a higher level even before taking any nutrition education classes, compared to students in schools without "Smart Lunchrooms."

MAES. Publication of peer-reviewed papers and success in obtaining external grants are typical measures of evaluating the quality of basic and applied research. The projects reported in this planned program led to the publication of 52 peer-reviewed journal articles during FY18.

Non-NIFA research funds and grants leveraged by PIs in this program include: Minnesota Department of Health, MnDRIVE Robotics and the Midwest Dairy Foods Research Center.

Additionally, Elizabeth Bye and Lucy Dunne were both issued patents related to their work with the Wearable Technology Lab: Protective Garments and Methods of Making (#EP 2 958 446) and Stitched Stretch Sensor (#9885621). Michael Sadowsky was also issued two patents: Compositions and Methods for Transplantation of Colon Microbiota

(#2012225305) and Compositions and Methods for Transplantation of Colon Microbiota (#9968638).

Key Items of Evaluation

Behavior change studies have found that when schools offer healthier lunch room meals, student's fruit and vegetable consumption grows to a higher level even before taking any nutrition education classes, compared to students in schools without "Smart Lunchrooms."

V(A). Planned Program (Summary)

Program # 10

1. Name of the Planned Program

Food Safety

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
501	New and Improved Food Processing Technologies	50%		70%	
503	Quality Maintenance in Storing and Marketing Food Products	25%		20%	
504	Home and Commercial Food Service	25%		10%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	7.0	0.0	11.1	0.0
Actual Paid	13.8	0.0	10.5	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
739440	0	285169	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1869064	0	934526	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
656319	0	772747	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

MAES. Researchers are dedicated to ensuring a safer food system by providing tools and information to protect consumers and developing easier, faster and cheaper methods for the food industry to catch contamination and avoid recalls. 2018 highlights include:

- Researchers found that processed almond hull powders exhibited significantly higher emulsifying capacity, oil holding capacity, and antioxidant content than some commercial fiber products. With these levels, these almond hull powders can be made into functional beverages and cosmetic products. Several conceptual products have been created.
- A study looking at two processes for flavor encapsulation used orange oil emulsion as an evaluation test material. Results showed that fluidized bed granulation produced orange oil encapsulates with more resistance to oxidation and of higher density than spray-dried orange oil but with poorer retention of flavor.
- Six studies exploring the efficacy of Bacitracin methylene disalicylate (BMD) against multidrug-resistant Salmonella Heidelberg (MDR SH) all showed BMD supplementation significantly reduced MDR SH in the cecum compared to the Salmonella controls. An average SH reduction of 4.5- and 3.0- log10 CFU/g of cecal contents ($P<0.05$) was observed in the 3- and 5-week-old broiler chickens. However, no significant reduction was observed in 7-week-old birds. These results show BMD was highly effective on the MDR SH in the cecum of young chickens, indicating its potential to contribute to the preharvest safety of broilers.
- Findings from a study on the role of eosinophils in allergen-induced inflammation of the GI tract suggest the sHE induced by soy proteins promotes allergic responses including eosinophilia and GI inflammation and that blockage of sHE can attenuate these responses and thus serve as a strategy in the management of food allergen-driven forms of eosinophilic GI disease.
- Researchers focused on the controlling the spread of PRRS are exploring the use of cold plasma for decontaminating food and food-processing surfaces. This new technology could not only reduce the spread of PRRS but also help control foodborne illness outbreaks.

Extension. In 2018, the Extension Food Safety Program (FSP) continued to focus on three priority areas: 1) food safety certifications for food service managers and employees; 2) food preservation and safety for entrepreneurs and home growers, especially assisting cottage industry businesses in addressing state laws to keep consumers safe; and, 3) farm to school food safety systems.

Several deadly outbreaks of foodborne illnesses in 2018 brought more visibility to food safety concerns. Extension increased its efforts to bring on-farm food safety training to local growers with the addition of an educator to be part of the local foods team. Work also continued to support food entrepreneurs through the Cottage Food training course and the development of a new course for licensed food processors.

2. Brief description of the target audience

In 2018, the team again expanded its audiences to reach small- to mid-size fruit and vegetable farmers, many of whom are people of color. The team has developed four Hmong language videos to educate Minnesota's Hmong farmers in produce safety practices.

MAES. Research supports the food development industry and food processing industry, while the direct audiences of the outreach efforts are food service workers through relationships with the National Restaurant Association, food handlers in community locations, entrepreneurs who market foods through farmers markets and other local channels, fishermen, and high-risk audiences through the organizations they trust.

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	14208	666486	30	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	4

Patents listed
Patents Issued
Detection Assays and Methods: 10006906 - 6/26/2018

Patents Filed
Enhanced Filtration Using A Compressible Sorbent: PCT/US2017/064233 - 12/1/2017; Porous Nanocomposites: PCT/US2018/024100 - 3/23/2018; Methods for Microbial Screening and Identification and Identification of Targets of Interest: 15/943,000 - 4/2/2018

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	2	6	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of workshops or other educational events conducted.

Year	Actual
2018	53

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Research will increase number of viable technologies to improve food safety.
2	Research will increase understanding of threats to food safety from microbial and chemical sources.
3	Percentage of participants that significantly changed one or more food safety practice as a result of attending classes intended to improve food safety practices.
4	Percentage of pass rates among those who participate in food safety education programs to become certified food managers. (The Minnesota Department of Health reports a decrease in critical inspection violations in establishments that employ a Certified Food Manager.)

Outcome #1

1. Outcome Measures

Research will increase number of viable technologies to improve food safety.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
According to the CDC, each year roughly 48 million people get sick, 128,000 are hospitalized, and 3,000 die of foodborne diseases. A 2010 report of the Pew Charitable Trusts estimates that foodborne diseases cost the U.S. about $152 billion per year in medical bills and lost workdays.

What has been done
Traditional diagnostic methods often require complex equipment and lab work that can take days. With the food industry in mind, Abdennour Abbas and his team set out to decrease not only time but also the cost to detect harmful bacteria.

To screen for microorganisms, green gold in the form of triangular nanoplates was combined with a reducing agent and luminol. This caused a strong, stable chemiluminescent reaction that lasted up to 10 minutes. When researchers introduced MRSA and other microorganisms into the combination, they consumed the gold nanoplates, causing the chemiluminescent intensity to decrease proportionally to the microbial concentration. This indicated a presence of microorganisms.

Results
The new method can screen and identify harmful or antibiotic-resistant bacteria within an hour using a portable luminometer and chemiluminescence, or the emission of light during a chemical reaction. More research is needed before the method can be used in real-world applications, but researchers are eager to make this process faster and easier for applications in both the food and healthcare industries.

4. Associated Knowledge Areas

KA Code	Knowledge Area

501	New and Improved Food Processing Technologies
503	Quality Maintenance in Storing and Marketing Food Products

Outcome #2

1. Outcome Measures

Research will increase understanding of threats to food safety from microbial and chemical sources.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Listeria monocytogenes is a microorganism of great concern for the food industry and the cause of human foodborne disease. About 1,600 people get listeriosis each year, and about 260 die. Pregnant women and their newborns, adults aged 65 or older, and people with weakened immune systems are especially vulnerable.

What has been done
David Baumler and his collaborators set out to generate genome-scale metabolic models (GEMs) for six different strains of L. monocytogenes, and to both qualitatively and quantitatively validate these GEMs to examine the diversity of metabolic capabilities of numerous strains from the three different serovar groups most associated with foodborne outbreaks and human disease.

Results
Following qualitative validation, 57 of the 95 carbon sources tested were present in the GEMs. Of these 57 compounds, agreement between in silico predictions and in vitro results for carbon source utilization ranged from 80.7 to 91.2 percent between strains. They then conducted nutrient utilization agreement between in silico predictions and in vitro results.

Quantitative validation showed that the L. monocytogenes GEMs could generate in silico predictions for growth rate and growth yield that were strongly and significantly ($p < 0.0013$ and $p < 0.0015$) correlated with experimental results.

These GEMs for L. monocytogenes are comparable to published GEMs of other organisms for agreement between in silico predictions and in vitro results. Therefore, as with the other GEMs, namely those for Escherichia coli, Staphylococcus aureus, Vibrio vulnificus, and Salmonella spp.,

they can be used to determine new methods of growth control and disease treatment.

4. Associated Knowledge Areas

KA Code	Knowledge Area
501	New and Improved Food Processing Technologies
503	Quality Maintenance in Storing and Marketing Food Products

Outcome #3

1. Outcome Measures

Percentage of participants that significantly changed one or more food safety practice as a result of attending classes intended to improve food safety practices.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	81

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
As consumption of fresh produce has increased, the number of foodborne illness outbreaks associated with fresh produce has also steadily increased, and have been deadly in some cases. As a result, some larger produce buyers, especially supermarkets and produce distributors, are requiring vendors to be audited by a third party to certify that they follow "Good Agricultural Practices" to minimize the risk of microbial contamination on their produce.

What has been done
In 2018, the food safety team conducted ten workshops covering Good Agricultural Practices and food safety for small to mid-size farmers. The goals were to help growers learn about Good Agricultural Practices and implement practices on their farm, as well as to help people write a food safety plan for their farm if that was required.

Results
Before the workshop, 76 percent of attendees did not have a written food safety plan and 9 percent had an incomplete food safety plan. At the end of the workshop, 81 percent of attendees said they would create a basic beginning written food safety plan within the next year. One hundred percent of growers said they were likely to implement at least one change on their farm. Changes they were likely to make included adding hand washing stations, providing worker

training, creating record keeping systems and log sheets, and cleaning and sanitizing harvest and storage containers.

4. Associated Knowledge Areas

KA Code	Knowledge Area
503	Quality Maintenance in Storing and Marketing Food Products
504	Home and Commercial Food Service

Outcome #4

1. Outcome Measures

Percentage of pass rates among those who participate in food safety education programs to become certified food managers. (The Minnesota Department of Health reports a decrease in critical inspection violations in establishments that employ a Certified Food Manager.)

Not Reporting on this Outcome Measure

V(H). Planned Program (External Factors)

External factors which affected outcomes

- Other (popularity of local foods movement)

Brief Explanation

A focus on foodborne illnesses for local food growers and has been needed. As the consumption of fresh produce has increased, the number of foodborne illness outbreaks associated with fresh produce has also increased.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Evaluations of continuing education for food managers, cottage food producers, and Master Gardeners focus on understanding whether participants are ready and motivated to practice food safety processes and promote food safety in other ways. Evaluations demonstrate that the program is promoting food safety in Minnesota. Cottage food producers will: 1) safely prepare cottage foods (100 percent of Cottage Food producers) 2) improve cleaning and sanitizing procedures to reduce foodborne illness or food allergic reactions (35 percent); 3) improve food handling practices, including checking and recording pH of canned products, proper hand washing, listing allergens on labels, using science-based recipes and using gloves after product is baked (93 percent). Master Gardeners, who both handle local food and train others, reported that they had increased food safety procedures like those above.

MAES. Publication of peer-reviewed papers and success in obtaining external grants are typical measures of evaluating the quality of basic and applied research. The projects reported in this planned program led to the publication of 6 peer-reviewed journal articles during FY18.

Non-NIFA research funds and grants leveraged by PIs in this program include: National Science Foundation, MnDRIVE Global Food Ventures, General Mills, Schwan Food Company and the Midwest Dairy Association.

Additionally, Abdennour Abbas, a USDA-NIFA supported researcher, was issued a patent on Detection Assays and Methods (#10006906).

Key Items of Evaluation

With a new emphasis on local foods, Extension is bringing food safety processes to the local foods industry. Cottage food producers and Master Gardeners both reported an increase in a myriad of food safety procedures after participation in Extension programming. Master Gardeners work with over 127,000 people across the state of Minnesota, meaning that this food safety information is likely to reach gardeners across the state who can use food safety information.

V(A). Planned Program (Summary)

Program # 11

1. Name of the Planned Program

Water Resources

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
111	Conservation and Efficient Use of Water	15%		10%	
112	Watershed Protection and Management	25%		20%	
133	Pollution Prevention and Mitigation	15%		20%	
135	Aquatic and Terrestrial Wildlife	15%		30%	
403	Waste Disposal, Recycling, and Reuse	15%		10%	
605	Natural Resource and Environmental Economics	15%		10%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	9.3	0.0	22.9	0.0
Actual Paid	14.8	0.0	43.2	0.0
Actual Volunteer	2.6	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
772289	0	405533	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
1944378	0	2729509	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
674867	0	4024653	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

MAES. From our ten thousand lakes to the great Mississippi River, water has been a key economic strength throughout Minnesota's history, and has helped to shape the state's identity. 2018 highlights include:

- A study on Eurasian watermilfoil in Lake Riley found the granular 2,4-d and granular triclopyr chemical treatment used on the lake is 2017 was effective in controlling Eurasian watermilfoil (47 percent in June to 3 percent in September) but that native plants were negatively affected and decreased in both abundance and richness (13 native species in 2016 to 8 species in 2017).
- A new startup technology company was founded, Claros Technologies (www.clarostech.com), to commercialize the sorbents developed for water remediation and wastewater treatment reported on over the last few years.
- The St. Paul District of the U.S. Army Corps of Engineers are now using University researcher recommended gate settings for Lock and Dam 8 that stop invasive carp without impacting navigation or erosion in the system.
- A new collaboration between University researchers and partners in Chile is exploring how antibiotic use in salmon farming affects human health and the environment.
- A new project exploring the biophysical, socio-cultural and public policy dimensions of manoomin (wild rice) protection is the western Great Lake Region led to two conferences aimed at identifying research agendas and developing responsible and respectful research protocols. Over 50 people attended each of the conferences as well as representatives from 15 different tribal nations, bands and communities.
- Researchers developed a novel bioreactor capable of removing both nitrogen and phosphorus while also being accessible for easy maintenance.

Extension. In 2018, the Water Resources Extension team achieved impacts in detecting aquatic invasive species and building public support for storm water management practices research.

Citizen scientists working across the state are keeping a watchful eye out for invasive species on a multitude of waterways. Water professionals are using training from Extension to guide their management practices to reduce storm water runoff and manage watersheds. Extension's influence is supporting practical local decisions as well as local and state policy and investments in research.

Extension's web redevelopment project provided the team an opportunity to update online publications available for water professionals and volunteers, resulting in a high number of new products identified in state defined outputs.

2. Brief description of the target audience

Water Resource Programs are available to communities across the entire state. We reach communities through local government and elected and appointed officials and their staff. Local government engineers and planners, consulting engineers, planners, and architects are also targeted because they help communities make decisions that impact Minnesota's waters. Natural resource and horticulture professionals are engaged as partners, learners, and agents of change. Homeowners and community members are another key audience, because their use of water and management of waste can positively and negatively affect water supply. Training and support of Master Naturalists equips them as citizen scientists to protect Minnesota's waterways.

3. How was eXtension used?

Stormwater practices and maintenance core course is offered for free through eXtension.

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	7045	60467	203	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year: 2018
Actual: 1

Patents listed
Patents Filed
Apparatus and Method for Detecting Pathogenic Bacteria: 62/621,272 - 1/24/2018

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	10	37	0

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Number of products developed to provide useful information about shoreland, storm water and septic system management in web links, printed products and media.

Year	Actual
2018	21

Output #2

Output Measure

- Number of educational events conducted about water quality, stormwater issues and shoreland management, revegetation and use of plants to maintain shoreland structures.

Year	Actual
2018	132

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Percentage of water resource professionals who are applying skills and resources learned while participating in programs that address specific water management responsibilities and to achieve water management goals.
2	Number of Aquatic Invasive Species detected by volunteer detectors using information about early detection taught by Extension.
3	Research on aquatic invasive species and/or water quality will improve the overall health of Minnesota Lakes and Rivers.
4	$1,700,000 was invested in storm water research in Minnesota as a result of Extension research and education.

Outcome #1

1. Outcome Measures

Percentage of water resource professionals who are applying skills and resources learned while participating in programs that address specific water management responsibilities and to achieve water management goals.

Not Reporting on this Outcome Measure

Outcome #2

1. Outcome Measures

Number of Aquatic Invasive Species detected by volunteer detectors using information about early detection taught by Extension.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	2

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Zebra mussels, starry stonewort, and other invaders crowd out native species in Minnesota's lakes and streams. Trained citizen scientists have the capacity to identify these species because of the time they spend in and near their lakes and streams.

What has been done
In 2018, six Aquatic Invasive Species (AIS) Detector workshops were held across the state to train 97 potential AIS Detector volunteers. These volunteers joined others in using new skills to detect AIS on their land, in their communities, and in waterways. AIS detectors also worked to educate others about how to detect AIS.

Results
AIS detector volunteers in 2018 discovered two new occurrences of aquatic invasive species in Minnesota lakes that were previously undocumented. When found early, lake associations and the Department of Natural Resources respond quickly, simply hand-pulling the species and monitoring it for control.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
133	Pollution Prevention and Mitigation
135	Aquatic and Terrestrial Wildlife

Outcome #3

1. Outcome Measures

Research on aquatic invasive species and/or water quality will improve the overall health of Minnesota Lakes and Rivers.

2. Associated Institution Types

- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	0

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
The common carp is one of the most damaging aquatic invasive species and are present in hundreds of waters in Minnesota. The common carp stir up sediments, uproot aquatic vegetation, and negatively affect water quality and ultimately recreation.

What has been done
From 2014 to 2016, Peter Sorensen and his graduate students assessed the abundance, movement and damage being caused by the common carp found in the Six Mile Creek-Halsted Bay Watershed with funding from the Minnehaha Creek Watershed District. They discovered some of the highest densities of common carp documented in North America as well as evidence they are causing significant ecological damage to this system. Using this information as well as information on their movement they then developed a tentative plan to reduce and control this destructive fish.

Results
Armed with these results and a clear pathway to restoration, the watershed district created a plan to remove the carp, limit their growth and promote predator populations.

In May 2018, the watershed district received a state grant of $567,000 to fund a three-year carp removal plan which follows recommendations of the Sorensen team and includes: carp batting

and removal, installing permanent barriers to stop movement, and aerating lakes so that bluegill sunfish have enough oxygen to survive the winter. Planners noted the connection to research enabled their plan and are continuing the collaboration by using Carp Solutions, a University of Minnesota startup company, to aid in their control efforts.

The carp are the first focus of a ten-year strategy to restore the wetlands and uplands of the sub-watershed. By combining the efforts of researchers, citizens, watershed districts and state government stakeholders, the issue can be addressed systematically by targeting carp populations before moving onto improving the overall ecosystem and increasing recreation use.

4. Associated Knowledge Areas

KA Code	Knowledge Area
112	Watershed Protection and Management
135	Aquatic and Terrestrial Wildlife
605	Natural Resource and Environmental Economics

Outcome #4

1. Outcome Measures

$1,700,000 was invested in storm water research in Minnesota as a result of Extension research and education.

2. Associated Institution Types

- 1862 Extension

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	1700000

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Many impaired urban waters in Minnesota are polluted by stormwater. The cost of meeting clean water goals is estimated to be $317 million per year (Barr Engineering, 2017). Storm water professionals concur that current storm water management is not as effective as it could be. Because past research informed actions that ultimately improved storm water management practices, we know that filling gaps in research can inform communities' capacity to manage and implement storm water runoff practices.

What has been done

Extension's Storm Water Research Roadmap, published in 2018, articulated major research needs to improve storm water management in Minnesota. The report included a summary of past research, a statewide survey of storm water professionals and policy administrators, interviews with policy makers and focus groups from other specific stakeholders. Finally, the team interpreted findings and made research recommendations.

Results
The Extension stormwater team gave multiple presentations to report their findings. As a result, research projects received a total of $1.7 million from Minnesota's Clean Water and Land Legacy Amendment, local units of government, and private businesses. We anticipate annual amounts of these funds will continue to grow as a result of this work.

4. Associated Knowledge Areas

KA Code	Knowledge Area
111	Conservation and Efficient Use of Water
112	Watershed Protection and Management
133	Pollution Prevention and Mitigation

V(H). Planned Program (External Factors)

External factors which affected outcomes
- Other (Impact reporting)

Brief Explanation

The knowledge/action outcome was not reported this year to favor other impacts that describe a higher-level condition impact. Results of evaluations are provided in the evaluation section.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

Evaluation of water resource team offerings measures whether participants are ready to use their knowledge to carry out water protection practices. Attendees of stormwater practices training noted that 92 percent were newly confident to carry out stormwater practices. Municipal Officials in three of Minnesota's watersheds said they were nnow ready to make water management decisions and recommendations. Aquatic invasive species detectors said they were ready to act to apply the science to their observation of local waterways. Ultimately, this resulted in spotting AIS in two new waterways in 2018.

MAES. Publication of peer-reviewed papers and success in obtaining external grants are typical measures of evaluating the quality of basic and applied research. The projects reported in this planned program led to the publication of 37 peer-reviewed journal articles during FY18.

Non-NIFA research funds and grants leveraged by PIs in this program include: National Science Foundation, University of Minnesota International Capacity Building Grant, Legislative-Citizen Commission on Minnesota Resources, USDA Forest Service, MnDRIVE

Environment, Minnesota Department of Natural Resources, Minnesota Aquatic Invasive Species Research Center and Minnehaha Creek Watershed District.

Additionally, University two startup companies have direct ties to the research reported in this planned program: Carp Solutions and Claros Technologies.

Key Items of Evaluation

The water resource team's educational offerings have proven that the citizen scientist and local professionals they train are ready to manage, decide, and protect waterways. This resulted in invasive species detection in 2018, adoption of best practices across watersheds, and new dollars invested in research to improve best practices.

V(A). Planned Program (Summary)

Program # 12

1. Name of the Planned Program

Climate Change

☑ Reporting on this Program

V(B). Program Knowledge Area(s)

1. Program Knowledge Areas and Percentage

KA Code	Knowledge Area	%1862 Extension	%1890 Extension	%1862 Research	%1890 Research
102	Soil, Plant, Water, Nutrient Relationships	10%		10%	
104	Protect Soil from Harmful Effects of Natural Elements	10%		5%	
123	Management and Sustainability of Forest Resources	10%		25%	
125	Agroforestry	20%		10%	
131	Alternative Uses of Land	20%		20%	
132	Weather and Climate	20%		20%	
605	Natural Resource and Environmental Economics	10%		10%	
	Total	100%		100%	

V(C). Planned Program (Inputs)

1. Actual amount of FTE/SYs expended this Program

Year: 2018	Extension		Research	
	1862	1890	1862	1890
Plan	0.0	0.0	27.2	0.0
Actual Paid	0.0	0.0	33.9	0.0
Actual Volunteer	0.0	0.0	0.0	0.0

2. Actual dollars expended in this Program (includes Carryover Funds from previous years)

Extension		Research	
Smith-Lever 3b & 3c	**1890 Extension**	**Hatch**	**Evans-Allen**
0	0	342559	0
1862 Matching	**1890 Matching**	**1862 Matching**	**1890 Matching**
0	0	2159831	0
1862 All Other	**1890 All Other**	**1862 All Other**	**1890 All Other**
0	0	3697974	0

V(D). Planned Program (Activity)

1. Brief description of the Activity

Extension. Climate change education is matriculating into all of Extension planned programs, as the impact of weather events are addressed in all programming. However, specific efforts to educate about climate change are also happening. In 2018, Extension piloted a new Climate Adaptation Course and gathered feedback about course content. The course delivers research-based education on the science of climate change, impacts on ecosystems and communication tools for conversations within a workplace or community. Content increases knowledge of the science behind climate change, climate adaptation strategies, planning for climate adaptation, and incorporating public participation. Topics were taken to teachers and natural resource volunteers who work with youth, resulting in the development of youth-driven podcasts over 24 weeks.

The Climate Change initiative is a multi-disciplinary program that mobilizes Extension programming and research in areas such as forestry, environmental science education, water, crops, horticulture and more. Extension FTEs are not formally aligned with the Climate Change planned program area. Other outcomes and outputs are likely to be described in other program areas.

MAES. University researchers are committed to uncovering new information and developing conservation plans to assist with adaptation strategies. From dealing with the fallout of extreme weather to sharing climate related information with Minnesotans, researchers are working hard to prepare the state and public for changes in climate and land use. 2018 highlights include:

- Tall tower observations from 2010 to present have shown that N2O emissions are highly sensitive to climate. In 2012, one the warmest years, researchers found that regional N2O emissions exceeded 585 Gg N2O-N y-1, implying that future warmer and wetter conditions will probably increase emissions.
- Researchers have successfully developed an Agro-ABIS modeling framework that captures rates of canopy uptake and canopy structure as a function of time as a forest stand ages.
- A study on the effects of climate warming on photosynthesis in boreal tree species found that soil moisture could play a key role in the process--perhaps even reversing the potential effects of climate warming on tree photosynthesis in mesic, seasonally cold environments.
- Researchers completed a statewide field study of phragmites and mapped 390 populations. They also verified the hybrid can be distinguished from the native genotype by non-professionals using pictorial guides.
- A study on abiotic stress tolerance in plants captured over 30,000 RGB and hyperspectral images of maize plants in controlled growth and in field conditions.
- A research project working on compiling and analyzing both historical and recent phenological observations has led to the successful collection and digitization of 865,221 Minnesota observations on

1,546 species and 84 different stages. All of the data collected is available to the public on a searchable website.

2. Brief description of the target audience

The new climate changed education course is designed for natural resource professionals, volunteers and others wanting to guide climate discussions, inform resource management decision-making and planning or deliver educational programming. Topics were also taken to teachers and natural resource volunteers who work with youth.

As programming is developed, new audiences will be targeted. Targeted audiences must be those with whom we can make a difference, and who can benefit from research-based information but also members of the public who would benefit from understanding the role climate plays in their lives and how climate change could affect them. Many audiences targeted by other program areas receive education related to climate change, as described in those plans of work.

3. How was eXtension used?

eXtension was not used in this program

V(E). Planned Program (Outputs)

1. Standard output measures

2018	Direct Contacts Adults	Indirect Contacts Adults	Direct Contacts Youth	Indirect Contacts Youth
Actual	144	13506	90	0

2. Number of Patent Applications Submitted (Standard Research Output)

Patent Applications Submitted

Year:	2018
Actual:	0

Patents listed

3. Publications (Standard General Output Measure)

Number of Peer Reviewed Publications

2018	Extension	Research	Total
Actual	0	70	70

V(F). State Defined Outputs

Output Target

Output #1

Output Measure

- Research projects will be conducted to develop information on climate change effects on northern forests.

Year	Actual
2018	12

V(G). State Defined Outcomes

V. State Defined Outcomes Table of Content

O. No.	OUTCOME NAME
1	Research will develop new knowledge and technologies related to climate change. (Measure: number of new crop varieties and genotypes with climate adaptive traits; number of new assessment and management tools developed, including models and measurements; number of new climate relevant databases, monitoring systems and inventories managed or under development)
2	Percentage of participants who self-report changes in decisions and behavior after educational events.
3	Researchers and Extension specialists will provide information and outreach that will lead to safer roads in Minnesota. (Reported as the percent reduction in accident injury severity in areas where recommended techniques are used).

Outcome #1

1. Outcome Measures

Research will develop new knowledge and technologies related to climate change. (Measure: number of new crop varieties and genotypes with climate adaptive traits; number of new assessment and management tools developed, including models and measurements; number of new climate relevant databases, monitoring systems and inventories managed or under development)

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Knowledge Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	9

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
For years, Minnesota climate and forest scientists have suspected the state's tree cover would creep northward as the Earth's climate warms. However, they have lacked the technical tools to predict these decades long changes and ability to localize the issue for Minnesota residents.

What has been done
A team of University scientists used a series of worldwide climate projection models and adapted them to predict local changes to Minnesota's climate and landscape. From roughly 40 computer models available, University researchers chose three, known as BCC, CCSM4 and Miroc, to capture the range of outcomes.

Because trees are sensitive to average temperatures and rainfall, and because Minnesota contains the edges of several biomes where tree species are especially susceptible to change, Minnesota's forest cover could transform in coming decades. Oaks that are common in western and southwestern Minnnesota are likely to migrate north while the pines of the boreal forest in northeastern Minnesota are more likely to recede north and perhaps disappear from the state entirely.

Results
The result of this localized research is nine maps--three CO2 scenarios, each with three different temperature predictions--reflecting thousands of variables that were painstakingly entered into computer models.

The maps feature a surprising level of detail, with each square representing a square kilometer. Projections related to precipitation levels, average summer temperature, and water balance allow researchers to predict what will be temperate forest, boreal forest and prairie for each square in 2070.

The study is highlighted in an exhibit at the new Bell Museum, called Weather to Climate: Our Changing World, which runs from Feb. 2 to April 28, providing a new way for researchers to share climate related knowledge with the public.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
104	Protect Soil from Harmful Effects of Natural Elements
123	Management and Sustainability of Forest Resources
131	Alternative Uses of Land
132	Weather and Climate
605	Natural Resource and Environmental Economics

Outcome #2

1. Outcome Measures

Percentage of participants who self-report changes in decisions and behavior after educational events.

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Action Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	96

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Data about phenology (the study of cycles and seasonal natural phenomena) creates a better understanding of the impact climate change has on the diverse ecosystems of Minnesota. We can create more robust data about climate change by involving citizen scientists to monitor and use phenology, simultaneously increasing environmental awareness and education.

What has been done
In 2018, Extension trained teachers and Master Naturalist volunteers in phenology, guiding trainees to work with youth to deliver weekly phenology podcasts about nature observations in schools and communities. Extension conducted three trainings throughout the year for 90 participants. In addition, one webinar and two conference presentations/posters were presented on phenology.

Results
Fourteen schools produced 24 weeks of student podcasts that were broadcasted on KAXE Radio's Phenology Talkback show in Grand Rapids, Minnesota. These podcasts are available online. Over 200 youth shared their stories on the podcast over 24 weeks. One of the podcasts was created for the Phenology Citizen Science project by the Circle of Life Academy in White Earth, Minnesota. For several reports, students shared not only their many observations, but also the Ojibwe words for those observations.

4. Associated Knowledge Areas

KA Code	Knowledge Area
102	Soil, Plant, Water, Nutrient Relationships
104	Protect Soil from Harmful Effects of Natural Elements
123	Management and Sustainability of Forest Resources
132	Weather and Climate
605	Natural Resource and Environmental Economics

Outcome #3

1. Outcome Measures

Researchers and Extension specialists will provide information and outreach that will lead to safer roads in Minnesota. (Reported as the percent reduction in accident injury severity in areas where recommended techniques are used).

2. Associated Institution Types

- 1862 Extension
- 1862 Research

3a. Outcome Type:

Change in Condition Outcome Measure

3b. Quantitative Outcome

Year	Actual
2018	40

3c. Qualitative Outcome or Impact Statement

Issue (Who cares and Why)
Driving on rural roads in the wintertime is dangerous. According the Minnesota Department of Public Safety, 13,650 car accidents resulted from snowy or icy conditions in 2017 alone. As we adjust to changes in our climate, research suggests extreme weather episodes will increase throughout the state leading to increased snowfall, record-breaking high and low temperatures and extreme wind events.

What has been done
In the late 1990s, U of M researchers led by Mark Seeley setout out to explore the effectiveness of "living snow fences" to help block snowdrift, which can cause icy roads and near whiteout conditions on highways and freeways in rural Minnesota. Strategies include planting natural shrubs and grasses, piles of hay bales, structural fences and leaving cornrows standing.

Through a partnership with the Minnesota Department of Transportation (MnDOT), University researchers and Extension specialists pinpointed 3,700 sites statewide in need of added snow protection measures. Extension Educators have conducted snow fence workshops for MnDOT staff and Extension specialists worked with MnDOT to develop a payment program for farmers willing to relinquish part of their farmable land to make way for a snow fence. The program includes two options: 1) a short-term agreement to grow rows of corn on their property 100 to 200 feet away from sides of roads; or, 2) a 10 to 15-year agreement where they commit to planting and maintaining woody vegetation.

Results
Between 2015 and 2016, farmer compensation for taking part in the program averaged $4,800 (between $1000 and $2000 per acre). But for MnDOT, the cost is well worth it since living snow fences can save thousands of dollars by limiting the need for continuous road maintenance and snow removal.

There is also a social element as where they have been successfully implemented; snow fences have proven extremely effective with MnDOT recently reporting strips of highway flanked by standing cornrows saw a 40 percent reduction in accident injury severity. During the extreme winter of 2018/2019, MnDOT reported 70 miles of newly installed living snow fences along state and federal highways providing a "night and day" difference in western Minnesota.

4. Associated Knowledge Areas

KA Code	Knowledge Area
104	Protect Soil from Harmful Effects of Natural Elements
131	Alternative Uses of Land
132	Weather and Climate
605	Natural Resource and Environmental Economics

V(H). Planned Program (External Factors)

External factors which affected outcomes
- Other (Public interest)

Brief Explanation

Recent weather events have increased public interest in climate change as a public issue, allowing us the opportunity to provide more direct education than in earlier years.

V(I). Planned Program (Evaluation Studies)

Evaluation Results

From evaluation of the Climate Change Adaptation Convenings, 96 percent felt more confident to engage in a climate adaptation conversation after attending the conference and 98 percent stated that they plan to incorporate the learning into their job or personal life.

MAES. Publication of peer-reviewed papers and success in obtaining external grants are typical measures of evaluating the quality of basic and applied research. The projects reported in this planned program led to the publication of 70 peer-reviewed journal articles during FY18.

Non-NIFA research funds and grants leveraged by PIs in this program include: Minnesota Legislative and Citizens Commission on Natural Resources, National Science Foundation and Minnesota Environmental and Natural Resource Trust Fund.

Additionally, Peter Reich was named to the National Academy of Sciences and was listed in the 2018 Highly Cited Researchers list published by Clarivate Analytics.

Key Items of Evaluation

Extension education is making Minnesotans more comfortable sharing information and discussion about climate change. In post-event evaluations, 96 percent felt more confident to engage in a climate adaptation conversation after attending the conference and 98 percent stated that they plan to incorporate the learning into their job or personal life.

VI. National Outcomes and Indicators

1. NIFA Selected Outcomes and Indicators

Childhood Obesity (Outcome 1, Indicator 1.c)	
0	Number of children and youth who reported eating more of healthy foods.
Climate Change (Outcome 1, Indicator 4)	
0	Number of new crop varieties, animal breeds, and genotypes whit climate adaptive traits.
Global Food Security and Hunger (Outcome 1, Indicator 4.a)	
0	Number of participants adopting best practices and technologies resulting in increased yield, reduced inputs, increased efficiency, increased economic return, and/or conservation of resources.
Global Food Security and Hunger (Outcome 2, Indicator 1)	
2	Number of new or improved innovations developed for food enterprises.
Food Safety (Outcome 1, Indicator 1)	
2	Number of viable technologies developed or modified for the detection and
Sustainable Energy (Outcome 3, Indicator 2)	
0	Number of farmers who adopted a dedicated bioenergy crop
Sustainable Energy (Outcome 3, Indicator 4)	
0	Tons of feedstocks delivered.