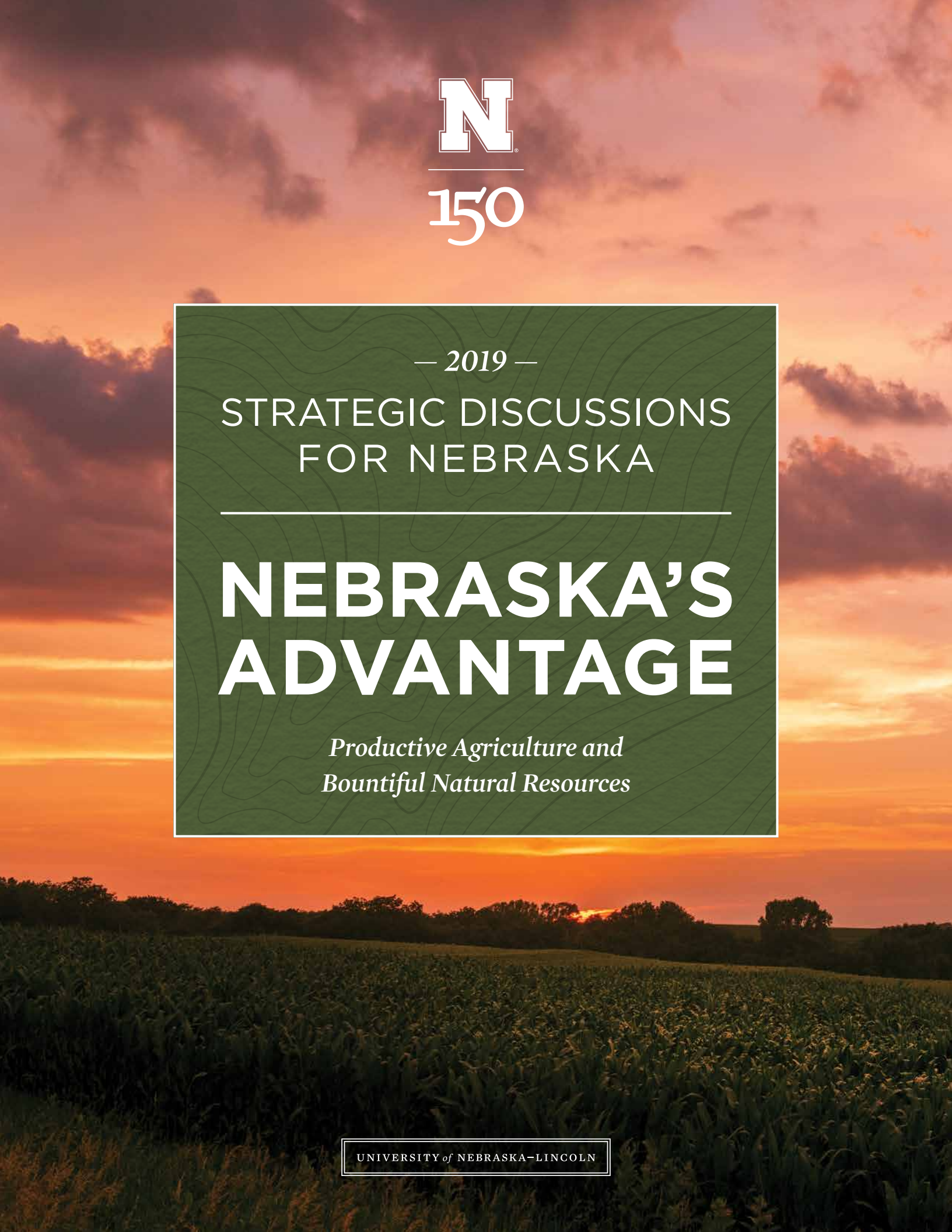

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— 2019 —

STRATEGIC DISCUSSIONS FOR NEBRASKA

NEBRASKA'S ADVANTAGE

Productive Agriculture and Bountiful Natural Resources

UNIVERSITY of NEBRASKA–LINCOLN

> “You can’t talk about healthy production systems and natural resource systems without also thinking about the resilience. We need to harmonize production agriculture in a way that ensures the resilience of our natural ecosystems and rural communities — all while addressing bundles of grand challenges.”

— *Michael J. Boehm* —

University of Nebraska Vice President for Agriculture and Natural Resources
University of Nebraska–Lincoln Harlan Vice Chancellor,
Institute of Agriculture and Natural Resources

BOMB CYCLONE AND FLOODING ACROSS NEBRASKA

In March 2019, a rare phenomenon "bomb cyclone" triggered catastrophic flooding across the state of Nebraska. Significant amounts of snow fell in a short amount of time and rapid snowmelt following the storm caused historic flooding.

Farms and ranches lost significant numbers of livestock, entire communities were evacuated because they were underwater and crop production was stunted, if not completely lost for the year.

The stories in this 2019 Strategic Discussions for Nebraska publication were written before this storm hit and were left in original form as the long-term impact of these events on Nebraska agriculture and natural resources is yet to be determined.

SDN sends our heartfelt thoughts to everyone across Nebraska and the Midwest impacted by the storm and the flood. Together, we are all #NebraskaStrong.

ABOUT STRATEGIC DISCUSSIONS FOR NEBRASKA

Strategic Discussions for Nebraska is an annual publication that highlights research and projects conducted at the University of Nebraska–Lincoln Institute of Agriculture and Natural Resources (IANR) and the impact the work has on the state of Nebraska and beyond. The Nebraska Legislature created IANR in 1973 through the enactment of LB149. The Institute focuses efforts in teaching, research and Extension around six communities:

1. Science Literacy
2. Stress Biology
3. Healthy Humans
4. Healthy Systems for Agricultural Production and Natural Resources
5. Computational Sciences
6. Drivers of Economic Vitality for Nebraska

Strategic Discussions for Nebraska helps share the IANR story. The annual Strategic Discussions for Nebraska publication translates research-based science to be understood by the general audience. A Strategic Discussions for Nebraska publication has been produced annually since 2008, each focusing on a different overall topic.

In recent years, the Strategic Discussions for Nebraska has rotated through the IANR six communities as a publication theme. This 2019 edition focuses on Nebraska's Advantage — Healthy Systems for Agricultural Production and Natural Resources.

According to Michael J. Boehm, University of Nebraska Vice President for Agriculture and Natural Resources and Harlan Vice Chancellor of the University of Nebraska–Lincoln IANR, the ultimate role of SDN is to share the story of both Nebraska and the Institute through a vast array of scientific research. Stories communicate the current state of projects as well as outline the impact and potential future directions for the work. Every seven years, a new chapter will be added to the volume of each specific community.

"SDN is a critical part of telling the narrative of our progress at IANR, through our amazing students, faculty, staff and partners," Boehm said.

Students in the Agricultural and Environmental Sciences Communication (AESC) program in the Department of Agricultural Leadership, Education and Communication (ALEC) produce the stories for the Strategic Discussions for Nebraska publication as part of their Senior Capstone Seminar course each spring.

For the 2019 publication, University Communication provided photography and graphic design and IANR Media offered website expertise and design. IANR provided funding as well as business and liaison services for the production of this publication.

A sincere appreciation is expressed for the original vision and financial support of the Robert and Ardis James Family Foundation, which founded Strategic Discussions for Nebraska in 2007.

Please visit our website, https://sdn.unl.edu for more information.

Thank you for your interest in Strategic Discussions for Nebraska!

Dr. Laura E. Young
Director and Editor
Strategic Discussions for Nebraska
Email: laura.young@unl.edu | Phone: 402.472.8790

INSTITUTE OF AGRICULTURE AND NATURAL RESOURCES

University of Nebraska–Lincoln Institute of Agriculture and Natural Resources (IANR) focuses on people and the food, energy, water, natural resources and communities that sustain them.

IANR scientific innovation in the land-grant mission areas of teaching, research and Extension places Nebraska on the leading edge of food production, environmental stewardship, human nutrition, business development and youth engagement.

IANR comprises the College of Agricultural Sciences and Natural Resources (CASNR), the Agricultural Research Division (ARD), Nebraska Extension, and the ARD and Extension components of three departments in the College of Education and Human Services.

IANR is committed to growing the future of Nebraska's people, businesses and communities.

Strategic Discussions for Nebraska highlights teaching, research, and Extension projects occurring within IANR with the goal of communicating the work and its impact on society to a general audience.

SPECIAL APPRECIATION

Strategic Discussions for Nebraska extends special appreciation for the vision, guidance, support and assistance of the following individuals and organizations:

Ronnie Green, Chancellor, University of Nebraska–Lincoln [unl.edu/chancellor]

Michael J. Boehm, University of Nebraska Vice President for Agriculture and Natural Resources and Harlan Vice Chancellor for the Institute of Agriculture and Natural Resources, University of Nebraska–Lincoln [ianr.unl.edu]

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Tiffany Heng-Moss, Dean, College of Agricultural Sciences and Natural Resources, University of Nebraska–Lincoln [casnr.unl.edu]

University of Nebraska–Lincoln administrators, faculty and staff. We are fortunate to work with these innovative, forward-looking individuals who are making the world a better place.

Nebraska Extension, led by Chuck Hibberd, Dean. Nebraska Extension administrators, specialists, educators and faculty members with partial Extension appointments take objective university research to the people of Nebraska and beyond. [extension.unl.edu]

Agricultural Research Division (ARD), led by Archie Clutter, Dean. The ARD is the major research unit of the Institute of Agriculture and Natural Resources and is the Agricultural Experiment Station. [ard.unl.edu]

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STRATEGIC DISCUSSIONS FOR NEBRASKA
Filley Hall 212
University of Nebraska
Lincoln, Nebraska 68583-0947
Phone: 402.472.8790 | Email: laura.young@unl.edu | Website: sdn.unl.edu

2019

STRATEGIC DISCUSSIONS FOR NEBRASKA STUDENT WRITERS

Students in the Agricultural and Environmental Sciences Communication (AESC) program in the Department of Agricultural Leadership, Education and Communication (ALEC) produce the majority of the stories for the Strategic Discussions for Nebraska publication during their senior capstone seminar.

The senior capstone course provides a learning experience similar to those students may encounter in the workplace, emphasizing accurate, clear and objective communication of science-based information.

During the course, students learn about scientific research being conducted at the university and the diverse funding sources required to support that research.

Throughout one semester, the students research and interview scientists from many disciplines and write stories based on those interviews. The stories in this publication were reviewed by the sources and approved for publication.

Kathryn Bagniewski

Kathryn is from Rochester, Minnesota and graduated from the University of Nebraska–Lincoln in May 2019 with an Agricultural and Environmental Sciences major and an International Agricultural and Natural Resources minor.

Michael Ferguson

Michael is from Kimball, Nebraska and graduated from the University of Nebraska–Lincoln in May 2019 with an Agricultural and Environmental Sciences major and a Leadership and Communication minor.

Leanne Gamet

Leanne is from Paxton, Nebraska and graduated from the University of Nebraska–Lincoln in May 2019 with an Agricultural and Environmental Sciences major and a Business minor.

Natalie Jones

Natalie is from Stapleton, Nebraska and plans to graduate from the University of Nebraska–Lincoln in December 2019 with an Agricultural and Environmental Sciences major and a Nebraska Beef Industry Scholars minor.

Rylie Kalb

Rylie is from Wataga, Illinois and graduated from the University of Nebraska–Lincoln in May 2019 with an Agricultural and Environmental Sciences major and an emphasis in Strategic Communication.

Bethany Karlberg

Bethany is from Mullen, Nebraska and graduated from the University of Nebraska–Lincoln in May 2019 with an Agricultural and Environmental Sciences major and an aerospace studies minor.

Cadrien Livingston

Cadrien is from Orchard, Nebraska and plans to graduate from the University of Nebraska–Lincoln in December 2019 with an Agricultural and Environmental Sciences major and a Political Science minor.

Halle Ramsey

Halle is from Ord, Nebraska and plans to graduate from the University of Nebraska–Lincoln in May 2020 with an Agricultural and Environmental Sciences major and minors in Engler Agribusiness Entrepreneurship and Global Studies.

Abby Steffen

Abby is from Crofton, Nebraska and graduated from the University of Nebraska–Lincoln in May 2019 with an Agricultural and Environmental Sciences major and a Leadership and Communication minor.

BRIEF HISTORY OF THE LAND-GRANT MODEL OF PUBLIC EDUCATION

By Mary Garbacz

The University of Nebraska is one of more than 100 land-grant institutions in the United States and its territories. Although the University of Nebraska–Lincoln was the original campus of the University of Nebraska, the land-grant mission extends to all four campuses of the University of Nebraska system. The land-grant college system was established by the passage of the Morrill Act in 1862.

The Morrill Act of 1862

On July 2, 1862, President Abraham Lincoln signed into law a bill that donated land to each state for the establishment of colleges to provide a liberal and practical education to the "industrial class," or the common person. These colleges would provide instruction in agriculture, military tactics, the mechanic arts and classical studies. Because of the land granted to each state and territory, the Morrill Act of 1862 became known as the land-grant act.

Sponsored by U.S. Congressman Justin Smith Morrill of Vermont, the bill allotted 30,000 acres of public land for each sitting senator and representative in Congress to establish these colleges. Morrill could not have known the future impact this law would have in providing equal opportunity to education to people in the United States and its territories.

Today, there are more than 100 land-grant institutions in the United States and its territories, each focusing on teaching, research and outreach – taking new knowledge to the people.

The University of Nebraska was founded on February 15, 1869 and designated a land-grant institution under the 1862 Morrill Act. The land-grant system formed the framework for the land-grant institutions' missions of teaching, research and Extension.

Hatch Act of 1887

Twenty-five years after the Morrill Act was passed, the Hatch Act of 1887 provided funding for agricultural research programs at state land-grant agricultural experiment stations in the 50 states of the United States, the District of Columbia and the U.S. territories. The Hatch Act established agricultural experiment stations in connection with the land-grant colleges so research could be conducted and applied in practice.

Named for Congressman William Henry Hatch, the Hatch Act established not only experiment stations, but also distribution of information to the people of the United States on subjects connected with agriculture. The Hatch Act also provided an annual payment to each state and territory for the expenses of research, as well as for printing and distributing the results.

Hatch research activities involve a range of options related to agriculture, land use, natural resources, family, human nutrition, community development, forestry and more and can be local, state, regional or national in scope. A further requirement of the Hatch Act of 1887 is that new information is to be extended to the public.

The Morrill Act of 1890

The Morrill Act of 1890 also established funding for land-grant institutions specifically for African-Americans. These institutions are sometimes called "1890 schools." These 16 public institutions, plus one private institution, are among the more than 100 historically black colleges and universities in the United States. The Morrill Act of 1890 also forbade racial discrimination in admissions policies for institutions receiving these federal funds.

Smith-Lever Act of 1914

The Smith-Lever Act of 1914 created a Cooperative Extension Service within each land-grant institution. Cooperative Extension, a partnership between the U.S. Department of Agriculture and agricultural colleges, helps to extend information produced by the research of scientists within each college's experiment station.

Equity in Educational Land-Grant Status Act of 1994

The Equity in Educational Land-Grant Status Act of 1994 provided land-grant status for certain American Indian colleges and institutions, bringing higher education to reservation communities. The act directed the U.S. Secretary of the Treasury to establish a 1994 Institutions Endowment Fund and the U.S. Secretary of Agriculture to make capacity-building grants to these institutions.

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— John Carroll —

Harmonizing Agricultural Production and Natural Resources

Michael J. Boehm

HARMONIZING AGRICULTURE AND NATURAL RESOURCES IN NEBRASKA:
Meeting the Grand Challenge at the Interface of Disciplines

Interview with Michael J. Boehm
By Bethany Karlberg

The world's population of 7.5 billion in 2019 is projected to grow to almost 10 billion by the year 2050, said Michael J. Boehm, University of Nebraska Vice President for Agriculture and Natural Resources and Harlan Vice Chancellor of the Institute of Agriculture and Natural Resources (IANR) at the University of Nebraska–Lincoln.

"If we think we have resource scarcity and wickedly complex challenges today, everything's going to feel like it's on steroids in the year 2050," Boehm said.

Boehm said that people who lack access to water often struggle to raise or grow food for their family. Such food shortages have been known to lead to civil unrest, which has the power to destabilize a society, topple governments, and in extreme cases, may lead to regional or global threats to security.

According to Boehm, to effectively address the extremely complex issues society faces regarding current and future food scarcity it will take different perspectives and new collaboration. Since coming to Nebraska in 2017, he has sought to work with a community of people who are interested in finding solutions to these issues.

IANR COMMUNITIES

IANR is composed of the College of Agricultural Sciences and Natural Resources (CASNR), Agricultural Research Division (ARD), Nebraska Extension, and the ARD and Extension components of three departments in the College of Education and Human Sciences.

The Institute strives to combine research, teaching and Extension in a multidisciplinary, collaborative environment that encourages the best thinking and expertise from across the university and private enterprise.

Boehm said this ensures Nebraska's competitiveness in a world of change and challenge. The Institute implements this within its six communities:

- Science Literacy
- Stress Biology
- Healthy Humans
- Healthy Systems for Agricultural Production and Natural Resources
- Computational Sciences
- Drivers of Economic Vitality for Nebraska

IANR's communities provide a depth of knowledge that individuals cannot reach on their own.

"We actually focus more on the collaborative complexity than we do the self," Boehm said. "The best solutions occur at the interface of disciplines."

Using this model, IANR works to build Nebraska's capacity in feeding a growing population, while addressing complex and ever-changing issues.

NEBRASKA'S ADVANTAGE

According to Boehm, Nebraska has the capacity to lead in fueling the growing population due to three main advantages.

- First, Nebraska is an economic driver. The Nebraska Department of Agriculture cites Nebraska as a leader in the production of corn, beef, soybeans, wheat, dry edible beans, pork, grain sorghum and eggs. Nebraska also houses at least 95% of center pivot irrigation systems and provides a vast infrastructure for agriculture transportation.

- Second, Nebraska has an expansive array of natural resources. Nebraska encompasses almost 80,000 miles of streams and rivers. It also sits on nearly 75% of the High Plains Aquifer (specifically the formation called the Ogallala Aquifer), and the World Bank has even recognized Nebraska for its superb water conservation methods. Further, the wide range of soils cultivate the diverse agriculture products across the state. From Western to Eastern Nebraska, soils drive different types of crops.

- Third, Nebraska pursues resilient agricultural practices to ensure that natural resources are not depleted. Through associations, such as the Natural Resources Districts, Nebraska has a uniquely structured regulatory system. Since Nebraska has differing topography across the state, districts have been formed to specialize in specific areas.

RESILIENCE IN THE HEARTLAND

Resilience is vital to increase Nebraska agriculture production while protecting its crucial natural resources.

"You can't talk about healthy production systems and natural resource systems without also thinking about the resilience," Boehm said. "We need to harmonize production agriculture in a way that ensures the resilience of our natural ecosystems and rural communities — all while addressing bundles of grand challenges."

In addition to maintaining resilient agriculture and natural resource systems, Boehm said there is a need to focus on the resilience of the people who produce the world's food. Research conducted at the university is working to create resilience while emphasizing healthy agriculture, natural resources and humans.

For instance, Andrea Basche, assistant professor in the Department of Agronomy and Horticulture, and her team research crop production resilience in the Resilient Cropping Systems Lab. According to Basche, Nebraska holds a key element in crop production — rich Nebraska soil. Basche and her team work to find new ways to help crops recover from drought or using cover crops to help sustain a healthy soil.

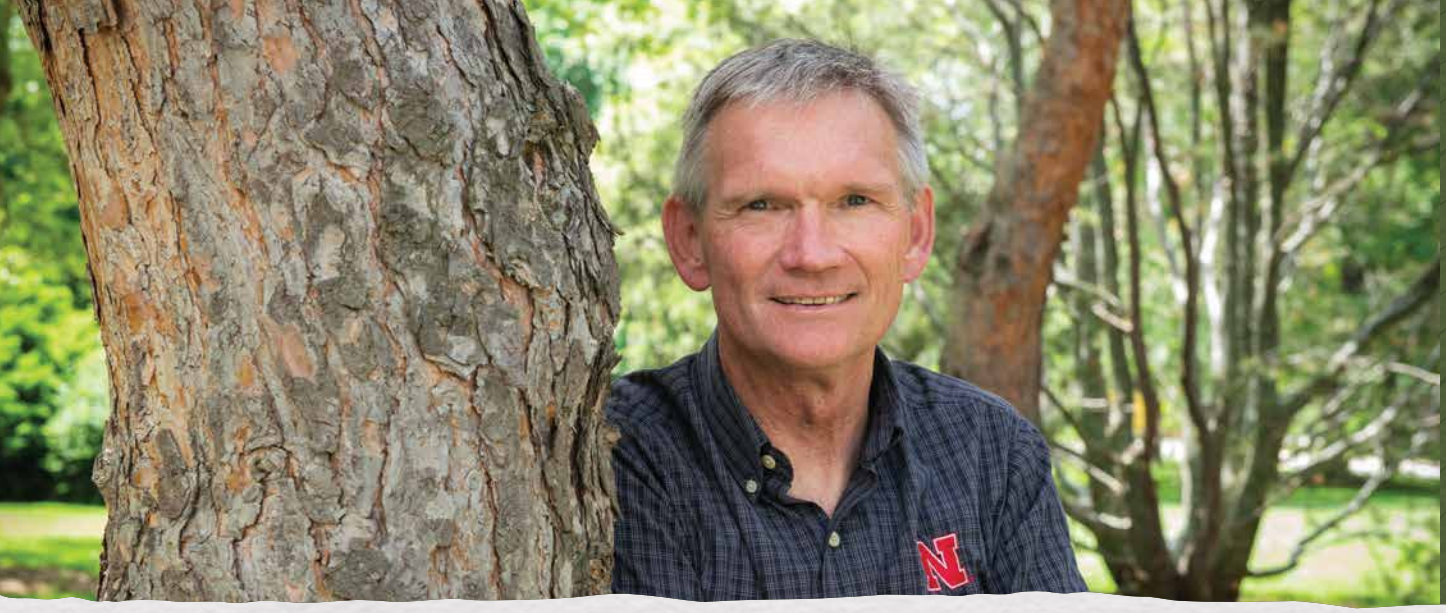
Along with rich soils, Nebraska holds another key element in crop production — sustainable water resources. According to Peter McCornick, executive director of NU's Daugherty Water for Food Global Institute (DWFI), managing water is vital for food system resiliency. DWFI aids in water management through collaboration with partners and innovative research.

This research, along with the state's robust agricultural operations and bountiful natural resources is why Boehm feels strongly that Nebraska is in an ideal position to address issues concerning global water and food scarcity.

KEY TAKEAWAYS

1. IANR strives to combine research, teaching and Extension in a multidisciplinary, collaborative environment that encourages the best thinking and expertise from across the university and private enterprise.
2. IANR ensures Nebraska's competitiveness in a world of change and challenge through the implementation of six communities: Science Literacy, Stress Biology, Healthy Humans, Healthy Systems for Agricultural Production and Natural Resources, Computational Sciences, and Drivers of Economic Vitality for Nebraska.
3. Nebraska has the capacity to lead in fueling the growing population because Nebraska is an economic driver, has an expansive array of natural resources and pursues resilient agricultural practices to ensure that natural resources are not depleted.
4. Resilience is vital to increase Nebraska agricultural production while protecting its crucial natural resources.

> "Resilience is vital to increase Nebraska agricultural production while protecting its crucial natural resources."
>
> — *Michael J. Boehm* —



John Carroll

NEBRASKA'S ADVANTAGE IS FINDING A WIN-WIN:
The Resilience of Agricultural Production and Natural Resources Management

Interview with John Carroll
By Kathryn Bagniewski

Feeding the growing global population by 2050 is a challenge that agricultural professionals around the world are trying to solve. The Institute of Agriculture and Natural Resources (IANR) at the University of Nebraska–Lincoln is dedicated to protecting and sustaining Nebraska's natural resources, while increasing and improving agricultural production.

Achieving global food security without harming the environment requires agricultural and natural resources professionals from a variety of IANR departments working together, rather than separately, to find solutions.

"You need experts from lots of disciplines working together to try to get answers to the problems that might arise for our society," said John Carroll, director of the School of Natural Resources (SNR) at the university.

Carroll said that SNR pursues solutions while keeping the environment at the forefront of the conversation. The relationship between Nebraska's productive agriculture and bountiful natural resources is complex and important. If both systems are not taken into account, ecosystems suffer, natural resources deplete and the environment supporting food production deteriorates, causing agricultural production to decrease.

SNR RESEARCH AND EDUCATION

The ultimate goal of SNR is to make this world a better place while realizing there are boundaries to what we can do to it, Carroll said. Protecting the world's ecosystems, wildlife and natural resources is critical for the survival of the planet and humanity.

With the support of IANR, SNR approaches global challenges by examining the whole ecosystem and identifying the relationships between agriculture and natural resources, Carroll said. This approach is dependent upon working with various departments across the University of Nebraska system so that both social sciences and physical sciences play a role. It is not enough to just look at climate, plants or animals without taking into account why and how people make the decisions about their environment and their role in that environment.

"Instead of answering a single question about making one part of our society better, we want to answer questions about a range of problems until we really understand how the whole system operates, rather than just how little parts of it operate," Carroll said.

LEVERAGING THE LAND-GRANT MODEL

The University of Nebraska–Lincoln is one of more than 100 land-grant institutions in the United States and its territories, which were established by the passage of the Morrill Act in 1862. The land-grant system formed the framework for the institutional missions of teaching, research and Extension. Twenty-five years after the Morrill Act was passed, Congress passed the Hatch Act in 1887, which established agricultural experiment stations in connection with land-grant colleges so research could be conducted and applied in practice.

Because of this model, the university has a dedication to agriculture, and in this design, IANR facilitates agriculture and natural resources across three pillars of research, teaching and Extension. Many faculty members within SNR focus research across these pillars. One example is tying water quality first to crop health and then to human health.

"Nebraska is one of the most agricultural states in the country," Carroll said. "Everybody in the School recognizes we're a very important agricultural state."

However, more pressure is being put on the state's natural resources as agricultural production evolves and continues to grow. Even so, Carroll sees the integration of natural resources with agriculture as Nebraska's opportunity to thrive. Nebraska's agroecosystems rely on finite natural resources, wildlife and climate to sustain its agricultural production.

"We can't just live by growing corn alone," Carroll said. "But, we can grow a lot of corn and do a better job integrating that with other land uses and making it more sustainable for the long term."

Producing corn — and other agricultural products — requires attention to surrounding ecosystems in order to be sustainable. For example, much of the state is dependent on irrigation to fuel crops, but responsible use of those water resources is necessary to prevent negative impacts on water quality and quantity. SNR helps prioritize this effort to be sustainable and resilient in its work with the other areas of IANR, Carroll said.

If those in agriculture and natural resources do not work together to solve the issues facing us, "then we're not doing our job," Carroll said. Both industries need to account for changes that affect the ecosystem whole — issues like climate change, nitrate runoff, and aquifer use — that affect future agricultural production and the ability to feed a growing population.

NEBRASKA'S ADVANTAGE

A large network of the state's most important natural resources centers and units finds a home and support in SNR. These include the Nebraska State Climate Office, the Conservation and Survey Division, the Center for Advanced Land Management Information Technologies and the National Drought Mitigation Center, among others.

"I think a lot of people in the state of Nebraska utilize what we produce," Carroll said. "But they may not recognize it's all part of this larger School entity." These units provide education, research and outreach to all Nebraska citizens — from producers to consumers.

SNR's reach also extends beyond Nebraska. "We want to make sure we do the best job we can in Nebraska and in the Midwest, but that does not stop us from having a global reach," Carroll said. This global reach is SNR's ability to work with other universities and agencies across the world to advance research on the earth's natural systems.

Under the facilitation of IANR, SNR supports state agencies, nongovernmental organizations and the federal government to better manage the world's natural resources. Supporting the state's farmers and private landowners, through Extension and research, is also a central mission for SNR.

Additionally, solving challenges and managing the state's natural resources is critical to SNR. One part of Nebraska's natural advantage is its superior system for managing its water. "We can grow crops using irrigation, which allows us to have very good yields compared to lots of other places, without damaging our aquifer resources," Carroll said, pointing to the Conservation and Survey Division's groundwater monitoring network that provides Nebraskans up-to-date information on the aquifer supply. When levels dip, communities can respond, curbing use and helping groundwater levels recover.

To ensure that natural resources are available for future generations while also feeding the growing

global population, SNR has placed an emphasis on resilience science.

AN INTERFACE FOR THE FUTURE

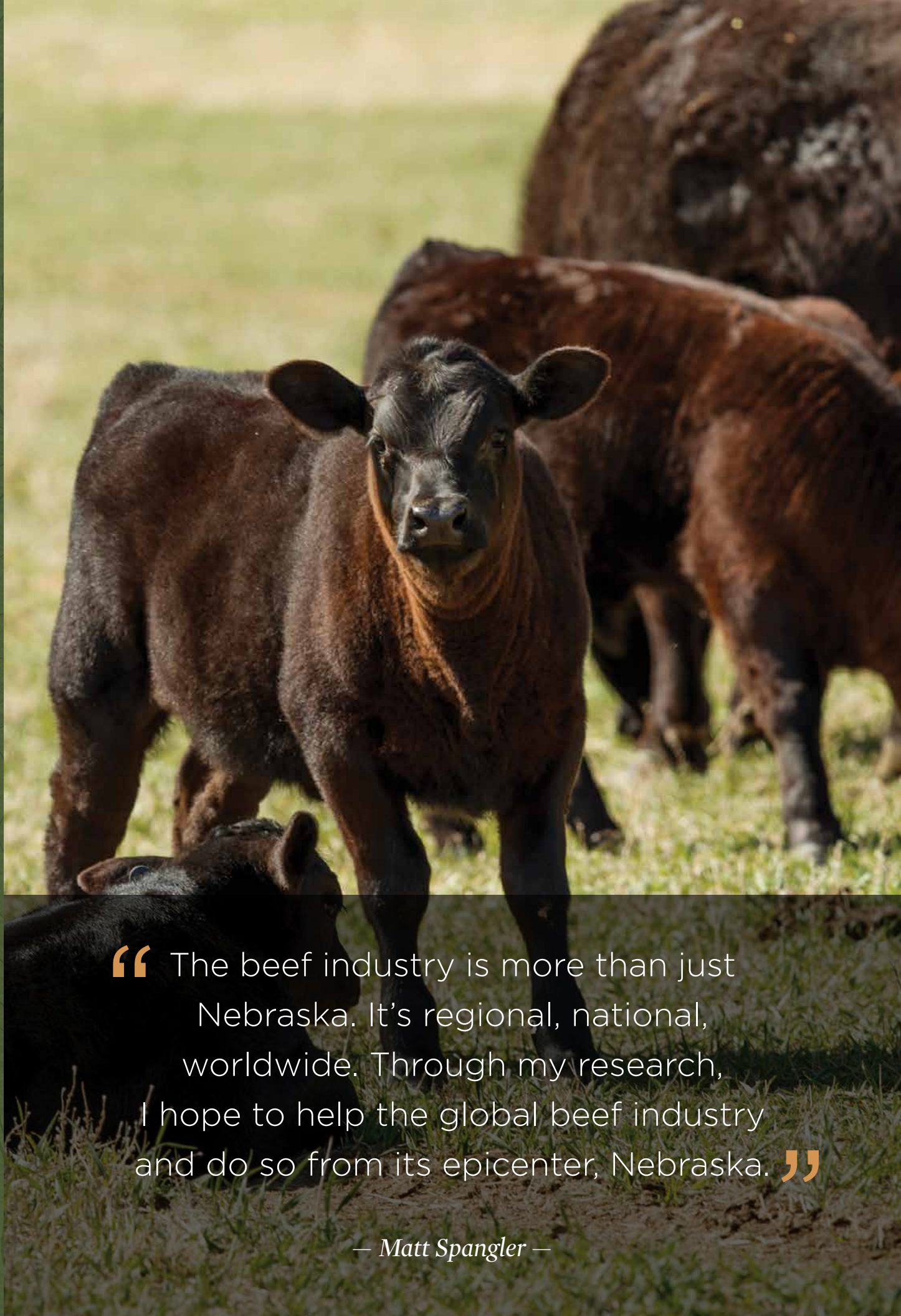
Producing food for the growing global population will put increasing pressure on Nebraska's ecosystems in the future. As the problems investigated within SNR continue to come to the forefront of agriculture, preparing natural resources professionals to solve them will rise rapidly in importance.

"Luckily for us, I think millennials and the generations coming after them — all of our students now — are quite well suited for studying those problems," Carroll said. SNR students will have to continue trying to integrate agriculture and natural resources into the future.

In Nebraska, natural resources professionals understand the importance of living in an agricultural state, according to Carroll. Similarly, agricultural producers realize that a focus on crop production without looking at other factors diminishes the opportunity of the agriculture and natural resources interface. It is truly when these two areas integrate and collaborate that the whole state — its agricultural industry, its ecosystems and its people — will thrive.

KEY TAKEAWAYS

1. Achieving global food security without harming the environment requires professionals to work together to find solutions.
2. The relationship between Nebraska's productive agriculture and bountiful natural resources is complex and important. If both systems are not taken into account, ecosystems suffer, natural resources deplete and the environment supporting food production deteriorates, causing agricultural production to decrease.
3. It is not enough to just look at climate, plants or animals without taking into account why and how people make the decisions about their environment and their role in that environment.
4. It is when the two areas of agriculture and natural resources integrate and collaborate that the whole state — its agricultural industry, its ecosystems and its people — will thrive.



“The beef industry is more than just Nebraska. It’s regional, national, worldwide. Through my research, I hope to help the global beef industry and do so from its epicenter, Nebraska.”

— Matt Spangler —

Agricultural Production Systems

Understanding Crop & Livestock Production

Daran Rudnick

TAPPING INTO NEBRASKA'S CROP PRODUCTION:
TAPS Program Builds Relationships between Growers and Extension Educators

Interview with Daran Rudnick
By Halle Ramsey

The University of Nebraska–Lincoln created the Testing Ag Performance Solutions program, also known as TAPS. The program gives growers across Nebraska and the Midwest opportunities to participate in sorghum and corn competitions designed to assist growers in experimenting with different management practices without using their own land, crops or investing in expensive equipment.

Daran Rudnick, assistant professor and irrigation management specialist in the Department of Biological Systems Engineering, is one of the founding members of TAPS, along with Chuck Burr, Nebraska Extension educator, and Matt Stockton, associate professor and agricultural economist. Rudnick, Burr and Stockton are stationed in North Platte, Nebraska, at the university's West Central Research and Extension Center (WCREC) where the TAPS field competitions are hosted.

"Really, we are coming up with a way to build that network of people in crop production. It's not just about growers, but the industry, financial institutions and consultants. We want to provide a platform where people can learn together," Rudnick said.

The TAPS program seeks to expand on the traditional model of Extension education by facilitating interactive, real-life farm management competitions in a low-risk environment. According to Rudnick, the TAPS program is unique to Nebraska and leverages Nebraska's Extension programming by fostering relationships between all stakeholders in crop production.

TAPS COMPETITIONS

The primary objective of TAPS is to actively engage growers across Nebraska in Extension research, Rudnick explained. To meet the needs of each individual grower, Rudnick and his colleagues decided to host competitions at WCREC that allow a large number of growers to compete with the same field conditions.

"It's difficult to comparatively assess differences in management practices and their outcomes across 50 producers due to differences in where people are located. So, we bring everybody to one location. That way, everybody has the same soil, the same climate and the same equipment. This way, we can truly evaluate the decisions that are being made and the outcomes of those decisions," Rudnick said.

Once the competitions commence each March, growers make all decisions regarding irrigation and nutrient management, seed selection, insurance and marketing by logging into the profile set up for them on the TAPS website, https://taps.unl.edu. Growers can form teams for each sorghum and corn competition. Each team is assigned a set of plots on the experimental field for the entirety of the competition season, which lasts until December.

"Teams submit forms to the TAPS team as they make production decisions, including what hybrid they want, the seeding rate, the nitrogen application and irrigation amount and timing. We then put those decisions into play in the field," Rudnick said.

Photos of each plot are made available for teams to have a better understanding of the condition of the test field. Information regarding the crop growth stage, past weather data and soil conditions is also regularly uploaded to the TAPS website throughout the competition.

While specific plot information is only released to the correlating team, the public can keep up with the progress of the competition through newsletters and general information about the test field on the TAPS website, Rudnick explained.

Ensuring the program mimics real-life farm decision-making is particularly important to the participants (i.e., growers, industry reps, etc.) and the TAPS team.

"We simulate a 3,000-acre corn farm and a 1,000 acre sorghum farm for the competitions. Basically, if they had 200 bushels of corn per acre on our field, we would say that is 200 bushels per acre across 3,000 acres. This way, there is the reality of actually putting decisions into play on the field as well as the simulation of upscaling it to the farm business," Rudnick said.

Rudnick said partnerships with agribusinesses have allowed TAPS to diversify the technology and competitions offered to participants. For example, a partnership with Eco-Drip Irrigation Solutions of Hastings, Nebraska, prompted the addition of a corn subsurface drip irrigation competition for the 2019 season. Eco-Drip Irrigation Solutions donated, designed and installed a subsurface drip irrigation system at WCREC for use in the corn competition.

At the end of the competition season, all participants gather for the annual banquet to recognize winners of each category. The winners are asked to speak at workshops and field days throughout the next year of competitions.

Through building the relationships between Extension educators and growers, the TAPS program provides an opportunity for each group to share experiences and knowledge in an interactive environment.

NEBRASKA'S ADVANTAGE

Rudnick said the extensive network and visionary leadership within Nebraska Extension as well as grower groups and associations such as the Nebraska Water Balance Alliance (NEWBA), Corn Board, Sorghum Board, among others are what allows Nebraska to provide opportunities like TAPS to growers.

"Nebraska is well suited for TAPS because of how strong our Extension program is statewide. We also have university leaders and administration that see value in a program like this, which helped provide the opportunities to pull it off," Rudnick said.

While Nebraska Extension was the driving force behind creating the TAPS program, Rudnick said other states, including Missouri, Colorado, Kansas and Oklahoma, have growers and Extension specialists represented throughout TAPS competitions.

By fostering relationships between all stakeholders in crop production, the TAPS program connects industry knowledge and Extension research to personal experiences of growers. Further, Rudnick said the TAPS program has even brought groups of growers from the same area of Nebraska closer together through interactions at field days and the annual banquet.

For example, a group of seven producers from Perkins County, Nebraska, has congregated at the same coffee shop for several years. Upon learning of the TAPS program, the seven growers formed a team and began competing.

"Producers from Perkins County said that the most valuable part of TAPS was not the outcome of the competitions, but that it provided them an opportunity to have conversations about more complex and sensitive topics, including marketing strategies and different philosophies on management practices," Rudnick said.

By leveraging the expertise of growers and Extension, the TAPS program offers a unique platform to build greater community within the crop production industry while allowing growers a low-risk environment to find the most efficient management practices.

KEY TAKEAWAYS

1. Testing Ag Performance Solutions, or TAPS, facilitates interactive, real-life farm management competitions in a low-risk environment.
2. TAPS gives growers an opportunity to test management practices without using their own land, crops, or investing in expensive equipment.
3. TAPS connects growers, financial institutions, consultants and others from the industry across the Midwest through a fun competition every year.
4. Teams submit forms to the TAPS team as they make production decisions, including what hybrid they want, the seeding rate, the nitrogen application and irrigation amount and timing.

Learn more at https://taps.unl.edu.

> "Really, we are coming up with a way to build that network of people in crop production. It's not just about growers, but the industry, financial institutions and consultants. We want to provide a platform where people can learn together."
>
> — *Daran Rudnick* —

Marc Libault

THE LIBAULT LAB:
Exploring Crop Response to Environmental Stresses at the Single Cell Level

Interview with Marc Libault
By Laura Young

Plant biologists are, among others, interested in understanding how a plant grows, how a plant adapts to its environment, the molecular mechanisms within the plant and the biochemical mechanisms of the plant, according to Marc Libault, associate professor and plant biologist in the Department of Agronomy and Horticulture at the University of Nebraska–Lincoln.

Libault's research primarily focuses on characterizing the molecular response of plant cells to environmental stress. Specifically, the Plant Single Cell Laboratory at the university, directed by Libault, studies how each plant cell responds to environmental stressors, such as drought, microbes (bacteria, fungi, viruses, etc.), or nitrogen deprivation. The lab uses innovative plant single cell approaches to investigate the plant response to these stressors.

THE LIBAULT LAB

The Libault Lab has two goals: 1) to understand plant interaction with its environment, including how plants and microbes work together, and 2) to understand how the plant genomic DNA molecule is used by the plant cells in order to adapt to various stresses. Libault's Lab offers a learning opportunity to those interested in plant cellular and molecular biology.

"One of the strongest interests in my lab is learning how plant root cells are interacting and working with microbes," Libault said.

Libault's work is primarily focused on legumes, such as soybeans, that are intensively grown in Nebraska. His lab specifically looks at soybean roots and how they interact with one type of soil bacteria – rhizobia. Libault referred to this process as symbiosis, or rather how the plant and rhizobia work together for the benefit of both the plant and the microbes.

"My lab is strongly interested in the symbiotic relationship and communication that exist between legumes (one example being soybeans) and atmospheric nitrogen-fixing microbes (one example being rhizobia) to benefit both partners," Libault said.

Other crops such as corn, maize and wheat cannot perform this kind of symbiosis. As such, they are completely dependent on the application of nitrogen fertilizers. Therefore, one of Libault's long-term objectives is to transfer his research in the lab on legumes to the non-legume crops to minimize application of nitrogen fertilizer, enhance sustainable agriculture, and improve the overall crop growth.

Due to his innovative single cell approach, Libault's research may eventually reduce the need for costly nitrogen fertilizers and enhance sustainable agricultural practices.

Overuse of fertilizers can pollute water due to runoff into lakes, rivers and streams. Libault said this pollution also impacts fish and wildlife that depend on these water sources for survival. Understanding the relationship between the plant and soil and the changes that may be required to reduce the need for nitrogen fertilizer use is what Libault researches most.

DROUGHT CHANGING PLANT GROWTH

Drought conditions have been one area of inquiry of Libault's team.

"Each plant species has a different level of tolerance to drought stress," Libault said.

For example, he said that sorghum is naturally more tolerant to drought conditions than corn. His team studies the molecular mechanisms activated in response to drought stress that various plants can withstand. He stressed the importance of knowing the unique molecular processes used by different plant species to tolerate drought.

"We apply the same kind of strategy, the single cell genomic approach, to various plants to understand how each cell in the plant adapts to the drought," Libault said.

This knowledge also has an impact on the environment.

Libault said the way a plant responds to drought also depends on its interaction with soil living organisms such as microbes. As such, his team tests the communication existing between the plant root and the soil microbial community.

MODIFICATION OF PLANT DNA

Libault said there might be long-term consequences if new strategies in food production are not developed. At times, these strategies require a modification in the plant genomic DNA. For instance, Libault said the genome (set of genes or genetic material) of plants that are sensitive to drought conditions may need to be modified to enhance plant growth without draining the water resource.

"If we can naturally engineer the genome of plants to be more resistant to environmental stresses, we have a way to improve the resistance of the plants to those stresses," Libault said. "Doing so would likely maximize the yield for the farmer and require less use of resources, such as water, fertilizers, pesticides."

SHARING FINDINGS

Libault stressed the importance of sharing research findings with multiple groups.

"Right now my lab is more focused on developing fundamental knowledge of plant cell biology. There will be a need for the transfer of this information to application to industry," Libault said.

He recently created new tools such as single cell approaches for the scientific community to better understand plant cell biology. He also works to enhance the understanding in the interaction between plants and microbes.

Marc Libault seeks to better understand soybeans and other legumes' mutually beneficial relationship with the bacteria rhizobia.

KEY TAKEAWAYS

1. The Plant Single Cell Laboratory (Libault's Lab) studies how plants respond to environmental stressors, such as drought, bacteria and viruses.
2. Libault's Lab primarily studies soybeans and the interaction with one type of soil bacteria – rhizobia.
3. Libault's innovative single cell approach may eventually reduce the need for costly nitrogen fertilizers and enhance sustainable agricultural practices.
4. There might be long-term consequences if new strategies in food production are not developed. Libault's Lab researches these new strategies.

For more information, please visit: https://libaultlab.unl.edu/

> "My lab is strongly interested in the symbiotic relationship and communication that exist between legumes (one example being soybeans) and atmospheric nitrogen-fixing microbes (one example being rhizobia) to benefit both partners."

— Marc Libault —

Matt Spangler

TECHNOLOGY AND GENETIC INFORMATION IN THE CATTLE INDUSTRY:
How Beef Producers Share Data

Interview with Matt Spangler
By Cadrien Livingston

There are roughly 32 million beef cattle in the United States and understanding the genetic composition of cattle can help producers make better decisions for the entire herd, according to Matt Spangler, professor and beef genetics specialist in the Department of Animal Science at the University of Nebraska–Lincoln. Spangler works in the area of beef genetics and his research offers new technology options to further the understanding of genetic information.

"If the beef industry wishes to remain competitive, we need to adopt technology at a much faster rate," Spangler said, "We need to make good use of the information we have."

Spangler said technology allows both genetic and genomic information to be shared more easily. *Genetics* is the study of heredity. More specifically, genetics focuses on how one trait is passed from one generation to the next. Spangler said studying the gene, the most basic unit of heredity, explains differences in the phenotype (set of observable characteristics) between animals and we know that cumulatively, genes have a substantial impact on understanding the animal.

Genomics looks at the entire genome (billions of base pairs) across the animal. Spangler said the amount of genomic data available has dramatically increased in the last decade. This genomic information allows producers to make decisions more accurately and efficiently than ever before.

The addition of genomic (DNA marker) information into genetic selection tools produces more accurate predictions of genetic merit, allowing producers to make more rapid genetic change to their herd to increase net profit whilst meeting consumer demands. One way this is achieved is by using genomic information to better quantify the relationships between animals. Further, producers using genetic information and sharing data throughout the beef chain helps beef continue to be a driving competitor of other protein choices.

However, Spangler said technological advances are needed to make data sharing a reality in beef genetics. His research focuses on developing and evaluating methods to enable data sharing underpinned by genomics with the hopes of better making use of data collected throughout the industry.

"If the industry could get even a fraction of that data to be shared through genetic evaluations, genetic selection tools used to decrease susceptibility to disease could be developed," Spangler said.

POWER IN PARTNERSHIPS

Spangler said partnerships may also be a path to share data among interested parties.

"Partnerships throughout the entire beef chain will also change the way data are shared and gathered," Spangler said.

The state of Nebraska has taken strides to create such partnerships to increase the sharing of information to improve genetic selection tools. Specially, Nebraska's resources of beef gives the state the advantage to be a leader in changing the way the beef industry uses technology.

As of February 2019, Nebraska ranks first in beef production, beef product exports and all cattle on feed, while ranking second in total number of cattle and calves, Spangler said. These resources in the state are vital for being a leader in beef genetic research.

Spangler said the synergies that exist between the Nebraska agricultural community and the university are critical to not only meet the demands of a growing population, but also to discover new tools, new methods and new strategies, as well as enhance agricultural production in the future.

He stressed the importance of partnerships between the industry and academia to drive public opinion. New, novel and perhaps unconventional partnerships will allow stronger market placement of products as well as better marketing of the use of technology in the industry, he said.

FUTURE OF BEEF GENETICS

Spangler offered suggestions on the direction of future research in beef genetics.

First, Spangler said the genetic and genomic information will continue to become even more accurate for use in making precise selection decisions (who should be retained for breeding) and will also become valuable in informing how animals should be managed. The process of predicting observable characteristics through genetic information will be more prevelant in research in future years.

Second, research in beef genetics will focus on "making use of the plethora of data that exists in this industry outside of seedstock herds," Spangler said. For example, the pedigree (record of descent of an animal) of animals in feedlots remains unknown, and therefore, there is limited information shared about these animals. Spangler said technology, like genomics, can help connect these animals to others that do have recorded pedigree. He plans to provide more information in this area in future years.

Finally, technology development such as genetic selection tools will continue to evolve to place even more focus on the healthfulness of meat products and eating quality, providing even greater consumer satisfaction.

"Genetic selection tools will not only be important in providing information on the traits we have now, but also for traits that we don't have now, such as the health of the animal," Spangler said. These tools are just one example of new technology advancements planned for beef genetics in the future.

The beef industry is not only important to Nebraska. Beef reaches across the nation and around the world. And therefore, improving the use of technology in beef genetics also stretches across the entire country.

"The beef industry is more than just Nebraska. It's regional, national, worldwide," Spangler said. "Through my research, I hope to help the global beef industry and do so from its epicenter, Nebraska."

> "If the beef industry wishes to remain competitive, we need to adopt technology at a much faster rate. We need to make good use of the information we have."
>
> *— Matt Spangler —*

KEY TAKEAWAYS

1. There are roughly 32 million beef cattle in the United States and understanding the genetic composition of cattle can help producers make better decisions for the entire herd.
2. Increasing the use of technology will allow both genetic and genomic information to be shared more easily.
3. Producers using genetic information and sharing data throughout the beef chain helps beef continue to be a driving competitor of other protein choices.
4. Spangler's research offers new technology options for producers with the hope of sharing data across platforms.
5. Partnerships throughout the entire beef chain will also change the way data are shared and gathered.

Thomas Burkey

GUT HEALTH IN PIGS TELLS A LARGER STORY:
Understanding Gut Health in Pigs and Connection to Humans

Interview with Thomas Burkey
By Laura Young

Maintaining and improving gut health is critical to improving overall health. With respect to anatomy and physiology, the pig gastrointestinal tract is highly similar to humans, which makes the pig a great model for understanding gut health in humans, according to Thomas Burkey, associate professor and gut health scientist in the Department of Animal Science at the University of Nebraska–Lincoln.

"The physiology of the pig is very similar to humans," Burkey said. "The way humans and pigs assimilate nutrients is very similar and the immune system of pigs and humans is more similar than it is to most other species. There is quite a bit of data to support that the pig is a very good model for human research."

Burkey's research focuses on understanding gut health of pigs with the goal of improving the gut health not only in pigs, but also in all nonruminant animals and humans. Nonruminant animals, also referred to as monogastric animals, are simple-stomached animals. Humans, cats, dogs, pigs and chickens are all considered nonruminants, according to Burkey.

Nonruminant nutrition, then, is being able to meet the requirements of those simple-stomached animals compared to ruminant animals. Ruminant animals have a more complex digestive tract and nutritional scheme.

"The real takeaway of gut health research is thinking about the interactions between nutrition, the gut microbes and the gut immune components," Burkey said. "Nutrition solves a lot of problems, but there's more to the puzzle than just nutrition."

"If we can do a better job of figuring out how nutrition and health interact, especially for sick animals, we have the opportunity to be very impactful," Burkey said.

A focus on gut health in pigs from birth to weaning can also lead to finding alternatives to antibiotics, according to Burkey. Understanding the microbes in the gastrointestinal tract and what those microbes are doing is most important. Ultimately, maintain/improving gut health increases the potential of a more sustainable production cycle.

ALTERNATIVES TO ANTIBIOTICS

To improve gut health, Burkey said that prebiotics and probiotics can be used as an alternative to antibiotics. He defined prebiotics as a type of fiber that the body cannot digest. Prebiotics selectively stimulate growth or activity of bacteria within the gut. Probiotics are viable microbes that may provide beneficial effects to the host, according to Burkey.

"The goal is to match the prebiotic to the probiotic to have a greater impact on gut health," Burkey said. Therefore, to understand gut health, one must find out what prebiotics are present and then match the microbes (probiotics) that are selectively enriched with that prebiotic.

Ideally, this would improve gut health, at least theoretically, Burkey said. If prebiotics and probiotics are correctly matched, producers may have a healthier, more efficient, heavier animal at weaning. If done correctly, issues are resolved proactively, rather than reactively with antibiotics after an issue arises. This study with pigs has led to a stronger connection to human gut health.

"We have data utilizing gnotobiotic pig and mouse models that supports that a pig model is better than a mouse model," Burkey said. "That's one of the most interesting and fun things that we've identified over the past five years."

This idea has the potential to impact not only pork production systems, but also can be used as a human model to look at metabolic diseases and the impacts of probiotics and prebiotics.

THE FUTURE IS BIG DATA AND TECHNOLOGY

The use of big data and technology is the wave of the future in gut health research, according to Burkey. An abundance of big data exists. However, at this point, the amount of data are difficult to organize and manage.

"There's so much information out there, we just need to figure out a way to use it," Burkey said. There is a need to have a central repository for all of the data collected and to make it easy for scientists to put the data collected into that repository. There is also a need for an engineer to derive algorithms to make that data useful."

In his study of pigs, Burkey generates a lot of data about what microbes are present and how the microbial profile changes as the pigs are fed different foods.

"What we don't know and what we need to know more about is what the microbes are doing, how they affect metabolism in the animal and how they are impacting nutrient assimilation," Burkey said. "The next step is to use the big data to hone in on what exactly are those microbes doing."

Technology advances will also steer the direction of gut health research in the future.

"Technology that tracks animals from a visual perspective will be key," Burkey said. "Using RFID tags and cameras, for example, would be beneficial to track the health of animals."

It is important to identify sick animals early so producers can intervene quickly and have healthier animals. Technology advances may help to maintain or improve gut health in pigs.

THE FUTURE IS MULTIDISCIPLINARY TEAMS

Gut health research is regularly shared with producers in the field. Burkey said it takes multidisciplinary teams to get answers to producers in a timely fashion.

"I rely on interactions from a lot of different people to try to make sense of all the information that's out there and try to formulate a research plan to help producers by providing answers to them," Burkey said.

Burkey serves as the U.S. representative to Digestive Physiology in Pigs. This research group meets every three years and includes scientists from all over the world who talk about gut health, gut immunity, digestive physiology and gut microbiology.

"We are able to interact locally, nationally, internationally and have an opportunity to impact agriculture and provide answers for producers," Burkey said. The conversation is geared towards sustainable production systems and looking at the whole system.

> “The real takeaway of gut health research is thinking about the interactions between nutrition, the gut microbes and the gut immune components. To improve gut health, prebiotics and probiotics can be used as an alternative to antibiotics.”
>
> — *Thomas Burkey* —

KEY TAKEAWAYS

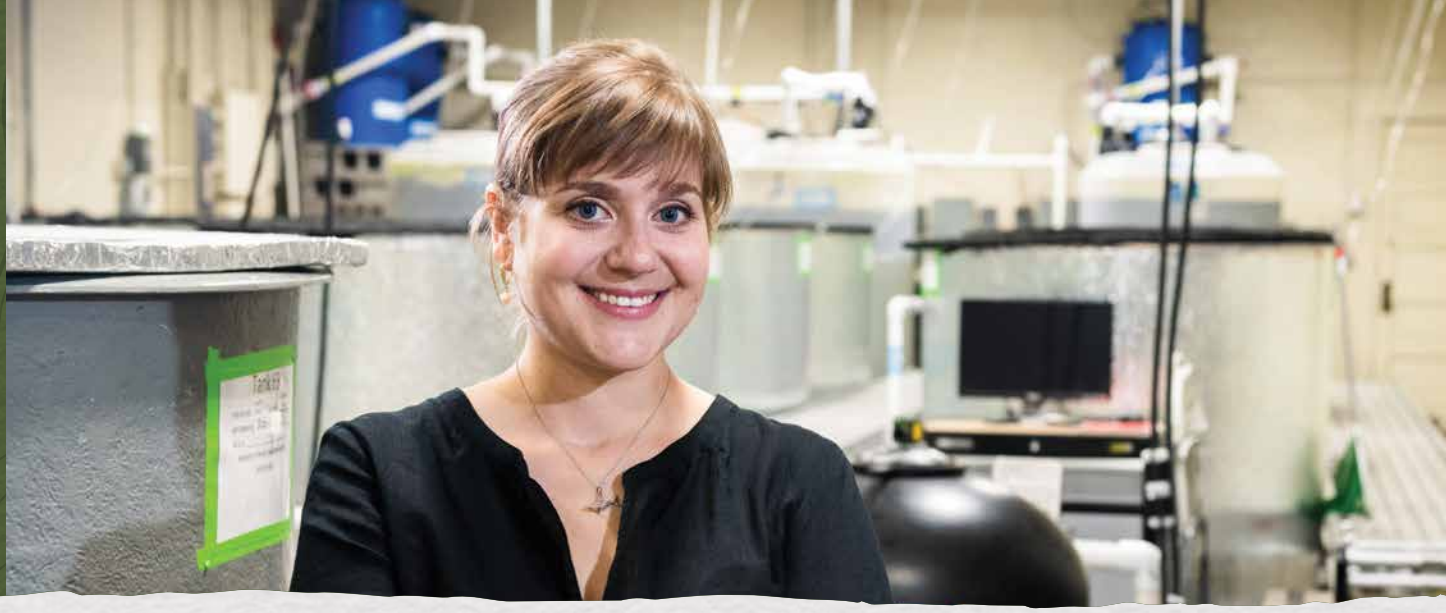
1. The pig is a great model for understanding gut health in humans.
2. Prebiotics and probiotics can be used as an alternative to antibiotics.
3. If we can do a better job of figuring out how nutrition and health interact, especially for sick animals, we have the opportunity to be very impactful.
4. There is an abundance of data on gut health, but a need in analyzing it.
5. Multidisciplinary teams are critical in getting information from researchers to producers.

A transwell cell culture system used an in vitro model to evaluate the effects of nutrients and microbes on intestinal mechanisms such as nutrient transport, barrier function, and immune parameters.

> “We rely on the same natural resources that many of the fish and wildlife rely upon. If they’re not taken into consideration, we’re not taking our own future into consideration.”
>
> *— Jamilynn Poletto —*

Natural Resources Systems

Exploring Fish, Wildlife, Landscapes, and Water



Jamilynn Poletto

FISH ECOLOGY – A TRUE "CANARY IN A COAL MINE": Improving Human Health through the Study of Fish Physiology

Interview with Jamilynn Poletto
By Leanne Gamet

Fish are an indicator species and may even be a signpost for human health dangers. University of Nebraska–Lincoln assistant professor in the School of Natural Resources and fish physiologist Jamilynn Poletto explained that some fish species are seen as somewhat of a "canary in a coal mine," as they are often early indicators for issues that could affect humans. Similar to the canaries that were sent down coal mines to detect the threat of dangerous gases that could be hazardous to coal miners, fish can help humans detect issues in water systems.

"If fish are sick, it is a really good indication that there is something wrong in that ecosystem. For fish in particular, it is usually associated with water quality. And unfortunately, the water that fish are swimming in is oftentimes the same water that we are drinking," Poletto said. "So anything that's going to be potentially detrimental to the health and survival of a fish could be detrimental to us [humans] as well."

Due to their sensitivity to various environmental conditions, a sick fish species could be a warning sign that other animals in the ecosystem could potentially become subject to the condition as well.

Ecology, or the behavior of organisms with others as well as their environment, has become a second language for Poletto. Specifically, Poletto and her research team determine how changes in the environment, many times referred to as stressors, interrupt normal fish behavior. Given the importance of fish to an ecosystem, Poletto also outlines ways to conserve various fish species. Together, this information can help to better understand ways that environmental impacts can alter the health and well-being of various fish species as well as the quality of water in a given area.

ENVIRONMENTAL STRESSORS FOR FISH

Changes in the environment can cause stress to various fish species because the change interrupts typical fish behavior. Three main stressors impact fish species in Nebraska: rising temperatures, water level fluctuations and pesticides.

First, rising temperatures cause a significant stress to fish because fish are ectotherms. An ectotherm's body temperature reflects the temperature of the water. Therefore, rising temperatures in the environment will, in turn, raise the body temperature of the fish.

"Every aspect of physiology is dependent on temperature," Poletto said. "As temperatures begin to increase, everything else begins to increase. For fish, the most notable is metabolic rate."

When the metabolic rate increases, fish growth also increases. When fish grow rapidly, their need for food naturally increases, yet a food source is not always available for the growing population of the fish. Poletto explained that researchers often pull fish out of rivers that are overly skinny and ill-looking, which can be an indication that warmer temperatures are increasing metabolic rates. Fish are unable to compensate with enough calories to balance out their high metabolism and the lack of food causes weight loss and health issues, Poletto said.

Second, because irrigation is such a key component in Nebraska's farmland, water level fluctuations are also an issue for fish.

"As we pull water out of the rivers for irrigation and for municipal use, the water levels begin to drop and fish can actually become stranded," Poletto said. For example, there are places in the Platte River that go dry and it happens rapidly. When this happens, fish may not have enough time to move to a new area and often become deserted.

Finally, while pesticides are an important aspect of the farming industry, they may burden fish populations if pesticide levels get too high. Pesticides are maintained at levels that are safe for humans to drink, but fish are much more susceptible to elevated levels. "They [fish] start to show abnormalities in behavior, physiology, growth, so we see that first," Poletto said.

Being aware of specific stressors that are impacting fish in Nebraska habitats is essential. This knowledge will be a cornerstone of the continuance of fish conservation.

CONSERVATION EFFORTS IN NEBRASKA

Many Nebraska residents are passionate about being outdoors. Hunting, fishing and watching nature are some of the many things in which Nebraskans are interested and contribute to the advantage of being in Nebraska. According to Poletto, some residents inherently want to be around wildlife populations. This often makes people more receptive to the importance of conservation and environmental restorations.

"I think we need to get the message across that if we don't continue certain conservation efforts or if we don't create new conservation efforts, we are going to lose these endangered fish species populations," Poletto said.

Moving forward, conservation projects and management will be crucial for species of all ecosystems, but especially for specific fish species because they represent nearly half of the vertebrate diversity that exists in the world.

"We have this amazing opportunity to study the diversity of fish species. For pretty much any physiological property or behavioral property you want to study, there is a fish species that is the shining exemplar of it. Studying fish allows us to continue to look into interesting scientific principles that maybe we can't study in mammals or in birds," Poletto said.

Human love for wildlife will be the drive for people to continue to keep conservation efforts resilient. When people are passionate about something, they typically work hard to keep it and fish need our help, she added.

"Endangered fish are not going to heal themselves, if we do not help them at this point. There are so many human imposed stressors that we have inflicted upon them," Poletto said. "It's important to keep studying them because they are interesting and they provide information that we didn't previously know."

Keeping conservation efforts alive will help maintain the resilience of these species that are constantly faced with stressors in their environments.

THE FUTURE OF FISH CONSERVATION

Technological developments to conservation efforts are currently happening at the university. "I think the future of conservation is using technology in really unique and creative ways. That is going to come from students who are studying technology and science right now," Poletto said.

Poletto's aquaculture laboratory, located behind the Nebraska Tractor Test Laboratory, is making

strides toward stronger fish resilience. Poletto's aquaculture lab houses recirculating systems where researchers can run tests to learn more about temperature, water quality and oxygen in fish.

Within this lab, Poletto and her team determine how well fish can swim (and in what conditions), the maximum temperatures that fish can withstand, how well fish are able to grow and survive in certain conditions as well as how fish respond to the stressors outlined previously. Together, this research helps to understand fish behavior in certain conditions as those same conditions may also impact humans.

"We rely on the same natural resources that many of the fish and wildlife rely upon," Poletto said. "If they're not taken into consideration, we're not taking our own future into consideration as well."

KEY TAKEAWAYS

1. Fish are an indicator species and may even be a signpost for human health dangers.
2. If fish are sick, it is a good indication that something is wrong with the ecosystem. Fish are a fundamental part of ecosystems in Nebraska, and if fish are showing indications of stress, it means the whole ecosystem is at risk.
3. If fish populations decline or there is a decrease in fish diversity, there will be lasting impacts on the ecosystem as a whole.
4. Poletto's aquaculture laboratory is making strides toward stronger fish resilience. This lab determines how well fish can swim (and in what conditions), the maximum temperatures that fish can withstand, how well fish are able to grow and survive in certain conditions as well as how fish respond to the stressors outlined previously.

Jamilynn Poletto in her aquaculture lab with undergraduate lab manager Octavious Bartek.

Troy Gilmore

PLUNGING INTO NEBRASKA'S GROUNDWATER DEPTH – A MASSIVE RESERVOIR:

Measuring Water Quantity and Quality in the Nebraska Sandhills

Interview with Troy Gilmore
By Natalie Jones

Nebraska's groundwater is a fundamental building block of life and a valuable resource for livestock and agriculture, according to Troy Gilmore, assistant professor and groundwater hydrologist in the University of Nebraska–Lincoln School of Natural Resources – Conservation and Survey Division and in the Department of Biological Systems Engineering. Gilmore studies Nebraska's groundwater and surface water as valuable natural resources.

Groundwater is located underground, typically in large aquifers. It must be pumped out of the ground to use for human and animal consumption and for crop irrigation, Gilmore said. Much of Nebraska overlies one of the largest reserves of groundwater in the United States — the High Plains Aquifer, commonly referred to as the Ogallala Aquifer. The High Plains Aquifer underlies approximately 174,000 square miles in portions of eight states, from North Dakota to Texas.

"Nebraska is atop some of the deepest and largest reserves of groundwater," Gilmore said.

Groundwater and surface water are interconnected, he said. The quality of one affects the quality of the other.

"One of the major advantages Nebraska has is this vast storage of groundwater below our land surface," he said. "The uniqueness of such a vast water resource below Nebraska soil allows the opportunity for groundwater research, which in return can lead to a resilience in resources."

WHAT IS AN AQUIFER?

Gilmore said an aquifer is simply pore spaces in sediment where groundwater can be stored and accessed.

"Sometimes, aquifers are pictured as an underground lake, which is not an accurate description," he said.

In fact, there are small spaces between soil particles where water infiltrates, forced downward into the spaces by gravity. Beneath the soil, there are often deposits of permeable materials such as sand and

gravel, which act as a giant sponge to soak up rainwater to recharge — or refill — the aquifer.

In many parts of Nebraska, there are "unconfined aquifers," meaning that the water that infiltrates moves freely downward to the water table, which rises or falls during wet or dry periods.

Approximately 69% of the entire High Plains Aquifer volume underlies Nebraska, and a substantial portion of that lies under the Sandhills in central and western Nebraska, Gilmore said. The region plays a key role in replenishing the aquifer and keeping water levels stable.

SANDHILLS SPRING WATER

The Nebraska Sandhills covers a quarter of the state and is the largest contiguous area of grass-covered sand dunes in North America. According to Gilmore, the Nebraska Sandhills region has a profound impact on the state's overall water culture and the resiliency of water resources.

Due to the nature of its sandy soil, there typically is little runoff, he said. Instead, the water infiltrates, or seeps into, the sandy soil. After precipitation in the Nebraska Sandhills, the land soaks up a portion of the water, but the rest infiltrates past the roots of the grasses and into the aquifer.

"The Nebraska Sandhills is a landscape that really kind of captures water without it quickly running off to streams and leaving the area," Gilmore said. "That is a unique aspect in the Sandhills."

WATER SYSTEMS

Nebraska has over 79,000 miles of rivers, and in many areas streams are fed by groundwater, Gilmore said. For instance, groundwater-fed streams flow out of the Nebraska Sandhills into the Platte River, flowing eventually into the Missouri River. Groundwater originating from the Nebraska Sandhills travels a long distance and has a great impact, Gilmore explained. The value of Nebraska Sandhills groundwater is high because it is a steady resource that continually moves into streams and rivers.

"Looking back at the history of streamflow out of the Sandhills, you can see that it's a very steady resource. If you look at streamflow data for more recent decades, there is even a slight increase in the flow out of the Sandhills," Gilmore said.

In Nebraska, Natural Resources Districts (NRDs), the Conservation and Survey Division, the Nebraska Department of Natural Resources, and the U.S. Geological Survey all work together to use technology to measure groundwater and surface water levels, Gilmore said.

These agencies also use real-time wells, which is on-demand data transmission connected to a satellite for more detailed groundwater-level monitoring. Gilmore said data from real-time wells and transducers can update databases instantly to generate maps online. This information indicates how much groundwater is currently stored in the aquifer, and when compared to surface water levels, can indicate when groundwater is more likely to seep out of the aquifer and into streams.

GUDMUNDSEN SANDHILLS LABORATORY

Gilmore and his team use a university laboratory located in the heart of the Nebraska Sandhills, in Grant, Hooker and Cherry counties. The Gudmundsen Sandhills Laboratory location, which is used for beef research and other environmental studies, has groundwater-fed ditches, hay meadows and streams.

Gilmore said the laboratory is an excellent research location because it is located directly over the top of the thickest part of the Ogallala Aquifer. He is working to estimate the recharge rate of water in the Nebraska Sandhills in a more consistent way.

"In the Sandhills environment, the stream flow is derived largely from groundwater. It's just a really accessible interface where you can get in the stream and sample groundwater as it actually seeps out into the stream," he said.

Gilmore and his team of scientists take groundwater samples from the Gudmundsen Sandhills Laboratory and send them to the Water Sciences Laboratory on the university's East Campus. Gilmore said the Water Sciences Laboratory is on the cusp of being able to estimate the age of groundwater by analyzing isotopes. Gilmore added that this is one of the few laboratories in the United States that is working on these kinds of innovations. Knowing the age of groundwater is key in determining contaminants it might contain, which determines the overall quality of the water.

Troy Gilmore at the Gudmundsen Research Laboratory installing a pressure transducer to measure the depth of the stream water with the goal of calculating the stream flow.

KEY TAKEAWAYS

1. Nebraska's groundwater is a fundamental building block of life and a valuable resource for livestock and agriculture.
2. Much of Nebraska overlies one of the largest reserves of groundwater in the United States — the High Plains Aquifer, commonly referred to as the Ogallala Aquifer.
3. The High Plains Aquifer underlies approximately 174,000 square miles in portions of eight states, from North Dakota to Texas.
4. Aquifers are not underground lakes. They are pore spaces in sediment where groundwater can be stored and accessed.
5. Groundwater and surface water are interconnected. The quality of one affects the quality of the other.

> "One of the major advantages Nebraska has is this vast storage of groundwater below our land surface. The uniqueness of such a vast water resource below Nebraska soil allows the opportunity for groundwater research, which in return can lead to a resilience in resources."
>
> *— Troy Gilmore —*

Lisa Pennisi

CONNECTING WITH SCIENCE ENSURES NATURAL RESOURCES RESILIENCE:
Next Generation of Environmental Stewards

Interview with Lisa Pennisi
By Halle Ramsey

Each spring, a majority of the Sandhill Crane population congregates on one 80-mile stretch of central Nebraska. The scope of this natural wonder is awe-striking and attracts thousands of people to Nebraska every year.

The future health of these birds largely depends on the actions of people. The hope is that those who had the experience of watching the migration will be more inspired to participate in conservation, according to Lisa Pennisi, human dimensions specialist and associate professor of practice in the School of Natural Resources at the University of Nebraska–Lincoln.

Pennisi's area of focus in human dimensions research uses experiences and emotional connections with nature to motivate people to make sustainable choices for nature and the environment.

"While people need to understand the science behind natural resources, it is equally important to work on people's environmentally responsible behaviors because nature manages itself just fine without us," Pennisi said.

Pennisi combines classroom experiences, science communication and Extension education to inspire others to make responsible daily decisions to ensure the resiliency of natural resources.

"We have to motivate everybody in all areas of society — business, billionaires, politicians, individuals — to care and to take action, because we all matter. We can't sit there and think, 'I'm just one person, what can I do?'" Pennisi said.

In order to build natural resources resiliency, people simply need to know what to do and how to be good environmentalists. The correct tools are essential.

PREPARING FUTURE ENVIRONMENTAL STEWARDS

Through coursework projects, Pennisi prepares students to connect general audiences with nature. The end goal to give students hands-on, real-world experiences that gain them the skills needed to succeed in their future careers.

For example, Backyard Wildlife Day, a project for the Zoo Keeping and Management course, requires students to be a zookeeper (without animals) for

a day, leading interactive education activities with Lincoln Children's Zoo guests.

Further, students in Pennisi's Environmental Education and Interpretation course each contribute 20 hours of service to a variety of agencies in Nebraska. Agencies include Nebraska Game and Parks Commission and the Ruth Staples Child Development Laboratory, a nature-based preschool. Designing and implementing thoughtful curriculum and activities to engage different audiences allow students to learn firsthand how to be effective environmental educators.

Pennisi's students also take ownership of the Backpacks for Adventure initiative. Since 2017, this program brought 105 science-themed backpacks into Community Learning Centers, an afterschool program for elementary children in Lincoln, Nebraska. For example, the wetland backpack includes a fish identification booklet, bingo, flashlights, a fishing bobber and much more. All items are intended for elementary children to check out from the Community Learning Centers and engage whole families in environmental education activities that encourage an appreciation of nature and understanding of science.

Finally, students in her Environmental Education Curricula course become certified in national environmental education curriculum, spanning pre-K-12 activities in various areas of natural resources. According to Pennisi, students can build environmental education programs based on the resources from certification.

NEBRASKA'S ADVANTAGE

IANR's philosophy on Extension and research programs is what makes Nebraska truly advantageous in natural resources management. Extension professionals dedicate their time to provide the most up-to-date health, business, agriculture and natural resource information so Nebraskans can make the most informed decisions possible.

Pennisi wants to see it go one step further, ensuring the message is delivered in a way that motivates change. People who feel emotionally connected to nature are more likely to want to care for it, she said.

"We want people to take care of Nebraska and the rest of the planet. We want them to love Nebraska," Pennisi said. "Understanding the science is not what's most important. What's important is that people care enough to change their behavior."

Sandhill Cranes in the Platte River migrating through Nebraska in Spring.

ECOTOURISM IN NEBRASKA

Ecotourism is tourism occurring in natural areas, with an emphasis on sustaining them, their flora and fauna, and the local people and their culture. Ecotourism facilitates emotional experiences that connect people to nature and foster responsible environmental stewards.

"We have studies that show people in forests or people whale watching can have really deeply moving emotional experiences that can profoundly impact them, making them want to do more to help. Ecotourism can be a really powerful tool to help people get connected to nature and become better stewards," Pennisi said.

Pennisi said Nebraska offers especially powerful experiences, such as hiking at Toadstool Geologic Park in northeast Nebraska or exploring the diverse wildlife across the state. The Sandhill Crane migration, which brings millions of dollars in revenue each year, is also an example of ecotourism in Nebraska.

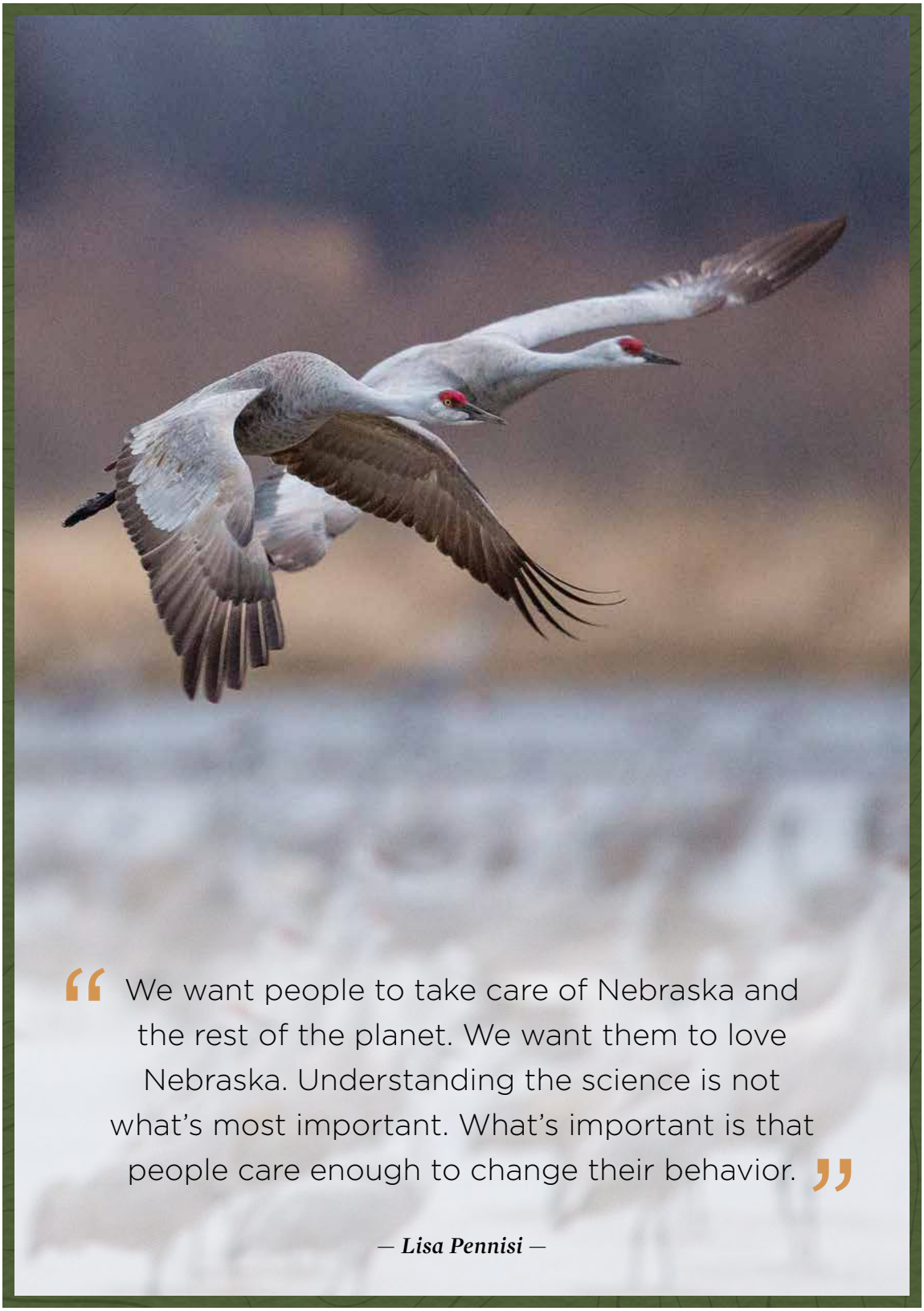
But communities must be cognizant that the tourism itself does not disturb the natural resources the people came to see. For example, "Keeping in mind the state needs good tourism opportunities to boost the economy and provide people with jobs, we need to make sure we don't disturb the crane migration, or they will disappear," Pennisi said.

Ethical ecotourism does just that by conserving wildlife and the environment and sustaining the well-being of local communities, Pennisi said.

By showcasing Nebraska's bountiful natural resources to create ecotourism opportunities that connect people to nature, future generations of Nebraskans can boost economic and environmental sustainability for years to come.

KEY TAKEAWAYS

1. Pennisi's area of focus in human dimensions research uses experiences and emotional connections with nature to motivate people to make sustainable choices for nature and the environment.
2. Pennisi combines classroom experiences, science communication and Extension education to inspire others to make responsible daily decisions to ensure the resiliency of natural resources.
3. In order to build natural resources resiliency, people simply need to know what to do and how to be good environmentalists.
4. Ecotourism can be a really powerful tool to help people get connected to nature and become better stewards.
5. By showcasing Nebraska's bountiful natural resources to create ecotourism opportunities that connect people to nature, future generations of Nebraskans can boost economic and environmental sustainability for years to come.



> We want people to take care of Nebraska and the rest of the planet. We want them to love Nebraska. Understanding the science is not what's most important. What's important is that people care enough to change their behavior.

— Lisa Pennisi —

> “Nebraska has a very strong cropping sector and livestock sector in the same proximity. We have the ability to recirculate nitrogen, phosphorus and carbon through our agricultural systems, unlike many other livestock intensive places.”

— Rick Koelsch —

Agricultural Systems and Natural Resource Systems Influence One Another

Crossover between Health, Soil, Climate, Water, Geology, and Management

Elizabeth VanWormer

NEBRASKA ONE HEALTH:
A Holistic Approach to a Healthy Nebraska

Interview with Elizabeth VanWormer
By Abby Steffen

Human health, animal health and environmental health are all interconnected, and this interdependence impacts the health of an entire ecosystem. Nebraska One Health at the University of Nebraska–Lincoln aims to increase awareness of these connections and works with diverse partners to enhance health.

"We live in an interconnected world where there are really strong links between the health of people, animals, plants and our shared environments. One Health recognizes those links and brings together different disciplines and stakeholder groups like universities, government agencies, nonprofit organizations and communities to address health challenges that affect people, animals and ecosystems," said Elizabeth VanWormer, Nebraska One Health coordinator and assistant professor in the School of Veterinary Medicine and Biomedical Sciences and the School of Natural Resources at the university. "It's really about bringing together diverse teams and perspectives."

As a trained veterinarian and epidemiologist, VanWormer looked to find ways to merge her interests.

"Instead of working as a veterinarian or an epidemiologist alone, I am able to work as part of a diverse team through a One Health approach. Building more holistic teams to look at complex challenges like disease transmission is the ultimate goal," VanWormer said. "One Health is a holistic approach to health."

VanWormer said one example of the One Health approach is to think of an emerging disease moving from wildlife to people or appearing in a new area in the world. Looking at these issues as connected, rather than individually, may help to find better solutions.

Nebraska One Health not only shares online resources, but also offers grant opportunities and holds regular meetings for those who are interested in becoming involved. Find out more at https://nebraskaonehealth.unl.edu.

THE ONE HEALTH APPROACH

The One Health approach is growing globally, according to VanWormer. Many One Health programs and research projects have been implemented in the US and around the world, and Nebraska One Health is the program in the state of Nebraska.

"There's been a growing appreciation for the value of bringing together different groups to look at the health of people, animals and the environment," VanWormer said.

One Health is more than a health resource. VanWormer said it also "provides an approach for bringing unique ideas together."

For example, when we think about the health of people and animals and their shared environments, a One Health approach might include teams that not only involve medical professionals and researchers, but also people who focus on climate science, hydrology, and land-use change, VanWormer said.

There is also a need for team members from social sciences, such as economics or anthropology. She said the One Health approach needs people who are good at communicating about health, including storytellers and artists.

The One Health approach is not new, but the topic has become more of a focus in recent years, VanWormer said. Human populations are growing; changes are occurring in the environment; and international travel has increased, causing humans and animals to have more contact than ever before.

Because animals and humans are both susceptible to diseases and environmental hazards, animals can serve as early warning signs for human health concerns.

NEBRASKA'S ONE HEALTH ISSUES

VanWormer sees the One Health approach as giving groups in Nebraska the opportunity to think more creatively about how we can improve the health of people, pets, livestock, wildlife, and our shared environments.

Formed in 2016, the program at the university is fairly new and is still working on implementing the practices of the One Health Approach on a statewide level. In addition to links with researchers at the University of Nebraska–Medical Center, University of Nebraska–Omaha, University of Nebraska–Kearney, Creighton University and Doane University, Nebraska One Health is building collaborations with individuals at United States Department of Agriculture, Nebraska state agencies, and organizations such as the Henry Doorly Zoo in Omaha, Nebraska and The Nature Conservancy.

According to VanWormer, those involved with implementing these practices are thinking about the best ways to build partnerships across the state. She hopes these partnerships will be able to address some of the big challenges affecting the holistic health of Nebraska, such as water quality and quantity, antimicrobial resistance and zoonotic diseases (diseases shared by people and animals).

"With livelihoods in Nebraska being largely involved in and impacted by agriculture, challenges such as water use, water contamination and runoff and land conservation are important in our state," VanWormer said.

Water is always identified as one of the key One Health issues in Nebraska, VanWormer said. Having the conversation about water and trying to work together to develop effective practices for water has the potential to not only keep agriculture strong, but also to keep the natural resources protected.

"When one discipline thinks about the challenge of contaminated water runoff, they might turn to the standard practices within their field," VanWormer said. However, when there are many people at the table thinking from diverse perspectives, there might be more integrated ways to approach the issue and measure it, she said.

For instance, "we could think about contaminated water just from the chemical perspective, but we could also think about pathogens running off from animals, either livestock, pets or wildlife," VanWormer said. "By bringing together these teams, we'll be able to think deeply about the challenge and how to most effectively address it for the benefit of health for all."

According to VanWormer, antimicrobial resistance and zoonotic diseases also are important concerns in Nebraska. Zoonotic diseases are diseases that can be shared between humans and animals. Some examples of these diseases include avian influenza, rabies and the West Nile Virus.

VanWormer said a future goal of Nebraska One Health is to build more connections with communities, farmers and ranchers, and wildlife and landscape managers.

"People who are out in the environment every day are often the first people to see signs of change," VanWormer said. "They have a strong connection to the land and we truly appreciate having them join the conversation."

Creating teams with diverse perspectives will help to identify and implement new solutions to protect the health of people, animals, and ecosystems.

KEY TAKEAWAYS

1. Human health, animal health and environmental health are all interconnected, and this interdependence impacts the health of an entire ecosystem.
2. Nebraska One Health increases awareness of these connections and works with partners to improve health across the state.
3. One Health is a holistic approach to health.
4. Because animals and humans are both susceptible to diseases and environmental hazards, animals can serve as early warning signs for human health concerns.
5. Creating teams with diverse perspectives will help to identify and implement new solutions to protect the health of people, animals, and ecosystems.

Find out more about Nebraska One Health at https://nebraskaonehealth.unl.edu.

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>
> — *Elizabeth VanWormer* —

Andrea Basche

NEBRASKA WON THE SOIL LOTTERY:
Soil Health and Why it Matters

Interview with Andrea Basche
By Rylie Kalb

Soil is a fundamental natural resource in agricultural production across the Midwest. "Nebraska and the Midwest won the soil lottery," said Andrea Basche, assistant professor in the Department of Agronomy and Horticulture at the University of Nebraska–Lincoln. Basche explained how Nebraska is blessed with "a disproportionate amount for our land area of some of the best soils in the world."

Soil serves as a vital component in cropping systems and is critical to the success of growing a bountiful crop. Basche researches various ways to support resilient cropping systems as well as various inputs that can be utilized in production agriculture, all while protecting the soil of Nebraska and the Midwest.

One input Basche is currently researching is the use of cover crops — crops grown for protection and enrichment of the soil. Cover crops are a useful tool to not only combat weeds and keep the soil healthy, but also serve as a food source for grazing animals.

In addition to her research, Basche's lab, the Resilient Cropping Systems Lab, investigates ways to make systems more resilient so that they can bounce back from disturbance. Specifically, her team examines the resilience of cropping systems when disturbances like floods or droughts occur and outlines ways cropping systems can be more resilient when responding to change.

SOIL IS KEY IN A CROPPING SYSTEM

According to Basche, a cropping system consists of all components of growing crops: soil, seeds, rainfall, sunlight, fertilizer and other inputs. People are also an important piece of cropping systems as they make decisions to produce the highest yield possible. Basche explained how critical soil is in cropping systems. "Soils are the foundation for what plants need to grow and take up nutrients and water," Basche said.

According to Basche, plants and soil are interconnected and form a feedback loop. "The plants influence the soil, but of course, the soil influences the plants too," Basche said.

Basche further explained that the soil stores water, a vital resource for plant growth. Water infiltrates the soil and reduces runoff and erosion through a process called soil infiltration. Soil infiltration — the process by which water moves deeper into the soil — makes water available for plants to absorb and complete growth processes.

Ultimately, Basche said that soil is the key piece to help make water and nutrients available for plants. However, some plants also serve as a tool to protect the soil.

IMPACT OF COVER CROPS

Basche explained that typically during the off-season when the soil would otherwise be bare, growers sometimes use cover crops as a tool to retain and protect the soil from erosion. Basche said a cover crop is a crop grown for the purpose of protecting the soil without the intention of harvesting for-profit crops like corn and soybeans.

"Cover crops can benefit soil in a variety of ways," Basche said. Specifically, cover crops hold the soil in place and can improve soil infiltration. They also can reduce the number of weeds that compete for resources. Cover crops can serve as a valuable feeding resource for grazing animals.

"By growing cover crops, the amount of time plant roots are in the soil doubles," Basche said. "Cover crops provide continuous coverage of the soil. The roots in the soil stimulate microbial activity, improve soil structure and improve water that's retained in the soil."

Basche explained that cover crops are often times planted directly after summer annual crops, like corn and soybeans. For example, Nebraska typically plants winter cereals as cover crops, such as winter rye, wheat and triticale.

According to Basche, these plants begin growing in the fall, remain dormant during the winter and continue growing in the spring prior to being removed to prepare for corn or soybean planting. While these crops are not grown directly for profit like corn and soybeans, they provide an opportunity to retain and protect the soil and keep it healthy.

Basche said that many growers believe cover crops are one solution to improving soil. However, there is not an annual reporting method to track the acreage of cover crops in the state. Basche explained that the lack of data makes it difficult to know year to year how much cover crops might be increasing in Nebraska.

"There's a lot of interest in cover crops among growers," Basche said. Cover crops are just one method used to enhance agricultural production systems and capitalize on the advantage soil is in the state.

NEBRASKA'S SOIL ADVANTAGE

Nebraska's soil advantage is a unique aspect of the state.

"One of Nebraska's advantages is definitely that we had great soil to begin with," Basche said. She described how the soil is blessed with natural resources that make the soil in Nebraska quite rich. However, Basche said Nebraskans must work together to conserve the current state of the soil.

"Growers might consider viewing agricultural production as a whole system to help the soil," Basche said.

Nebraska has such rich soil today and the goal is to continue to have this healthy soil for years to come. Because soil is integral to the entire cropping system, Basche said it is the responsibility of the people to protect the soil and see that it is conserved for the future generations.

Agricultural field of winter wheat under snow.

KEY TAKEAWAYS

1. Soil serves as a vital component in cropping systems and is critical to the success of growing a bountiful crop.
2. Nebraska and the Midwest won the soil lottery due to a disproportionate amount for our land area of some of the best soils in the world.
3. Nebraska's soil advantage is a unique aspect of the state.
4. Cover crops are a useful tool to not only combat weeds and keep the soil healthy, but also serve as a food source for grazing animals.
5. Basche's Resilient Cropping Systems Lab investigates how to make systems more resilient so that they can bounce back from disturbance.

Find out more at https://agronomy.unl.edu/basche-research.

> "By growing cover crops, the amount of time plant roots are in the soil doubles. Cover crops provide continuous coverage of the soil. The roots in the soil stimulate microbial activity, improve soil structure and improve water that's retained in the soil."

— Andrea Basche —

Rick Koelsch

TRENDING UPWARD – MANURE NUTRIENT MANAGEMENT:

Manure as a Valuable Resource and More Natural Option

Interview with Rick Koelsch
By Bethany Karlberg

Manure is a valuable resource and a natural key piece to the biological cycle. Manure contains key nutrients that can be used in place of fertilizer on crops for a more natural option. Nebraska has the key advantage of recycling manure nutrients by having sufficient cropland next to the livestock sectors. According to Rick Koelsch, professor in the Department of Biological Systems Engineering at the University of Nebraska–Lincoln, Nebraska has an advantage over many other livestock producing regions because of its livestock and crop production capacity.

Recycling manure was highly valued before the popularity of commercial fertilizer. "I think my grandfather knew the importance of manure recycling because he didn't have the alternative of using commercial fertilizers," Koelsch said.

Koelsch works to communicate the importance of using manure as a valuable resource, instead of seeing it as a waste product. Manure is commonly used in place of fertilizer, but the two have distinct differences.

A COMPLIMENTARY RELATIONSHIP

Both manure and fertilizer have important advantages. Complimentary use of both fertility sources can be used to our advantage. According to Koelsch, the organic nitrogen in manure is released at a slow rate through the growing season. The organic material decomposes through the growing season to release the nitrogen more closely timed to season crop needs.

The slow release of nitrogen is beneficial because it reduces leaching risk, Koelsch said. Leaching is movement of nitrogen through the soil. Once the nitrogen moves beyond the roots of a crop, the crop can no longer use the nutrient. Fertilizer nitrogen is readily available following application and in a form that can leach.

For manure nitrogen to achieve this environmental advantage, it must be applied at a rate that matches the crop requirement. Precision application of fertilizer nitrogen has been a historical advantage of commercial fertilizers. Improving manure

application equipment and fertility programs that integrate fertilizer and manure — and their individual advantages — can produce environmentally friendly results.

Aside from the environmental benefit, Koelsch said the economic value of manure is also notable, depending on the hauling distance. Especially for dry and composted animal manure, longer haul distances are proving economical for fields that utilize all of the manure's components (particularly nitrogen, phosphorus, potassium and carbon).

According to Koelsch, the economic value is dependent on two factors: 1) which nutrients an individual field requires and 2) the proximity of the manure options available. The farther away the farming operation is from the livestock manure, the less affordable the manure is due to the cost of hauling.

However, Koelsch said most farmers can afford to haul drier manures 10+ miles and slurry manures a few miles, before the cost of hauling begins to outweigh the economic values. Although hauling manure can be a challenge, Koelsch said that manure should be valued for its fertility, soil health improvement, yield benefit, and even its environmental benefits.

MANURE NUTRIENT MANAGEMENT IS ALL ABOUT RECYCLING

Koelsch explained that manure nutrient management is connecting a biological cycle. Farmers apply nutrients to cropping fields essential to crop growth. Farmers then feed corn and other products to their cattle because those nutrients are essential to cattle growth. The cattle eat the corn, utilizing 10 to 50% of the nutrients, and the unused nutrients are in the manure. Manure contains nitrogen, phosphorus and carbon, which are nutrients essential for crop production, thus completing the biological cycle.

"The animal is never going to recover all of the nutrients," Koelsch said, so manure recycling becomes a natural piece of the process. The nutrients that the livestock do not recover need to be brought back to the cropping fields. If the livestock farmers do not return the nutrients through the manure to our cropland, the biological cycle has been broken and an environmental risk has increased dramatically.

Koelsch said that manure nutrient management works to recreate this recycle loop and doing so builds resiliency within agriculture and the environment.

A nutrient cycle of:

can be an environmentally and economically successful biological cycle.

A nutrient cycle of:

is a broken biological cycle, burdened with environmental and, possibly, economic risks.

"Manure nutrient management is all about recycling manure as nutrients — the nitrogen and the phosphorous and the carbon — as efficiently as we can," Koelsch said.

CAPITALIZING ON THE NEBRASKA ADVANTAGES

Nebraska has an advantage in manure nutrient management over other areas across the nation due to the proximity of both crop operations and cattle operations. Koelsch said that Nebraska should not take manure for granted because manure provides significant benefits, if recycled efficiently.

"Nebraska has a very strong cropping sector and livestock sector in the same proximity," Koelsch said. "We've the ability to recirculate nitrogen, phosphorus and carbon through our agricultural systems, unlike many other livestock intensive places."

Nitrogen, phosphorous and carbon are key elements in farming, Koelsch explained. Nitrogen and phosphorous are primary nutrients for the growth of a crop. Nitrogen is the main nutrient absorbed by plants and helps form the crop's protein, and phosphorus is essential to many essential plant processes. Carbon is another primary nutrient in manure critical to the health of soils.

According to Koelsch, manure adds to many soil physical and biological processes, leading to improved water infiltration rates, greater water storage, reduced soil erosion, and increased nutrient cycling.

"Carbon is essential for healthy soils," Koelsch said. Carbon is important because it feeds the bacteria in soil. According to Koelsch, the soil bacteria produce "sticky glue" that forms soil aggregates. Aggregation occurs when the soil sticks together and produces clumps of soil increasing water infiltration into the soil, reducing runoff, and increasing soil storage of water for thirsty crops. This process helps protect fields against drought. Soil aggregates are also more stable and less prone to erosion.

OBTAINING THE GREATEST VALUE

According to Koelsch, there are three main challenges with manure nutrient management.

First, knowing how much manure to apply to a field is essential to successful management. Koelsch explained that manure is a mix of both readily- and not-so-readily available nutrients. He also said it is a challenge to predict how much nitrogen is going to be available from the manure and how much the farmer can restrict fertilizer application.

Second, Koelsch said the odor released when spreading manure is a concern for neighboring farms. Manure odor can be carried by the wind to neighbors. Farmers can help prevent this by incorporating manure into the soil or, for surface-applied manure, being conscious of wind direction and speed, spreading manure only when weather conditions are right.

Finally, Koelsch said that compaction in the soil can result from the heavy manure application equipment. Compaction causes the soil to be less permeable by air and water. Avoiding use of application equipment on wet fields will minimize this risk. And previously discussed soil biology processes are working around the clock to reduce compaction.

Ultimately, manure nutrient management is vital to maximize the benefits of our agricultural resources, Koelsch said. Using manure promotes a healthy biological cycle with economic and environmental benefits to be gained from using manure.

KEY TAKEAWAYS

1. Manure contains key nutrients that can be used in place of fertilizer on crops for a more natural option.
2. Nebraska has the key advantage of recycling manure nutrients by having sufficient cropland next to the livestock sectors.
3. Complimentary use of both manure and fertilizer can be used to an advantage.
4. Improving manure application equipment and fertility programs that integrate fertilizer and manure — and their individual advantages — can produce environmentally friendly results.
5. Manure nutrient management is vital to maximize the benefits of our agricultural resources.
6. Using manure promotes a healthy biological cycle with economic and environmental benefits to be gained from using manure.

Michael Hayes and Martha Shulski

RESEARCHING IN A CLIMATE CROSSROADS:
Nebraska's Climate Research Informs National Climate Assessment

Interviews with Martha Shulski and Michael Hayes

By Leanne Gamet

Weather varies around the world and researchers often travel hundreds of miles to study different climates. The state of Nebraska is described as a researcher's gold mine, as Nebraska is situated in a climate crossroads, according to Martha Shulski, Nebraska State Climatologist, director of the Nebraska State Climate Office and associate professor, and Michael Hayes, drought specialist, climatologist and professor in the School of Natural Resources at the University of Nebraska–Lincoln.

"Nebraska lies at an intersection — a crossroads of climate — where it is relatively wet in the east and relatively dry in the west, and there is a gradient that ranges from colder to warmer from north to south across the state. We get such variable climate that it is a really interesting place to study," Shulski said. Multiple research centers exist in Nebraska and these centers allow scientists to study climate variability all in one place. This research is then shared around the globe.

For example, Shulski and Hayes had the opportunity to share research conducted in Nebraska in the Fourth National Climate Assessment, published in 2018. Specifically, Shulski and Hayes partnered with eight other individuals to work on chapter 22 of the assessment. The Northern Great Plains chapter focused on Nebraska, Montana, North Dakota, South Dakota and Wyoming.

According to Shulski, the National Climate Assessment is a mandatory report submitted to the U.S. Congress every four years, as stated in the United States Global Change Research Act of 1990. This assessment is available to the public at https://nca2018.globalchange.gov/ and can be used as an educational tool to make more informed decisions about climate.

"That's really what the National Climate Assessment is all about — bringing science to the user and making it understandable to people. And that's been a really exciting part about being involved with it," Shulski said.

Both Hayes and Shulski use components of the assessment in their work. For example, Hayes said he uses the assessment in his own classes as data references and learning aids and hopes that high

schools begin to incorporate the assessment into their curriculum as well. In March 2019, Shulski used the assessment to inform the first Nebraska Climate Summit hosted at the university with the goal of bringing locals into the climate conversation.

WHAT IS CLIMATE?

Shulski described climate as the averages and variations of weather gathered over a long-term period of time. According to Shulski, knowing the difference between weather and climate is key when explaining how climate changes over time.

Shulski shared the example she typically uses when teaching about climate. "Weather is what I'm wearing today and climate is the clothes in my closet," Shulski said. "Climate is the whole spectrum of weather that we can experience. Climate describes the average conditions that you would expect to experience." Research on climate change focuses on climate trends, not daily weather patterns, according to Shulski.

The university takes advantage of the variable weather across the state in the best way possible, according to Hayes. He said that the university has a great setting for research given the variability and the availability of unique facilities.

Research facilities located at the university include the High Plains Regional Climate Center; the National Drought Mitigation Center; the Daugherty Water for Food Global Institute; the Center for Advanced Land Management Information Technologies; and the State Climate Office, which includes the operations of the Nebraska Mesonet, a statewide weather observation network with nearly 70 locations across Nebraska that assess local conditions. Together, these resources make Nebraska a leader in climate research and a great opportunity for undergraduate and graduate student education, according to Hayes.

"I think it's really unique here at Nebraska that we have a suite of centers that exist," Hayes said. Scientists in these research facilities disseminate a wide variety of climate information products from the data that are collected.

RESEARCH FACILITIES

1. High Plains Regional Climate Center
2. National Drought Mitigation Center
3. Daugherty Water for Food Global Institute
4. Center for Advanced Land Management Information Technologies
5. Nebraska State Climate Office
6. Nebraska Mesonet

SPREADING CLIMATE AWARENESS

Shulski and Hayes mentioned the importance of spreading awareness and starting conversations on the topic of climate. However, they say they sometimes face challenges when communicating research findings to the public. Both said that communicating a message in a scientific way is most successful — especially when conversing with those who are unconcerned about the climate change topic.

"One question I've been asked when giving presentations is 'you don't believe in all this, do you?' And I usually say, well, it doesn't necessarily matter what I believe. We are looking at the science and we are looking at data and analyzing that. It is not a personal belief system. It is data," Shulski said.

Shulski explained that it is important to listen to the public to understand what matters to them. From there, the conversation can connect what they think is important or interesting to the change that is happening to climate.

CHANGING THE FUTURE

Shulski and Hayes said it is important to find common ground when making goals about what individuals can do to slow down the climate change that is occurring. Individuals can first consider their own carbon footprint.

"We can't manage what we don't measure. Everyone can start to measure his or her own impact on the environment," Shulski said.

Every person can start evaluating his or her own carbon footprint by using weather and climate research as a tool to learn about impacts and adaptations of climate. Shulski and Hayes suggested that people be aware that change is happening and assess personal use. To lower one's carbon footprint, individuals might consider:

- Consciously driving fewer miles
- Purchasing food grown locally instead of food that must be transported many miles
- Purchasing clothing sold locally to reduce environmental costs of transportation
- Considering the carbon costs of food consumed or other goods purchased
- Reducing the amount of work-related travel

"We have the brain power to fix this and define solutions. We just need the willpower to do it," Shulski said.

Shulski uses social media as an outlet to educate the public. Using the Twitter handle @mshulski3 and the Nebraska State Climate Office Facebook page, Shulski frequently posts information with statistics, models and facts that are quick reads for the public.

Shulski and Hayes, among others, work hard to make information available to the public. From this research, the public can then make well-informed decisions.

KEY TAKEAWAYS

1. Nebraska lies at an intersection — a crossroads of climate — where it is relatively wet in the east and relatively dry in the west, and there is a gradient that ranges from colder to warmer from north to south across the state. The variable climate makes it an interesting place to study.
2. Research conducted in Nebraska was shared in the Fourth National Climate Assessment in 2018 with the goal of bringing science to the user and making it understandable to people.
3. Weather and climate are not interchangeable words. Climate is the whole spectrum of weather that we can experience. Weather changes daily.
4. Research on climate change focuses on climate trends, not daily weather patterns.
5. Everyone can evaluate his/her own carbon footprint and begin to reduce impact on the environment.

Daugherty Water for Food Global Institute is located at Nebraska Innovation Campus.

Peter McCornick

NEBRASKA'S GROUNDWATER STORY SPLASHES GLOBALLY:
DWFI Stresses the Importance of Sustainable Water Resources Management

Interview with Peter McCornick
By Bethany Karlberg

According to the Food and Agriculture Organization, the world will need to provide enough food and water for nearly 10 billion people by 2050. This will require developing countries to almost double their crop production. Peter McCornick, executive director of Daugherty Water for Food Global Institute (DWFI) at the University of Nebraska–Lincoln, said the United States can help developing countries close that food production gap through more efficient and effective use of water in agriculture.

Groundwater management is essential to sustainable water use for the production of food and Nebraska has been a leader in this area for years, according to McCornick.

"Nebraska's story is an excellent example for how you can develop groundwater and develop it in a way that is sustainable," McCornick said.

McCornick's role is to lead the strategic vision of DWFI and collaborate with their partners. Building on Nebraska's water resources management expertise, DWFI is pursuing innovative research and policy development to advance understanding of water management and improve food production around the world.

DAUGHERTY WATER FOR FOOD GLOBAL INSTITUTE

Daugherty Water for Food Global Institute was established at the University of Nebraska through a gift from the Robert B. Daugherty Foundation in 2010. Robert B. Daugherty was the founder of Valmont Industries and led the commercialization of center-pivot irrigation. Mr. Daugherty's vision was to create a research institute that would harness Nebraska's vast expertise in agriculture, water management and natural resources systems to achieve water and food security for our growing world.

DWFI leverages the University of Nebraska's knowledge leadership and extends it through strong local and international partnerships with other universities, businesses, non-governmental organizations and foundations, and government agencies. It works through research and policy development, provides education and

communication to enhance knowledge, builds capacity and develops effective techniques to sustainably manage water and increase food security. DWFI's impact is achieved through the work of 120 Faculty Fellows from all four University of Nebraska campuses, associate fellows, post-doctoral researchers and students in wide variety of fields who pursue projects focused on increasing water and agricultural productivity.

To maximize the expertise of its staff and Faculty Fellows, DWFI focuses its research in five key areas:

1. Closing water and agricultural productivity gaps
2. Improving groundwater management for agricultural production
3. Enhancing high productivity agriculture
4. Supporting freshwater and agricultural ecosystems and public health
5. Managing agricultural drought, focusing on drought monitoring and mitigation across all other research areas.

"With the water that's available, whether it's in the soil, in the rivers, in the ground or from the rainfall, managing that water is key to resilient food systems," McCornick said. "Resilience is at the center of what we do."

McCornick said agricultural producers are stewards of the landscape and water, while community leaders, researchers and decision-makers all contribute to sustainable water resource management.

A GLANCE INTO NEBRASKA'S STORY

McCornick said Nebraska's water management "story" includes three major areas: 1) the development of technology, such as wells and center pivots, 2) the specific groundwater management system and 3) supporting the investment of farmers into agriculture.

First, with one of the largest aquifers in the country and the world's largest center pivot companies located in Nebraska, the state's farmers, water managers and policymakers understand the importance of creating a resilient water resources management system. According to McCornick, a center pivot irrigation system allows the farmer to become more resilient against droughts. The center pivot provides a drought-mitigation solution by creating access to the groundwater below, so a farmer does not have to solely rely on rain to water the crops.

Second, McCornick explained that Nebraska has developed an effective and quite unique governance approach to water through Natural Resource Districts (NRDs), which manage groundwater locally. Nebraska is a large state with vastly diverse water needs depending on location. For this reason, the state is divided into 23 different NRDs, which have supported Nebraska's successful water management. The success stems from each NRD having the ability to set its own water regulations according to the needs of the area. Other parts of the world are now beginning to recognize the importance of local governance. While water and agricultural needs vary in different parts of the world and understanding the local context is the most vital aspect of water management, according to McCornick, there are important lessons to be drawn from Nebraska's experience.

Third, McCornick said farmers lead the water-to-food transformation, using water systems to nourish crops and grow the food source. Creating a resilient groundwater management system is a fundamental step, but farmers are the ones who plant and grow the actual crop, which eventually becomes the food that consumers purchase at their local grocery store or market. Helping farmers improve their resilience to water fluctuations and maximize yields is a win-win situation for the farmer, consumers and the environment.

McCornick experienced the success of Nebraska groundwater management before he moved to the state in 2016. In the mid-1980s, McCornick had worked in eastern Colorado where residents were concerned about the groundwater levels in the Ogallala dropping rapidly. When he first visited Nebraska in 2009, he was surprised to find that Nebraskans had figured out how to expand and intensify agriculture, and do so with less water and a stable water resources system.

DWFI focuses on translating the success of Nebraska's story to other parts of the world. According to McCornick, while most Nebraskans understand the value of groundwater and water management, beyond the state it they are not as well known.

'BOOTS ON THE GROUND'

Nebraska has a lot to share with — and learn from — other countries. "We tend to have global ideals that don't always translate well into various local conditions," McCornick said.

To address this, DWFI employees work with partners in other states and countries to learn the local conditions and understand the specific challenges farmers face. From there, DWFI works with partners to develop solutions specific to the local issues.

One area DWFI has been working in is northeast Brazil. This region has a groundwater resource larger than the Ogallala Aquifer formation of the High Plains Aquifer in Nebraska, but Brazilians have not yet made the investments or institutional capacity to ensure the aquifer is sustained. There are many political, institutional, social, environmental and management issues that need to be considered.

DWFI's aim is to support local communities, universities, farmers groups, and other leaders in this part of Brazil to evaluate their water resources and determine how best use it without damaging or diminishing the resource.

"The impact is still a few years away, but the developments are very encouraging," McCornick said. "It really comes from our Brazilian colleagues recognizing the importance of the Nebraska experience."

Working with Brazil is only one example of DWFI's meaningful work.

"It's very important from the Nebraska perspective to understand that what has been learned here is of considerable value in avoiding irreparable damage to important water resources systems in other parts of the world," McCornick said.

Daugherty Water for Food Global Institute is capitalizing on Nebraska's groundwater management knowledge and agricultural expertise to achieve sustainable water resources for food production. Attaining this goal is critical to producing enough food for the future. According to McCornick, while regulations are often viewed as essential pre-requisite for effective water management, building trust within the local communities and working collaboratively through organizations, such as the Natural Resources Districts here in Nebraska, have proven to be effective.

KEY TAKEAWAYS

1. The United States can help developing countries close the food production gap through more efficient and effective use of water in agriculture.
2. Groundwater management is essential to sustainable water use for the production of food and Nebraska's story is an excellent example for how to develop groundwater in a way that is sustainable.
3. DWFI pursues innovative research and policy development to advance understanding of water management and improve food production around the world.
4. DWFI's 120 Faculty Fellows, associate fellows, post-doctoral researchers and students pursue projects focused on increasing water and agricultural productivity.
5. Nebraska's water management "story" includes
   - development of center pivots
   - NRDs
   - supporting the investment of farmers
6. DWFI works in northeast Brazil to share Nebraska's story.

Amit Jhala

HERBICIDE-RESISTANT WEEDS ARE A GROWING PROBLEM:
The Persistent Battle Against Weeds

Interview with Amit Jhala
By Rylie Kalb

Nebraska agriculture is a part of feeding the world, yet crop production continuously battles weeds. The use of herbicides — chemicals used to control unwanted weeds — is an important tool for growers as they rid weeds competing for resources. However, weeds are fighting back and becoming resistant to herbicides, which complicates herbicide options for weed control.

Amit Jhala, associate professor and Extension weed management specialist in the Department of Agronomy and Horticulture at the University of Nebraska–Lincoln, explained that when herbicides with the same site of action are used continually in a field, a weed could become resistant to herbicides designed to control it. "Any weed can evolve resistant to any herbicide if it is used repeatedly in the same field," Jhala said.

According to Jhala, using herbicides as per the label recommendation is the most efficient method farmers have been using to control weeds and maintain a stable production system.

However, natural reproductive processes in weeds, such as pollen-mediated gene flow, where genetic information travels from one place to another through the movement of pollen, forces growers to consider numerous weed management methods. Jhala's team works to find ways to mitigate this issue.

WHY HERBICIDES?

Eastern Nebraska crops, such as corn, soybeans, sorghum and popcorn, compete with weeds for nutrients, water, light and space, according to Jhala. Herbicides are important for controlling weeds, and weed control is important to maintain optimum crop production. Jhala said that without weed management, crops would essentially be starved from a lack of resources they need, and growers would not be able to yield the same quantity or quality of crops. Therefore, weed control is not only important — it is necessary. Herbicides are a key tool to battle weeds.

"On average, landholding for a grower in Nebraska could be more than 3,000 acres. On that many acres, it is not possible to control weeds as efficiently by any other method than herbicides," Jhala said. "That is why herbicides are the most important for weed control for corn and soybean producers in Nebraska."

According to Jhala, herbicides provide the most efficient method to control weeds and their use is regarded as safe as long as the products are used as per the label recommendation. "As long as an herbicide is labeled, it is safe. If growers are using them as the label recommendation, it is safe," Jhala said.

Jhala explained that every herbicide goes through a rigorous review process to determine if it is safe to bring to market. If approved, the industry works with the federal government to bring the herbicide to market. Each herbicide has a label, which is a legal document that includes information on how to use, how much to use and when to use the product. All information is mandated by the Environmental Protection Agency. One of the most popular herbicides — glyphosate — has historically been the most common and effective herbicide to control a number of weed species.

Herbicides, like glyphosate, specifically target weeds while keeping the crop safe (if crop is resistant to glyphosate such as glyphosate-resistant corn and soybean), according to Jhala. To do so, the crop needs to be resistant to the herbicide. The popularity of glyphosate increased significantly when scientists grew the first glyphosate-resistant corn and soybean. Farmers could spray glyphosate before or after the crop started growing and the crop would grow while killing the weeds. Growers have used glyphosate continuously for many years, which has caused weeds to become resistant to it.

RESISTANT WEEDS

The difficult part about weed control is that some weeds grow resistant to herbicides designed to control them, according to Jhala. When a weed fails to respond to an herbicide, it is deemed "resistant" to that specific herbicide. If growers use a specific herbicide program year after year, eventually some weeds can evolve resistance and survive.

The first herbicide-resistant weed appeared in Nebraska in 1994, according to Jhala. In 2019, at least six weeds in Nebraska are resistant to glyphosate. Growers are forced to consider different herbicides and methods to maintain a consistent yield. Although these weeds are becoming harder to control, herbicides continue to be the best method to control weeds.

POLLEN-MEDIATED GENE FLOW

Jhala explained there are two primary ways that herbicide resistance travels from plant to plant or to another field — by seeds or pollen. When a crop is harvested, resistant weed seeds may be harvested with it. If so, those seeds can be transferred to another field by machinery. Jhala and his team have begun research on how pollen can carry genes and how it spreads resistance through pollen-mediated gene flow.

Although pollen naturally carries genetic information, Jhala's team is one of the first studying it and how it carries resistance.

"It's not something new," Jhala said. "But nowadays, the research on pollen-mediated gene flow becomes very important because of the issue of resistant weeds and to know how rapidly it disseminates."

Common waterhemp, a multiple herbicide resistant weed found across Nebraska, carries resistance through pollen.

"When a male plant of common waterhemp is resistant to an herbicide, and if the pollen from that resistant plant crosses with a female plant of common waterhemp that is not resistant to an herbicide, the seeds produced will be resistant to that particular herbicide because herbicide resistance is a dominant trait," Jhala said. If resistance spreads, it forces growers to reevaluate their herbicide program to find a new herbicide or herbicide with alternate site of action.

THE FUTURE OF WEED CONTROL

While the fight against resistance continues, Nebraska still holds many agricultural advantages, according to Jhala. In eastern Nebraska, growers have access to irrigation facilities. Growers couple these resources with their knowledge of production agriculture to be leaders in the Midwest.

Nebraska is also the No. 1 popcorn-producing state in the country and produces about 45% of the total popcorn produced in the United States. Because of this, Jhala and his team have started to dig into weed control options in popcorn to make sure popcorn growers are reaping the benefits of research.

Corn and soybean growers can best fight resistant weeds by knowing what weed is in their field. Growers can access the *2019 Guide for Weed, Disease and Insect Management in Nebraska*, a 300-page reference book with resources to manage weeds in number of crops grown in Nebraska, at https://marketplace.unl.edu/extension/ec130.html. Additionally, Jhala presents at winter Extension meetings and conducts Extension field days during June and July to educate growers about identification of weeds and their management (learn more at agronomy.unl.edu/jhala). He also writes articles for the Nebraska Extension website called CropWatch (https://cropwatch.unl.edu/), where growers can access real-time updates on crop information. These resources provide knowledge to better understand the weeds in fields and how to control them.

While the fight against resistant weeds is still persistent, Jhala and his team continue to seek solutions. For example, he and his colleagues are investigating multiple herbicide-resistant corn and soybean and their crop safety, cover crops for weed suppression, and use of UAVs for weed scouting and weed identification. His research helps the agricultural industry remain resilient against weed challenges and gives it the tools to find control.

"The greatest enjoyment of my role as an Extension specialist is to help and educate stakeholders for weed management in crops and answer on an average 400+ phone calls/e-mails every year to solve their problems," Jhala said.

KEY TAKEAWAYS

1. Without weed management, crops would essentially be starved from a lack of resources they need, and growers would not be able to yield the same quantity or quality of crops.
2. Herbicides provide the most efficient method to control weeds and their use is regarded as safe as long as the products used as per the label recommendation.
3. The difficult part about weed control is that some weeds grow resistant to herbicides designed to control them.
4. Corn and soybean growers can best fight resistant weeds by knowing what weed is in their field. Growers can access the *2019 Guide for Weed, Disease and Insect Management in Nebraska*, a 300-page reference book with resources to manage weeds in number of crops grown in Nebraska, at marketplace.unl.edu/extension/ec130.html.
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Learn more at agronomy.unl.edu/jhala and cropwatch.unl.edu.

Walter Schacht

GRASSLAND ECOLOGY IN THE NEBRASKA SANDHILLS:
Efficiency of Grazing Lands in a Cool Season Grass Pasture

Interview with Walter Schacht
By Natalie Jones

With the world population set to reach almost 10 billion people by 2050, there is a great opportunity to produce more protein for the hungry world through proper management of grasslands. Many look to innovative farming practices to produce more food, but Walter Schacht, professor in Department of Agronomy and Horticulture at the University of Nebraska–Lincoln, said that there is another resource that is crucial to meeting future food demands — grasslands.

"Grasslands play a large role in food security. Managing the grasslands resource for efficient production purposes is crucial to the health and needs of consumers as well as the long-term productivity and sustainability of these rangelands," Schacht said.

The most efficient way that grasslands can be managed for food production is by having ruminant animals, or cattle, graze the land. According to Schacht, beef production represents the largest segment of the agricultural industry in Nebraska. Beef cattle grazing is the principal means of converting grassland, which is largely undigestible by humans, to protein that humans can digest.

Schacht explained that Nebraska's grasslands are a critical component of the beef industry. As cities and recreation grow and grassland acres are lost, more pressure is put on the remaining grasslands to be highly productive. Complete and efficient use of the remaining grazing lands, while preserving wildlife habitat and the long-term productivity of diverse forages, is vital.

According to Schacht, Nebraska's advantage is the sheer number of acres of grassland and the opportunity to maintain the balance between forage production for grazing livestock and multiple other ecosystems services, such as biodiversity and wildlife.

Schacht's research focus is on the grasslands of the Nebraska Sandhills, particularly as it relates to grazing and management of these grasslands. Specifically, he studies ecosystem responses to grazing management in the Nebraska Sandhills and other grasslands in the central Great Plains.

RANGELAND DIVERSITY IN THE NEBRASKA SANDHILLS

Schacht said nearly 40% of the surface area of the United States is grassland. The grassland resource as a whole must continue to be managed in sustainable ways both from an agricultural production aspect and a natural resource base. The Nebraska Sandhills region is grassland, and its resilience plays a large role in meeting food demands in the future, he said.

The Nebraska Sandhills is a semiarid region of mixed-grass prairie on grass-stabilized sand dune formations. In total, the Nebraska Sandhills consist of about 12.75 million acres, or approximately 19,300 square miles of rangeland. Over 90% is privately owned, according to Schacht. The region is home to the largest sand dune formations in the western hemisphere. From the uplands of the Nebraska Sandhills to the wetlands and subirrigated meadows, the region has a wide range of ecosystems.

Uplands in the Nebraska Sandhills are the rolling and vast grass-covered sand dunes, he said. Lakes and subirrigated meadows are common in the valleys. This variation in habitat results in a broad diversity of plant communities, grazing land types, and wildlife species.

Schacht said the 720+ plant species that grow in the Sandhills without cultivation provide for resilience to periodic harsh conditions (e.g., drought) and sustain forage plant production for grazing livestock. Grasses are classified as being a cool season or warm season species, which is based on their growth response to air temperature.

GRAZING MANAGEMENT PLANS

Grazing management plans are critical to the success of grassland areas, according to Schacht. Specifically, he said, grazing management plans enhance native grassland ecosystems, while sustaining wildlife and natural resources. Schacht works with students and ranchers in the Nebraska Sandhills to assist them in implementing the best practices for each operation.

"There is not one single recipe or best rotational grazing system that can work for everyone's ranching operation — rather, each plan should be customized to fit the production environment and needs of the operation," Schacht said.

However, Schacht typically uses five management components in identifying the best practices for grazing management plans when helping ranchers maintain healthy grazing land ecosystems for livestock and wildlife.

To determine a grazing management plan for ideal grazing, Schacht suggests that ranchers consider:

- **Intensity of grazing:** how many cattle are in a specific pasture
- **Frequency of grazing:** how often a pasture or grassland is grazed
- **Timing of grazing:** which season or part of a season is a pasture grazed
- **Length of grazing period:** how long a pasture is grazed (e.g., half-day or season long)
- **Length of recovery period:** how long a pasture is not grazed

TYPES OF GRAZING MANAGEMENT

Schacht said there are several grazing management methods that ranchers can use to better manage their grasslands for livestock production and wildlife purposes. The implementation of grazing methods allows ranchers to enhance the production and quality of grasslands to aid in production of livestock to feed the world.

Management Intensive Grazing

Management-intensive practices are characterized by rapid rotation of cattle through a relatively large number of pastures (eight or more) multiple times during the growing season, according to Schacht. These practices generally reduce selective grazing, resulting in relatively even use of pasture vegetation and high grazing efficiency. Optimizing the amount of forage harvested is the goal of short-duration, high-intensity grazing, often referred to as mob grazing, he said.

Season-long Continuous Stocking

In season-long continuous stocking, Schacht said ranchers manage the herd by keeping them in the same pasture throughout the grazing season, which is typically from mid-May to mid-October. Season-long continuous grazing with low to moderate stocking rates allows for greater forage selectivity by livestock, which increases the nutritional quality of forage consumed.

However, Schacht said that because of the selective grazing, livestock will graze more in areas near water, near the mineral supplements, in the shade or on north-facing slopes. This is low-management intensity, resulting in a loss of efficiency of grazing from a livestock production perspective.

Simple Rotational Grazing

Simple rotational grazing strategies involve moving livestock through a series of pastures (<8) a single time at scheduled intervals, commonly deferring grazing on one pasture until after the growing season, according to Schacht. Grazing periods are longer than they are with management-intensive grazing. Grazing efficiency is commonly greater with simple rotational grazing than with continuous grazing.

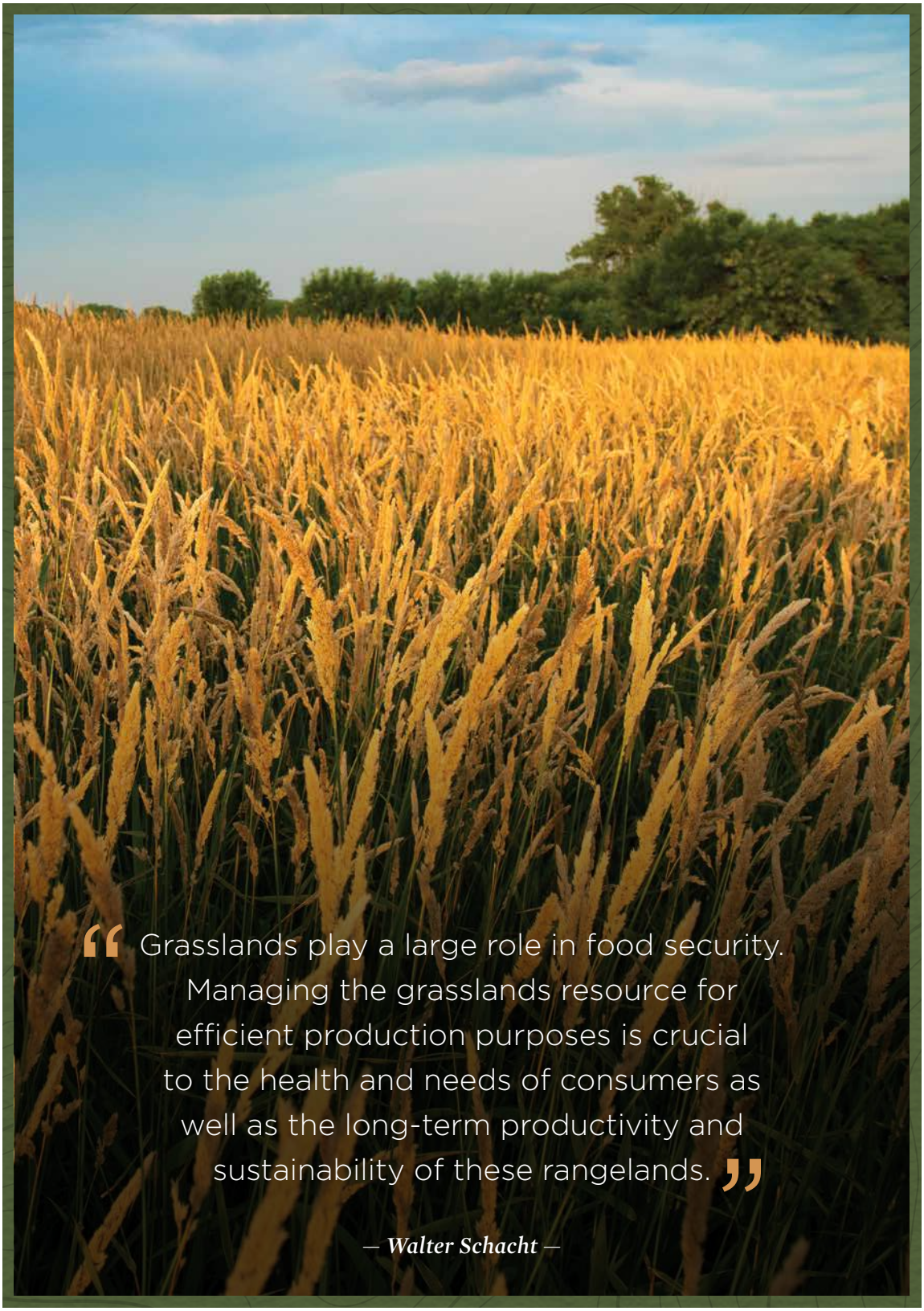
Schacht said the grazing methods are specifically tailored to sustained forage plant production and livestock production on grazing lands. Managing grazing lands in Nebraska is primarily focused on beef production.

"With a growing beef industry, I think the intensity of management of grazing lands is going to increase. The evenness and use of our grazing lands are going to increase as we need to produce more beef per acre because we will have fewer acres of grazing lands," Schacht said.

KEY TAKEAWAYS

1. Grasslands play a large role in food security.
2. Managing the grasslands resource for efficient production purposes is crucial to the health and needs of consumers as well as the long-term productivity and sustainability of these rangelands.
3. The most efficient way that grasslands can be managed for food production is by having cattle graze the land.
4. Nebraska's grasslands are a critical component of the beef industry.
5. Beef cattle grazing converts grassland, something humans cannot digest, into a protein that humans CAN digest.
6. Grazing management plans are critical to the success of grassland areas.

> "There is not one single recipe or best rotational grazing system that can work for everyone's ranching operation — rather, each plan should be customized to fit the production environment and needs of the operation."
>
> *— Walter Schacht —*


“Grasslands play a large role in food security. Managing the grasslands resource for efficient production purposes is crucial to the health and needs of consumers as well as the long-term productivity and sustainability of these rangelands.”
— Walter Schacht —

“The wind in Nebraska is, on average, extremely high compared to most places. Those challenges that we deal with out here lead to innovation and that can be applied across different parts of the world.”

— Joe Luck—

Agricultural and Natural Resources Resilience and Sustainability

Developing Longevity for the Future

Santosh Pitla

DRIVERLESS TRACTORS – COMING SOON TO A FIELD NEAR YOU:
A New Age in Agriculture

Interview with Santosh Pitla
By Michael Ferguson

Technology around the world is becoming more advanced every year and the agricultural industry is no exception. Santosh Pitla, associate professor of advanced machinery systems in the Department of Biological Systems Engineering at the University of Nebraska–Lincoln, is currently developing an autonomous tractor using ground robotics.

"We're almost getting to a point where we can easily take the operator out and see the machines operating by themselves," Pitla said. "There is a need on the farm for automation because statistics suggest that only 2% of the population in the United States are farmers." With so few people working to provide food for the world, tractor automation is key for producers to keep up with growing demands.

The idea of autonomous tractors began in the mid-2000s and has developed to a near reality. Pitla's research looks to transform tractors from larger, higher horsepower engines to smaller, low horsepower machines that may become fully electronic.

Pitla and his team are currently working on one of the only autonomous tractors of its kind in the country. Named Flexible Structured Robotic Vehicle (FlexRo), the tractor is currently used for plant phenotyping, which is measuring the physical characteristics of the plant. According to Pitla, cameras are added to the machine to collect images that characterize plant conditions.

In addition to phenotyping, the FlexRo platform has enough power to perform other operations such as two row planting and targeted weeding (both mechanical and chemical).

AUTONOMOUS TRACTOR DESIGN

Non-autonomous tractors can have engines ranging from 100- to 600-horsepower. These are large machines to send into a field without an operator to manage the systems. A solution to this problem is a scale-neutral tractor, or rather shrinking the large machines to smaller sizes.

"One of the things we are looking at is if we can replace a 500-horsepower tractor with 10, 50-horsepower tractors," Pitla said. Many safety features would be added to the machine, like

sensors to detect surrounding objects or prevent a "mechanical fault," or machine malfunction. Pitla said mechanical faults are likely but believes having a smaller, lower horsepower tractor will drastically lower the damage done by a machine fault.

SAFETY OF AUTONOMOUS TRACTORS

Pitla said that in 2005, auto-steer technology, in which a computer system controls the machine with GPS guidance, took a strong hold of the agriculture industry and was widely adopted by farmers. The idea of removing the operator completely from the machine began to form. Since then, systems have become more automated and the operator has fewer tasks to perform. Safety remains the most important concern as the idea continues to develop.

"When you take an operator out of the machine, the biggest challenge is safety and liability," Pitla said. Technology has continued to advance, such as a machine's computing power and machine learning systems.

Ultimately, the advancement of these systems in agriculture makes the idea of autonomous tractors possible. As of 2019, autonomous tractors are not commercially available. Unmanned vehicles are quite possibly the way of the future for the agriculture industry, and FlexRo is the first of its kind leading the way.

FLEXIBLE STRUCTURED ROBOTIC VEHICLE: AN AUTONOMOUS TRACTOR

The development of FlexRo began in 2015 and Pitla has been a part of the development team since its inception. FlexRo is a 46-horsepower robotic machine with four-wheel drive and four-wheel steering. The machine has a 10-foot by 10-foot frame and has a ground clearance of 5 feet. FlexRo's footprint addresses the safety concerns of size. FlexRo is a machine that few other universities in the United States are developing.

Pitla said the current goal is to phenotype plants. This includes growth, physical characteristics, chlorophyll content, and stressors to the plant, and this can all be measured with FlexRo. As the technology progresses, new testing practices will need to be developed to measure a machine's computing capacities. Instead of testing machines based on their physical power, such as pulling power or fuel efficiency, these machines will need to be tested on their ability to process information, or rather their thinking power.

FlexRo not only removes the need to have an operator in the field, it also saves time and energy through more efficient operating patterns. "In a field, the biggest inefficiency from the machinery perspective is turning around at the end of the row, but with FlexRo you have four-wheel steering, so you can run in different configurations to save time in terms of turning," Pitla said.

Further, FlexRo also provides the ability to operate for 20 hours a day since it is autonomous and does not need an operator. Being only a 46-horsepower machine also reduces soil compaction compared to a much larger tractor. There are many advantages to having autonomous vehicles in agriculture production, but Pitla said there are still questions that need to be answered regarding costs.

Flexible Structured Robotic Vehicle (FlexRo)

TECHNOLOGY COST

Tractors can range from tens to hundreds of thousands of dollars and adding an autonomous component will indeed raise prices. Pitla said that to understand the cost of this technology an economic analysis needs to be completed for each individual operation.

Looking at a general agricultural budget for producers, Pitla can see benefits to the technology for two distinct reasons. First, autonomous tractors could improve the accuracy of application operations, which would cut back on seed and chemical costs. Second, conventional tractors are designed to include office-like features for comfortability. However, an autonomous tractor would not need any of these features. This could offset the higher prices. For instance, "air conditioning, cab, active suspension, radio and leather seating are all expensive," Pitla said. Removing these amenities will remove a large sum from the cost of building one of these machines. These two factors would reduce the impact an

autonomous tractor purchase would have on a farmer's overall budget.

THE FUTURE OF AUTONOMOUS TRACTORS

Nebraska is home to the only tractor-testing laboratory in the western hemisphere. The Nebraska Tractor Testing Laboratory in the Department of Biological Systems Engineering opened in 1919. The laboratory was a result of Nebraska legislation that stated every tractor sold in the state had to be performance tested. This requirement was to protect farmers from buying equipment that had lesser abilities than advertised. As autonomous tractor technology continues to develop, new testing practices will also need to be developed to evaluate the machine's capabilities. This may even include testing in fields, rather than in the laboratory.

With less than 2% of the United States population actively farming, autonomous tractors will allow producers to better meet the demand for food around the world. While Pitla estimates a timeline of 5 to 10 years before fully autonomous tractors are available for farmers, smaller developments will likely be introduced to the public in increments. The steps of this gradual introduction could unfold in several different ways. Pitla believes it is likely that test producers will direct a few autonomous vehicles as part of their operations. Several trial runs will follow with selected producers, starting with a few machines and gradually progressing to a fully automated system.

KEY TAKEAWAYS

1. Santosh Pitla and his team are currently developing an autonomous tractor using ground robotics – FlexRo.
2. FlexRo is one of the only autonomous tractors of its kind in the country.
3. FlexRo can be used for phenotyping, row planting, and targeted weeding.
4. FlexRo not only removes the need to have an operator in the field, it also saves time and energy through more efficient operating patterns.
5. Unmanned vehicles are quite possibly the way of the future for the agriculture industry and FlexRo is the first of its kind leading the way.

> "There is a need on the farm for automation because statistics suggest that only 2% of the population in the United States are farmers."
>
> — *Santosh Pitla* —

John Gamon

REMOTE SENSING: SEEING IN NEW WAYS:
A Tool for Monitoring Biodiversity in Nebraska

Interview with John Gamon
By Abby Steffen

Remote sensing is an aerial technology used to help scientists see things in new ways. John Gamon, professor of remote sensing at the University of Nebraska–Lincoln, said that people use remote sensing every day.

"Our eyes are great remote sensing instruments. We don't think of them that way, but we look at things from a distance and our eyes and brain tell us what we're seeing – that is remote sensing," Gamon said.

Instruments on aircraft and satellites can now view the world from a distance, often in new ways and at larger scales, providing evermore powerful ways to conduct remote sensing.

Gamon believes that remote sensing research and technology have the potential to vastly impact Nebraska's agricultural practices and natural resources and biodiversity management by maintaining landscapes throughout the state with the capacity to bounce back under stress.

According to Gamon, remote sensing research helps producers increase crop yields over time. It also provides researchers and producers early information to help design more efficient or cost-effective precision agriculture practices.

For instance, remote sensing research reports how a crop is growing and can detect problems early, before the human eye could. This could help producers reduce the amount of inputs, such as fertilizer and water, that they apply to crops.

In addition, remote sensing research could lead to the production of crops that are more efficient in combating heat and nutrient stress, allowing producers to save on input costs.

REMOTE SENSING EXPLAINED

When an object being viewed is too small or too far away, aircraft and satellite remote sensing instruments come into play.

"Remote sensing instruments can go far beyond what our eyes can see," Gamon said. These instruments can be anything from a drone a few feet above Earth's surface, to a satellite in Earth orbit. Without the evolution and development of remote sensing, many daily tasks, such as checking

the weather forecast or mapping out a travel route, would be impossible, he said.

"Historically, remote sensing techniques have been used for military intelligence gathering," Gamon said. In 2019, however, his research is focusing specifically on using a plane and/or satellite to conduct remote sensing research on vegetation. With the help of aircraft instruments, Gamon is able to look at an area of the Earth's surface in a new way. He is able to observe and record the spectral reflectance and signature of the vegetation he is studying.

"Spectral reflectance is the amount of light being absorbed by or bouncing off an object," Gamon said. "Every object identified through remote sensing will reflect its own unique spectral signature."

By studying the spectral signatures of plants, Gamon is better able to understand the factors that affect plant growth and determine ways to improve growing conditions and more cost-effective, efficient application practices and plant varieties in general.

The unique spectral signatures help researchers tell the difference between land, water or vegetation. For instance, the spectral signature that a field of corn reflects would look different than the spectral signature of a lake.

The spectral signature data Gamon collects does not look like a regular geographic map or picture of the Earth's surface. Gamon's remote sensing instruments work to record an object's spectral reflectance and translate its unique spectral signature onto a line graph or into false color images.

"Spectral signatures are sort of like fingerprints that tell us what kind of plant we're looking at or how healthy it might be," Gamon said. "These aren't as perfect as the signatures of our fingers, and there's overlap in these signatures, but the patterns of reflected light allow us to infer a lot of information about the identity and function of the surface we're looking at, whether that's living or nonliving."

In addition, a single plant's signature can vary due to many different factors including the health of the plant, the rate at which it is photosynthesizing and even heat stress, he said.

REMOTE SENSING DEVELOPMENT PROJECTS

Gamon is currently involved in remote sensing research programs with several organizations: SpecNet, National Aeronautics and Space Administration (NASA), the National Science foundation, the European Space Agency, and the University of Nebraska–Lincoln.

SpecNet is a nonprofit organization that encourages the use of remote sensing, particularly for measuring vegetation, photosynthesis and productivity of plants. If plants are not being as productive as possible, Gamon and other researchers can compare the results to other areas of vegetation that are more productive.

The Arctic Boreal Vulnerability Experiment, or AboVE, is a NASA-funded project. Gamon leads an AboVE project and works with other researchers in the university system to study the effects of global change and climate variation on ecosystems.

The European Space Agency funds research at the Eastern Nebraska Research and Extension Center on vegetation photosynthesis and plant stress.

NASA and NSF support research in biodiversity detection and are leading to new ways to monitor changing biodiversity over large areas.

According to Gamon, the team tests new remote sensing equipment and techniques that can later be applied to the biodiversity monitoring and landscape level research in Nebraska and around the world — a technology that in the future, will help Nebraska researchers design ways to better maintain the state's biodiversity.

"We don't really know the limits of what we can see and that's what a lot of the work we do is, to try and understand that," Gamon said.

The Center for Advanced Land Management Technologies, or CALMIT, is a University of Nebraska–Lincoln program that studies the use of remote sensing and other spatial technologies.

"The university has had a reputation for this work in remote sensing for quite a long time, which is one thing that attracted me to work with people at the university," Gamon said.

A unique feature of the CALMIT is its airborne research program, which Gamon supervises. Gamon explained that CALMIT has a multiscale ability to do basic and applied research from the ground, and aircraft or satellites. A variety of methods is used to study the health and productivity of human-controlled vegetation and natural ecosystems.

According to Gamon, few, if any, universities in North America have the same capabilities as Nebraska and its CALMIT program.

REMOTE SENSING RESEARCH AND NEBRASKA

Gamon said that remote sensing research can be used to design approaches more efficient in nutrient usage and application to avoid environmental damage to the state's water quality and help Nebraska researchers implement better ways to maintain the state's biodiversity.

"Biodiversity research today involves a range of approaches to understanding all the different kinds of life on the planet," Gamon said. These approaches include looking at and measuring both species diversity and genetic diversity in Nebraska and elsewhere.

Species diversity is defined as the number of different species in a given place and how those species change and evolve across landscapes, according to Gamon. Whereas, genetic diversity measures how much variation in genetic composition exists in a landscape, and also functional diversity. These both can be studied using remote sensing.

Biodiversity provides resilience by itself. According to Gamon, this is a basic ecological principle. In other words, biodiverse ecosystems provide themselves with the capacity to solve their own problems and bounce back under stress.

"Plants reproduce in different ways. They function differently. So, having a diversity of functional types is actually quite important for resilience," he said. This is what the CALMIT program is trying to provide the state of Nebraska: heat-resistant crops, healthy water quality and diverse environments that will be able to bounce back on their own.

While there are many benefits to remote sensing research, Gamon acknowledged that due to expanding agriculture in Nebraska, there is a decline in biodiversity.

However, with the improvements to Nebraska's precision agriculture practices along with the university's ability to monitor the state's biodiversity through CALMIT, the field of remote sensing has the potential to vastly impact the monitoring of Nebraska's agriculture and natural resources biodiversity.

KEY TAKEAWAYS

1. People use remote sensing every day.
2. Our eyes are great remote sensing instruments. We don't think of them that way, but we look at things from a distance and our eyes and brain tell us what we're seeing – that is remote sensing.
3. Remote sensing research helps producers increase crop yields over time.
4. Remote sensing research reports how a crop is growing and can detect problems early, before the human eye could.
5. Remote sensing research could lead to the production of crops that are more efficient in combating heat and nutrient stress, allowing producers to save on input costs.

Joe Luck

REDUCING SPRAY DRIFT:
Keeping Chemicals in Place

Interview with Joe Luck
By Michael Ferguson

Chemicals have been used in agriculture since the early days of civilization. Chemical use can be traced back to when the Mesopotamians used elemental sulfur dusting as one of the first known pesticides. The practice has grown to a large sector of agriculture with fertilizers, herbicides and pesticides, all of which are strictly regulated by the Environmental Protection Agency. However, there are times where the chemicals fail to stay where they are intended.

Joe Luck, associate professor specializing in precision agriculture engineering in the Department of Biological Systems Engineering at the University of Nebraska–Lincoln, develops ways to make application systems more efficient in reducing spray drift.

Luck explained spray drift as chemicals being carried by an external force (wind, for example) to an area other than the original intended area. With the expanding use of chemicals in agriculture, wind is a natural factor producers often fight to keep applied chemicals in the intended space.

According to Luck, Nebraska is a great place to study this issue because "the wind in Nebraska is, on average, extremely high compared to most places. Those challenges that we deal with out here lead to innovation and that can be applied across different parts of the world." Studying this issue in a place that has an abundance of one of the main factors to cause chemical spray drift puts Luck in a prime position to find the best ways to minimize it.

Agriculture is the No. 1 industry in Nebraska. Luck said that farmland takes up 45.2 million acres, which is 90% of the state's total land area. Many producers use chemical application to keep up with growing food and fuel demands. Luck said that because drift is inevitable, it is imperative that producers do all they can to reduce spray drift. Minimizing spray drift protects Nebraska's main industry and reduces chemicals introduced to the environment. Ultimately, minimizing spray drift is needed to protect other farmers, the public and the environment.

CAUSES AND SOLUTIONS OF SPRAY DRIFT

Luck said it is important to first understand the causes of spray drift so solutions can be made. Spray drift can be impacted by one or two operational factors. First, according to Luck, the droplet size of

the chemical being applied plays an important role. Smaller droplet sizes have a higher probability of not reaching their intended target in the field.

"As far as the application goes, the droplet size is obviously critical to accurate application," Luck said. When the sizes of droplets become small, drift potential grows.

Second, Luck said sprayer boom height can also impact spray drift. A sprayer boom is the mechanism in which spray nozzles are attached to distribute chemicals from the sprayer. If a sprayer boom is set to a height that is higher than necessary (many times by accident), there are higher chances of drift.

"If a 20-inch height is optimal for a certain setup that a farmer is using, any more above that would give more potential for spray drift," Luck said.

Luck currently is developing a spray nozzle that will allow an operator to change droplet sizes while in the field. "If weather conditions change, larger droplets have less drift potential. Smaller droplets have a greater drift potential," Luck said. "The ideal situation would be you'd have less chemicals moving off-target into the environment."

Luck said his new spray nozzle accounts for different application practices of varying chemicals. Chemicals that only require a few drops per leaf to kill a plant would use larger droplet sizes, while other chemicals that require the leaf to be totally coated to be effective, would use smaller droplet sizes.

"There's potential that we could use this technology so farmers don't have to worry about making any changes on the sprayer. Just put in what droplet sizes are needed, the application rate and the control system compensates for that," Luck said. This technology will allow operators to not have to make any adjustments manually on the machine. Instead, the system's computer would take care of any adjustments needed. Luck said that easier control of droplet sizes reduces spray drift potential when accounting for external factors, and reducing spray drift has significant advantages.

ADVANTAGES OF SPRAY DRIFT REDUCTION

Luck said that being more accurate in the application of chemicals and reducing spray drift has three specific advantages. First, by being more precise with where chemicals are applied, there are fewer chances of a neighboring producer being affected by the chemicals applied by another farmer. For instance, if a farmer grows a crop that becomes resistant to a type of chemical meant to kill plants, the farmer will spray the chemical but if spray drift occurs, the chemical could affect a neighbor.

"You can spray a field with weed killer and it'll kill the weeds in the field but not the herbicide-resistant crop. If you were a producer with a field next door that didn't have those hybrids and chemical drifted over there it may cause damage," Luck said.

Second, reducing spray drift limits chemicals being introduced to the environment. "I think any time you can reduce environmental impacts, that will help the sustainability of crop production systems," Luck said. Chemicals are an important part of production agriculture because they allow farmers to produce enough food to feed the growing population. However, Luck believes producers must ensure that the environment is minimally impacted.

Finally, Luck said using fewer chemicals also lowers the chances of chemical-resistant plants or pests. Chemical resistance is a result of improper application of an herbicide or pesticide, Luck explained. When a chemical that is intended to kill a weed only sickens the plant, the plant has the chance to come back stronger and produce seeds resistant to that chemical in the next year. This may then require a need for additional chemicals. Being more precise with application will lessen chemical-resistant weeds.

A COST-SAVING OPTION

Based on his past experiences, Luck notes that the farming industry can be a financial struggle. Commodity prices in 2019 have seen low numbers and farmers have been forced to find additional forms of income.

As a result, Luck acknowledged that few farmers are buying new equipment. Luck said, however, that farmers might benefit from a relatively low-cost spray nozzle.

"What you're seeing is that people may not be spending a lot of money on new equipment, but they might be spending a little money to upgrade technologies on their [current] equipment," Luck said.

KEY TAKEAWAYS

1. The natural force of wind can carry chemicals — referred to as spray drift — outside of the intended area.
2. Joe Luck is currently developing a spray nozzle that will allow a farmer to change droplet sizes of the spray while in the field.
3. Minimizing spray drift protects Nebraska's main industry and reduces chemicals introduced to the environment.
4. Nebraska is a great place to study this issue because the wind in Nebraska is, on average, extremely high compared to most places.
5. Minimizing spray drift is needed to protect other farmers, the public and the environment.

> "There's potential that we could use this technology so farmers don't have to worry about making any changes on the sprayer. Just put in what droplet sizes are needed, the application rate and the control system compensates for that."
>
> *— Joe Luck —*

The self-propelled agricultural sprayer is one of the applications for Joe Luck's new application control system.

Tami Brown-Brandl

PRECISION ANIMAL MANAGEMENT – CHANGING THE WAY PRODUCERS USE TECHNOLOGY:
A Vision for the Future

Interview with Tami Brown-Brandl
By Cadrien Livingston

Technology has not only changed the livestock industry, but also brought important changes to traditional agriculture. Tami Brown-Brandl, professor in the Department of Biological Systems Engineering at the University of Nebraska–Lincoln, uses an engineering approach to research ways technology can improve production agriculture. Her work is termed "precision animal management" and according to Brown-Brandl, Nebraska leads the United States in this work.

Precision animal management, sometimes referred to as precision livestock farming, is defined by Brown-Brandl as gathering real time data on individual animals within a production system through technology. This technology helps producers quickly understand animals.

"Part of precision animal management is that we must create a vision for the future," Brown-Brandl said. "We have to know how and when to use the technology to keep farming resilient."

Brown-Brandl said livestock producers can use precision animal management to be more efficient with time. She suggested specific, cost-friendly technologies for producers to use such as a smart phone app focused on identifying heat stress conditions for feedlot cattle, depth imaging cameras to estimating pig weight, and RFID system to help identify sick animals.

HEAT STRESS APP

Technology is an important component to combat heat stress in livestock. Heat stress occurs when an animal absorbs too much heat, which causes stress, illness or even death, according to Brown-Brandl. When a heat wave (a period of 3 or more days with high daytime temperatures with little or no night time cooling) hits, producers have to work to keep livestock alive.

Brown-Brandl said when livestock are exposed to heat stress, feed intake, respiration rate and body temperature all are affected. At times, heat stress can even cause death due to higher internal temperatures. To combat this, shade or a sprinkler system is needed to protect the livestock. Brown-Brandl said that it is important for producers to know when the next heat wave is expected, so facilities are properly equipped to handle hot temperatures.

Brown-Brandl, United States Department of Agriculture and Hollman Media released a heat stress app in April 2015. Using forecast data from the National Weather Service, a map allows producers to pinpoint the location of their feedlot. This app then allows producers to anticipate an impending heat stress event and be prepared to keep their livestock cooler and stress levels low. Producers can find this app in the Google Play store or Apple Store by searching the term "heat stress." The image for the app is the graphic here.

DEPTH IMAGING TECHNOLOGY

Depth imaging technology has helped producers in the pork industry. According to Brown-Brandl, when taking a photo, depth imaging cameras use distance, instead of color, to capture the frame.

Brown-Brandl and others are working on projects using depth imaging technology with the goal of finding better ways to determine specifics of each animal. For example, depth imaging technology can help identify the weight of each animal, whether an animal is in the correct condition — not too fat nor too thin — or if an animal is lame (unable maintain a normal stance). Brown-Brandl said that depth imaging technology allows producers to identify animals that need attention more easily and more quickly in a large group.

Depth imaging technology is also used to help create farrowing crates. Brown-Brandl described a farrowing crate as a metal enclosure used for housing a sow and her newborn litter of piglets. For the health of the animals, it is critical to create farrowing crates large enough for the sow and her piglets. She said that depth imaging cameras can help determine how the pigs are utilizing the space, thus helping design a better farrowing crate.

RADIO-FREQUENCY IDENTIFICATION TAGS

Precision animal managment also uses RFID tags to identify animals in a producer's herd. According to Brown-Brandl, an RFID tag is a radio-frequency identification system that uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically stored individual numbers that can be used to identify animals or objects.

Brown-Brandl said an animal's feeding behavior can be tracked through RFID tag identification placed in an animal's ear. Data are captured when an animal is feeding. This system allows the producer to know how much time each individual animal spends at the feed bunk.

RFID tag technology offers a great deal of information to many. Brown-Brandl said that this information can be used to detect illness on an individual animal basis. In addition, this information can help engineers understand the animal dynamics within the animal space so they can design better pens. This information can also be used by geneticist to help select animals that have better characteristics such as better heat tolerance.

"RFID systems like these can be the eyes and ears of the producers and the barn 24/7, 365 days a year. They help producers make sure all animals are eating. We can look at the data and see how much animals ate yesterday and predict what they should eat today," Brown-Brandl said.

With this technology, producers can monitor each animal. For example, if there is a decrease in feed intake, they can identify that animal more quickly and treat the problem.

ADVANCING CAREER OPPORTUNITIES IN FARMING

Precision animal management allows qualified recent graduates to explore new career opportunities in the agricultural industry. Brown-Brandl said careers in computer science, animal science, agricultural engineering and mechanized systems management are just a few examples of careers that can impact the agricultural industry with precision livestock technology.

Brown-Brandl said these career opportunities are a great option for those not wanting work in traditional agriculture, but may want to return to a farm. Others that have no background in agriculture can also use this career opportunity to be a part of an emerging technology area and a driving workforce, while enhancing the future of precision animal management.

Producers will not be replaced when adding new technology to their farm, but rather, technology could increase profits for operations. Animal agriculture will not only be able to remain resilient by attracting new workers into the field, but also allow producers to manage their time efficiently while being more productive.

Finishing pig engaging with a toy added for environmental enrichment.

KEY TAKEAWAYS

1. Technology has changed both the livestock industry and traditional agriculture.
2. Precision animal management gathers live data on individual animals within a production system.
3. Producers can use these technologies to be more efficient with time. Three technology advances include:
   - A smartphone app that helps combat heat stress.
   - Depth imaging technology to help producers identify animals that need attention more easily and more quickly in a large group.
   - RFID tags to help detect issues with individual animals before they become issues among groups of animals.

> "RFID systems like these can be the eyes and ears of the producers and the barn 24/7, 365 days a year. They help producers make sure all animals are eating. We can look at the data and see how much animals ate yesterday and predict what they should eat today."

— Tami Brown-Brandl —

Bertrand Clarke

STATISTICS IN AGROECOSYSTEMS:
Leveraging Prediction for Agricultural Production

Interview with Bertrand Clarke
By Kathryn Bagniewski

Nebraska has a wealth of biodynamic data gained from its productive agriculture and its bountiful natural resources. Because of this breadth of data types, Bertrand Clarke, professor and chair of the Department of Statistics, said the University of Nebraska–Lincoln is a first rate place to study statistics.

As part of the Institute of Agriculture and Natural Resources (IANR), the Department of Statistics uses existing statistical methods in innovative ways and invents new techniques to analyze data and reach conclusions about the systems studied by IANR researchers. Clarke said that statistical analysis and the methodological work that supports it helps agricultural and natural resources professionals make sounder decisions for the landscapes and ecosystems throughout Nebraska and beyond.

The future for agriculture and natural resources data analyses, in Clarke's eyes, is in prediction. Decision-making, however, is even more complex than prediction.

"You can't go back in time, press replay, and evaluate how good your decision was compared to other decisions you didn't make," Clarke said.

For example, a farmer may use statistical analysis to decide the right amount of irrigation for a field, and when to apply it, to optimize production. This would be based on a prediction of how much water the field needs at various times, but it is the decision that must be optimal. The farmer would have to determine if the decision was effective by analyzing how the crops in the field grew. If the amount of irrigation water did not increase production satisfactorily in the absence of knowledge of what would have happened had he or she made a different decision.

Clarke said the complex nature of decision-making leads to many agricultural and natural resources professionals using consulting services for help with statistical analyses.

STATISTIC CONSULTANTS

A key arm of the Department of Statistics is its consulting work. The Statistical Cross-disciplinary Collaboration and Consulting Lab (SC3L), informally known as the Help Desk, assists Nebraska graduate students, faculty and staff in making decisions and other inferences for agricultural and natural resources systems.

Clarke said that recognizing the maturation of consulting as a leading branch of statistics will help to set Nebraska apart from other universities. The Department of Statistics faculty has expertise in various established and emerging areas of statistics, which helps them build collaborative relationships with faculty members from other disciplines throughout IANR.

Through collaboration and consulting, Nebraska's statisticians design complex experiments, conduct analyses and make recommendations for agricultural producers. They also study other biomedical populations and other aspects of data to keep current with contemporary trends and to make predictions and other inferences. According to Clarke, predictions help the university's researchers study natural resources, other ecosystems, and other topics germane to IANR research areas.

PREDICTION AND DECISION-MAKING

Approaching statistical problems predictively can help agricultural and natural resource professionals make decisions. The reason is that predictions can be evaluated against measurements, in particular through online techniques. According to Clarke, this helps ensure that scientists make inferences that are consistent with the systems they study.

For example, if a researcher predicted that the city would get 3 inches of rain tomorrow, he or she can simply wait until tomorrow to see how much rain the city will actually get. If the city only received 2.5 inches of rain, the researcher knows that his or her prediction was incorrect by 0.5 inches of rain.

Based on this information, the researcher can determine whether or not his or her prediction was valuable in making decisions. The same is true for a farmer predicting future data for his or her field. Technological advancements help speed this process.

TECHNOLOGICAL ADVANCEMENTS

The field of statistics continues to evolve and grow "as a consequence of massively improved technology for data gathering," according to Clarke. With the influx of data obtained in multiple ways in agricultural and environmental systems, there are more demands on producers to use statistics when managing ecosystems and farms.

"Many fields which were historically not very quantitative have become extremely quantitative," Clarke said. He explained that businesses across all industries — particularly agriculture — are relying more on quantitative data before making important decisions. With more data types than ever to collect and emerging techniques for how to make inferences from them, the Department of Statistics has more opportunities than ever to integrate itself within IANR. One example, among many, is sensor data. Another is streaming data collected by Unmanned Aerial Vehicles.

Unmanned aerial vehicle over a corn field.

"The whole field of statistics and computational sciences is itself a moving target," Clarke said. "The world has changed, chiefly through increased data gathering, and statistics has to change with it." Society has adapted to the evolving trends in technology, specifically advances and accessibility, and according to Clarke, statistics has been evolving to stay valuable amidst these trends.

"This is simply the onward march of science," he said of this adaptation of statistics to recent technological advancements. Indeed, mainstream statistics has always been continuously reinvigorated by new data types and technologies as society progresses.

HISTORY

In July 2003, the university merged the Department of Biometry in IANR and the statistics division of the Department of Mathematics and Statistics in the College of Arts and Sciences to create what is now known as the Department of Statistics. In the summer of 2018, the Department of Statistics moved to be entirely within IANR. Due to its importance in collaboration, consulting and research, statistics as a field has been growing rapidly. This is likely to continue for at least a decade.

For instance, Clarke noted there is a growing importance of statistics and statistical research for precision agriculture and natural resources. Sometimes this falls under the heading "big data". These sources of data continue to grow, and the Department of Statistics helps IANR's programs continue to provide cutting-edge research and education. The relationship between IANR and the Department of Statistics is both strategic and critical, according to Clarke.

As data sets become bigger and more complex, Clarke observed, "prediction and testing your predictions against real-world measurements becomes more important, regardless of what statistical techniques you use or philosophy you follow."

KEY TAKEAWAYS

1. Statistical analysis helps agricultural and natural resources professionals make sounder decisions for Nebraska and beyond.
2. The future for agriculture and natural resources data analyses is in prediction.
3. The complex nature of decision-making leads to many agricultural and natural resources professionals using consulting services for help with statistical analyses.
4. The Statistical Cross-disciplinary Collaboration and Consulting Lab (SC3L), assists Nebraska graduate students, faculty and staff in making decisions and other inferences for agricultural and natural resources systems.

> "The whole field of statistics and computational sciences is itself a moving target. The world has changed, chiefly through increased data gathering, and statistics has to change with it."
>
> *— Bertrand Clarke —*

Taro Mieno

FROM PLOWS TO PRECISION AGRICULTURE:
Maximizing Profitability through Precision Technology

Interview with Taro Mieno
By Halle Ramsey

Modern farming has evolved since the days of horse-drawn plows. According to Taro Mieno, assistant professor in the Department of Agricultural Economics at the University of Nebraska–Lincoln, little research is dedicated to the true economic impact of adopting precision technology on farms. Mieno's research focuses specifically on how precision agriculture technologies impact profitability for farmers.

Mieno said precision agriculture recognizes the diversity of characteristics within a field through technology. Some examples of precision agriculture include drones, Global Positioning Systems (GPS) and irrigation technologies. The goal of precision agriculture is to learn new management practices to increase the profitability of agriculture production.

"The core of my research assists farmers to maximize their profitability. The most rewarding part of economic analysis is helping farmers decide how to provide monetary value through those technologies," Mieno said.

According to Mieno, farmers should consider which technologies add value to management practices. Drones and similar equipment may be the face of futuristic agriculture production, but these technologies are not necessarily the answer to maximizing profit for all farmers because of their high costs at the moment, Mieno said.

According to Mieno, technology adoption can be an expensive undertaking and the key is to focus on the specific needs of the land or crops each farmer grows. Through intentionally gathering data and collaborating with university researchers, farmers can weigh the costs and benefits of adopting certain precision agriculture technologies. Due to the diversity of farming practices, assessing the benefits of precision agriculture technology adoption on farms is most accurately found by analyzing the specific needs of each field or crop.

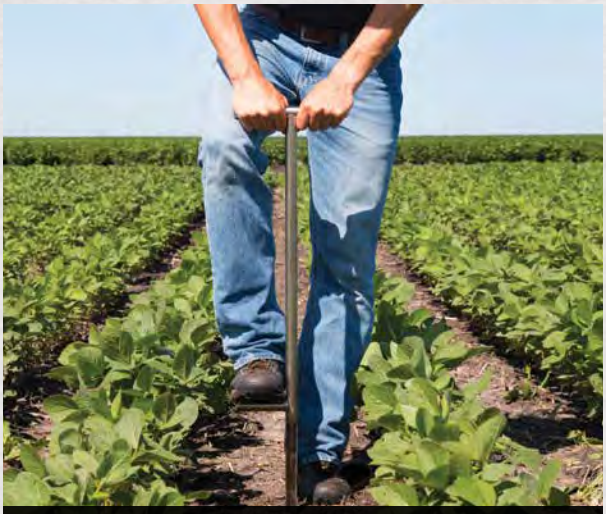
"Sometimes simple is best. Farmers shouldn't automatically assume certain precision agriculture technologies that work for everyone else will automatically work for their field. Whether a certain precision agriculture technology is profitable or not is very field-specific," Mieno said.

COLLABORATION BETWEEN FARMERS AND RESEARCHERS

Mieno typically works with farmers on-site at a farm. On-farm research is particularly useful to Nebraska producers due to the variability of land and crop characteristics across the state. According to Mieno, on-farm research empowers farmers to learn about the specific needs of their crops.

"The idea of on-farm research is quite powerful because you learn about your field. That means you get to learn how to manage your own field instead of inferring what happened on a different field," Mieno said.

Methods such as soil sampling provide valuable insight for farmers. However, Mieno said it is critical for farmers to evaluate the return on investment of collecting the data. For example, the more soil that is gathered from a given field, the more information is available to farmers about the characteristics of the field. This information assists in making management decisions.



Soil Sampling in Soybeans

"Obviously, the more soil sampling, the better information you have, but you are paying for the soil sampling. So, there's a race between the cost of collecting information and the benefit of having that information," Mieno said.

Further, the data collected instructs farmers to use amounts of fertilizer and water that maximize yields while minimizing excess use of resources. According to Mieno, the data gives farmers necessary knowledge to minimize input costs, which positively impacts profitability.

Ultimately, the primary objective of precision agriculture is to improve profitability for farmers, but precision agriculture technologies also provide farmers key data to responsibly steward Nebraska's natural resources through precise nutrient and water application.

According to Mieno, as technologies continue to evolve, farmer preference will be the determining factor regarding which precision technologies become sustainable solutions. Consequently, creating technologies that suit farmer needs are at the forefront of the university's research efforts.

"We must continue to identify the needs of farmers. Extension educators and researchers are doing research to assist farmers to make the best decisions," Mieno said.

Mieno said collaboration between farmers and researchers, including on-farm research and other scientific studies, will continue to be critical as technologies develop in precision agriculture to maximize yields and profits for farmers.

PRECISION TECHNOLOGY BUILDS ENVIRONMENTAL RESILIENCE

The effects of precision agriculture technology extend far beyond the fields of rural Nebraska. According to Mieno, precision agriculture technologies, such as the use of nitrogen and moisture sensors, are tools to assist farmers in maximizing profit and yield while also keeping Nebraska's natural resources resilient.

In the case of nitrogen application, nitrogen sensors attached to tractors allow farmers to analyze what areas of fields need varying levels of specific nutrients. Precision agriculture technologies also assist farmers to efficiently apply water on cropland, Mieno said.

Moisture content is especially important regarding soil health and according to Mieno, conventional methods can make it difficult for farmers to identify the exact moisture content in soil. Therefore, many farmers are turning to soil moisture sensors. Mieno explained moisture sensors give farmers the information to be precise in water application, which also has an impact on groundwater availability for future generations of Nebraskans.

"You cannot test water content in the deepest part of the soil. Soil moisture sensors give farmers information about how much water soil has, which will help them avoid applying water when it is not actually needed," Mieno said, "Using less water for irrigation means farmers can use groundwater for a longer period of time."

Precision technologies empower farmers to make management decisions that preserve resources while maximizing profitability. Fully leveraging the information precision technologies provides requires intentional collaboration between farmers and university researchers to meet the needs of farmers and the world's increasing population.

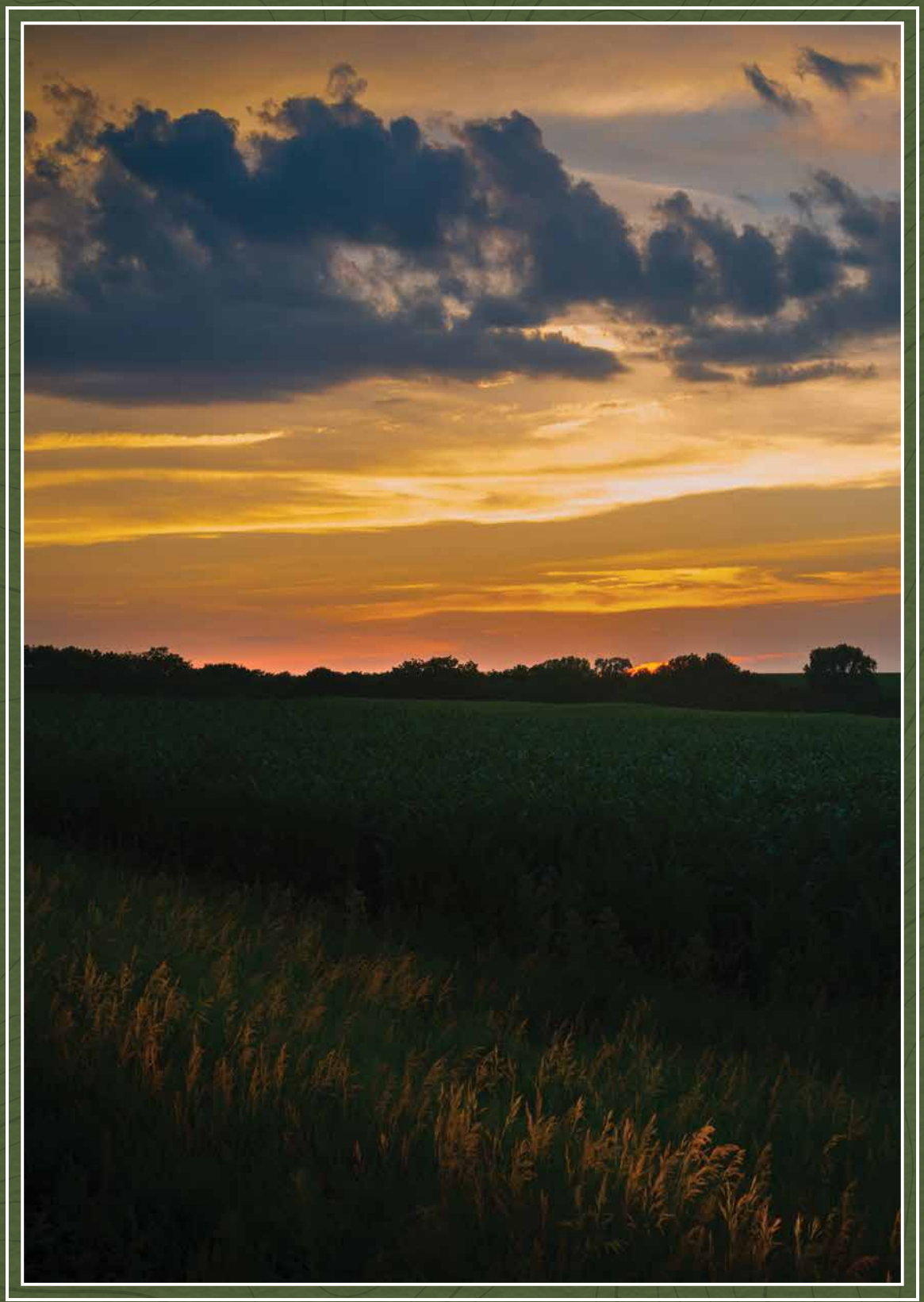
KEY TAKEAWAYS

1. Precision agriculture, such as drones, GPS, and irrigation technologies, recognizes the diversity of characteristics within a field through technology.
2. One goal of precision agriculture is to learn new management practices to increase the profitability of agriculture production.
3. The primary objective of precision agriculture is to improve profitability for farmers, but precision agriculture technologies also provide farmers key data to responsibly steward Nebraska's natural resources through precise nutrient and water application.
4. Farmers should consider which technologies add value to management practices.

> "Sometimes simple is best. Farmers shouldn't automatically assume certain precision agriculture technologies that work for everyone else will automatically work for their field. Whether a certain precision agriculture technology is profitable or not is very field-specific."
>
> *— Taro Mieno —*

“In Nebraska, natural resources professionals understand the importance of living in an agricultural state. Similarly, agricultural producers realize that a focus on crop production without looking at other factors diminishes the opportunity of the agriculture and natural resources interface. It is truly when these two areas integrate and collaborate that the whole state — its agricultural industry, its ecosystems and its people — will thrive.”

— John Carroll —



IANR

Institute of Agriculture and Natural Resources
P.O. Box 830924
Lincoln, NE 68583-0924

SDN.UNL.EDU