Report on MnDRIVE Initiative to Minnesota State Legislature

For July 1, 2021 through June 30, 2023
covering fiscal years 2022-2023

February 28, 2025

Prepared by:
The report was prepared by staff from the Research & Innovation Office (RIO) at the University of Minnesota.

Report Preparation Costs:
Per the requirements set forth in Minnesota Statue 3.197, the cost to prepare this report was $5,000.

Background, Metrics and Results

Background

MnDRIVE – Minnesota's Discovery, Research, and InnoVation Economy – is a landmark partnership between the University of Minnesota and the State of Minnesota that aligns areas of University research strength with the state's key and emerging industries to address grand challenges.

Beginning in FY 2014, the state began investing approximately $18 million annually in four research areas identified by the University and its corporate partners as the most promising areas for partnership: Robotics, Sensors and Manufacturing; Global Food; Advancing Industry, Conserving our Environment; and Discoveries and Treatments for Brain Conditions. Research Computing, which fosters and accelerates data-intensive research and high-performance computing, receives partial funding from MnDRIVE and provides key support to these projects. In its 2017 session, the Minnesota Legislature passed additional funding ($4 million annually) for a MnDRIVE cancer initiative, to form a state-wide cancer clinical trials network.

MnDRIVE represents a unique, collaborative research model involving interdisciplinary research projects across the University that address grand challenges and include industry partnerships as a key component. The University of Minnesota's Research and Innovation Office (RIO) provides accountability measures for the initiative and serves as an advocate for the program at the Legislature. Each of the five research areas have committees and advisory boards to oversee project implementation and outreach.

Metrics & Results

During the fourth biennium of MnDRIVE funding (July 1, 2021 through June 30, 2023 covering fiscal years 2022-2023) RIO worked with principal investigators of each of the five MnDRIVE areas projects to gather data every six months. RIO requested information on:

1. **Invention disclosures to theTechnology and Commercialization office**
2. **Funding acquired from external grants (e.g., NSF, NIH, USDA, corporate funding)**
3. **Success stories resulting from MnDRIVE research and participation**

For items 1. and 2.: MnDRIVE researchers submitted **129 disclosures for inventions** to University of Minnesota Technology Commercialization and they competed for and won **$153 million in external funding.**

MnDRIVE Success Stories

MnDRIVE Robotics, Sensors, and Manufacturing

MnDRIVE support has helped the University of Minnesota (UMN) to:

- Launch and grow the Minnesota Robotics Institute (MnRI);
- Create the world-class Gemini-Huntley Robotics Research Laboratory on the East Bank of the Twin Cities campus;
- Enhance Minnesota's leadership in robotics research and education, with UMN's robotics program now ranked #10 globally and #8 in the US (csrankings) through the institute and its many interdisciplinary initiatives; and
- Foster a robust innovation ecosystem for Minnesota's economy, with activities revolving around research, education, and outreach.

In sum: MnDRIVE support for robotics has produced an ecosystem with a tremendous return on investment— not just for education but for the economics of the state.

Research

Some of our significant research activities during this reporting period include:

Artificial Intelligence (AI) for Flexible Manufacturing

Many industries can benefit from reconfigurable industrial robotic systems that automatically adapt to their environment. Industrial robotic systems, which are widely integrated into various manufacturing markets, create a proven economic benefit due to their performance, scale, and production quality. They have successfully produced high-volume, discrete products specially designed to be automated.

We have designed and built robots and software to meet specific, rigid industrial demands. Our work helps manufacturing companies move quickly from mass production to mass customization of products (often needed with defense applications) and aids them in adapting to shorter life cycles, smaller batch sizes, and different product variations.

Our partnership with companies in Minnesota like Honeywell and PAR Systems integrates advanced AI techniques with state-of-the-art sensor technology to automate industrial robot operations. Using research from ROSEHUB (Robots and Sensors for Human Well-Being with the National Science Foundation and Industry-University Cooperative Research Partnerships), we are using AI (deep learning, generative AI, and Large Language Models (LLMs)) to create more flexibility and user transparency in these operations. **This work supports core manufacturing operations in Minnesota and increases the competitiveness of companies as small as start-ups and as big as Honeywell, 3M, and PAR Systems.**

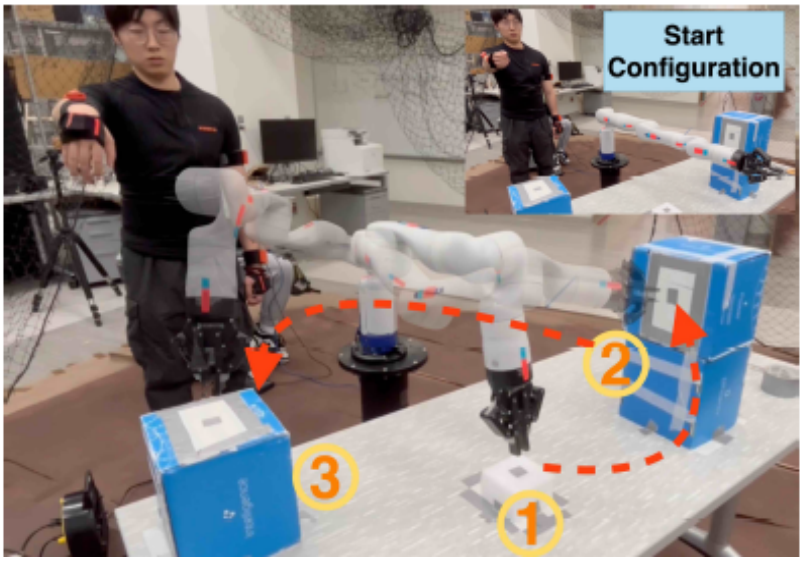


Figure 1: The photo shows a human-robot interface. An expert uses AI principles to teach a complex robot to execute tasks such as obstacle avoidance and grasping objects—all in a fraction of the time required by current state-of-the-art algorithms.

Robotics for Precision Agriculture

MnRI researchers have significantly advanced the use of robotics in agriculture. In corn crops, for example, nitrogen or potassium deficiencies during the growing season translate directly to significant financial losses. Early detection and treatment of these nutrient deficiencies is crucial. Still, standard field surveillance practices must be done manually or with satellite imaging, offering farmers only infrequent, incomplete, and costly data. Farmers thus tend to minimize risk by applying uniform fertilizer rates to their corn fields in autumn before planting their corn in spring. This approach overestimates the fertilizer needed while producing surface and groundwater nitrogen contamination.

Our work promotes using autonomous teams of small aerial and ground co-robots to map corn fields, monitor nitrogen and potassium deficiency, estimate crop biomass, and produce accurate estimates of the amount of fertilizer needed. This work aims to introduce an automated strategy for corn field robotic mapping, monitoring, nitrogen and potassium deficiency detection, and crop biomass estimation to better determine the nutrient fertilizer requirements. Through the capacity of the robotic team to autonomously select and follow the viewpoints that enable comprehensive multi-modal 3D reconstruction of the corn canopy structure (biomass) at arbitrary resolutions, a superior alternative to high-altitude aerial imaging is suggested. **This work can save millions of dollars in annual fertilizer costs for Minnesota corn crops alone. It can also improve water quality throughout the state and the Mississippi River ecosystem by reducing runoff of excess fertilizer.**

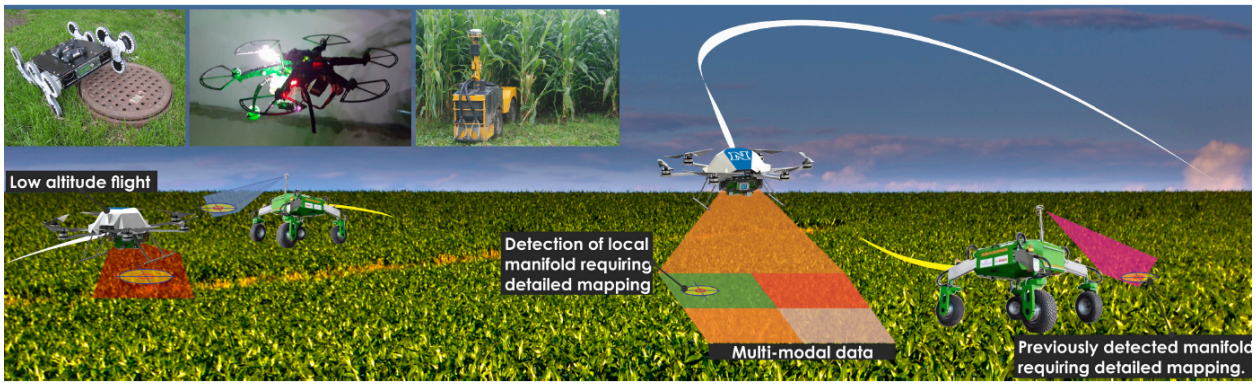


Figure 2: Autonomous robots inspecting crop fields to detect and map nutrient deficiencies.

AI and Computer Vision for Mental Health Assessment

UMN researchers have been using novel AI methods to assist in early detection, diagnosis, and treatment of Tourette Syndrome, autism, obsessive-compulsive disorder, and attention-deficit hyperactivity disorder. Our data-driven algorithms can analyze behavioral patterns, speech, facial expressions, and gaze tracking to aid clinicians in making more **accurate diagnoses and monitor the effectiveness of interventions.** We have also been increasing access for rural communities to mental health treatments. **Telepsychiatry and AI present a powerful solution that enables residents in rural communities to connect with mental health professionals and AI tools remotely and from the privacy of their homes.**

Other MnRI Work

- **Water Quality Monitoring Tools**: MnRI researchers created the Minnebot, an amphibious robot that could ultimately help improve our knowledge of water quality in the state and beyond.
- **Safety:** MnRI collaborates on a vehicle lane-assistant tool to boost driver safety and on the development of an AI tool for forest fire suppression.
- **National Institute of Food and Agriculture (NIFA) AI Institute:** MnRI supported a group of investigators in submitting a $20 million proposal. Acceptance of the proposal led to the creation of the AI Climate Institute, led by Professor Shekhar.
- **Medical Research Advances:** MnRI has led innovation on many projects, including a 3D-printed transparent skull implant that could provide new insights into brain conditions, compression garments that promote healthy blood circulation and can treat diabetes, burns, and other severe health conditions, and vision-enabled robots that recognize what they “see” to detect and track objects and features and can, for example, measure the degree of motor function during stroke rehabilitation.
- **Global Collaboration:** In the context of the Kidney and Kidney Tumor Segmentation Challenges (KiTS19-KiTS23), researchers from MnRI have made substantial contributions to the advancement of medical image analysis on kidney tumors. These challenges promote collaboration among various international groups, leading to over 1,200 peer-reviewed publications.

Examples of MnRI Industry Partnerships

- **Medtronic:** MnRI is working with Medtronic to develop 3D-printed, patient-specific models of heart valves and a robot that can reduce mortality during stroke treatments.
- **Sentera:** MnRI collaborates with Sentera, a Minneapolis-based drone and sensor manufacturer for agriculture, to design software to help farmers protect their crops from pests such as soybean aphids.
- **Honeywell:** As part of ROSEHUB, MnRI works with Honeywell to create AI-based manufacturing solutions.
- **Danfoss:** MnRI provides Danfoss, which creates energy-efficient technologies, with state-of-the-art facilities for advanced testing.
- **PAR Systems**: MnRI supports and collaborates on AI-based friction stir welding and fastening solutions with PAR Systems.

MnRI Master's Program in Robotics

- 135+ enrolled Robotics Master's students.
- 63 students graduated between 2021-2024.
- 78+ applications submitted for 2025.
- Our alumni are employed by and have interned at more than 40 companies, including local startups and global firms. They have also pursued PhDs.
- MnDRIVE funding led to a $10 million private donation to Gemini-Huntley Robotics Research Laboratory. This has created top-of-the-line robotics facilities in Shepherd Labs for these students.

The MnRI Master of Science in Robotics program is a highly specialized curriculum that promotes innovation and nurtures the next generation of professionals in the robotics field. **The program, which has grown remarkably since its inception, currently boasts more than 135 students. Sixty-three students graduated between 2021 and 2024**—underscoring the program's capacity to equip its participants for achievement in both the industrial and academic sectors—and nearly 80 applications have already been submitted for fall 2025. Our alumni are employed by and have interned at more than 40 companies, including local startups and global firms, and numerous alumni have pursued PhDs, enhancing their expertise and contributing to pioneering research in robotics and affiliated fields. The MS in Robotics program is integral to UMN's larger MnDRIVE initiative, leveraging the collaborative synergy between interdisciplinary research and advanced industry partnerships.

The funding acquired through MnDRIVE **facilitated a substantial private donation of $10 million for the Gemini-Huntley Robotics Research Laboratory** at MnRI. This funding resulted in the establishment of state-of-the-art robotics facilities within Shepherd Labs. These advanced laboratories offer exceptional resources, affording students hands-on experience with innovative technologies, including drones and underwater robotics. The program's distinguished track record proves its effectiveness in developing highly skilled robotics professionals equipped to take leadership positions within renowned global industries such as 3M, Medtronic, and Honeywell.

Outreach

MnRI invites and hosts experts nationwide to present weekly seminars, disseminate research results, and support MnRI scholars in engaging with K-12 students through outreach activities: 60 activities annually, and 10,000+ children introduced to science and engineering through summer camps and outreach programs provided by undergraduate and graduate students in the MnDRIVE Scholars program. Examples include three-day Tech Camp for middle and high school students; giving tours to high school robotics teams, and students in computer, physics, and chemistry classes; hosting events to recruit high school students; and hosting events for elementary school students.

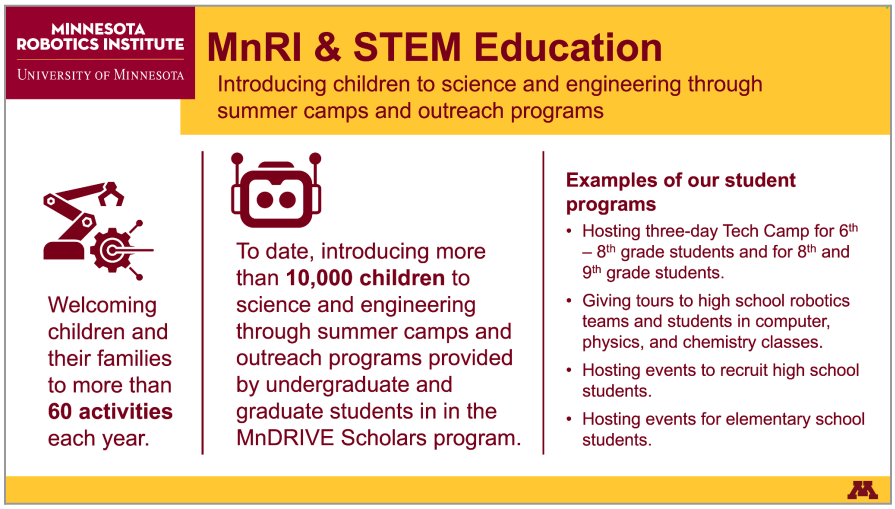


Figure 3: The full spectrum of outreach activities for the reporting period.

MnDRIVE Global Food

GEMS Informatics

GEMS Informatics is a path-breaking undertaking to ensure UMN and the state's agri-food sector remain at the forefront of the data revolution in agriculture. GEMS is a joint venture led by the U's College of Food, Agricultural, and Natural Resource Sciences (CFANS) and Research Computing (including the Minnesota Supercomputing Institute and U-Spatial) to make **G**enomics, **E**nvironmental, **M**anagement, and **S**ocioeconomic data interoperable in ways that generate actionable information and promote new public-private innovation partnerships to accelerate growth in food and agricultural systems. **MnDRIVE support has been pivotal in developing and maintaining cutting-edge digital and data informatics systems and assembling a first-rate data analytics team that spurs data-driven innovation and sustainable productivity growth throughout the state's agri-food economy.** GEMS has successfully leveraged MnDRIVE funding to secure more than $32 million in additional funding by way of competitive grants, contracts, and industry funding. Below is a brief review of some of the strategic efforts GEMS currently has in the works and the economic and environmental impact focus of that work.

Crop Loss Estimation to Prioritize Soybean Aphid Control in Minnesota: Over the past few decades, soybean aphids have spread across the state to become one of the costliest crop pests to control for Minnesota farmers and beyond. **Getting a better, data-driven handle on the extent and spatial location of losses associated with this pest is key to cost-effective pest management strategies and for informing strategic research targets.** Leveraging funding made possible by the Minnesota Invasive Terrestrial Plants and Pests Center, GEMS is leading a two-year project to develop an innovative, evidence-based bio-economic evaluation framework that assesses the long-term, spatially variable risk of soybean aphid damage across the state. In collaboration with Dr. Robert Koch's lab from the Department of Entomology, the GEMS team compiled and analyzed over five years of geo-referenced aphid abundance data and over 70 pesticide trial experimental data. Integrated with high-resolution soybean production maps and historical weather data, these comprehensive datasets enabled the development of a machine learning model to analyze spatial and temporal dynamics of soybean aphid populations and meso-scale yield damage. The project provides a replicable analytic method for helping to set investment and pest management priorities for stakeholders such as state agencies and crop commodity groups, and offers a priority-setting framework adaptable to other crop pest challenges regionally and beyond.

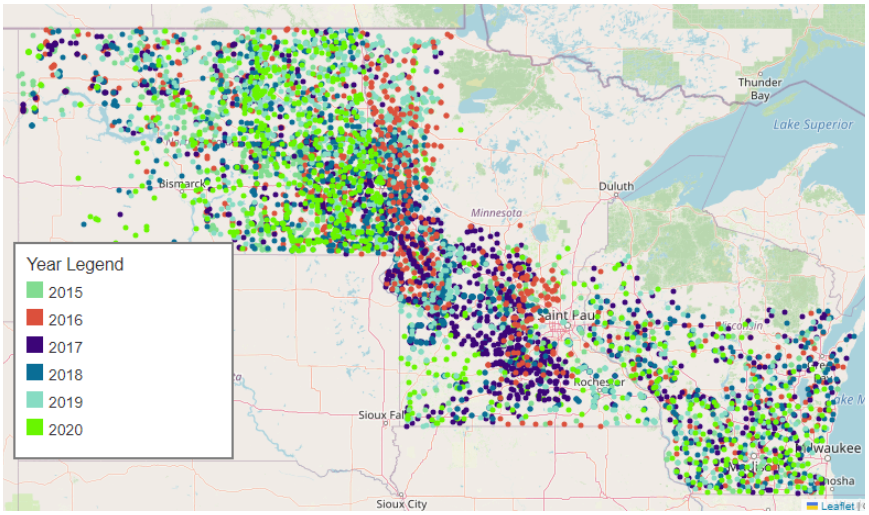


Figure 1: *Soybean aphid occurrences in farmers fields across Minnesota, North Dakota, and Wisconsin, 2015-2020 (GEMS Informatics).*

Sensing Below Ground Environments: Soil borne pathogens cause economic harm to potato growers and increase pesticide usage hurting the environment. GEMS Informatics has deployed soil environment sensing systems to map out below ground environmental conditions in the same research field where intensive research on the *perennially* problematic fungal disease *Verticillium wilt* is being conducted by Dr. Ashish Ranjan's Lab at UMN's Sand Plains Research Center in Becker, Minnesota. Results to date reveal a significant difference in the above and below ground values of the environmental variables that are identified to be most important for the development of the *Verticillium* wilt causing pathogen. Currently a machine learning model for predicting disease risk at a field level using the GEMS sensor and other ancillary datasets is being developed. **Once finalized, the model will be deployed to predict where, when, and how soil borne pathogens emerge and damage potato crops.** These end-to-end systems once completed have the potential to be adopted by potato growers across Minnesota and the United States, positively impacting both the bottom line of farmers and improving the environment.

Greenhouse Gas Monitoring, Reporting, and Verification: County and local governments across Minnesota have set aggressive greenhouse gas reduction goals. Most rely on a policy of "net zero" where some emissions remain, but are offset by sequestration. **GEMS Informatics partnered with Hennepin County, the Metropolitan Council, watershed districts, and cities** to account for current greenhouse gas emissions (GHG) from natural and agricultural lands, and **to identify where and how nature-based solutions could be used to offset greenhouse gas emissions**. This work is resulting in cutting-edge research in GHG accounting and decision-support tools to help organizations target their actions to meet their GHG policy goals.

Precision Agriculture: Precision agriculture is about putting the right amount of water, fertilizer, and seed in the right place at the right time and in the right form. GEMS Informatics has partnered with the Minnesota Department of Agriculture, local Soil and Water Conservation Districts, and local farmers to develop precision ag tools focused on improving water quality and making more cost-effective decisions by farmers regarding the quantity of water to use. **One example is the Irrigation Management Assistant tool, which is used on over 5,000 acres of Minnesota farmland. This tool recommends the right amount and time of water for irrigators to reduce groundwater use in priority areas.** We've expanded the tool statewide by improving the data inputs and models driving the system, and placed the tool with the UMN Irrigation Extension program to ensure long-term impacts on Minnesota irrigators.

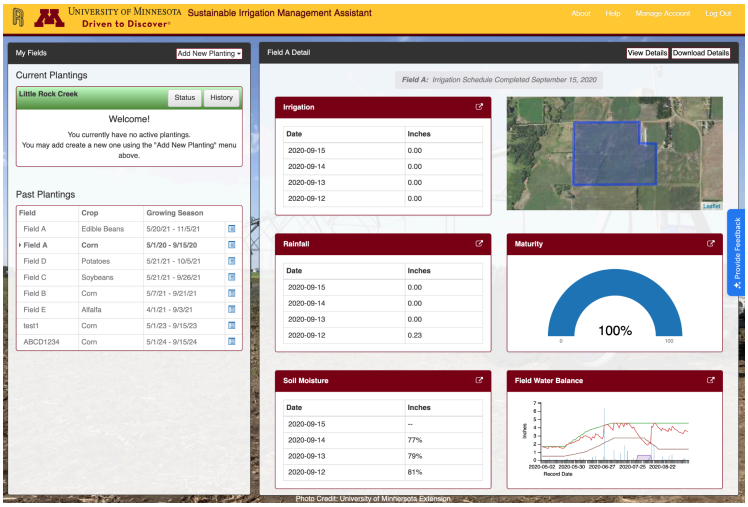


Figure 2: *Screenshot from the IMA Tool used by irrigators across Minnesota (GEMS Informatics).*

AI and Remote Sensed Data Analytics to Clean Up Agricultural Fertilizer Runoff into Minnesota Lakes: A decade ago, the Minnesota Department of Agriculture (MDA) initiated the Minnesota Agricultural Water Quality Certification Program (MAWQCP). This program uses incentives to encourage Farmers to adopt new Best Management Practices (BMPs), such as strip-till, no-till, cover crops and buffer strips to improve the soil, minimize runoff, and generally improve stewardship of the land. Currently more than 1,500 producers have signed up, spanning over 1.1 million acres (~5% of MN farm acreage). GEMS has partnered with MDA to develop an automated AI pipeline to ingest satellite imagery, train on this MDA "ground truth" data, and use these AI models to classify the BMPs on the 95% of non-certified acreage. This is enabling us to investigate the impact of BMP adoption on downstream lake water quality, and identify what other factors (e.g., farm slope, weather events, soil type, distance to waterways) may be mitigating or enhancing these effects. **At this stage we have completed the AI modeling of different types of tillage (no till / reduced till / conventional till) and made classifications on all 20 million resolution patches of farmland in Minnesota.**

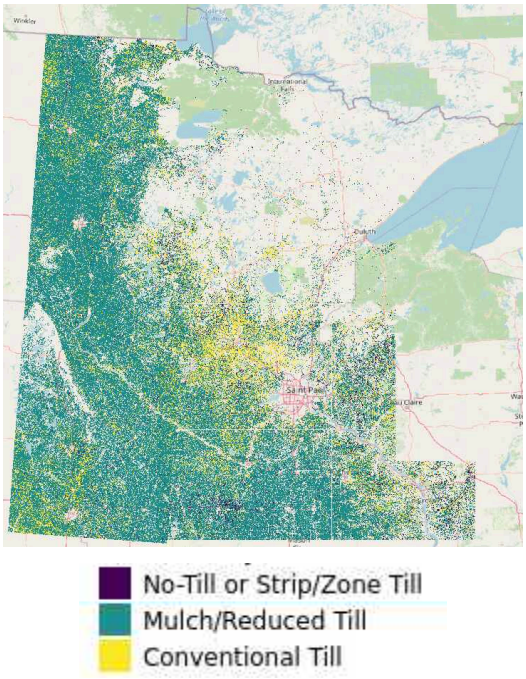


Figure 3: *Prediction of the tillage class using GEMS new AI model for all farm acreage in MN in 2022 Note: Predictions are made only for locations classified as 'cropland' by USGS LCMAP. The year 2022 aligns with the MN Agricultural Census, enabling us to make an independent validation of tillage class acreage aggregated at the county level (GEMS Informatics).*

Global Food Ventures Fellows

During fiscal years 2022–2023, MnDRIVE funding supported the research of 32 graduate students in the College of Food, Agricultural and Natural Resource Sciences (CFANS), the College of Veterinary Medicine (CVM), and the School of Public Health (SPH) at the University of Minnesota through the Global Food Ventures Fellows initiative. The graduate student researchers engaged in these projects are making significant contributions to the future of global food security, safety, and sustainability.

- By investigating the health and performance of dairy cows, swine, and poultry, these researchers are improving animal welfare while ensuring efficient and ethical food production.
- Their work on probiotics, viral pathogen detection, and vaccine development for livestock has the potential to reduce disease outbreaks, minimize antibiotic use, and increase food system resilience.
- Furthermore, their focus on sustainable cropping systems, such as soybean intercropping, nutrient-dense oats, and holistic nitrogen management, is paving the way for more environmentally responsible and productive farming practices that can sustain future generations.

Beyond production efficiency, these projects also address the broader socioeconomic and environmental dimensions of food systems.

- Research on urban agriculture, food co-operatives, and equitable supply chains is fostering community-driven solutions to food insecurity and access. Novel food processing technologies, such as non-thermal milk protein treatments and improved prion detection in venison, are enhancing food safety and expanding market opportunities.
- By exploring alternative protein sources, sustainable soil health practices, and improved biosecurity measures, these graduate students are shaping a future where food production is not only more productive but also more ethical, diverse, and resilient in the face of climate change and global challenges.

MnDRIVE Environment

Background

MnDRIVE Environment drives cutting-edge research that directly addresses state-wide environment and sustainability challenges, including emerging contaminants and climate change, positioning Minnesota as a national leader in environmental innovation. These projects and partnerships—along with robust outreach and engagement efforts—directly support state priorities by fostering economic growth, enhancing citizens' health and well-being, building statewide resilience, and bolstering key industries in line with the legislative mandate. The University of Minnesota is a globally recognized leader in sustainability and climate-related innovation and was recently recognized as the world's top public research university for interdisciplinary science.

Since its inception, MnDRIVE Environment has expanded and leveraged the University's wide-ranging strengths in environmental science, increasing the University's impact and reputation as a trusted, nonpartisan facilitator and catalyst for sustainability outcomes.

Overview of impact. MnDRIVE Environment has helped attract leading researchers to our state, fostered collaborations and partnerships with key industries, and enabled world-class research of direct relevance to the residents and industries of Minnesota. Through strategic partnerships and active community engagement, MnDRIVE Environment projects are delivering outcomes that benefit Minnesota's economy, ecosystems, and people. MnDRIVE Environment is helping build a more resilient Minnesota, driving key industries and economic growth, and accelerating the translation of environmental discoveries into real-world solutions.

Seeding new transformative research. MnDRIVE Environment creates research impact—and the translational benefits of research—through the seed grant program. During the reporting period (07/21 – 06/23), MnDRIVE Environment funded researchers on **more than two dozen high-impact projects** in a variety of focal areas including: PFAS remediation and nutrient recovery; bioremediation and environmental cleanup; wastewater treatment and nutrient management; climate change mitigation and adaptation; and pollution prevention and monitoring; biocorrosion, biofouling, and chemical cycling.

Sustaining the work of a faculty cohort. During the reporting period, MnDRIVE Environment also **supported five preeminent faculty members** who work in the areas of water sustainability, hydrology, microbiology, and environmental biotechnology. These faculty were recruited to the UMN—as a direct result of MnDRIVE Environment investments—to pursue research and teach on bioremediation and wastewater treatment.

Program Administration Transitions

From July 1, 2021, to Dec. 21, 2021, MnDRIVE Environment was led by Dr. Paige Novak and Dr. Michael Sadowsky of the Biotechnology Institute, College of Biological Sciences. During this period, MnDRIVE Environment was focused primarily on **bioremediation and wastewater treatmen**t.

From Jan. 1, 2022, through Aug. 2023, MnDRIVE Environment was led by Dr. Forest Isbell, Department of Ecology, Evolution and Behavior, College of Biological Sciences. While maintaining the legacy focus on bioremediation, Dr. Isbell responded to evolving state needs, expanding MnDRIVE Environment funds to address a **wider set of environment-related imperatives and opportunities**—specifically, extreme weather, climate change, and biodiversity loss, regarded by global experts as the most severe environmental risks over the next decade.

With climate change, extreme weather has already become more frequent, intense, and destructive—with cascading economic, social, and environmental impacts felt across Minnesota. Climate change and biodiversity loss, meanwhile, have been recognized as intertwined challenges since the Rio Earth Summit in 1992. Many of nature's benefits to Minnesota citizens depend directly on biodiversity, including wood production in forests, livestock forage in grasslands, pollinators in croplands, and fish in aquatic ecosystems. This focal expansion has allowed MnDRIVE Environment to engage with and leverage the expertise of a wider set of researchers, multiply environmental research capacity across the UMN, and expand impact for the State of Minnesota and its citizens.

The Future of MnDRIVE Environment

In September 2023, the reins of MnDRIVE Environment were passed to Dr. Jessica Hellmann, a faculty member in the Department of Ecology, Evolution and Behavior (College of Biological Sciences) and the executive director of the UMN Institute on the Environment (IonE). This transition has created a unique opportunity **to leverage the resources and infrastructure of IonE to create even greater ROI for MnDRIVE Environment investments.**

The results of this transition in leadership will be provided in future reports, but have already included: further broadening participation in MnDRIVE Environment across UMN faculty, continued expansion of MnDRIVE Environment topics to a wide range of environment-related fields, and strengthening industry and community partnerships through the Midwest Carbon Leadership Project (MWCLP), a platform focused on industry collaborations that leverages the strengths of our state and positions Minnesota as a global leader in sustainability solutions.

As it has since its creation, **MnDRIVE Environment aims to solve real-world challenges, amplify impact, foster interdisciplinary collaborations, and enhance public engagement, ensuring Minnesota's continued leadership in environmental innovation.**

Research Highlights

(Seed projects funded from July 2021 through June 2023)

PFAS Remediation and Nutrient Recovery: During this reporting period, MnDRIVE Environment research teams worked **to deliver critical solutions to address and remediate poly- and perfluoroalkyl substances (PFAS)**, known as "forever chemicals," while recovering valuable nutrients. In recent years, PFAS have been found in a growing list of new places, with new evidence indicating they can threaten human health even at extremely low or undetectable levels. PFAS remediation is expected to be the major environmental cleanup concern and a significant business opportunity over the next decade and beyond.

The project *Mycoremediation of PFAS* is leveraging fungal pathways to break down PFAS, offering a scalable, cost-effective solution that reduces environmental contamination and protects public health. This research, for the first time, confirmed that fungal species can defluorinate PFAS chemicals – in essence, disassembling these chemicals. Another project, *Reactive Biomaterial to Adsorb and Degrade PFAS from Water,* is engineering advanced materials that efficiently sequester and destroy PFAS using novel reactive biomaterials, ensuring cleaner water sources and reducing human exposure risks. The team reports engagement with 3M, ExxonMobil, Barr Engineering, and Cyclopure, among others.

Complementing these efforts, a team working on a *Novel Approach to Remediate PFAS and Recover Nutrients from Minnesota Food Waste* is **pioneering a dual-benefit approach that removes PFAS while recovering essential nutrients**, advancing circular economy goals. In Spring 2023, the MnDRIVE project team at the Natural Resources Research Institute (NRRI) visited the Ramsey/Washington Recycling and Energy (RWR&E) facility and have been in close communication regarding the initiation of their food waste collection program. RWR&E are currently in the process of designing a food waste treatment train incorporating dry digestion and pyrolysis, and the team will work with RWR&E to incorporate their findings regarding dry digestion/pyrolysis into community education materials.

These three projects are not only enhancing environmental health, but also driving growth by fostering new technologies and strategic industry partnerships, positioning Minnesota as a leader in PFAS remediation.

Bioremediation and Environmental Cleanup: During this reporting period, MnDRIVE Environment researchers have also been working to develop **cutting-edge bioremediation solutions that leverage microbial and fungal pathways to clean up environmental contaminants**. As one example, in Minnesota, more than 1,300 petroleum release incidents were reported between 2017 and 2021—and most of them occurred in the Twin Cities metro area, which is notably underlain by unconsolidated sediments and fractured aquifers. Bioremediation is considered a key solution to this problem, and the global market is projected to reach $334.7 billion by 2027.

Researchers on the projects *Using Branching Fungus to Bioremediate Hard-to-Reach Contaminants* and *Microbial Enzyme Bioremediation via Genetically Engineered Animal Delivery Systems* are pioneering novel delivery mechanisms that enhance the efficiency of contaminant degradation, enabling more effective cleanup of polluted sites. The *Branching Fungus* team has already **successfully filed a provisional patent through UMN Technology Commercialization**, while the *Microbial Enzyme Bioremediation* team reports substantial progress towards proof-of-concept laboratory systems demonstrating the use of microbial enzymes in genetically engineered animals that are able to degrade environmental pollutants.

Another team—*Cyanotoxin Bioremediation with Microbes*—is working to protect public health by **identifying microbial communities that neutralize harmful cyanotoxins**, safeguarding Minnesota's freshwater resources and reducing waterborne health risks. Harmful algal blooms (HABs) are an ecological and water supply risk due to a mixture of undesired effects: water anoxia, undesirable odors, and cyanobacterial toxins. HABS are an emerging problem in freshwater rivers, lakes, and reservoirs throughout Minnesota, in large part because of eutrophication and climate change.

These innovative bioremediation strategies are advancing Minnesota's leadership in environmental sustainability—and supporting healthier more resilient communities and ecosystems.

Wastewater Treatment and Nutrient Management: Addressing a critical need for sustainable wastewater treatment, MnDRIVE Environment projects during this reporting period also tested **innovative solutions to improve water quality while promoting circular economy principles.** *Evaluation of Biochar and Iron-Enhanced Sands in Septic Systems* set an ambitious goal of "using waste to purify wastewater," and was able to demonstrate a 99% phosphorus reduction and significant bacterial removal using a proven ratio of agricultural waste-derived filtration materials, enhancing water quality and reducing nutrient pollution.

The project team working on *Regenerable Membranes for Phosphate Removal and Recovery from Water* is advancing nutrient recovery technologies that **prevent water pollution while supporting sustainable agriculture.** The overarching goal is to close the "P cycle" by sequestering phosphate from polluted wastewater and recovering it as slow-release fertilizer—a strategy that is key to the long-term sustainable use of two critical resources (e.g., both water and phosphate). These projects are positioning Minnesota as a leader in sustainable water management.

Climate Change Mitigation and Adaptation: In response to the escalating impacts of climate change, MnDRIVE Environment projects are also developing adaptive strategies to protect and build the resilience of Minnesota's ecosystems and communities.

During this reporting period, the State of Minnesota set ambitious climate and environmental goals, including achieving net-zero emissions by 2050, which will require removal of carbon dioxide from the atmosphere. A major carbon dioxide removal (CDR) technology readily implementable in Minnesota is biochar production and use. The research team working on *Evaluation of the Multifunctional Values of Urban Biochar Applications* is exploring **the co-benefits of urban biochar for pollution mitigation, carbon sequestration, and soil health.** This project is specifically designed to match Minneapolis feedstock availability with the range of production parameters of the city's new pyrolysis plant so that the city can produce high quality and safe biochars with the optimal material properties for its various applications.

Meanwhile, *Restoration of Peatland Hydrology to Mitigate Greenhouse Gas Emissions* is evaluating **hydrological interventions that reduce carbon emissions from peatlands**, contributing to climate change mitigation. Drainage of peatlands has altered the biogeochemical and microbial processes occurring in peatlands, converting them into carbon sources rather than sinks. This is a critical issue for our state and region; Minnesota has more peatlands – more than 6 million acres – than any other state in the US except Alaska.

The *Adaptive Silviculture for Climate Change in an Urban Floodplain Forest* team is working to identify **forest management practices that enhance climate resilience and protect communities from flooding**. The Upper Mississippi River System spans more than 2.6 million acres and supplies clean drinking water to millions, provides habitat for more than 40% of all North American waterfowl and shorebirds, and generates billions in economic revenue through shipping. Currently, due to lack of research, land managers have more questions than answers in how to regenerate floodplain forests in a changing environment; this project is working to close critical information gaps about effective practices to maintain and restore floodplain forest in the face of current stressors.

The team on *Understanding the Aquatic Carbon Cycle through Community Engaged Research* is engaging Minnesota high school students in their work to better understand the environmental and biogeochemical controls that ultimately determine if carbon is degraded or preserved within a lake ecosystem. By engaging high school students as co-investigators, this project will both contribute to a fundamental understanding of the aquatic carbon cycle that is imperative for developing effective management practices, while developing Minnesota youths' connections to nature.

Last and not least, the project *Quantifying Effects of Climate Change on Microbial Necromass Decomposition* is investigating carbon cycling dynamics under changing climate conditions, contributing to predictive models of ecosystem health. Understanding how carbon enters and leaves soil – the largest active terrestrial carbon pool – represents a critical research focus due to rising global temperatures associated with increasing atmospheric carbon dioxide.

Innovative Pollution Prevention and Monitoring: To address emerging pollutants and environmental health threats, MnDRIVE researchers are also developing next-generation pollution prevention and monitoring technologies. A project team working on *Graphene Sensors to Monitor Phosphate for Stormwater Pollution Prevention* is providing **real-time monitoring of phosphate pollution**, enabling proactive water quality management and reducing nutrient runoff. The research team is excited to have demonstrated a viable solution for real-time, on-site phosphorus detection with high sensitivity and selectivity, addressing significant gaps in environmental monitoring needs.

The team working on *Sustainable Ways of Microplastic Extraction Using Bioflocculants* is **pioneering bio-based extraction techniques that reduce microplastic pollution,** safeguarding Minnesota's beloved aquatic ecosystems and protecting public health. Small plastic particles (<5 mm), called microplastics and nanoplastics, are a recognized threat – but their removal from wastewater remains a challenge. The addition of a flocculant, such as a charged polymer, can help aggregate these small particles, but they come with their own environmental risks. Bio-flocculants (such as seed oils, derived from materials that are naturally abundant) present a potentially sustainable solution. These projects support Minnesota's leadership in environmental technology, while driving economic growth through new product development and industry partnerships.

Biocorrosion, Biofouling, and Chemical Cycling: MnDRIVE researchers are also advancing sustainable industrial practices by developing **innovative solutions to tackle biocorrosion, biofouling, and chemical cycling challenges.** Biofouling is the spontaneous colonization of submerged natural or artificial structures by a broad spectrum of aquatic organisms, which has a range of adverse effects on ships' hydrodynamic performance, fuel consumption, and port infrastructure. Anti-fouling coatings exist, but are toxic to the environment. Our project *Exploring Enzyme Combinations to Reduce Biofouling and Biocorrosion* is addressing these industrial challenges by engineering enzyme-based solutions that reduce maintenance costs and environmental impacts, supporting Minnesota's manufacturing and technology sectors.

Meanwhile, compostability without sacrificing functionality is the requirement for **the next generation of disposable adhesive products**. Our project *Closing the Loop on the Life Cycle of Pressure-Sensitive Adhesive (PSA) with Biological Remediation* is developing biological solutions for such synthetic adhesives, reducing chemical waste. (A number of Minnesota companies produce, coat, or use PSA; it is a product whose market increases 5% annually and is expected to grow to nearly $13 billion by 2025.)

Another project, *Engineering Biofilms to Optimize Biodegradation of Lignin Waste,* is working to optimize **the transformation of pulp and paper industry by-products into valuable bioproducts**—such as bioplastics and biofuels—supporting the state's bioeconomy and promoting sustainable manufacturing.

Conclusion

These cutting-edge research projects exemplify MnDRIVE Environment's commitment to driving environmental innovation and economic growth, supporting resilience and adaptation, and improving the health and well-being of all Minnesotans. By leveraging the strengths of our state and the UMN, MnDRIVE Environment is transforming environment and sustainability challenges into opportunities to benefit Minnesota industries, agencies, and communities—and positioning Minnesota as a regional and global leader in a rapidly changing world.

MnDRIVE Brain Conditions

Background

MnDRIVE Brain Conditions' mission is to build the University of Minnesota's capacity for **world-class neuromodulation research** for the benefit of all Minnesotans and beyond to improve quality of life. This initiative combines neuroscience, engineering, and medical research to position Minnesota as a leader in brain and neurological health advancements. This mission is divided into **five objectives**:

- **Develop Innovative Treatments** of diseases with a focus on neurological and psychiatric disorders such as Parkinson's disease, epilepsy, traumatic brain injury, obsessive compulsive disorder, and depression.
- **Enhance Brain Imaging and Neuromodulation** by improving diagnostic tools and therapeutic interventions using cutting-edge technologies such as deep brain stimulation, transcranial magnetic stimulation, optogenetics, and vagal nerve stimulation.
- **Collaborate with Medical and Industry Partners** by working with hospitals, companies, and policymakers to translate research into real-world solutions.
- **Improve Patient Outcomes** by developing and implementing new therapies to enhance the lives of individuals with brain conditions.
- **Strengthen Minnesota's Research and Medical Economy** by supporting workforce development, innovation, and public-private partnerships in the medical field.

MnDRIVE Brain Conditions attracts top researchers, fosters collaborations with industry, supports gathering of pilot data needed for federal grant applications, and accelerates the translation of scientific discoveries into real-world treatments. By funding MnDRIVE, the state has and will continue to enhance healthcare outcomes, reduce long-term medical costs, and drive economic growth through job creation and innovation in medical technology. **Continued support ensures that Minnesota remains a leader in neuroscience and neuromodulation, benefiting both public health and the state's economy.**

Major Achievements

- MnDRIVE Brain Conditions funding has resulted in **$237 million of additional funding from external sources** since its inception.
    - ~$135 million in the recent reporting period.

- MnDRIVE Brain Conditions infrastructure directly contributed to the University of Minnesota being awarded a **Udall Center of Excellence for Parkinson's Disease Research** by the National Institutes of Health, one of only three awarded across the country.
- Funding from MnDRIVE Brain Conditions has allowed the University **to attract and recruit leading clinicians and researchers.**
    - **Sixteen leading researchers** in Neurology, Neurosurgery, Psychiatry, Neuroscience, Biomedical Engineering, and Rehabilitation Medicine have been recruited to Minnesota with resources provided by MnDRIVE Brain Conditions. Four faculty were recruited in the recent reporting period.
- MnDRIVE Brain Conditions has facilitated **the training of 53 graduate students, 40 postdoctoral fellows, 15 clinical fellows, 10 industry partnership fellows, and 42 undergraduates.**
- MnDRIVE Brain Conditions has **three research cores: deep brain stimulation, noninvasive neuromodulation, and optogenetics**. Specializing in these research services has been essential for driving innovation in neuromodulation by providing cutting-edge resources, expertise, and infrastructure to support groundbreaking research.
- MnDRIVE Brain Conditions clinicians have provided **services to 10,341 patients** during the current reporting period.
- MnDRIVE Brain Conditions faculty have had **41 Intellectual Property disclosures** in the past reporting period.
- From this reporting period, MnDRIVE Brain Conditions has a total of **473 publications** which demonstrates the program's significant contributions to advancing neuromodulation and brain-related research.

Faculty Recruitment

Leonardo Brito de Almeida. M.D., M.S. - Neurology. Dr. Almeida has been recruited as an Associate Professor in the Department of Neurology with subspecialty training in movement disorders. He joined the University of Minnesota in 2022 to serve as the division chief of the Movement Disorders Program. He has expertise in Deep Brain Stimulation (DBS) for movement disorders including Parkinson's disease, essential tremor, and dystonia. Dr Almeida sees patients in the neurology clinic, focusing on DBS, and works as a clinician-researcher in order to contribute to the field in developing more efficient ways to deliver neuromodulatory therapy to patients and continue to improve patient outcomes.

Jacqueline Palmer, D.P.T., Ph.D. - Rehabilitation Medicine. Dr. Palmer was successfully recruited to the University of Minnesota in September of 2023. Dr. Palmer's research aims to understand the neurophysiologic and neuromechanical control of balance and mobility and the effects of aging and age-related neuropathology such as stroke. Her lab uses multimodal functional neuroimaging approaches to biomechanical analyses, and noninvasive brain stimulation to identify and modulate brain networks involved in balance and walking.

Edgar Peña, Ph.D. - Biomedical Engineering. Dr. Peña's lab develops computational models that push the state-of-the-art to enable personalized neuromodulation therapies. In parallel, his lab leverages state-of-the-art modeling, electrophysiology, and data science methods to understand emerging methods for selective nervous system modulation. Given the growth in electrical neuromodulation for both autonomic and central nervous systems (e.g., excessive inflammation in rheumatoid arthritis, blood pressure in hypertension, and rehabilitative therapies post-stroke), his lab pursues outcomes that will have a widespread impact on clinical practice.

Jan Zimmermann, Ph.D. - Neuroscience. The primary research goal of the Zimmermann lab is to better understand decision making. Making a choice, independent of it being a complex decision about your retirement allocations or which flavor of ice-cream to pick, is the normative consequence of any behavior that is observable. To understand this process, the Zimmermann lab combines a multitude of tools that allow the study of neural function associated with decision making.

NIH Funding Highlights

Dr. Jerrold Vitek's application for a 5-year Udall grant was funded, which secured $11.6 million to continue the University of Minnesota's Udall Center of Excellence for Parkinson's Disease Research, which is a joint effort of 31 staff and 25 faculty. This prestigious funding from the National Institute for Neurological Disorders and Stroke places the center among an elite group of three national sites advancing Parkinson's disease research.

A MnDRIVE Brain Conditions research team received a $2.2 million, five-year NIH epilepsy grant to investigate ways to improve deep brain stimulation outcomes for epilepsy patients. This funding supports efforts to enhance treatment effectiveness and epilepsy patient outcomes.

Several of the MnDRIVE Brain Conditions faculty were part of a team that was awarded a $21 million dollar grant (REVEAL) from the NIH to better understand the effects of vagal nerve stimulation (a form of neuromodulation). REVEAL is dedicated to investigating the anatomical pathways and functional impacts of vagus nerve stimulation (VNS), an FDA-approved therapy for epilepsy and depression. The initiative combines a large-scale clinical study, involving up to 144 individuals undergoing VNS, with three supplementary studies. By conducting this research, the team aspires to develop one of the most comprehensive publicly accessible datasets on VNS effects in humans.

Clinical Impact and Translational Research Highlights

MnDRIVE Brain Conditions Faculty Drs. David Darrow, Tay Netoff, Ziad Nahas, and Michael Park are leading a University of Minnesota study aimed at overcoming the challenges of treatment-resistant depression. Their research seeks to address the variability in patient responses and improve neuromodulation-based therapies.

A startup company based on MnDRIVE Brain Conditions member Dr. Noam Harel's research reached a major milestone in improving deep brain stimulation (DBS) for Parkinson's disease. Surgical Information Sciences (SIS) announced the first commercial use of its SIS System, which generates patient-specific 3D brain maps to enhance DBS lead placement and optimization, making the treatment more precise and effective.

Dr. Alik Widge and his team demonstrated that merging AI with targeted brain stimulation can enhance self-control and mental flexibility. This pilot study offers a promising new approach for treating severe mental illnesses.

Dr. Michael Park and Dr. Rohan Lall performed the world's first integrated spinal fusion and neuromodulation procedure as part of SynerFuse's proof-of-concept study. This study evaluates the safety and effectiveness of combining spinal fusion hardware with a dorsal root ganglion neurostimulator to treat chronic lower back pain.

Drs. David Darrow, Tay Netoff, and their team are seeing remarkable results in a clinical trial using spinal cord implants to restore movement in patients with paraplegia. All 20 participants experienced significant improvements, including one patient who regained leg movement after 23 years.

Drs. Christine Conelea and Suma Jacob are collaborating on innovative research to support children with neurodevelopmental disorders. Their work, featured in Discovery magazine, explores new approaches to improving care and treatment for these conditions using transcranial magnetic stimulation technology combined with behavioral therapy which can help children and adolescents better manage symptoms associated with tic disorders.

MnDRIVE Brain Conditions researchers Dr. Sophia Vinogradov and Dr. Jazmin Camchong were recently awarded prestigious grants from the U of M's Office of the Vice President of Research, recognizing their impactful work in mental health and neuromodulation. Dr. Vinogradov received a grant to study mental health stigma in the Somali American community, while Dr. Camchong was awarded a Summer Grant-in-Aid of Research to explore the effects of neuromodulation on substance use relapse. These awards highlight MnDRIVE's commitment to advancing research that addresses critical societal and neurological challenges.

Highlights in Outreach and Rural Community Engagement

MnDRIVE Brain Conditions has actively engaged with public, educational, industry, research, and patient communities through a variety of outreach initiatives, including participation in high-profile events such as the Minnesota State Fair, Spotlight Science: Brain Power at the Bell Museum, and the Spring Parkinson's Patient Symposium.

Additionally, MnDRIVE has hosted the prestigious **Minnesota Neuromodulation Symposium** for 12 years, bringing together leading researchers and industry partners from across the country to foster innovation and collaboration in the field. The program has contributed to community outreach, educational research conferences for students and trainees, and industry collaborations aimed at advancing neuromodulation technologies.

MnDRIVE scholars and researchers have presented at **major scientific conferences,** facilitating knowledge exchange and interdisciplinary partnerships. These outreach efforts play a crucial role in bridging the gap between research and real-world applications, promoting awareness, collaboration, and innovation in neurological and psychiatric solutions.

MnDRIVE has actively supported initiatives to **broaden science participation**, developing new programs such as the MnDRIVE Early Faculty Career Development Award, funding undergraduate summer research internships annually, and contributing to the creation of STEM Advantage—an undergraduate education program in partnership with the Louis Stokes NorthStar STEM Alliance Program.

MnDRIVE Brain conditions faculty have traveled throughout greater Minnesota to provide clinical care information to patient populations and support groups in areas such as Duluth, St. Cloud, Coon Rapids, and Stillwater. In addition, MnDRIVE Brain conditions has also had success in **increasing enrollment in clinical trials** from a wide geographic area, bringing clinical trial access for neuromodulation to the entire State.

Conclusion and Future Directions

MnDRIVE Brain Conditions has made remarkable strides in advancing neuromodulation research, attracting top-tier talent, securing substantial external funding, and translating cutting-edge discoveries into clinical applications. State funding has been instrumental in fostering these achievements, ensuring that Minnesota remains at the forefront of neuroscience and neuromodulation innovation. Moving forward, continued investment will be crucial to sustaining this momentum, enabling groundbreaking research, expanding industry collaborations, and improving patient outcomes. Strengthening partnerships with federal agencies, healthcare institutions, and technology companies will further drive translational impact and economic growth. By maintaining strong state support, MnDRIVE Brain Conditions can continue to push the boundaries of neuromodulation research, ultimately improving lives and solidifying Minnesota's leadership in brain health and medical innovation.

MnDRIVE Cancer Clinical Trials Network

Background

The **Minnesota Cancer Clinical Trials Network (MNCCTN)** was established with the purpose to "create a new, multi-site cancer clinical trials network to improve cancer care statewide." State funding has been instrumental in building an innovative and unique partnership model with measurable statewide impact, positioning Minnesota as a national leader in advancing an equitable and sustainable approach to cancer clinical trial participation.

The State of Minnesota is fortunate to have **two National Cancer Institute (NCI)-designated Comprehensive Cancer Centers - CCC** (Masonic Cancer Center, University of Minnesota and the Mayo Clinic Cancer Center). In addition, there are **three NCI-Community Oncology Research Program**s - NCORP (Metro Minnesota Community Oncology Research Consortium, Essentia Health NCORP, and Sanford NCORP of the North Central Plain). Each of these federally funded centers have a goal of enrolling their community subjects into cancer clinical trials. However, these centers have not previously worked together to achieve this goal.

MNCCTN Clinical Partners	
Essentia Health	14 sites
M Health Fairview	3 sites
Mayo Clinic Health System	2 sites
Metro-MN Community Oncology Research Consortium (MMCORC)	1 site
Sanford Health	4 sites
MNCCTN Research Partners	
Masonic Cancer Center	
Mayo Clinic Cancer Center	
The Hormel Institute	

Since receiving funding in FY 2018, MNCCTN has established collaborative partnerships and built infrastructure across the state to bring cancer clinical trials to underserved communities and has leveraged the strengths of the NCORPs and the two CCCs. Tasked with expanding access to cancer clinical research to new geographic locations without existing research capabilities, MNCCTN consists of small to medium size oncology clinics outside of the seven county metro area that, prior to participating in MNCCTN, had not participated in clinical trial research. Led by the Masonic Cancer Center, the MNCCTN is made up of five Clinical Partners and three Research Partners. Each Clinical Partner has varying numbers of sites. **As of June 30, 2023, MNCCTN had 24 sites across Greater Minnesota.**

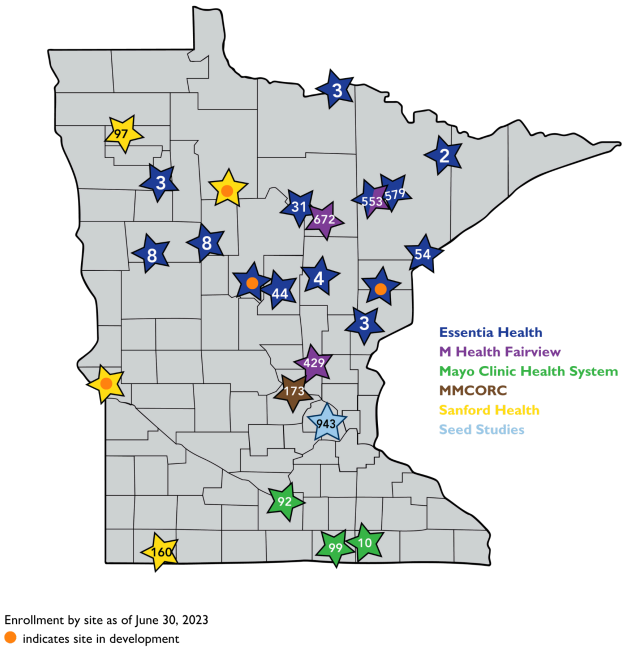
The HUB team based at the University of Minnesota collaborates closely with every partner, employing a hands-on approach to strengthen research infrastructure statewide.

The MnDRIVE investment and organizational structure of MNCCTN are **unique among cancer clinical trial networks in the United States.** While many community oncology research networks exist, none benefit from this level of direct state investment. MnDRIVE funding allows us to work across multiple healthcare systems, which enables us to provide critical infrastructure support to community clinics. By leveraging MnDRIVE funding, we have been able to enhance workforce development, strengthen clinical research capacity across the state, and continue to cultivate a robust pipeline for future research efforts.

Portfolio & Enrollment: July 1, 2021 - June 30, 2023

In this reporting period, MNCCTN offered cancer clinical trials to Greater Minnesotans at **24 different site locations** throughout the state, with two new sites opening in Bemidji and Ortonville in collaboration with Sanford Health. MNCCTN **enrolled 3,409 participants** to cancer clinical trials between July 1, 2021 to June 30, 2023. This brought MNCCTN's total enrollment from inception to June 30, 2023 to 3,967. **86 total clinical trials** were open or slated to open at sites.

MNCCTN Enrollment at Current & Historical Sites



Enrollment by site as of June 30, 2023
● indicates site in development

Job Creation & Workforce Development: July 1, 2021-June 30, 2023

During this reporting period, **138 people** were working with the network statewide, and **89 positions w**ere fully or partially funded with MnDRIVE investment. The majority of these positions are located in Greater Minnesota. In addition to these paid positions, **49 other positions** are supported in-kind by the University of Minnesota and our Partners. Each MNCCTN Partner has demonstrated their commitment to this collaboration by allocating internal funding to pay clinical professionals and research administrators to collaborate with us on this important work.

Research Successes & Return on Investment: July 1, 2021-June 30, 2023

MNCCTN's support of cancer researchers at the University of Minnesota has helped UMN researchers secure **nearly $1.1 million in external grant funding** as of June 20, 2023. MNCCTN has also created research success stories through trials, community engagement, and grant funding.

Investigator Initiated Research

A network achievement in 2022 was opening **a new study, Port Flush,** that was initiated by MNCCTN Partner Essentia Health. The study focuses on implanted port devices, which are used to administer cancer treatments. Typically, these ports are flushed every 4-6 weeks when not being used for treatment. The Port Flush study assesses the safety of a 12-week port flush schedule compared to a 4-week schedule. The study idea behind Port Flush came about due to the COVID-19 pandemic. As patients were making fewer visits to clinics, ports were flushed less frequently out of necessity. The Port Flush study was then developed by Essentia Health Community Cancer Research Program (EHCCRP), with Bret Friday, MD, PhD, serving as Principal Investigator.

The Port Flush study highlights the strength of the MNCCTN collaboration by engaging Partners in research that is truly impactful for rural Minnesotans. Traveling to clinics every 4-6 weeks for a port flush can be a significant burden in rural areas. If proven to be safe and effective, a less frequent schedule could save both patients and clinics in terms of time and money by eliminating unnecessary flushes. The

study is open at MNCCTN sites across all MNCCTN Partners, with at least one participant enrolled at each Partner. The study is open to all cancer types and has a larger enrollment goal, so it gives significant opportunities for patients statewide to participate.

Research and Community Engagement Grants

In addition to the network's efforts at clinical sites across the state, MNCCTN leads **an annual grant program to fund cancer-focused research** that addresses the unique cancer burden of Minnesotans. From the program's inception to June 30, 2023, the MNCCTN grant program has awarded $823,036 to support 3 research projects and 5 clinical trials.

	MNCCTN Grant: Project Title	**Awardee Organization**
2021	"Colchicine for the Management of BRAF/MEK Inhibitor Associated Pyrexia"	Essentia Health
2021	"Restorative Microbiota Therapy (RMT) in patients with steroid refractory severe immune-checkpoint inhibitor induced colitis"	UMN
2021	"Implementation of proactive colon cancer screening program for the Native American community"	UMN
2022	"Reishi mushroom for treating Aromatase inhibitor-associated toxicities"	Mayo Cancer Center
2022	"Cultural Awareness pilot project" with the American Indian Cancer Foundation	Essentia Health
2023	"Increasing Lung Cancer Screening Through Multi-Site Screening Facilitation"	UMN
2023	"Increasing Lung Cancer Screening Through Implementation Facilitation in a Safety Net Health System"	HCMC
2023	"Evaluating the Time Burdens of Home-Based Cancer Care"	UMN

One of these grants was awarded for a community study to assess the effectiveness of a **proactive outreach colorectal cancer (CRC) screening program for patients at the Minneapolis Native American Community Clinic (NACC).** The study used a proactive outreach approach that incorporates a mailed invitation to screen, followed by navigation to a colonoscopy if the initial screening is positive. The study team also conducted qualitative interviews to learn about CRC screening barriers and facilitators. Ultimately, the study team found that CRC screening rates were 16.8% higher in the group that received the proactive screening approach compared to the control group. NACC and the study team will utilize this information to inform and improve future screening programs. The study team published an article, "Multilevel Interventions to Improve Colorectal Cancer Screening in an Urban Native American Community: A Pilot Randomized Clinical Trial" by Shaukat et al. (PMID 38365095), on the study in the high-impact journal *Clinical Gastroenterology and Hepatology*. MNCCTN and NACC are also pursuing a longer term relationship to address Native American health disparities.

Conclusions and Future Directions

With MnDRIVE funding, we have created a **statewide network designed to engage rural communities into cancer clinical research**. Using the existing strengths in MN (NCORPs and CCCs), MNCCTN expanded the reach of these NCI-funded centers by expanding clinical research to rural sites throughout greater MN. In addition, MNCCTN has expanded outreach to urban communities historically under-represented in cancer clinical research with a focus on Native American subjects. MNCCTN has created a productive and effective partnership which is meeting its goals of engaging Minnesotans as clinical research partners, providing training opportunities for research staff throughout the state, allowing our clinical and research partners to conduct trials designed to address a clinical dilemmas seen in their everyday practices, and providing infrastructure for our research partners to use in federal grant applications.

In the future, MNCCTN plans to increase the scope and impact of the network through several strategies.

- First, we hope to **engage St. Cloud and CentraCare** in the network. As a new site for UMN Medical School, we aim to provide clinical research opportunities for their patients.
- Second, we plan to **expand the types of trials offered to our partners** by opening sponsored clinical trials. There are several consortia (such as the Big 10 Cancer Research Consortium) that brings cancer clinical trials funded by industry to all the cancer centers in the Big 10. We have approval of their leadership to open therapeutic clinical trials within MNCCTN. We will also explore other opportunities to bring industry funded studies into the network. We expect MNCCTN will provide efficiency to the process of opening trials by offering a “one stop” place to go to enroll patients in the entire state.
- Third, we will continue to **build partnerships with urban community providers** who focus on under-represented communities such as our ongoing partnership with the Native American Community.
- Fourth, we will use MNCCTN to **educate providers and Minnesotans throughout the state on the value and impact of participation in clinical research.** In partnership with the American Indian Cancer Foundation (AICAF) and the Center Clinic, a rural community clinic in Dodge Center, MN, we will conduct community outreach and focus groups to identify the community’s needs, beliefs, and learning objectives around cancer, clinical trials, and health. Ultimately, these learnings will inform tailored clinical trial education strategies to best reach the communities the organizations serve

MnDRIVE Cross-Cutting Support for AI and Data Science

Background

Minnesota's MnDRIVE initiative has played a pivotal role in advancing both **foundational and applied research in Data Science and Artificial Intelligence (AI)**. By strategically investing in cutting-edge research, infrastructure, and workforce development, MnDRIVE funding has strengthened Minnesota's position as a leader in AI and Data Science innovation. This section of the report highlights three key areas where MnDRIVE AI and Data Science support has made a significant impact: preparing a highly skilled workforce, accelerating research that drives growth in core sectors of the state's economy, and enhancing advanced computing and cyberinfrastructure. Through these efforts, MnDRIVE continues to fuel technological advancements that address critical societal and economic challenges.

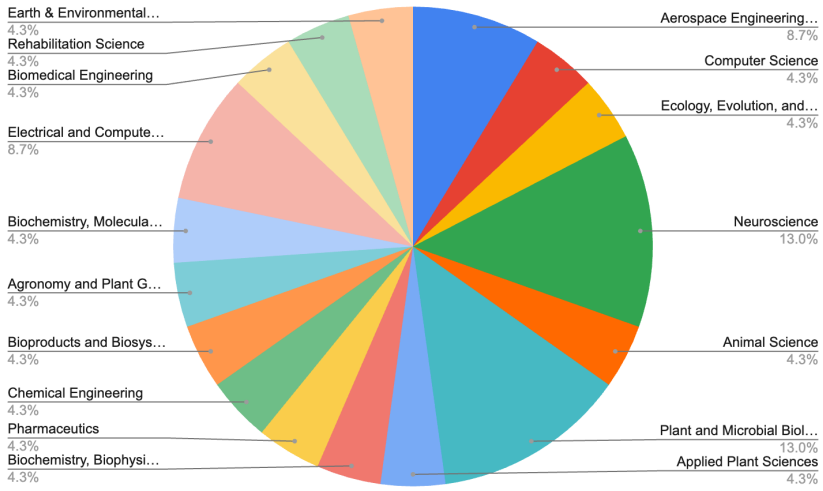
Workforce Development: Training Minnesota's Next Generation of AI and Data Scientist Leaders

MnDRIVE funding for **Ph.D. Graduate Student Fellowships in Data Science and AI** is playing a crucial role in shaping Minnesota's next generation of industry leaders and researchers. By supporting graduate students who focus on cutting-edge AI and data science applications, this initiative is cultivating a highly skilled workforce equipped to drive innovation in critical sectors of the state's economy. These fellowships provide financial support, mentorship, and access to state-of-the-art computing resources, allowing students to focus on high-impact research that bridges the gap between academia and industry. As a result, Minnesota is developing a pipeline of experts who are not only advancing the frontiers of AI and data science but are also prepared to translate these innovations into real-world solutions.

In Fiscal Year 2022 and 2023 a total of **23 Ph.D. fellowships** were awarded at a value of **$1.1M.** These awards not only cut across all of MnDRIVE's focal areas, but they were also broadly distributed across **17 UMN departments** (see figure below) exemplifying the multidisciplinary nature of Data Science and AI. The total number of Ph.D. fellowship applications exceeded the availability of MnDRIVE funds by four fold. The highly competitive nature of this fellowship meant that award winners under this program represent the best of the best. The following is a sample of the fellowship titles awarded in FY 2023 in four of the MnDRIVE focus areas.

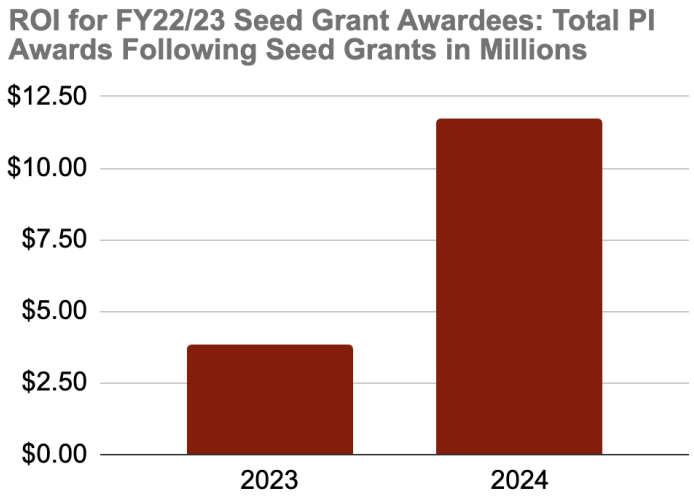
- **Brain Conditions:** Developing patient-specific biophysical models of ventral capsule/ventral striatum deep brain stimulation for treating obsessive-compulsive disorder
- **Global Food:** Developing tools to predictively assess masa (corn) quality through machine learning and computer vision
- **Robotics:** In-flight Data-Driven Robust Control of Hypersonic Vehicle for Autonomous Flight Testing
- **Environment:** Metagenome mining to inform bioremediation: elucidating the impact of microbial metabolism on the transport fate of sulfur in MN groundwater

The impact of these fellowships extends across multiple industries vital to Minnesota's well-being, including healthcare, agriculture, manufacturing, and environmental sustainability. By fostering collaborations between academia, industry, and government, MnDRIVE-funded researchers are applying AI-driven solutions to enhance medical diagnostics, optimize food production, improve manufacturing efficiency, and address climate-related challenges. Graduates of these programs are becoming the leaders who will shape the future of Minnesota's economy, ensuring that the state remains competitive in an increasingly AI and data-driven world. Through these strategic investments, MnDRIVE is not only advancing research but also securing a strong, technologically adept workforce that will sustain Minnesota's growth and innovation for years to come.



Enabling and Accelerating Data Science and AI Research and Their Application

In fiscal years 2022 and 2023, MnDRIVE's strategic allocation of seed grants has significantly accelerated AI and Data Science research at the University of Minnesota. By requiring grantees to delineate clear pathways to external funding, these seed grants have achieved remarkable financial leverage, **yielding returns on investment ranging from 3 to 11 times the initial funding** (See figure below). This impressive multiplier effect underscores the efficacy of MnDRIVE's approach in fostering sustainable research initiatives that attract substantial external support.



Among the many notable projects benefiting from MnDRIVE seed funding is the project entitled, "Using Multi-omics Methods to Understand Pancreatic Cancer." Led by Dr. Rick Jansen and co-PI Dr. Sarah Munro, this project employs integrative multi-omics analysis to identify key gene expression, miRNA, and methylation markers crucial to the progression of pancreatic ductal adenocarcinoma (PDAC). By analyzing tissue samples from 32 pancreatic cancer patients, the team aims to uncover unique biological and molecular tumor signatures, facilitating the development of effective treatment strategies and early detection biomarkers. This cutting-edge research not only advances the understanding of a particularly lethal cancer but also positions the team to secure further external funding, exemplifying the transformative impact of MnDRIVE's seed grant program.

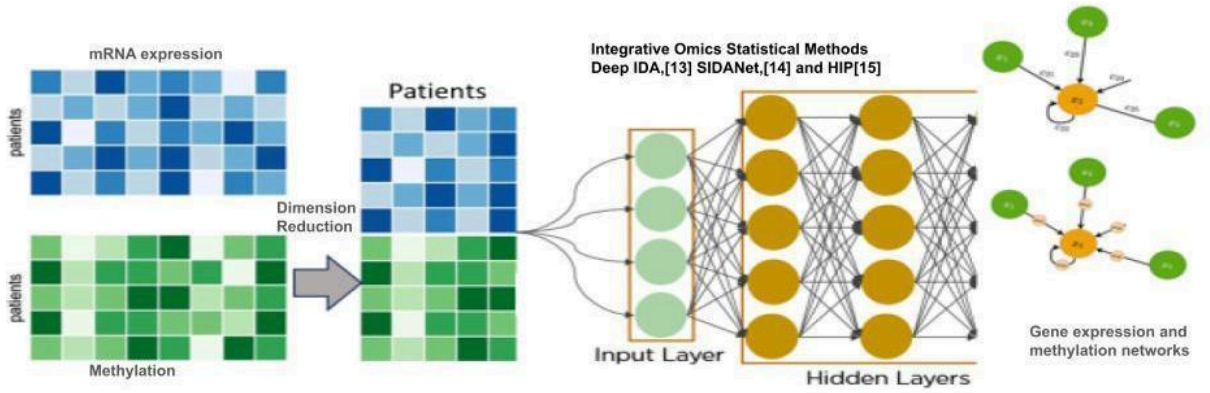


Figure from "Using Multi-omics Methods to Understand Pancreatic Cancer."

Another exemplary project is "Using AI and Computer Imaging for Dairy Cow Management," spearheaded by Ph.D. student Drew Swartz. This initiative focuses on integrating camera-based vision and artificial intelligence to assess locomotion in dairy cows, aiming to detect early stages of lameness—a critical aspect of animal welfare and dairy production efficiency. By incorporating factors related to the cow's biology into machine learning algorithms, the project seeks to enhance the accuracy of early lameness detection compared to traditional human observation methods.

The successful implementation of this technology has the potential to revolutionize livestock management practices, attracting interest and investment from both established agribusinesses and innovative startups.

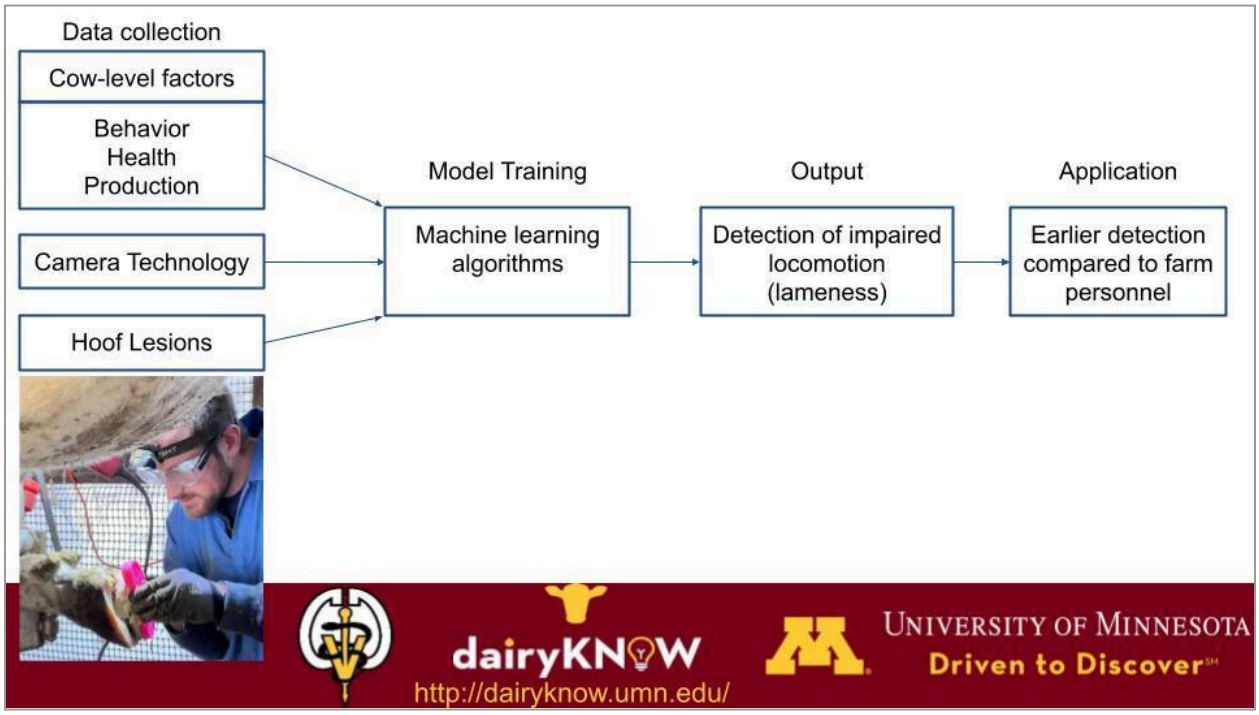


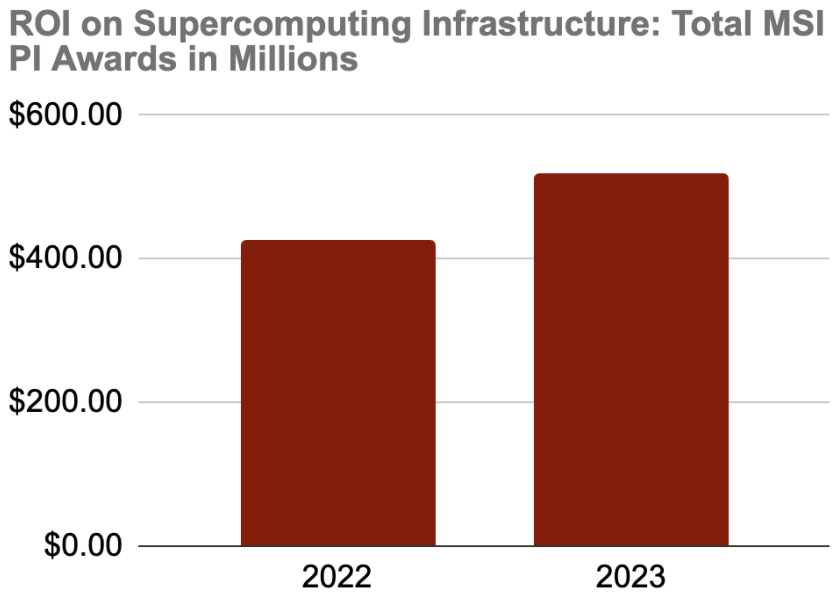
Figure from "Using AI and Computer Imaging for Dairy Cow Management."

These projects underscore the importance of MnDRIVE seed funding in elevating the University of Minnesota's research stature and reinforcing Minnesota's appeal as a hub for Fortune 500 companies and emerging startups. By investing in pioneering AI and data science research with clear trajectories toward external funding, MnDRIVE not only fosters academic excellence but also stimulates economic growth and innovation within the state.

Building Cutting-Edge Computing and Data Storage Infrastructure to Advance Data Science and AI Research

MnDRIVE's investment in advanced research computing and data storage infrastructure is essential to the University of Minnesota's ability to develop and sustain leading-edge research programs. In fiscal years 2022 and 2023, a $2.5 million investment in a state-of-the-art data storage system has been critical in accelerating data-intensive and AI-driven computational research. These high-performance computing resources enable researchers across disciplines to analyze vast datasets, train complex AI models, and conduct simulations that would be impossible with standard computing capabilities. The impact of these resources is reflected in the success of the Minnesota Supercomputing Institute (MSI), whose principal investigators secured $424.9 million and $516.7 million in external research funding in fiscal years 2022 and 2023, respectively (See figure below).

This return on investment underscores how essential cutting-edge computational infrastructure is for attracting significant research grants and sustaining Minnesota's position as a leader in AI and data science.



Beyond securing research funding, these resources play a crucial role in **attracting and retaining top-tier faculty and students.** Access to high-performance computing and large-scale data storage is a key factor for researchers considering where to conduct their work, as these capabilities enable them to push the boundaries of discovery in fields ranging from biomedical science to climate modeling and precision agriculture. The ability to offer such infrastructure strengthens the University of Minnesota's reputation as a premier research institution and enhances the state's ability to develop a highly skilled workforce. As the demand for AI and data-driven research continues to grow, ongoing investments in advanced computing will be vital to ensuring Minnesota remains a hub for innovation and economic development.