

## **North Dakota Research Universities: Strengths & Opportunities**

North Dakota is a state rich in natural resources. It has long been a key contributor in both energy and agriculture. However, dependence on these industries is inherently tied to turbulent economic markets under unpredictable, and often uncontrollable, outside pressures. ND's economic diversification is acknowledged as a mitigating factor for the risk that is inherent in the fluctuating energy and agriculture sectors. In a sparsely populated state of small urban, rural, and farm communities punctuated by only a handful of larger urban centers, these labor-intensive industries are particularly impacted by workforce shortages. Across the spectrum, retaining and attracting new North Dakotans by offering a quality of life that ensures access to excellent opportunities for education, high quality jobs, social engagement, world-class healthcare, and community services is critical for the state's prosperity. North Dakota leadership is committed to improving health outcomes and healthcare for its citizens, including those in rural communities, and has also invested to diversify North Dakota's economy and expand its emerging technology sectors, such as autonomous systems, to secure a sustainable and enriched future for its citizens.

ND's state legislature has long supported and consistently funded a robust system of higher education that provides access and opportunity across the state, coordinated and supported by the North Dakota University System (NDUS) office. The NDUS's mission to enhance North Dakotans' quality of life (economic and social) by discovery, sharing, and application of knowledge has set research excellence and innovation as one of its five priorities. It recognizes the value of faculty in the application of knowledge through teaching, scholarship, creative activity, and innovation. The intent is to enhance value added opportunities within and beyond the state's core agriculture and energy industries, more efficiently and effectively meeting the unique needs of the state, enhancing big data competencies increasingly essential in all fields, and diversifying the economy with expanded investments in autonomous capabilities. Complementing those existing points of focus will be research serving, on a statewide basis, the physical and social infrastructure of North Dakota and its wide array of communities, diversifying the state's economy, and creating measurable statewide improvements in the quality of life for all North Dakota citizens.

### **Research Universities**

ND's two research universities (RUs) lead the university system's efforts to advance discovery and develop technologies that spawn economic diversity, support industry development, and encourage industry recruitment to the region. This support is particularly impactful because, unlike other entities that conduct research, research universities combine the dual responsibilities of generating knowledge through research discovery and developing a highly skilled workforce that participates in the state's advances. In workforce development, RUs provide technical opportunity and hands-on research experiences for undergraduate students and enable graduate students to develop technical and disciplinary expertise through conducting mentored, independent research.

As entities that serve the citizens of the state, RU missions and values are aligned with established areas of importance to North Dakota, and strategies for advancing these missions support the strategic plan of the NDUS system. They serve the state in growing research impact and benefits, and, thus, the RU research process generates a sustained state knowledge resource, vital for technological advancement, economic development, and attracting industry to the state. In furthering research, RUs leverage internal investment to pursue external funding from federal and industry sponsors. External research funding enables RUs to parlay the internal investments to advance research and provide at least a 2-3x multiplier for actual economic impact. The funding,

particularly large collaborative state-focused grants (e.g., NSF EPSCoR and INBRE grants), enhance research opportunities for faculty and students in all of the state's colleges and universities.

RUs are the established key research drivers in the region with mature research and development activities that inform forward looking strategic state interests. Their combined efforts not only advance science and technology in the workplace, they recruit, teach, and train a highly educated workforce that fuel the future of the state and support community building. Today, their unique and combined expertise builds upon established strengths and expands into emerging technology sectors to help diversify the economy. Public-private partnerships between the RUs and industry innovators support efforts to advance technological discovery and implementation that support business development, spawn economic diversity, and encourage industry relocation to the region.

### **One UND Strategic Plan & Grand Challenges**

Under the One UND Strategic Plan, UND has focused its research discovery on five Grand Challenges. Each Grand Challenge is led by a "Champion" with a depth of knowledge and faculty expertise in the area. Champions work consistently with the president, provost, VPR, deans, and faculty. Each Champion has organized a team of experts and developed plans and goals that guide investments in the Grand Challenge.

- Energy & Environmental Sustainability
  - Addressing the state, national and global energy and environmental challenges
  - Enhanced oil production, sustainable/efficient energy, carbon capture, renewables, environmental technology for air, water, soil
  - Core: Energy & Environmental Research Center
    - 200 people and over 20 students
  - Champion: Dr. Michael Mann
  - Highlight: \$3.2M award from DOE (CEO of EERC, Charlie Gorecki) to study enhanced oil recovery while reducing carbon emissions in the Williston Basin
  - Highlight: Dr. Alena Kubatova (Chemistry) extracting biofuel acids with potential market applications (with College of Engineering faculty Wayne Seames and Brian Tande)
- Human Health
  - Basic biomedical research, clinical & translational work to improve health outcomes
  - Develop health care professional workforce
  - Tied to industry partners and providers in the state
  - Core: School of Medicine & Health Sciences (SMHS)
  - Champion: Dr. Colin Combs
  - Highlight: \$20.3M NIH CTR grant (Mark Basson, SMHS) to counter high cancer rates in North Dakota
  - Highlight: \$2.25M NIH grant (Jonathan Geiger, SMHS) to find new targets for therapeutics against epilepsy
- Rural Health and Communities
  - Rural health outcomes and technology transfer addressing mental health and addiction
  - Produce rural health care professional workforce
  - Tied to providers in the state and region
  - Core: College of Nursing and Professional Disciplines (CNPD), Center for Rural Health
  - Champion: Dr. Thomasine Heitkamp

- Highlight: \$3.2M from the Department of Health and Human Services, Substance Abuse and Mental Health Services Administration in grants to use science to treat behavioral health, increase mental health service in rural ND, and combat drug abuse, particularly related to opioids (Thomasine Heitkamp, CNPD).
- Autonomous Systems
  - ND State poised to lead the world in UAS, a state strength
  - Technology
    - Command & Control, BVLOS, Data, Policy, Testing
    - Unmanned Traffic Management, Counter UAS
  - Applications: Air, Ground, Underground, Underwater
  - Partnerships
    - Northern Plains UAS Test Site, Grand Sky, Industry and Community Partners
    - State and Federal Agencies
    - State Investment: NPUASTS, BVLOS network infrastructure
  - Core: Research Institute for Autonomous Systems (RIAS)
  - Champion: Dr. Mark Askelson (RIAS)
  - Highlight: RIAS, Northern Plains UAS Test Site, and Harris Corporation developed the technology and network to enable commercial BVLOS UAS flight
- Big Data
  - Collect, Protect, and derive reliable actionable meaning from data
  - Big Data: building from a smaller existing base; an emerging critical area
    - All sectors of research and industry scrambling to build
    - It is crucial for all Grand Challenges; Critical for ND
  - Core: Computational Science Initiative 2.0, College of Engineering & Mines (CEM)
  - Champion: Dr. Ryan Adams (School of Electrical Engineering & Computer Science, CEM)

### **NDSU Grand Challenges**

In a similar vein, NDSU has identified three areas of importance that represent significant challenges for the state and beyond. These Grand Challenges highlight the benefit of working on complex issues within the strong, stable interdisciplinary infrastructure that the research university uniquely provides. While some thematic areas fall under the established strengths of programs at NDSU, many aspects of both NDSU's and UND's challenge areas are enhanced when the complementary expertise of both faculties is employed, providing rich opportunities for collaboration.

- Food systems and security
  - Sustainability and expansion of ND agriculture to feed a growing world
  - Enhancing disease resistance, environmental stress tolerance, and yield, as well as providing new ways to use technological advances to ease workforce constraints
  - Stakeholders: producers and consumers of ag products and ag-associated businesses
  - Highlight: ND ag biotechnology
    - Engineering more nutritious crops that are better able to withstand adverse conditions
  - Highlight: multidisciplinary Precision Agriculture research and training program
    - Core: multiple disciplines in the Colleges of Agriculture, Food Systems, and Natural Resources; Science and Mathematics; and Engineering; as well as county Extension and the 7 Research Extension Centers across the state
    - New academic major to support the industry and enable new technologies

- Industry/community collaborations: Grand Farm, Grand Sky, multiple startups and spinoffs in the state
- Healthy population and vital communities
  - Sustainability, health, and growth of ND's rural, small urban, and urban communities
  - Highlight: interdisciplinary biomedical science research teams working on breast, prostate, and pancreatic cancer testing and treatment
    - Core: interdisciplinary research teams from Biology, Biochemistry, Business, Chemistry, Civil Engineering, Communications, Computer Science, Manufacturing Engineering, Pharmaceutical Sciences, and Public Health
    - Interdisciplinary discovery-based learning teams of undergraduate researchers and a new biomedical engineering graduate program
    - Industry/community partners: Sanford, Aldevron, startups in the area
  - Other healthcare highlights:
    - Telepharmacy delivery in Pharmacy Practice
    - Public Health disease prevention initiatives including childhood vaccination and diabetes education
- Sustainable energy, environment, and societal infrastructure
  - Energy
    - UAS, UND-EERC/NDSU collaboration with current patent application
    - Using CO<sub>2</sub> waste from the energy industry to boost plant growth and act as a carbon sink
  - Environment
    - New uses for ag products that decrease reliance on petroleum-based plastics
    - Advanced coatings for marine and cold weather applications
    - Major hub of pollinator research and biocontrol for plant disease
    - Integrated management of rangeland benefits soil, crops, and pollinator ecosystems
  - Societal infrastructure
    - Rural Leadership programs
    - Entrepreneurship collaborations with community partners
    - The new Challey Institute provides research on evidence-based social practices for civic prosperity

ND RUs have a solid foundation and demonstrated success in these areas, but enormous potential remains. Additional state support will propel success and enhance state goals.

### **Collaborate and Excel**

Both RUs strategically have invested internal time and resources in the past several years in efforts to build capacity and attain a sufficient critical mass, a sufficient depth, of faculty experts who bring disciplinary perspectives, professional networks, and successful granting experience to pursue larger competitive federal funding in priority research areas. The depth, or bench strength, is critical for the RUs goals to innovate new technologies, best prepare the next North Dakota workforce, convert research into commercial success, and prepare for yet-to-be-discovered applications and development. Importantly, this bench strength allows for enhanced collaboration with other higher education institutions and commercial partners and expand the impact of research statewide. RUs have taken several specific strategies in managing their research priorities:

1. Managing internal funds and programs focused on research priorities addressing Grand Challenges

- Invest in strategic research initiatives, directing internal seed funding to develop and support teams and training in focused areas of need
  - Support existing faculty through collaborative programs, contract flexibility, and goals for external funding
  - Support high-quality recruitment with opportunities for new faculty to participate in established, successful collaborative programs
2. Enhancing collaboration between the RUs and with other NDUS institutions across the state
- NDUS' RUs have a history of collaboration
  - The RUs also collaborate with the other higher education institutions across the state whose faculty provide students with research opportunities and contribute disciplinary expertise to research activities
  - RUs have unique and complementary strengths and shared depth in key areas
  - RUs are committed to working together
  - RUs can maximize collaborative opportunities through shared Terms of Engagement
    - Shared expertise enhances competitiveness
    - Coordination and additional perspectives increase impact and network
3. Pursuing industry-university partnerships and increasing commercialization efforts
- RUs partnering with ND Department of Commerce and the Bank of ND
    - New commercialization developer, Cortnee Jensen, to support efforts of both RUs
  - Aggressively pursuing industry-university research collaborations
    - To drive commercial application-based research
      - RU Research Offices
      - NDSU's Research & Technology Park
      - UND's Center for Innovation

### **Potential Areas of Research for ND**

RUs are the state's research and innovation arm, representing the largest source for R&D potential in the state. Research is an investment that pays dividends, not only with applications that are immediate and clearly tangible, but also for fundamental research that changes the way we do things. Because ND RUs are relatively small, our research impact is constrained by a relative lack of depth or limited capacity across our priority areas. Enhancing the capabilities of our RUs by providing additional resources to deepen research capacities through personnel, infrastructure, and leveraging funds will, in turn, enhance our ability to address the emerging needs of North Dakota and the nation.

Many opportunities exist for North Dakota's RUs, building on their existing strengths, to play an increasingly important role in advancing emerging technologies important to the state. The state investment in the Northern Plains UAS Test Site and the statewide Beyond Visual Line of Sight (BVLOS) network infrastructure coupled with industry and community initiatives such as Emerging Prairie's Grand Farm in Fargo, the Grand Sky partnership at the Grand Forks Air Force Base, and Microsoft's investment in technology across the state are key nodes in a network of possibilities for, among other things, research innovations in autonomous systems technologies. Data infrastructure provided through investment by the state in the Northern Tier Network and high-performance computing capacity at the RUs as well as industry investments in high-speed broadband internet service is critical to support the development, demonstration, and integration of emerging technologies to the small and rural communities and farms of the region. This is an area in which UND and NDSU can combine their complementary strengths to help move the needle regionally and nationally, allowing rural communities to

participate in the digital economy that urban areas have already tapped into. The data infrastructure can also enable research in data science, drawing from expertise in cybersecurity, algorithm development, AI, analytics, deep learning, machine learning, machine vision, to bring computationally intensive applications across other RU research areas.

Other areas include advanced agricultural technology and precision agriculture. Working together to utilize autonomous drone technology, policy advancements coming out of the UAS state-wide test site, the conglomeration of integrated electronic systems and engineering around agriculture, and new data science capabilities, and capitalizing on the proximity of NDSU and UND, the RUs are at a perfect place to collaborate in this fast-moving emerging field. Many other opportunities exist in expanding clinical and translational research, e.g., opiate addiction, virtual care delivery to rural and underserved populations, and the utilization of data science with large patient health datasets to assist health care systems and clinicians in the identification and management of patients and populations, especially those at high-risk and high cost. Finally, established research leadership from the RUs in energy and agriculture research, application and innovation continues with enormous potential impact.

RUs will direct further state investment toward building the research capacity primarily through recruiting and positioning additional faculty to drive discovery aligned with the universities' research foci. The faculty will be expected to secure external funding, which will support new students, postdoctoral fellows, vital research equipment, engage our other higher education institutions throughout the state, and support new collaborations. Success in winning external funding has a parlay effect as it brings new money into North Dakota and expands the impact of the RU research enterprise. Of course, positioning new and existing faculty for extended success requires research infrastructure that can support research and adapt to new opportunities.

The benefits of the investment in research capacity at RUs are many. One is the fundamental benefit from advancing knowledge through discovery. Another is the contributions to industry and economic development as RU research, and in particular the foci on state-relevant Grand Challenges at both RUs, support existing state industries' need for technological innovation while sustaining a state research asset of great value for recruiting new and relocating industry partners. Perhaps most importantly, targeted investment in RU research fundamentally benefits students, and, by extension, North Dakota because it develops human capital. Both undergraduate and graduate students are afforded hands-on and applied research opportunities that put into practice problem solving, teamwork, critical thinking, and communication, all important and transferable skills for the future workforce of North Dakota. Critically, RU research, because it does and will continue to involve every higher education institution in the state, spreads this impact to students across the state, particularly through large collaborative grants. Finally, discovery through the broad reach of research across North Dakota's research universities can, has, and will continue to improve the quality of life for the state's citizens.