S. HRG. 115–645

TECHNOLOGY IN AGRICULTURE: DATA-DRIVEN FARMING

HEARING

BEFORE THE

SUBCOMMITTEE ON CONSUMER PROTECTION, PRODUCT SAFETY, INSURANCE, AND DATA SECURITY

OF THE

COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

ONE HUNDRED FIFTEENTH CONGRESS

FIRST SESSION

NOVEMBER 14, 2017

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SENATE COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION

ONE HUNDRED FIFTEENTH CONGRESS

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TECHNOLOGY IN AGRICULTURE: DATA-DRIVEN FARMING

TUESDAY, NOVEMBER 14, 2017

U.S. SENATE,
SUBCOMMITTEE ON CONSUMER PROTECTION, PRODUCT SAFETY, INSURANCE, AND DATA SECURITY,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Subcommittee met, pursuant to notice, at 2:32 p.m. in room SR–253, Russell Senate Office Building, Hon. Jerry Moran, Chairman of the Subcommittee, presiding.

Present: Senators Moran [presiding], Blumenthal, Blunt, Fischer, Inhofe, Lee, Young, Klobuchar, Hassan, and Cortez Masto.

OPENING STATEMENT OF HON. JERRY MORAN, U.S. SENATOR FROM KANSAS

Senator MORAN. Good afternoon, everyone. Thank you for joining us this morning. Our Subcommittee's hearing is on "Technology in Agriculture: Data-Driven Farming." That's this Subcommittee, and that hearing will come to order.

The agricultural community's adoption of field sensors, drones, satellite imagery, advanced machinery, and similar technology is increasing at an incredible pace. Our Commerce Committee and this Subcommittee have been paying a lot of attention to those issues. And the result of that increasing pace is greater crop yields and improved sustainable practices in farming. The most profitable farms are often the most sustainable ones. This rapidly evolving technology will have a vital role in preserving farmers' most important assets—their land—with the potential increase farmers' margins to unprecedented levels.

The collection and analysis of data has enabled farmers to reduce costs through more efficient applications of inputs like fertilizers and pesticides; improve production decisions through enhanced recordkeeping and more accurate yield predictions; and enhance land stewardship and sustainable practices by removing inefficiencies in planting, harvesting, water use, and the allocation of other resources. With an increasing volume of quality data, in tandem with improved data analysis, data-collection technology has the potential to dramatically increase farm productivity and profitability.

The collection and use of such data raises issues regarding control of the data, transparency of agreements between farmers and data firms, and barriers to expanding internet access to rural America.

Additionally, as data collection and sharing practices become more popular across the ag economy, farmers are well-positioned to benefit from their "commoditization" of data collected from their land, especially as equipment manufacturers, service providers, cooperatives and other businesses seek access to that data.

The goal for this hearing is to educate and empower our nation's farmers to understand the value of the information they are creating, and certainly to allow Members of Congress to have a better understanding of the current lay of the land and what the future holds.

It's my pleasure to introduce the panel today, and I thank you all for being here.

Justin Knopf is a farmer from Gypsum, Kansas, right in the middle of our state. He grows wheat, alfalfa, soybeans, grain sorghum, corn, and multi-species of cover crops. As part of his sustainability-focused farming operations, he practices what is referred to commonly as "no-till" farming and utilizes a variety of technologies that assist his monitoring efforts to be a good steward of the land while improving his yield.

Jason Tatge is the Co-Founder and CEO of Farmobile, a technology firm based in Overland Park, Kansas; that's a suburb of Kansas City. His company's services provide farmers with real-time access to ownership of current and historical data pertaining to their land. By providing a user-friendly, simplified, and comprehensive overview of relevant data, Farmobile's customers are able to make educated decisions in a much more timely fashion.

Dr. Shannon Ferrell is an Associate Professor at Oklahoma State in the Department of Agricultural Economics. He also serves as an agricultural industry representative to the Oklahoma Environmental Quality Board, which oversees operations of the Oklahoma Department of Environmental Quality. And the Senator from Oklahoma will have an opportunity to introduce Dr. Ferrell shortly.

Mr. Todd Janzen is President of Janzen Agricultural Law, LLC, and the Administrator of the Ag Data Transparency project. This project makes available the Ag Data Transparency Evaluator, which aims to provide clarity to consumers as to what businesses do with the data that is shared with them all.

And, finally, Dr. Dorota Haman is Professor and Chair of the Department of Agriculture and Biological Engineering at the University of Florida. She specializes in irrigation water management and efficiencies, and has been an active leader in providing irrigation technologies in developing countries, in the Americas, and in Africa.

[The prepared statement of Senator Moran follows:]

PREPARED STATEMENT OF HON. JERRY MORAN, U.S. SENATOR FROM KANSAS

Good afternoon. Welcome to the Subcommittee's hearing on "Technology in Agriculture: Data-Driven Farming." The Subcommittee will come to order.

Thank you for being here today to discuss the advancements and benefits of agricultural technology and the potential of "Big Data" in farming.

The agricultural community's adoption of field sensors, drones, satellite imagery, advanced machinery and similar technology is increasing at an incredible pace to increase crop yields and improve sustainable practices. The most profitable farms are often the most sustainable ones. This rapidly evolving technology will have a vital role in preserving farmers' most important asset, their land, with the potential to increase farmers' margins to unprecedented levels.

The collection and analysis of data has enabled farmers to reduce costs through more efficient applications of inputs like fertilizers and pesticides; improve production decisions through enhanced recordkeeping and more accurate yield predictions; and enhance land stewardship and sustainable practices by removing inefficiencies in planting, harvesting, water use, and the allocation of other resources. With an increasing volume of quality data, in tandem with improved data analysis, data-collecting technology has the potential to drastically increase farm productivity and profitability.

The collection and use of such data raises issues regarding control of the data, the transparency of agreements between farmers and data firms and barriers to expanding Internet access in rural areas.

Additionally, as data collection and sharing practices become more popular across the agriculture economy, farmers are well-positioned to benefit from the "commoditization" of data collected from their land, especially as equipment manufacturers, service providers, cooperatives, and other businesses seek to access and utilize this data.

My goal for this hearing is to educate and empower our Nation's farmers to understand the value of the information they are creating.

It is my pleasure to introduce our panel today. Thank you all for being here.

Mr. Justin Knopf is a farmer from Gypsum, Kansas, and he grows wheat, alfalfa, soybeans, grain sorghum, corn, and multi-species cover crops. As a part of his sustainability-focused farming operations, he practices what is commonly referred to as "no-till" farming and utilizes a variety of technologies that assist his monitoring efforts to be a good steward of the land while improving his yield.

Mr. Jason Tatge is the Co-Founder and CEO of Farmobile, a technology firm based in Overland Park, Kansas. His company's services provide farmers with real-time access to and ownership of current and historical data pertaining to their land. By providing a user-friendly, simplified yet comprehensive overview of relevant data, Farmobile's customers are able to make educated decisions in a timely fashion.

Dr. Shannon Ferrell is an Associate Professor at Oklahoma State University Department of Agricultural Economics. He also serves as the agricultural industry representative to the Oklahoma Environmental Quality Board, which oversees the operation of the Oklahoma Department of Environmental Quality.

Mr. Todd Janzen is President of Janzen Agricultural Law, LLC and the Administrator of the Ag Data Transparency project. This project makes available the Ag Data Transparency Evaluator, which aims to provide clarity to consumers as to what businesses do with the data that is shared with them.

Dr. Dorota Haman is a Professor and Chair of the Department of Agricultural and Biological Engineering at the University of Florida. She specializes in irrigation water management and efficiencies, and has been an active leader in providing irrigation technology to developing countries in the Americas and Africa.

I look forward to hearing the testimonies of this expert witness panel. I now turn to my colleague Ranking Member Blumenthal for his opening remarks.

Senator MORAN. I look forward to hearing the testimony of these expert witnesses. And before we do that, let me turn to the Ranking Member, the Senator from Connecticut, Mr. Blumenthal.

STATEMENT OF HON. RICHARD BLUMENTHAL, U.S. SENATOR FROM CONNECTICUT

Senator BLUMENTHAL. Thank you, Mr. Chairman.

And thank you to the witnesses for being here today. And thank you to the Chairman for having this hearing.

I represent the State of Connecticut in the United States Senate. And I want to welcome witnesses from the states that do a different type of farming. We do have farming in the State of Connecticut. And I have an additional connection to what you folks do for a living, which is that my grandfather had a farm, and my first job literally was shoveling manure on his farm at the age of probably about 7 or 8 years old.

I would bet the most complicated piece of machinery on his farm in the 1950s and 1960s was the radio in his house, and the idea of data and farming being in the same sentence would have totally

perplexed him. But, in fact, data has enabled us to increase yield and productivity in ways that would have been unimaginable to him and many farmers of his generation and maybe the generation afterward. And the benefits have been widely shared by America and the world because America's farmers have led the world in using technology to raise productivity and yield.

At the same time, the advances in data have raised questions about who owns it, who controls it, how do we protect privacy, and how do we prevent others from, in effect, profiteering at the expense of our farmers, who really should be the ones who own that data and control it?

So these kinds of questions bring us here today. And I thank you for shedding some light on an enormously important and complex topic that occupies this Committee in a number of different realms, and this one is certainly one of the preeminently important ones.

Thank you very much.

Senator MORAN. Mr. Blumenthal, thank you very much. Thank you for explaining how you got your start in politics.

[Laughter.]

Senator MORAN. I would recognize the Senator from Oklahoma for purposes of an introduction.

STATEMENT OF HON. JIM INHOFE,
U.S. SENATOR FROM OKLAHOMA

Senator INHOFE. Well, since I don't know anything about Dr. Ferrell, I won't introduce him except to say that he is here on behalf of Oklahoma State University, and he's got to be a good guy if he's with the Oklahoma State University. Thank you.

Senator MORAN. He was smart enough, Senator Inhofe, to wear the KU tie, however.

[Laughter.]

Senator MORAN. Perhaps that's just patriotic.

Senator Young has the floor for purposes of introduction.

STATEMENT OF HON. TODD YOUNG,
U.S. SENATOR FROM INDIANA

Senator YOUNG. Thank you, Mr. Chairman. I appreciate you holding this very timely hearing on the agricultural technology and digitalization, if I can say that word, of the farm.

I am happy to introduce Todd Janzen, a fellow Hoosier and expert in the field. He is the President of Janzen Agricultural Law in Indiana, and his experience in the industry began at an early age. Todd grew up on a grain and livestock farm in Kansas, where he learned the ins and outs of the industry. After graduating from Bethel College in Kansas, Todd made his way to the great Hoosier state and attended my alma mater, Indiana University's McKinney School of Law, where he began his law career in Indianapolis.

In addition to his work at Janzen Ag Law, Todd serves as General Counsel for the Indiana Dairy Producers. He's a member of the Indiana Farm Bureau Property Rights Policy Committee, and previously he sat on the Board of the Council for Agriculture, Science, and Technology.

Todd maintains a blog on law and technology issues facing the agricultural industry, and his writing has been republished by nu-

merous journals and news sources. Todd is the Administrator of the Ag Data Transparency project, which is making ag data publicly available to farmers all across the world. These insights will be especially relevant today I know as the Committee discusses ag technology and examines the many potential benefits and considerations that lie ahead.

I want to thank Mr. Janzen for taking the time to testify. And I look forward to hearing the entire panel's discussion this afternoon.

Senator MORAN. Thank you both for those introductions, and let us now hear from our witnesses. We'll start with Mr. Knopf and work our way to his left.

STATEMENT OF JUSTIN KNOPF, VICE PRESIDENT, KANSAS ASSOCIATION OF WHEAT GROWERS

Mr. KNOPF. Mr. Chairman and Ranking Member Blumenthal, members of the Subcommittee, thank you for the opportunity to address you today. My name is Justin Knopf. I am a fifth generation farmer from Gypsum, Kansas, as Chairman Moran mentioned.

I also currently serve as Vice President for Kansas Association of Wheat Growers. Working alongside my dad and brother, we grow wheat, alfalfa, soybeans, grain sorghum, corn, and multi-species cover crops across our 4,500-acre farm.

Like most U.S. farms, we are a family farm. As my father has always said, the most important thing we raise on our farm is children. My wife Lindsey and I have two daughters and a son, and my brother and his wife have two sons. We utilize a holistic approach in our farm management, rooted in values of faith and family with a multi-generational view. This decisionmaking process examines not only our economic returns, but also the returns to natural and human resources.

For the past 15-plus years, our dry land operation has utilized a cropping system focused on continuous no-till practices and cropping rotations. This system protects the soil, allows biology in the soil to thrive, is more resilient to extreme weather, and increases carbon content in soils by sequestering carbon dioxide from the atmosphere.

Never before has our society had the access to data and information that we have today. The same is true in agriculture. Data collection, processing, and the utilization of data for improved decisionmaking has become a core competency for many, if not the majority of farmers. The amount of knowledge per acre and amount of knowledge about each acre are significant drivers in the amount of profit per acre.

There are three main areas on our farm where data shapes our decisionmaking and has impact: economic sustainability, environmental stewardship, and transparency with consumers. And I'd like to share a brief example of each with you.

As you know, the current low commodity prices equate to a difficult economic reality on the farm. Managing costs is critical right now. We are utilizing data to divide fields into specific management zones; for instance, high-, average-, and low-producing areas of the field. When growing corn, seed is one of more expensive inputs. We are prescribing different planting populations for each

yield zone, planting more seed in areas of the field that consistently produce more, maximizing our return on that investment, and planting less seeds in areas of the field that are consistently lower producing, lowering our costs on those acres.

Farmers understand the importance of environmental stewardship and protecting our natural resources for future generations. That being said, we've made our fair share of mistakes and always have room for improvement. On our farm, we have a significant focus on protecting the soil and improving its health and resiliency. Cover crops are an important tool in this endeavor. Utilizing data collection equipment on our machinery to carry out on-farm research trials has enabled us to better quantify the impact of cover crops to subsequent crop yields and other agronomic factors.

Consumers today, and, therefore, the supply chain, are increasingly interested in how their food is produced and that it's done in a way that corresponds with their values. This past year, we enrolled our wheat acres into a sustainability program with ADM. Basically, we entered field information, things such as the amount of fertilizer rates used in each field and yield data into a web-based software. The software utilizes sustainability metrics designed by the collaborative group field to market, and then gives us quantifiable environmental impact metrics on our farm, benchmarks on how our farm compared to other farms, and then the supply chain receives the aggregated data.

The agricultural economy is at a crossroads right now, depressed prices, increased costs, and rising debt levels are creating economic angst. The average age of farmers continues to increase while the number of us continues to decrease. There is this great challenge of intensifying our farming system and doing so in a way that is sustainable, if not restorative, to our natural resources. Consumers are increasingly removed from the farm and wary of technological innovations in farming.

These are all significant challenges. However, the minds and spirits engaged in what will be the next generation of agriculture are as bright as ever. There will be a record percentage of farms transitioning to this next generation in the coming decade. This transition represents a great opportunity for change and innovation not only in improved productivity, but also in environmental stewardship. It is critical that we collaborate, learn, and adapt in order that we may have continual improvements.

I appreciate genuinely the opportunity to share the value of data with you today. And I appreciate that Congress is willing to listen to the people who may be impacted by future legislation.

[The prepared statement of Mr. Knopf follows:]

PREPARED STATEMENT OF JUSTIN KNOPF, VICE PRESIDENT, KANSAS ASSOCIATION OF WHEAT GROWERS

Mr. Chairman, Ranking Member Blumenthal, and Members of the Subcommittee, thank you for the opportunity to address you today. My name is Justin Knopf and I am a fifth generation farmer from Gypsum, Kansas. I also serve as the Vice President of the Kansas Association of Wheat Growers. Working alongside my dad and my brother, we grow wheat, alfalfa, soybeans, grain sorghum, corn, and multi-species cover crops across our 4500 acre farm.

As my father has always said, we also grow people on our farm. For my brother and I, farming is a lifelong learning process. The local young people who find a summer job with us grow in responsibility, work ethic, and perspective. My wife Lindsey

and I have three young children, two daughters and a son, and my brother also has two young sons. Our farm is not unlike most farms in the United States. According to the USDA, farming is still overwhelmingly comprised of family-owned businesses. 99 percent of U.S. farms are family farms, and they account for 89 percent of farm production.[1] The USDA also estimates that small farms make up 90 percent of the farm count and operate nearly half of America's farmland.[2]

We utilize a holistic approach to our farm management, rooted in values of faith and family, with a multi-generational view. Farmers understand the need for good stewardship and conservation. This is what we do every day. We depend on clean water and healthy soils to make a living and feed the world. This decision making process examines not only our economic returns, but also the returns to natural and human resources. For the past fifteen plus years, our dry land operation has utilized a cropping system focused on continuous no-till practices and crop rotations. This system protects the soil, allows soil biology to thrive, is more resilient to extreme weather, and increases Carbon content in soils by sequestering CO_2 from the atmosphere.

Although we have been blessed with some bountiful harvests in the last few years, the current economic reality on the farm is difficult and the coming years are shaping up to be some tough times. Farm income levels are at their lowest point since 1985. Net farm income dropped 95 percent from 2014 to 2015, and net farm debt levels have increased 25 percent over the last 3 years.[3] This downturn has largely been caused by low commodity prices, which are due to record highs in both local and worldwide production over the past two years.[4] These production levels have increased supply, while overall demand has waned, due to a strong U.S. dollar and decreasing exports.[5] Another major factor is that while revenues have only gone down, the cost of production and expenses have gone up. From 2009 to 2015 the cost of production has increased almost 50 percent.[6] This rise in costs has forced farmers to look for ways to find efficiencies and minimize costs. Our ability to adapt to changes is what will keep us going when times get tough.

According to the United Nations there will be 9.1 billion people on the planet in the year 2050.[7] One of the more significant long term challenges facing our world is how we feed a growing global population. Food security isn't just an agricultural issue; it is a national security issue. As farmers, we must find a way to produce more food, on less land, with less water, all while protecting our soils and natural resources. As stewards of the land it is our job to find ways to do more with less. It will take all available tools to meet these challenges. Agricultural innovations, like technological improvements, seed technology, and on farm efficiencies, are all important. Research within private entities and public institutions is critical. Perhaps most fundamental is collaboration with others, an eagerness to learn, and a willingness to adapt.

Never before has our society had the access to data and information that we have today. Data is all around us, and there is value in it all. While a record of Google searches and websites visited may be useless history to me, analysts and marketers see valuable information that allows them to adjust the content they create. The same, of course, is true in agriculture. While some may see a jargon-filled spreadsheet or just a bunch of various colors on a field map, I see ways to maximize efficiency in my operation, both for my pocketbook, as well as for the land that provides the livelihood of my family. Data collection, data processing, and the utilization of data for improved decision making has become a core competency for many, if not a majority of, farmers.

The obvious benefit of data is the ability to make improved management decisions. Data has become an important layer in our decision making process and a driver in our economical sustainability and environmental stewardship. The amount of knowledge per acre, and amount of knowledge *about* each acre, are significant drivers in the amount of profit per acre.

There are three main types of data we utilize on our farm. Microdata is data we collect and produce that is specific to our farm. Service provider data is data that is provided to us by service partners that is specific to our farm. And Macrodata,

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[1] *https://www.ers.usda.gov/webdocs/publications/eib164/eib-164.pdf*
[2] *https://www.ers.usda.gov/webdocs/publications/eib164/eib-164.pdf*
[3] *http://www.agmanager.info/kfma/state-summaries*
[4] *https://www.wsj.com/articles/whats-behind-the-glut-in-agricultural-commodities-1476670020*
[5] *https://www.wsj.com/articles/the-next-american-farm-bust-is-upon-us-1486572488*
[6] *http://www.agmanager.info/kfma/state-summaries/2015-state-summary-detailed-cost-summary*
[7] *http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf*

or big data, is data we provide to others and they, in return, give us an idea of what is happening in the industry on a larger scale.

Specifically on our farm, we collect and utilize this data in a number of different ways. As on many farms, our seeding, spraying, and harvesting equipment all has hardware and software that measures and records spatially what is being done or happening in the field. Performing on-farm research with sound scientific and statistical principles is one way we use this technology. For example, we were able to quantify the impacts of cover crops on subsequent crop yields, which has led to a broader adoption of cover crop practices. We utilize satellite imagery as a way to help us identify management zones within a field and predict yield variability. These management zones allow us to modify our seeding rates based on the productivity of the land, which lowers our seed cost on acres that are less productive. We use zone soil sampling to quantify soil fertility levels in differing areas of the field, which allows us to fertilize based off specific soil conditions and fertility levels. It allows us to focus inputs on the areas that need them and to avoid applications on areas that don't. We enter data into ADM's sustainable wheat program, and in return we receive sustainability metrics based off the field to market calculator. Through this program we are able to use key sustainability outcomes and metrics and benchmark our farm's performance to others in the program.

I also share economic, cost, and revenue data with the Kansas State University (K-State) Farm Management program and receive informational data back on my farm's profitability in relation to other like-sized no-till farms. This program allows me the ability to know how my business is doing in relation to others in the industry, what business strategies I should implement to become more profitable, or what investments I should make in my business.

The quality and the quantity of data in agriculture, and its importance, is driving the improvement of farming practices and its value will only continue to grow. It is vital that our stakeholders and collaborators work alongside our public research institutions, such as K-State, to continue to develop the tools farmers need to be successful. Private industry is rapidly expanding in this space and the technology is changing by the day. Competition for the "digital acre" is increasing and it is rapidly driving innovation.

For example, we can now use crop sensors mounted to sprayers that utilize algorithms, developed by K-State and other land-grant institutions, that tell us in real time how much nitrogen each plant needs, while giving credit to biological nitrogen that already exists in the plant. As the sprayer travels through the field the sensors will tell us in real time how much nitrogen the plants in that spot need. This technology allows us to put the right amount of nitrogen in the right place which saves money and increases environmental stewardship.

There are also proprietary tools from companies such as Pioneer and Monsanto that utilize soil and weather data to predict a crop's nitrogen needs and the amount of available nitrogen in the soil. This data helps farmers tune the timing and quantity of fertilizer applications to increase efficiencies.

A researcher from Kansas State has been utilizing land on our farm and others to test and develop a sensor that can quickly and efficiently quantify soil water-holding capacity differences across a field. As water is typically one of our most limiting factors for crop production on many farms in the Great Plains, efficient access to this information would be very valuable in developing management zones and insight in how to best manage each area within the field.

Data is also important to those off the farm as well. Consumers have an ever growing interest in their food. They want to know more about how their food is produced, how it is processed, and if it is being grown in a way that aligns with their values. Our use of data allows us to tell our story to the consumer and enables us to do so with transparency like never before.

However, as we begin to find new ways to collect and utilize this valuable data we need to make sure we protect the ownership interests and rights of farmers. We need to make sure that government and regulatory agencies do not try and access proprietary data that is critical to a farmer's business. We need to make sure third party dealers and vendors do not try and take ownership of data that was generated and collected by the farmer. Finally, we need to ensure that the privacy rights and ownership interests of the farmer are respected by all those who may want to access this data. The last thing we need is for those who are not aligned with our farm interests to twist and misconstrue what we do on the farm.

The agricultural economy is at a crossroads right now. Depressed prices, increased costs, and rising debt levels are creating economic angst. The average age of farmers continues to increase while the number of us continues to decrease. There is this great challenge intensifying our farming system, but doing so in a way that is sustainable if not restorative to our natural resources. Consumers are increasingly re-

moved from the farm and wary of technological innovations in farming. However, the minds and spirits engaged in agriculture and farming are as bright as ever. There will a record percentage of farms transitioning to the next generation in the coming decade. This transition represents a great opportunity for change and innovation, not only in improved productivity, but also in environmental stewardship. It is critical that we collaborate, learn, and adapt in order that we may have continual improvement. I appreciate the opportunity to share the value of data with you today, and I appreciate that congress is listening to the people who may be impacted by future legislation. There is an immense amount of technology, both here and on the horizon, that will allow American farmers to continue to meet these challenges. This drive for continual improvement and understanding of the complex biological ecosystem we farm with is what will allow my children, and their children after them, to continue feeding the world and protecting the natural resources long after I am gone. I urge you to continue to listen as your shape future legislation.

Senator MORAN. Thank you, Justin.

And now Mr. Tatge.

STATEMENT OF JASON G. TATGE, CO-FOUNDER, PRESIDENT AND CEO, FARMOBILE

Mr. TATGE. Chairman and members of the Subcommittee, thank you for the invitation today to share my ideas about how to improve the collection, standardization, and interoperability of agricultural data for the benefit of every American.

My name is Jason Tatge, Co-Founder, President, and CEO of Farmobile. We help farmers collect and organize data so they can use it to better manage their own operations, share the data with their trusted partners, and even license their data to vetted third parties to create a brand new revenue stream for their business.

I've been on over 200 farms in the Midwest in the last few years, and I've had hundreds of conversations with farmers defining the future of global agriculture. I'd like to share what I've learned from listening to the men and women on the ground.

One of the most important topics we discuss on the farm is data. Who has it? Who does it belong to? And what's it being used for?

Through my conversations, I've come to believe that for the sake of a safer, more productive food future, farmers need to be able to own their data outright. Farm data needs to be accessible in real time and compatible with multiple systems. In short, we need a standard for the agricultural industry.

I will start with the question of ownership. Big agricultural companies know it will benefit them to own the digital content coming out of the farmers' fields. When a U.S. farmer spends hundreds of thousands of dollars on a new piece of equipment, the largest manufacturers profit from the initial sale of the equipment, then they profit again from the data generated from the farmer using that equipment. This is wrong, because the data being collected by many big ag companies is the farmers' proprietary intellectual property. It is a unique formula or secret recipe for operating their successful businesses.

Attempts to get big players in the ag industry to voluntarily enact transparent data policies have been slow. In fact, organizations who played a big role in drafting the best practices for data transparency have failed to sign on or adopt them. Asking a farmer for their secret recipe would be bad enough, but tricking them into signing it away, the unique formula, with complicated legal agreements, is appalling to most, and the main reason I sit here.

The potential value in this data to farmers and agricultural communities writ large cannot be overstated. If farmers own their data and can license it multiple times, we're talking about an opportunity to create an estimated billion dollar annual new revenue stream returning that money to rural agricultural communities of America.

To further illustrate the importance of data ownership, I want to talk about the value data represents for a farmer. Here's an example. We know the genetic yield potential for corn in the U.S. is over 500 bushels per acre, yet the national average for corn is only about 170 bushels. Why is this? The answer lies in the data.

Farmer-controlled digital records to document the farming practices will help U.S. agriculture and individual farmers determine best practices for maximizing their yields. Those records enable farmers to make better decisions, identify efficiencies, boost productivity, and mitigate risks as well as aid the industry in streamlining the manual process required to participate in Federal programs and crop insurance.

These kinds of ag data benefits, however, require agriculture to get past the roadblocks of data interoperability. Many farmers operate mixed fleets today, and that means they have separate data systems for each equipment brand. Ag companies make it incredibly labor-intensive to move data out of one system and into another. This stifles competition and customer choice in an already dramatically shrinking landscape of agricultural giants.

I believe we need to properly align incentive structures and drive standardization across the industry. Every farmer has a right to access and use their data regardless of where it came from or what system contains it. We should encourage the flow of information that could help farmers and their trusted advisers to make the best decisions for their farms and the food industry at large.

The power of data can go way beyond the field. When farm data is available in real time in a standardized portable format, like Farmobile's electronic field records, there's a huge potential to reduce the volatility in commodity markets.

Agricultural markets are volatile for good reason: there's a massive lag time in getting the information. The USDA is the gold standard, but even the USDA sometimes takes 3 weeks to get out information in the right form for release, but most row crops are only alive for about 90 days. Faster information will dramatically reduce the volatility in the markets and enable traditional risk management strategies, like hedging, to work again for farmers and the agricultural businesses that rely on these commodities to produce their products.

In 1960, John F. Kennedy said, "The farmer is the only man in our economy who has to buy everything at retail, sell everything at wholesale, and pay the freight both ways." It's unfortunate that this statement is still very true today.

But disruption is coming in the form of technology. We need to make sure that our legal system keeps up with the technology available and is informed on the formative debates that will define the future in my industry. Most farmers I talk with believe we have 2 to 3 years to figure this out, or they will lose. Farmers need policies that safeguard data rights, are interoperable, and improve

data access to drive efficiencies in innovation and food production. As you consider these issues further, ask yourselves, "Why is it ever okay for others to own or control farmers' data? And how do we enact policies that create true data interoperability?"

I firmly believe that done right, data is the answer to advancing agriculture and the entire food industry while protecting America's farmers.

I appreciate your openness to ideas and action from the private sector as well as administrative and legislative change. I look forward to working with the industry as well as the members of the Committee to advance this vision. Thank you.

[The prepared statement of Mr. Tatge follows:]

PREPARED STATEMENT OF JASON G. TATGE, CO-FOUNDER, PRESIDENT AND CEO, FARMOBILE

Chairman and Members of the Subcommittee:

Thank you for the invitation, today, to share my ideas about how to improve the collection, standardization and interoperability of agricultural data for the benefit of every American.

My name is Jason Tatge, co-founder, president and CEO of Farmobile—a relatively small agtech startup company, from Kansas, with a creative business model that turns our farmer customers data into a monetizable commodity and shares the revenue with the farmers. We recently celebrated our four-year anniversary and employ over 40 people with plans to add at least 20 more over the next 12 months. Farmobile offers a "data as a service" subscription that properly aligns our company's future success with our farmers' success. Practically speaking, we help farmers to collect and organize their data so they can use it to better manage their own operations, share their collected data with their trusted partners and/or sell their data to interested third parties, the same way musicians can sell their music.

I've been on over 200 farms in the Midwest in the last few years and am completely amazed by how ridiculously awesome these people are at growing our food. These folks are the "rock stars" of global agriculture.

One of the most common topics we discuss when on the farm is data ownership. Many are confused over how we've gotten to this current place or when data ownership even become a question They are confused about who has access to their data and what they are doing with it. All have an expressed interest in being able to establish a value for the data they generate. As one farmer, David Seba from Cleveland, Missouri told me, "Big ag has been collecting our data for so long, that there's this attitude that the way we farm carries no value. Well, it does. For farmers, the field is our business and the way we manage it is our formula for success. So, why is it okay for these companies to claim the data as theirs and then sell it without our knowledge?"

At Farmobile we are proud to be working alongside some of the most innovative farmers in the world, and we are passionate about providing these farmers the opportunity to establish ownership and directly profit from the data generated from their field activities, if they choose to sell licenses to their data.

Introduction

Whether you represent the 2 percent of the U.S. population who farm or the non-farm constituents who—like all of us—eat, farm data will become a digital currency that impacts both farmers and food buyers. Today, I'll share my thoughts about the state of the industry, and the needs, risks and opportunities we have.

Data and analytics are disrupting and changing most industries. From grocery shopping to political campaigns, the world is forever changed by data. Farming is no different, although I'd suggest we are a few years behind other industries when it comes to data collection. That's changing fast, and we have a lot to learn from other industries that have already made the move from analog to digital, like healthcare.

A big part of farming today is being able to manage a large mixed fleet of equipment. Real-time data connectivity empowers farmers to remotely manage their logistics like never before by using any Internet connected device. While adoption of precision agriculture technologies has been on the rise for years, now that it's available

in real-time, adoption has accelerated because farmers quickly "see" the value of data.

Real-time data is the "game changer" for the future of farming because of the ability to gain insights and react "right now" during the season. This is the foundational driver to improve yields, lower input costs, strengthen stewardship and pave the way for cutting-edge programs like yield guarantees that enable seed and chemical companies to "share the performance risks" associated with their recommended products.

Big ag companies certainly agree that the industry is going digital. Look no further than public statements made by ag business giants framing this opportunity for their shareholders. They absolutely know it will benefit them to own the digital content coming out of the farmers' fields.

But this comes with a cost to the farmers, not only do these big companies expect to get the data for free, but they also create "silos" for the data and make it very difficult to get that data back out from their systems. This stifles competition and customer choice in an already dramatically shrinking landscape of agricultural giants, whose recent mergers have reduced the big six to the big four.

Farmers are just beginning to understand that their data has value outside the perimeter of their operations, and that data ownership and a neutral digital strategy is necessary to be competitive today. Because of this, some farmers are starting to ask tough questions about data: Who owns it? How will it be used? How do I extract maximum value from it? And, most importantly, how do I put a "fence" around my data so that it's protected for future generations?[1]

This brings me to the first opportunity and risk for farmers—data ownership.

Farmers and Data Ownership

As business owners, farmers face a very real risk from many ag companies with whom they do business because: 1) companies gain access, control and sometimes ownership over the farmer's private data; and 2) these companies can lock farmers into their data policies.

At the center of this growing concern is the method in which ag companies typically collect and use a farmer's data. To understand it, let me provide a consumer-facing illustration that everyone understands—Google.

When I choose to use Google to search the web (for free), I understand that Google is collecting information about me through my interaction with their technology. I know that Google turns this collected data into information by combining it with other datasets. Further, I realize Google makes money from selling this information to marketers that want to learn more about me. In spite of this, I choose to use Google search because it is of value to me, and it's free.[2]

On the other hand, when I purchase a license to use Microsoft Office, I gain access to tools like Microsoft Word, Microsoft Excel and Microsoft PowerPoint. These tools provide value to me. When I use these tools, Microsoft does not get rights to the content I create. Could you imagine the types of congressional hearings we'd be having on that topic—if Microsoft treated its customers the way big ag treats their customers?

When a U.S. farmer spends hundreds of thousands of dollars on a new piece of equipment, the largest manufacturers profit from the initial equipment sale PLUS they profit from the data generated from the farmer using that equipment. The collection of this data often happens without the farmer's knowledge due to complex and heavy-handed user agreements.

While the fact that Google is collecting search data doesn't bother me as a consumer, the stakes are much higher and far different in the farmer example. The data being collected by many big ag companies is the farmer's Intellectual Property—the special and unique formula or "secret recipe" for operating their successful business.

Imagine if we, as a user of Google, asked for its search engine algorithms. Or, as a customer of Microsoft, if we asked for its source code to the Microsoft Office Suite? Asking a farmer for their "secret recipe" would be bad enough, but tricking them into signing away that unique formula with complicated legal agreements is appalling to most and the main reason I am here today.

We believe farming practices represent Intellectual Property that could be copyright protectable. Yet, today, it is difficult to establish who owns this information because farmers are caught in the habit of unknowingly giving this data for free when they sign complicated legal agreements pertaining to an entirely different subject. It is my personal motivation to help farmers by providing alternatives with upside potential.

I've been working for the better part of three years with the American Farm Bureau Federation (AFBF) to address these issues. The AFBF has shown great leader-

ship in trying to bring transparency to these confusing legal contracts farmers are required to sign. Working with commodity groups, farm organizations and agriculture technology providers, the AFBF established the Privacy and Security Principles for Farm Data in November 2014. Thirty-seven different organizations participated in drafting the "Core Principles" document. Many of these organizations were very opinionated around the wording of the Ag Data Transparency Evaluator's ten questions, but only nine of these companies have agreed to become Ag Data Transparent! The ones who haven't signed are challenging the very need for "ownership" of farm data to be defined in the "Core Principals."

Make no mistake about it, these companies are intentionally delaying participation because they hope this issue will blow over and farmers will continue to operate the way they have in the past—by unknowingly checking a box in a legal contract in order to take delivery of their product.

Missouri Farm Bureau President Blake Hurst of Tarkio, Missouri describes the situation like this: "So much of what we do is done by habit. As soon as we get in the habit of giving that data away, no company is going to remark on the fact that it is a heck of a good deal for them. If we don't start out doing it the right way, it will be very harmful to farmers in the future."

In agriculture, we are at a point in time where there is a great opportunity to "do the right things for the right reasons" on behalf of the people who produce our food.

Data Interoperability

We know the genetic yield potential for corn in the U.S. is over 500 bushels per acre, yet the national average for yield is about 170 bushels per acre. Having farmer-controlled digital records (such as Electronic Field Records) to document farming practices will help U.S. agriculture better determine best practices farmers. Those records enable farmers to make better decisions, identify efficiencies, boost productivity and mitigate risks, as well as aid the industry in streamlining the manual processes required to participate in Federal programs and crop insurance.

These kinds of ag data benefits, however, require agriculture to get past roadblocks to data interoperability and over the "not-invented-here" syndrome. Farmers need a uniform standard that allows data to be portable and enables them and their trusted service providers to make real use of the information.

The need for data interoperability is not a new issue. My written remarks contain an excerpt from the testimony of the late Neal Patterson, who spoke before the Senate Committee on Health, Education, Labor and Pensions in June of 2015.[3] Neal was a personal friend and mentor of mine as well as co-founder and CEO for Cerner, a leading health information technology company.

Neal believed, as I do, in the parallels between Electronic Health Records and Electronic Field Records. His testimony stated: "The intersection of healthcare and IT is one of the most important in modern society. Every citizen touches and depends on both."[3]

I absolutely believe the same is true for agriculture, everyone eats. Every farmer has a right to access and use their data, regardless of where it came from or what system contains it. We should encourage the flow of information that could help farmers—and their trusted advisors—to make better-informed decisions about their businesses and food production.

In agriculture, sensor technology and communication protocols exist for data to move quickly across different systems; however, many existing companies are not interested in building tools that would allow standard data to move efficiently. At Farmobile, we build technology that supports interoperability; we are a neutral provider that enables farmers to compare "apples to apples" when looking at products and services offered to them.

It is not by accident that big ag companies use their war chests of cash to hold farmer data hostage in their platform. They make it very labor intensive to move the data from one system to another. I believe in properly aligning incentive structures to drive standardization and financially benefit farmers—who are the creators of Electronic Field Records. The Electronic Field Record is a universal commodity in support of digitizing agriculture, and both farmers and consumers benefit.

Farmobile is the first company to build a business model around the monetization of standardized farm data whereby farmers share in the revenue, and data buyers can drive further innovation as the consumers of this valuable information. This is a powerful new revenue opportunity—a true win-win for farmers and the industry. (Figure 1)[4]

The idea of farmers harvesting their data and selling it as a new "crop" is a game-changer. It adds economic strength to rural communities, and also contributes to food safety—which is in the national security conversation.

Real-time Data and the Impact on Commodity Markets

After graduating with a Bachelor of Arts in Financial Economics from Gustavus Adolphus College in St. Peter, Minnesota, I spent the next 20 years trading agricultural commodities—the pure economic theory of supply and demand fascinated me and still does today. I first traded for the Pillsbury Company and then for a large regional player, The Scoular Company. When my career began, commodity trading was done "in the pits" using an open outcry system. There was an inherent time delay to disseminate pricing data—first from the pits in Chicago to the local grain buyers, then from the grain buyers to the farmers. This created an unfair advantage for those, who could afford to pay for the real time pricing feeds. For years, this opportunity was used to take advantage of additional margin—and the farmers paid the freight for decades.

The last 10 years of my trading career were all about challenging the status quo in the commodity trading world and changing sides from being the buyer to helping the seller. My company helped farmers become better grain marketers by utilizing new technology, which enabled them to take advantage of real-time data feeds in their marketing plans. This opportunity was fueled by the Chicago Mercantile Exchange acquisition of the Chicago Board of Trade which rapidly accelerated the use of electronic trading and hedging.

Today a similar opportunity exists to ramp up the creation of farm data into "tradeable" information in the form of Electronic Field Records. To work, the data must be interoperable and available in real-time to those who desire to purchase it. This data liquidity will dramatically accelerate the foundational science to help solve the looming global food challenge and identify best practices, minimize environmental impact and maximize nutritional content of food being produced. Every time this information is "sold," it is with the explicit permission of the farmer, and the farmer who created it shares in the revenue. The same digital information can be sold multiple times with an opportunity to create an estimated $1billion annually of new revenue returned to rural agricultural communities of America.

Once you get something faster, you rarely go back. The commodity markets are no different. I will challenge anyone to debate the notion that real-time data, data ownership and interoperability would not be good for the farmer.

The reason that there is so much volatility in the agricultural markets is because of the massive time lag in getting the information. The USDA is the gold standard in historical commodity information. However, this information is released three weeks after it is observed due to the process required to get that information in the right place. The delay causes much of the volatility given the fact that most row crops are alive about ninety days and it takes about 21 days to get the data from the county offices to the markets in the form of USDA reports.

The technology exists today to get that information to the market daily. Faster information will dramatically reduce volatility in the markets and enable traditional risk management strategies, like hedging, to work again for farmers and the agricultural businesses that rely on these commodities to produce their products.

Many large commercial grain trading companies have reported significant losses in the markets recently as traditional hedging practices are introducing more risk than they are reducing. Faster access to better information will help normalize markets and monetarily benefit the farmers who choose to sell licenses to their information.

Conclusion

I'd like to conclude by revisiting history. It is 1960 and John Fitzgerald Kennedy is running for president when he visits a group of farmers in Senator Thune's home state of South Dakota and he says: "The farmer is the only man in our economy who has to buy everything at retail, sell everything he sells at wholesale, and pay the freight both ways."

It's pretty incredible to think that—with all the change we've seen in the last 57 years—this statement is, unfortunately, as true today as it was then.

But disruption is coming and it's coming in the form of technology. We need to make sure that our legal system keeps up with the technology available. Most farmers I talk with think we have probably two to five years to figure this out, or they will lose.

Thank you for your time today. I hope my testimony sheds some light on what is happening in the industry and I look forward to continued conversations about the many ways we can help the farmer finally stop paying the freight both ways. I firmly believe that, done right, data is the answer.

1. Farmers need policies that safeguard their data rights, and allow interoperability and accessibility to drive efficiencies and innovation in food production.

2. As you review this topic, ask yourselves:
   - ○ Why is it ever "o.k." for others to own or control a farmer's data?
   - ○ How do we affect policies for true data interoperability?

I appreciate your openness to ideas and action from the private sector, as well as administrative and legislative change. I look forward to working with the industry, as well as members of the Committee, to advance this vision.

Thank you.

cc: Addendum

ADDENDUM

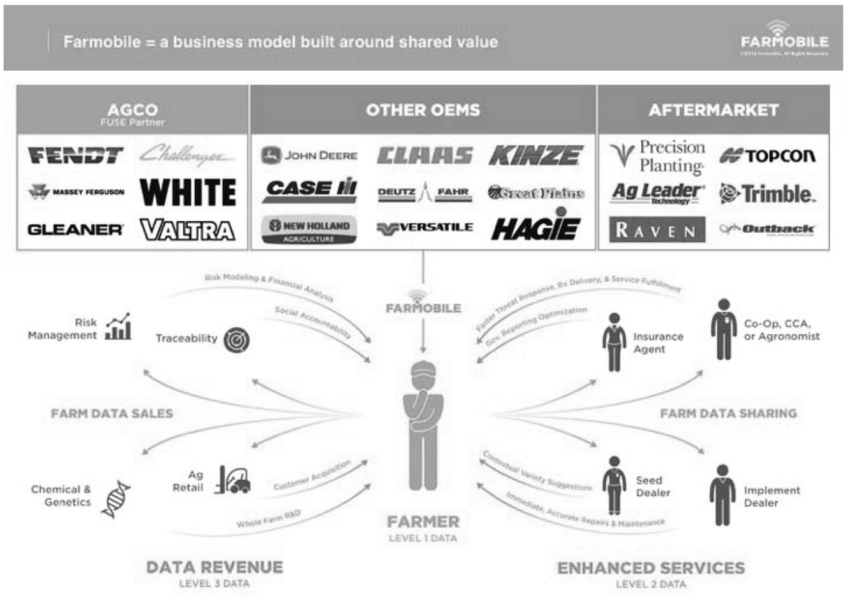
Additional References

[1] The Problem of Vendor Lock-In for Ag, *http://bit.ly/2xHeie5*

[2] Farmobile: Changing the Game in Ag Data, *http://bit.ly/2oObquw*

[3] Testimony of Neal L. Patterson, Co-founder, Chairman and CEO of Cerner Corporation, U.S. Senate Committee on Health, Education, Labor and Pensions, Hearing: Health Information Exchange: A Path Towards Improving the Quality and Value of Health Care for Patients, June 10, 2015, *http://bit.ly/2zLI1YB*

[4] Farmobile's Business Model (Figure 1)



(Figure 1, Farmobile's Business Model)

Senator MORAN. Thank you, Jason.

Dr. Ferrell.

STATEMENT OF SHANNON L. FERRELL, J.D., M.S., ASSOCIATE PROFESSOR, OKLAHOMA STATE UNIVERSITY DEPARTMENT OF AGRICULTURAL ECONOMICS

Dr. FERRELL. Subcommittee Chairman Moran, Ranking Member Blumenthal, and members of the Subcommittee, thank you for the opportunity to present my observations in the collection and utilization of data in agriculture, the opportunities and challenges that presents, and the legal issues surrounding agricultural data collection, transmission, and use.

The new frontier in agriculture presents a fascinating and sometimes paradoxical mix of cutting-edge technology, recent legal changes, and centuries-old common law.

Farm equipment rolls off the assembly line with a suite of sensors and transmitters enabling it to share unprecedented amounts of farm-level or "Small Data," that gives farmers the ability to proactively manage risks that heretofore they may have found unmanageable and, in some cases, even unknowable.

At the same time, this perfusion of Small Data can now be aggregated by many means into what we call agricultural "Big Data." Analysis of big data in agriculture holds many potential advantages for producers, who can apply Big Data insights to their individual operations, and at the same time, we now have the opportunity for better market analysis, as Mr. Tatge was just saying, and Mr. Knopf as well, and we can now manage agricultural risk at a national and potentially even global scale in a few years.

Within the policy and academic realms, Big Data holds the potential for us to provide more timely responses to industry crises and have better evaluation of farm policy impacts and food programs. So Big Data may eventually be able to predict many crises before they even emerge.

However, agricultural data faces a peculiar chicken-and-the-egg problem in that the development of datasets sufficiently large to take full advantage of all the opportunities ag data opposes requires participation by a large number of producers. At the same time, farmers are often reluctant to participate in those agricultural data systems if they're concerned about the share of the value that they're going to receive for the contribution of their data.

Further, despite a little potential shown by agricultural data, the current technological, economic, and legal environment raises some issues about how the value of agricultural data will be shared between data aggregators and producers, as Mr. Tatge just mentioned, so producers receiving what they deem to be sufficient value is going to be a gateway issue for us having a critical mass of producers making data contributions to really truly understand the value that agricultural data could pose for our industry.

So addressing the concerns of producers with respect to their rights and data, the value it creates, and their privacy if they choose to share their information is vital. Farmers often express concerns like this collectively under the question of, "Who owns their data?" And that may not be the question that has a clear answer in our current intellectual property framework, although, arguably, there is a colorable argument to be made that they do own their data. The question is, "What does that ownership actually mean?"

So that question of ownership may not be as important as ensuring farmers always have access to their data once it has been shared, that they can receive value from its use, and they can feel comfortable with the level privacy or that they're, conversely, comfortable with the lack of privacy that they're going to experience as a result of sharing those agricultural data platforms.

Well, agricultural technology making use of data grows at an exponential rate, but the technology and policies for protecting data has not. For example, opting out of data collection is going to grow

increasingly difficult as more and more of even the used equipment machinery fleet has embedded technologies that make data sharing something you must opt out of rather than opting into. And, indeed, many producers may not even know that they have an option of opting out of data sharing if they so choose.

Further, in some circumstances, it may be almost impossible to truly anonymize data once it has been shared, because with the addition of some publicly available data, we could almost interpolate everything that you would want to know about that operation from what data has been shared, even though, ostensibly, it was supposed to be amalgamated with others and rendered anonymous.

The resolution of these issues may depend on the relative bargaining power of those at the table when data use agreements are negotiated, and historically farmers have been at something of a disadvantage in that regard. However, significant steps are already underway to facilitate consensus among industry stakeholders regarding those issues, and you'll hear about some of those steps today, and you already have heard some of those in passing from the previous witnesses.

There are a number of ways I think the Subcommittee and Congress, as a whole, can facilitate the realization of agricultural data's true potential.

First, Congress can support continuing efforts to build industry consensus between farmers, equipment manufacturers, and data service providers. Whether through consensus or with legislation, Congress could also consider support of a clear framework of right-to-know issues with respect to how your data is being used, the right to opt out of data collection if you so choose, guidelines for the disclosure of agricultural data uses by service providers, and protections against the disclosure of data. It can also fund research and educational efforts to help agricultural producers make informed decisions about how to engage agricultural data systems and how to develop protections for agricultural data shared with service providers and the government.

Finally, if the agricultural data revolution is to realize its true potential, sustained efforts to build and maintain a robust broadband Internet infrastructure for rural America must be sustained, as you mentioned, Chairman. The current support of rural broadband access from a supply perspective is having a positive impact, but we also need to support demand-side drivers for rural Internet access as well. Widely available wireless and hardwired broadband connectivity both are crucial to realizing the potential of agricultural data as well as maintaining the economic opportunities that can revitalize rural America.

Chairman Moran, Ranking Member Blumenthal, and members of the Committee, thank you for the opportunity to share, and I look forward to helping you explore this issue further.

[The prepared statement of Dr. Ferrell follows:]

PREPARED STATEMENT OF SHANNON L. FERRELL, J.D., M.S., ASSOCIATE PROFESSOR—OKLAHOMA STATE UNIVERSITY DEPT. OF AGRICULTURAL ECONOMICS; JOINTLY PREPARED BY THE WITNESS AND DR. TERRY GRIFFIN, ASSISTANT PROFESSOR, KANSAS STATE UNIVERSITY DEPT. OF AGRICULTURAL ECONOMICS

Executive Summary

Today's technology affords farmers the ability to instantaneously collect data about almost every facet of their cropping (and increasingly, their livestock operations) year-round. As a result, there has been unprecedented growth in the amount of data collected at the farm level. This farm-level "Small Data" increasingly provides management insights to agricultural producers allowing them to manage more risk factors than ever before. At the same time, this profusion of Small Data can now be aggregated by many means to create agricultural "Big Data." Analysis of Big Data in agriculture holds many potential advantages for producers and creates the opportunity for better macroeconomic analysis of farm policy tools, food programs, and management of agricultural risk at a national scale.

The current technological, economic, and legal environments raise issues about how the value of agricultural data will be captured among the agricultural producers generating the data and the agricultural technology providers (ATPs) aggregating it. Producers receiving what they deem to be sufficient value for their data contributions is critical as a potential gateway issue for making those contributions; without large, robust participation in agricultural data systems, such systems will fail to reach their full potential.

Thus, addressing the concerns of agricultural producers with respect to their rights in data, the value it creates, and their privacy if they choose to share their information is vital to see that the agricultural industry collectively maximizes the value of these data technologies. Farmers often express these concerns collectively as a concern about who "owns" their data, and there are no clear answers in the current intellectual property framework. However, the question of agricultural data ownership may not be as important as ensuring farmers always have access to their data can receive value from its use, and can feel comfortable with the level of privacy—or lack thereof—that can be afforded to those participating in Big Data platforms.

Significant steps are already underway to facilitate consensus among industry stakeholders regarding these issues. This Committee and Congress as a whole may best be able to facilitate the realization of Big Data's potential advantages to U.S. agriculture through support of this consensus effort, support of educational efforts to help agricultural producers make informed decisions about how to engage with Big Data systems, continued development of more robust protections for agricultural data shared with the government, and continued support of improved broadband access in rural areas.

Acknowledgements

Dr. Terry Griffin of Kansas State University's Department of Agricultural Economics was instrumental in the preparation of this testimony, and his assistance in the creation of this document is gratefully acknowledged. Dr. John Fulton of Ohio State University's Department of Food, Agricultural, and Biological Engineering, Ms. Maureen Kelly Moseman, Adjunct Professor of Law at the University of Nebraska College of Law, Mr. Todd Janzen of the Janzen Agricultural Law firm, Mr. Ryan Jenlink of the Harness, Dickey & Pierce law firm, Dr. Keith Coble of the Mississippi State University Department of Agricultural Economics, Dr. Ashok Mishra of the Arizona State University Morrison School of Agribusiness, and Mr. Matthew Steinert of Steinert Farms, LLC also provided vital input in the development of this testimony.

Perhaps the greatest contribution to this testimony and my understanding of agricultural data systems, though, was made by Dr. Marvin Stone. Dr. Stone was a giant in the agricultural data field, contributing tremendously to the development of the Green Seeker technology that significantly advanced machine-sensing of plant health. He was also instrumental in the development of the SAE J1939 standard that forms the foundation for many of the machine data technologies at the heart of this discussion. Beyond being a giant in the field we examine here today, Dr. Stone was a mentor to myself and hundreds of other students at Oklahoma State University. He and his wife were both killed in the tragic Oklahoma State University homecoming parade accident of October 24, 2015. I hope this testimony honors his memory, the contributions he made to this field, to the U.S. agriculture industry, and to all his students.

Issue Analysis

1. Introduction

I would like to thank Subcommittee Chairman Moran, Ranking Member Blumenthal, and the Members of the Committee for the opportunity to present my observations on the collection and utilization of data in agriculture and the legal issues surrounding the concept of Big Data and its application to U.S. farmers and ranchers. This new frontier in agriculture presents a fascinating and sometimes paradoxical mix of cutting edge technology, recent legal changes, and centuries-old doctrines of common law. In my testimony today, I will discuss how both "Small Data" and "Big Data" in agriculture are being utilized by agricultural producers and what lies just over the horizon for those technologies. I will also discuss some of the opportunities and challenges posed by the advancements in agricultural data technology. Then, I lay a framework for discussing the legal issues surrounding Big Data in agriculture, discuss how the current U.S. legal environment addresses ownership and privacy rights in agricultural data, and suggest some potential avenues for policy responses that may facilitate the economic advantages to be gained from the application of Big Data principles to agricultural data while dealing with the concerns associated with such applications.

2. The growth of Small Data and Big Data in production agriculture

The concept of Big Data has exploded in a relatively short period of time. However, there would be no Big Data in agriculture were it not for Small Data. Since these definitions and the issues surrounding data use in agriculture continue to evolve, my testimony today will provide some framing for both.

2.1 Defining core terms in the Data-Driven Farming discussion

Three terms immediately rise to the top in an examination of the agricultural data discussion: agricultural data, Small Data, and Big Data. Taken together, the use of Small Data and Big Data in agriculture is increasingly referred to as "*digital agriculture.*"

The concept of *agricultural data* is almost too broad to define, but looking at research in the field and conversations surrounding agricultural data indicates the term centers around two more specific concepts: "telematics" or "machine" data and "agronomic" data. *Telematics data* (sometimes called "*machine data*") refers to the information an agricultural implement (such as a planter) or self-propelled vehicle (such as a tractor or combine) collects about itself. Almost by definition, telematics data comes from agricultural equipment owned, operated, or hired under contract by the agricultural producer. *Agronomic data* refers to information about a crop or its environment, such as "as-planted" information from a seed planter, "as-applied" information from a fertilizer sprayer, yield data from a grain combine, and so on. While agronomic data resembles telematics data in that much of it is gleaned directly from agricultural implements, agronomic data can also be obtained from many other sources such as hand-held sensors, aerial platforms such as manned survey flights or flights by unmanned aerial systems (UAS, commonly called "drones"), and even satellite imagery.

Another piece of the agricultural data puzzle is so-called "metadata," which includes management information such as seeding depth, seed placement, cultivar, machinery diagnostics, time and motion, dates of tillage, planting, scouting, spraying, and input application. In addition to data on the products and how those products are applied, information on external environmental circumstances such as weather including precipitation events, evapotranspiration, and heat unit accumulation help to round out the complete agricultural data package.[1]

Beyond these data sources, numerous other data sources continue to emerge in the agricultural data space. Work continues to build data collection technology in the livestock industries, ranging from GPS-enabled cattle ear tags to "bolus" sensors that can be swallowed by animals to provide health data. Some would argue that vendor-generated data about producers might also fit into this category; such data could include everything from payment history data to customer relationship management (CRM) information (does the producer try to negotiate input prices, have preferences for some products over others, typically buy inputs from one salesperson versus others, etc.).

Agricultural data is the foundation for Small Data systems. In simplest terms, farms use "*Small Data*" when data are isolated to the fields where the data originated. Farmers who use information technology to conduct their own on-farm ex-

[1] T. Griffin, *et al.,* "Big Data Considerations for Rural Property Professionals." JOURNAL OF THE AMERICAN SOCIETY OF FARM MANAGERS AND RURAL APPRAISERS, 2016:167, 168.

periments, document yield penalties from poor drainage, or negotiate crop share agreements are using data that is considered "small."

Perhaps ironically, the evolution and revolution in agricultural Big Data comes from the expansion of "Small Data" in agriculture.[2] There has been remarkable growth in producers' ability to collect data pertaining only to their own operation through the growth of techniques and technologies such as grid soil sampling, telematics systems for farm equipment, Global Positioning Systems (GPS)/Global Navigation Satellite Systems (GNSS), farm aerial imagery acquired via small unmanned aerial systems (sUAS) and the like. Producer adoption of these information technologies has increased dramatically in recent years,[3] giving rise to a profusion of agricultural data heretofore unseen.[4]

The new abundance of field-level information provided by these technologies could improve the ability of producers to make profit-maximizing decisions benefitting the producer operating the field, *i.e.* Small Data.[5] However, pooling the datasets of hundreds or thousands of fields could hold a much greater potential value both to individual producers and the agricultural industry as a whole. Agricultural Big Data—farm data that has been combined into an aggregate form—has the potential to reveal undiscovered insights. Currently, only limited quantitative evidence exists regarding the value of assembling data from precision agriculture technology into a community; however, indirect evidence suggests farm data has economic value.

While the term *Big Data* is relatively new, it refers to a concept that is not. There are many definitions for the term, but a straight-forward one might be "a collection of data from traditional and digital sources inside and outside your company that represents a source for ongoing discovery and analysis."[6] While this definition sounds much like traditional data analysis (and it is), recent advances in both data collection and transmission increase the analytical power of data analysis procedures by orders of magnitude. The "big" in Big Data comes from the fact data sets continue to grow exponentially both in breadth (with more and more firms collecting data) and depth (with data from more and more sources long the food supply chain being aggregated by more firms). Conceptually, Big Data is defined as the analysis of datasets requiring advanced tools to manage the data due to four factors: volume, velocity, variety, and veracity.

Table 1: Big Data defining factors

Factor	Definition
Volume	The sheer amount of data precludes its storage on a single computer system; analytic software must aggregate the data from multiple systems
Velocity	New data enters the analysis continuously at high rates of transmission.
Variety	Data is aggregated from a variety of sources, many of which may use different data formats.
Veracity	Accuracy of the data is vital to correct analysis, while the data source may apply varying (or no) methods of data validation. Thus the Big Data system may have to independently validate the data or make assumptions about its accuracy.

Agricultural data has arguably already crossed over into the realm of Big Data as measured by these factors.

Existing technologies can already generate over 10 MB of data per acre, and when extrapolated over the 90 million acres of corn ground in the U.S., this means 900 terabytes (TB, 1 TB being equal to 1,000,000 MB) of data could be generated on corn

[2] K. Coble, T. Griffin, A. Misrha, and S. Ferrell, "Big Data in Agriculture: A Challenge for the Future," forthcoming in APPLIED ECONOMICS AND POLICY PERSPECTIVES (accepted for publication October 20, 2017).

[3] T. Griffin, Miller, N.J., Bergtold, J., Shanoyan, A., Sharda, A., and Ciampitti, I.A. 2017. Farm's Sequence of Adoption of Information-Intensive Precision Agricultural Technology. APPLIED ENGINEERING IN AGRICULTURE 33(4):521–527 DOI: 10.13031/AEA.12228.

[4] B. Erickson, and D. Widmar. 2015. *Precision Agricultural Services Dealership Survey Results.* West Lafayette, Indiana, Purdue University, August. Accessed June 21, 2016: *http://agribusiness.purdue.edu/files/resources/2015-crop-life-purdue-precision-dealer-survey.pdf*

[5] Griffin, *supra* note 1.

[6] L. Arthur. 2013. What is big data? FORBES, CMO Network blog entry. Available at *http://www.forbes.com/sites/lisaarthur/2013/08/15/what-is-big-data/,* last accessed November 15, 2014.

acres alone.[7] A student at Ohio State University recently completed the "Terra Byte" project to determine how much data could be garnered from one corn plant, with a resulting 18.4 gigabytes) of data; over a 100 acre corn field, this would be the equivalent of 60 petabytes (PB, 1 PB being equal to 1,000,000,000 MB).[8] Already, the commodity dataset has grown too large to be transported via broadband connections, or even physically via external hard drives, meaning analytical software must go to the data[9] Thus, the volume requirement for Big Data is satisfied.

Looking only at as-planted data collected from planters via telematics, 5.5 MB of data on location, speed, cultivar, and other geo-spatial and meta-data are collected for each acre planted. During planting seasons, the size of the aggregated farm data community becomes much larger every day. Although agricultural operations are seasonal, it should be recognized that even for commodity crops like corn, cotton, soybean, rice, and wheat that peak planting times differ for each such that as-planted data are collected during several months of the year rather than all at once. In addition to planting, other field operations such as tillage, spray applications, and harvest occur at other times during the season; each operation adding to the community of data. Thus, Griffin observes, planting data alone would satisfy the "velocity" component of Big Data.[10] By the same token, each of these data points are being collected by different brands of equipment using different file formats and supplemented using manually-collected data such as soil samples, all of which may be reported in non-standard formats, satisfying the "variety component."[11]

That leaves the "veracity" component and agricultural data can certainly pose veracity challenges. Such challenges arise from the problems inherent in trying to measure biological processes by mechanical means. Data quality has been a contentious topic in precision agriculture for decades; especially regarding raw yield monitor data and other farm data collected by on-the-go sensors. A part of the debate on the veracity of yield data involves whether the farmer or combine operator properly calibrates the yield monitor. Therefore, both sensors and human error influence farm data quality. Given this, agricultural data appears to more than satisfy the Big Data test.[12]

Although not as prominent to the discussion as Big Data and agricultural data, another important term to define is service provider. *Service provider* (sometimes called an "*Agricultural Technology Provider*" or "*ATP*") is the term frequently used to describe a party external to the farm providing some service regarding either crop production or management of the crop enterprise. Crop production services could include fertilizer or chemical applicators, custom operators, or harvest contractors whose equipment generate agricultural data regarding the farm. Management services include traditional services such as crop consulting and scouting, but increasingly include services targeted specifically at data collection and analysis.

2.2 Opportunities and Challenges arising from Small and Big Data use in Agriculture

It is important to note this discussion would not occur were it not for the tremendous potential the nascent farm data revolution promises. Existing technologies such as real-time kinematics (RTK) and "auto-steer" (sometimes referred to as "GNSS-enabled navigation technology) have already provided substantial economic returns to farmers.[13] Improved sensing of soil conditions, crop health, and yields has led to significantly improved management information for agricultural producers. As mentioned above, this represents Small Data, with data generated—and decisions made—at the farm level.

To date, much of the gains from improved sensing technologies and their sharing with service providers have come from eliminating inefficiencies in the utilization of agronomic and machinery inputs. Put another way, we have seen significant increases in the use of Small Data.

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[7] T. Griffin, "Can Agricultural or Farm Data Be Considered Big Data?" Kansas State University, *https://www.agmanager.info/machinery/precision-agriculture/precision-ag-farm-data-blog/can%C2%A0agricultural%C2%A0or%C2%A0farm%C2%A0data%C2%A0be* (last visited November 8, 2017).

[8] M. Brookhart and M. Reese. "World Record for Data Collection Set by OSU Precision Ag Team." Ohio Country Journal, October 11, 2017, *http://ocj.com/2017/10/world-record-for-data-collection-set-by-osu-precision-ag-team/#.Wd45GMwR0Qo.twitter* (last visited November 8, 2017).

[9] Grifin, *supra* note 7.

[10] *Id.*

[11] *Id.*

[12] *Id.*

[13] *See, e.g.,* M. Darr, "Big Data and Big Opportunities," paper presented at PrecisionAg Big Data Conference, August 21, 2014 (Ames, Iowa).

Small Data sees a variety of farm-level uses. Data kept isolated to the originating farm has value, but the value of that data is limited to just that farm or potentially to farms in relative proximity. The primary uses of farm data are those for which the data were initially generated such as documenting within-field site-specific yields with a yield monitor.[14] Typically, primary uses of data are restricted to the field that the data originated; consider the analogy of using a computer when that computer is not connected to the Internet. Primary data uses are "local" to the field or operation from which they originate and are not connected to data from other areas.

Considerable effort has been made by farmers, researchers, and others from within and external to the agricultural industry to profitably utilize data generated from precision agricultural technologies. The majority of these efforts have historically focused on one-field-at-a-time or maybe even at the whole farm level but for only that one farm. The value of farm data when isolated to a specific farm has been limited and only of value to that particular farm (or some value for the next farmer of the land). At the very least, the value of that data decays very quickly with distance from the field.

Indeed, it is possible that the site-specific value of farm data might actually play a role in farmland values themselves. Griffin and Taylor[15] explored how big data could impact farmland values and rental rates, stating "It remains unclear whether the 'data premium' [for farmland conveyed with a significant farm-specific dataset] will be a true premium (an amount added to the market price of land) or a penalty (an amount deducted from the market price of land). In the short-run, early movers who choose to provide data to land buyers may see a premium. However, as the transfer of data with a land sale becomes more common, a penalty to land parcels without data may become more common." They also describe how biophysical data, such as historical yield, soil test results, and other production data have been included in farmland sales and/or rental agreements, but they suggest these data have not substantially influenced farmland values nor are sufficient to be considered "big." These historical data could be annual whole-field yield written on paper or site-specific geospatial data including GPS yield monitor data or grid soil samples in either electronic form or printed maps. Although the above mentioned data may provide evidence of historical productivity and soil amendment utilization, they do not impact farmland values directly. Farmland values and rental rates will likely be a function of both quantity and quality of geospatial metadata once the big data sector of the agriculture industry matures.

Farmers have made use of precision agriculture technology and farm data in a variety of ways, and oftentimes in ways that the manufacturers had not anticipated. An early report on how farmers used yield monitors indicated the primary uses of yield data include but not limited to: 1) conduct on-farm experiments, 2) tile drainage decisions, and 3) split crop share rents.[16] To estimate the value of farm data for each of these examples, the alternative decision making process must be evaluated. However, back of the napkin extreme examples make the point that the value of the above scenarios are finite and limited to a single farm.

Perhaps the most dramatic gains lie ahead, though, as agriculture puts the "Big" in Big Data by compiling datasets of sufficient size to enable much more robust statistical analyses of multiple factors influencing commodity production. Examples of how the aggregation of farm data across large datasets can significantly increase value to farmers are illustrated in Table 2 below.[17]

Table 2: Comparison of Primary and Secondary Agricultural Data Uses

Data	Primary Use "Small Data"	Secondary Use "Big Data"
Yield monitor data	Documenting yields; on-farm seed trials	Genetic, environmental, management effect (G x E x M) analyses

[14] Note that secondary uses of data will be discussed later in this testimony.

[15] T. Griffin., and Taylor, M.R. (2015). Precision Agriculture Data Impact on Farmland Values: Big Data in Ag. K-State Department of Agricultural Economics AgManagerInfo AM–TWG–PRAG–4.2015 Online: *http://www.agmanager.info/crops/prodecon/precision/PrecisionAgData_FarmlandValues.pdf.,* last visited November 8, 2017.

[16] T. Griffin, "Farmers' Use of Yield Monitors," University of Arkansas Fact Sheet FSA36, available at *https://www.uaex.edu/publications/pdf/FSA-36.pdf* (last visited November 8, 2017).

[17] Table and scenarios taken from Terry Griffin, "Big Data Considerations for Agricultural Attorneys," paper presented at American Agricultural Law Association Annual Symposium, October 23, 2015 (Charleston, South Carolina).

Table 2: Comparison of Primary and Secondary Agricultural Data Uses—Continued

Data	Primary Use "Small Data"	Secondary Use "Big Data"
Soil sample data	Fertilizer decisions	Regional environmental compliance
Scouting	Spray decisions	Regional analytics of pest patterns

As an example of initial or primary use of farm data, yield monitor data on one farm can help document the farm's productivity on a field-by-field basis and can illustrate how a seed hybrid performed on that farm in one year, given the environment of that farm for that year and the management practices employed during that year. Interesting opportunities arise when that data is "re-used" in Big Data aggregation with similar data across hundreds or even thousands of farms, and this aggregation creates the bridge linking Small and Big Data.

Such aggregation allows for the evaluation of that cultivar across tens of thousands of permutations of factors such as management practices, soil type, and climate. This enables both seed companies and agricultural producers to learn via observational data in one or two years what would take decades of collections by use of traditional seed trials via experimentation. Soil sample data coupled with yield data can inform an agricultural producer about the nutrient uptake of the crop on his or her farm, but Big Data could allow all the agricultural producers in a region to effectively tackle nutrient loading to impaired water bodies through voluntary management of non-point pollution. Crop scouting can help an individual agricultural producer make decisions about the application of a specific pesticide, but Big Data could allow a crop industry to spot trends in plant pathogens that could be used to head off the spread of potentially devastating plant health threats. The true maturity of Big Data in agriculture may come when the value of secondary uses realize greater aggregate economic value than the primary uses of the data.[18]

The integration of Small Data and Big Data at the farm level could hold important implications for farms competitiveness.[19] Early adopters of big data in other industries (such as healthcare, transportation, and retail) are shown to have gained a competitive advantage within their industries and have realized significant increases in operating margins.[20] There is an emerging discussion in the agribusiness industry and its literature about the potential of big data and its capacity to change the basis of competition in agriculture.[21] This belief is based on the previous trends in the history of innovations powering productivity and enhancing competitiveness in the agri-food supply chain, enabled by information and communication technology (ICT). Among such examples is precision agriculture powered by GPS, remote sensing, and variable rate technology (VRT) technologies in crop farming. While the adopters of ICT-based applications in agricultural production were primarily motivated by the efficiency gains, they also have laid the foundation for the big data infrastructure within agriculture. As a result, modern farms are generating, or have a capacity to generate, a substantial amount of agricultural production data. This data becomes an important intangible resource alongside the physical and human resources, which if managed effectively, can produce substantial value for the farming operation. The important question to ask is under which circumstances the data, as an intangible resource, can become a source of competitive advantage?

Beyond the benefits of Big Data to production agriculture, it also presents the agricultural economics community with numerous opportunities to enhance and expand the analysis of numerous microeconomic, macroeconomic, and agricultural pol-

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[18] V. Mayer-Schönberger, and K. Cukier, *Big Data: A Revolution That Will Transform How We Live, Work, and Think,* Kindle Edition. Houghton Mifflin Harcourt Publishing Company, New York, NY. 257 pp. 2014.

[19] This discussion of agricultural data and competitive issues is taken from Griffin, *et al., supra* note 1.

[20] J. Manyika, Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., & Byers, A. H. (2011). "Big data: The next frontier for innovation, competition, and productivity." McKinsey Global Group report, available at *https://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/big-data-the-next-frontier-for-innovation,* last visited November 8, 2017).

[21] S. Sonka. (2014). Big Data and the Ag Sector: More than Lots of Numbers. International Food and Agribusiness Management Review, 17(1), 1–20. Available online at *http://www.ifama.org/files/IFAMR/Vol%2017/Issue%201/(1)%2020130114.pdf,* last visited November 8, 2017.

icy issues.[22] For example, microeconomic farm management issues could now be analyzed by aggregating data across thousands of farms using management decisions as variables instead of using a farm-by-farm case study approach. Food program evaluations, regulatory impact analysis, and demand estimation could be accomplished by rapid aggregation and analysis of grocery store UPC scanner data. Geospatial analysis of crop yields could lead to improved precision in the pricing of crop insurance products. Broad environmental sensor networks coupled with farm data could significantly enhance the ability to manage crop fertilizer applications to minimize nutrient runoff impacts.

To understand the potential policy implications of Big Data's growth in agriculture, one must recall that one of the defining characteristics of agricultural Big Data is combining data from multiple farms into a community. A leading reason for this is that each farmer becomes a variable (rather than a constant) once a critical mass of farms is in the community. When farm data were isolated to a single farm, then there was no opportunity to evaluate the management practices specific to that farmer, *i.e.* the management was held constant.

Farm data must be aggregated to perform community analysis. A leading example of community analysis is evaluating how a product (G for "genetics," from classic varietal or hybrid tests) in a given location (E for "environment," including soils, weather, and other uncontrolled factors) under the farm's production practices (M for "management," including controlled factors such as planting dates, seeding rates, timing of operations, tillage practices and many others). When farm data are not aggregated across numerous farms, then the data remain 'small' and the value is limited since the M in analysis known as GxExM, is not a viable variable (only the traditional GxE). When data are aggregated such that M is a variable to the analysis GxExM, insights can be discovered for a majority of participants. Examples of previously unknown discoveries may include which products or bundle of products (seed, fungicides, planting dates) maximize profitability for a given region under specific farm production practices.

Each player (and each group of players) benefit differently with respect to the big data system. One must consider how these different players benefit to comprehend how the value of Big Data systems may be captured relative to the data contributors (farmers) and aggregators (ATPs). The economics of networks are important to fully understand the value gained from the big data community. The value of the data community depends not only on the quality of the data but on how many others participate in the system. Data from numerous farms aggregated into a community are more valuable than data from any one individual farm. In the long run, the aggregator controlling the flow of data enjoys the majority of the value. Other groups, such as those offering analytic services of the aggregated data, enjoy their value capture especially in the short run. Once a critical mass of farms are in the data community, *i.e.* the long run, farmers' bargaining power with the data aggregator likely will be greatly reduced.

In the long-run the majority of the value will be enjoyed by the one controlling the data community, *i.e.* the data service provider. Other players such as input manufacturers, retailers, and advisors may enjoy their own levels of varying value capture. The important part to be cognizant is that 1) the farmer is not the only player at the big data table and 2) the farmer is not likely to receive the vast majority of the value from participating in the big data system. However, that is not to say that farmers will not still see potentially important benefits from the analyses provided by Big Data systems. Such systems pose the opportunity of providing potentially unprecedented insights to inform farm management decisions, decreasing production risk, and potentially reducing financial and market risks as well.

While there are countless potentially positive uses of Big Data tools, any tool can also be misused. Farmers, ranchers, and other participants in the agricultural industry have expressed concerns about several potential misuses of agricultural data beyond the mere disclosure of confidential information (discussed below). Some producers worry that the ability of equipment manufacturers to access a significant amount of data about their operations, giving the manufacturers the ability to interpolate the farmer's financial condition and use such information to an unfair advantage in transactions with the farmer or to alter the balance of negotiating power in the manufacturer's favor for any number of transactions. Others worry about government agencies taking advantage of aggregated datasets to acquire information that the producer could not be compelled to produce without a formal legal process. Yet another concern is that falsified data could be introduced into individual or ag-

[22] The following examples are taken from K. Coble, T. Griffin, A. Misrha, and S. Ferrell, "Big Data in Agriculture: A Challenge for the Future," forthcoming in APPLIED ECONOMICS AND POLICY PERSPECTIVES (accepted for publication October 20, 2017).

gregated agricultural datasets to skew environmental assessments of farm performance.

One additional Big Data challenge worries both producers and economists. As stated in Coble, *et. al:*[23]

> The Holy Grail for market participants is to get perfect information as soon as it is knowable, and preferably before it is knowable to others. While Big Data has a long, long way to go before achieving this, bigger steps toward that goal are being taken faster than ever before. Thus, a significant concern with aggregating agricultural data is whether—either legitimately or not—a small number of market participants (or a single actor) could get access to information sufficient to move (or even manipulate) markets faster than, or to the exclusion of, other market participants. While there are numerous rules in place to deal with a broad range of market-manipulating activities, none of these current rules contemplate the type of actions that could take place with a sufficiently large aggregated dataset. Currently, there are various rules restricting insider trading (see 17 C.F.R. § 1.59(a), 17 C.F.R. § 1.3(ee)), and government employees are prohibited from using data for financial gain that has not been disseminated to the public (7 U.S.C. § 6c(a)(3)). However, there are no rules governing "very good market information" such as that which could be obtained through completely legal means by aggregating sufficient telematics data (as an example). As a result, research on the potential market effects of growing market asymmetries that could be triggered by growing Big Data aggregations and the implications of policies restricting the use of aggregated data in commodity market transactions could do much to inform the development of law in the arena.

Only time and experience will tell whether these concerns are well-founded, but the fact they exist may well impact producers' willingness to participate in Big Data systems, and thus impact the future of the industry. Most industry observers believe the benefits to individual producers and the agricultural industry as a whole far outweigh the potential risks. However, bringing about the full economic benefits of Big Data in agriculture requires a robust system by which large numbers of agricultural producers can share their data since the predictive power of statistical analysis increases with the number of observations available for each variable examined.[24] The agricultural data industry is working tirelessly to create those systems. The issue is one of trust—farmers must feel they can trust Big Data systems before they will participate. Thus, the issue of most concern to this hearing may not be whether we will have systems that *can* accept and analyze that data; it is perhaps how Congress can facilitate the development of an environment in which farmers *will* share their data. Metcalfe's Law states that the value of a network is proportionate to the number of its members. Put another way, Facebook has little value if you are its only member, but it has tremendous value when populated by millions of members. Thus, agricultural producers can only harness the value of Big Data if we can foster an environment in which they are comfortable sharing their data. However, that participation might be inevitable given the increasing prevalence of data-collection technologies. As Griffin and Shanoyan observe, going "off the grid" with respect to agricultural data may be possible in the near term, but eventually will require farmers to use then-antiquated technology, placing them at further competitive disadvantage.[25]

Given this potential inevitability of data sharing, one must turn to questions of what rights farmers can retain in their shared data. Do they retain ownership of their information? Is there any hope of retaining their privacy in that information once it is shared?

2.3 Framing the legal issues surrounding data in agriculture

The issues involved in the discussion of data in agriculture are almost innumerable, but many can be brought under the umbrella of two over-arching concepts: agricultural data ownership, and protections against its unauthorized disclosure. Although each of these issues is discussed in greater detail later in this testimony, a brief framing of each issue is provided here.

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[23] *Supra,* note 4.

[24] *See generally* GEORGE G. JUDGE, ET AL, INTRODUCTION TO THE THEORY AND PRACTICE OF ECONOMETRICS (2nd ed, 1988), 96.

[25] T. Griffin and A. Shanoyan, "Is Going Off the Grid Possible in the Age of Farm Data?" Kansas State University, *https://www.agmanager.info/machinery/precision-agriculture/precision-ag-farm-data-blog/going-grid-possible-age-farm-data* (last visited November 7, 2017).

2.3.1. Ownership of agricultural data

As agricultural producers began to realize the information they were generating (and, in some cases, sharing with service providers) had potential economic value, questions began to arise regarding who had the superior "ownership" right to that information, given that multiple parties had a hand in its creation. Further, the realization of agricultural data's value changed the relative negotiation power between parties. This is an important concept; if their data is shared by someone other than them with a third party, that sharing may cause the farmer to lose negotiation power with vendors, landlords, and the like as a result. Thus, farmers may wish to assert "ownership" of data so as to exercise one of the rights of property ownership, namely, to exclude others from its use. Thus, this issue might be framed as "*Who owns data generated about an agricultural producer's operation?"*

2.3.2. Privacy rights for agricultural data

As discussed in more detail below, it is possible—and even likely –the greatest economic value of agricultural data to the farm owner comes not from his or her own analysis of the data but from its aggregation with data from hundreds or even thousands of other farms (in a true Big Data model) to provide management information and trend identification that could not be derived from any smaller dataset. For example, one of the most common analyses provided by ATPs to farmers are "comparative analytics" (for example, benchmarking performance relative to similarly-situated operations). While that might have some economic value for the producer, much greater benefits await via advanced analysis. The balance of negotiating power between the farmer and the aggregator will eventually determine what proportion of the analyses conducted benefit each party. While aggregation may in some ways reduce the disclosure or discovery of information about any one farm (through the anonymization of individual farm data by aggregation with many other farms), it naturally also raises fears about the release of that information (whether the result of intentional activity such as database hacking or an accidental disclosure). This leads to the second question: "*What protections prevent the disclosure of agricultural data to outside parties?"*

3. Current Legal Framework for Ownership of Agricultural Data

The United States has one of the most robust systems of property rights in the world, empowered by a legal system making it easy (relatively speaking) to enforce those rights. Thus, the first place many look for a means of protecting one's data from misappropriation and/or misuse is the property right system. This requires one to examine who "owns" agricultural data. The answer to the question is not simple, though, as traditional notions of property ownership find challenge in their application to pure information.

The notion of property ownership typically involves some form of six interests, including the right to possess (occupy or hold), use (interact with, alter, or manipulate), enjoy (in this context, profit from), exclude others from, transfer, and consume or destroy. Some of these interests do not fit, or at least do not fit well, with data ownership. Excluding others from data, for example, is difficult, particularly when it is possible for many people to "possess" the property without diminishing its value to the others, just as the value of a book to one person may not be diminished by the fact other people own the same book.[26] Thus, the better question may be "*What are the rights and responsibilities of the parties in a data disclosure relationship with respect to that data*?" [27]

Data is difficult to define as a form of property, but it most closely resembles intellectual property. As a result, the intellectual property framework serves as a useful starting point to define what rights a farmer might have to their agricultural data. Intellectual property can be divided into four categories: (1) trademark, (2) patent, (3) copyright, and (4) trade secret. The first three areas compose the realm of Federal intellectual property law as they are defined by the Constitution as areas in which Congress has legislative authority.[28] Since trademark is not relevant to a discussion about data,[29] the analysis will focus on patent, copyright, and trade secret.

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[26] L. Smith. 2006. "RFID and other embedded technologies: who owns the data?" SANTA CLARA COMPUTER AND HIGH TECHNOLOGY LAW JOURNAL

[27] R. Peterson. 2013. "Can data governance address the conundrum of who owns data?" Educause blog, *http://www.educause.edu/blogs/rodney/can-data-governance-address-conundrum-who-owns-data,* last accessed November 8, 2017.

[28] U.S. Constitution, Article I, § 8, clause 8.

[29] The Federal Trademark Act (sometimes called the Lanham Act) defines trademark as "any word, name, symbol, or device, or any combination thereof . . . to identify and distinguish his

3.1 Application of patent law to agricultural data

The U.S. Patent Act states "whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor" (35 U.S.C. § 101). Generally, for an invention to be patentable, it must be useful (capable of performing its intended purpose), novel (different from existing knowledge in the field), and non-obvious (somewhat difficult to define, but as set forth in the Patent Act, "a patent may not be obtained. . .if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains").[30] Patent serves as a poor fit for a model of agricultural data ownership since it protects "inventions." Raw data, such as agricultural data, would not satisfy the definition of invention.

It should be noted patentable inventions could be derived from the analysis of agricultural data. While this does not mean the data itself is patentable, it does suggest that any agreement governing the disclosure of agricultural data by the agricultural producer should address who holds the rights to inventions so derived.

3.2 Application of copyright law to agricultural data

The Federal Copyright Act states the following:

Copyright protection subsists, in accordance with this title, in original works of authorship fixed in any tangible medium of expression, now known or later developed, from which they can be perceived, reproduced, or otherwise communicated, either directly or with the aid of a machine or device. Works of authorship include the following categories:

literary works;

musical works, including any accompanying words;

dramatic works, including any accompanying music;

pantomimes and choreographic works;

pictorial, graphic, and sculptural works;

motion pictures and other audiovisual works;

sound recordings; and

architectural works.[31]

More so than trademark and patent, the copyright model at least resembles a model applicable to agricultural data. At the same time, however, the model also has numerous problems in addressing agricultural data. First, the list of "works of authorship" provided in the statute strongly suggests a creative component is important to the copyrightable material. Second, the term "original works of authorship" also has been interpreted to require some element of creative input by the author of the copyrighted material. This requirement was highlighted in the case of *Fiest Publications Inc. v. Rural Telephone Service Company,*[32] where the U.S. Supreme Court held the Copyright Act does not protect individual facts. In *Fiest,* the question was whether a pure telephone directory (consisting solely of a list of telephone numbers, organized alphabetically by the holder's last name) was copyrightable. Since the directory consisted solely of pure data and was organized in the only practical way to organize such data, the Supreme Court held the work did not satisfy the creative requirements of the Copyright Act.[33] This ruling affirmed the principle that raw facts and data, in and of themselves, are not copyrightable. Put another way, the fact that ABC Plumbing's telephone number is 555–1234 is not copyrightable. However, an author can add creative components to facts and data such as illustrations, commentary, or alternative organization systems and can copyright the creative components even if they cannot copyright the underlying facts and data. Continuing the analogy, ABC's phone number alone is not copyrightable, but a Yellow Pages® ad with ABC Plumbing's number accompanied by a logo and a description of the company's services *would* be copyrightable.

Agricultural data in and of itself may not be copyrightable, but it can lead to copyrightable works. For example, agricultural data may not be copyrightable, but a report summarizing the data and adding recommendations for action might be. Again,

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or her goods, including a unique product, from those manufactured or sold by others and to indicate the source of the goods, even if that source is unknown." 15 U.S.C. § 1127.

[30] 35 U.S.C. §§ 102, 103.

[31] 17 U.S.C. § 102(a).

[32] 499 U.S. 340 (1991).

[33] *See id.*

then, it is incumbent upon those disclosing agricultural data to include language in their agreements with the receiving party to define the rights to such works derived from the data.

A separate issue regarding copyrights deriving from agricultural data also continues to emerge. Increasingly, the original agricultural data is never even disclosed to the agricultural producer; rather, the data has been processed into a report or a new form through use of a computer algorithm. Quite simply, agricultural producers may often receive a completely computer-generated report with no human author. This requires moving into the realm of copyrights in computer generated works—an area that is far from settled.[34] The evolution of understanding who holds the rights to computer-generated works with regard to agricultural data played out recently in the discussions surrounding comments by Deere & Company on proposed exemptions to the Digital Millennium Copyright Act[35] regarding copyright protection systems in vehicle software.[36]

3.3 Application of trade secret law to agricultural data

While trademark, patent, and copyright do not appear to fit as models for farm data ownership, trade secret has the potential to serve the agriculture industry's concerns regarding rights in data shared with Big Data service providers. Importantly, trade secret is a function of state law (unlike trademark, patent, and copyright, which are all creatures of Federal law). At the time of this testimony, all but three states have adopted the Uniform Trade Secrets Act, providing a degree of consistency in trade secret law across most states.

Under the Uniform Trade Secrets Act ("UTSA"), a "trade secret" is defined as:

> . . . information, including a formula, pattern, compilation, program, device, method, technique, or process, that:
>
> (i) derives independent economic value, actual or potential, from not being generally known to, and not being readily ascertainable by proper means by, other persons who can obtain economic value from its disclosure or use, and
>
> (ii) is the subject of efforts that are reasonable under the circumstances to maintain its secrecy.

Importantly, this definition makes clear "information . . . pattern[s], [and] compilation[s]" can be protected as trade secret. This, at last, affords hope of a protective model for farm data. This is not to say that trade secret is a perfect model for protecting farm data, however. Note the two additional requirements of trade secret: first, the information has actual or potential economic value from not being known to other parties, and second, it is the subject of reasonable efforts to maintain the secret.

The first provision requires that to be protected as a trade secret, farm data such as planting rates, harvest yields, or outlines of fields and machinery paths must have economic value because such information is not generally known. While a farmer may (or may not) have a privacy interest in this information, the question remains as to whether the economic value of that information derives, at least in part, from being a secret. The counterargument to that point is the economic value of the information comes from the farmer's analysis of that information and the application of that analysis to his or her own operation—a value completely independent of what anyone else does with the information—and that the information for that farm, standing alone, has no economic value to anyone else since that information is useless to anyone not farming that particular farm.[37] One can see this first element poses problems for the trade secret model. It should be noted here there is a clear economic benefit to the collection of farm data; otherwise companies would not be investing billions of dollars to position themselves in the agricultural

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[34] *See generally* M. Leaffer, UNDERSTANDING COPYRIGHT LAW, 109–110 (5th ed. 2011).

[35] 17 U.S.C. §§ 512, 1201–1205, 1301–1332; 28 U.S.C. § 4001

[36] *See* Deere & Company, "Long Comment Regarding a Proposed Exemption Under 17 U.S.C. 1201" (2015). Available at *http://copyright.gov/1201/2015/comments-032715/class%2022/John_Deere_Class22_1201_2014.pdf* (last visited November 8, 2017). *Compare* K. Weins, WIRED (Business Blog Section, online edition) (editorial) "We Can't Let John Deere Destroy the Very Idea of Ownership," April 21, 2015. *http://www.wired.com/2015/04/dmca-ownership-john-deere/* (last visited November 8, 2017).

[37] An agricultural producer could, hypothetically, use such data to bid rented agricultural land away from another tenant if they could somehow demonstrate they could provide the landowner with evidence they could increase the landowner's returns. However, this seems a tenuous argument for the economic value element of the UTSA test and has no application at all in a scenario with owned agricultural land.

data industry.[38] This represents a question yet to be answered clearly by the body of trade secret law: whether one can have trade secret protection in information that standing alone has no economic value to other parties, but does have such value when aggregated with similar data from other parties.

The second provision—the data be subject to reasonable efforts to maintain its secrecy—also finds problems in an environment where the data is continuously uploaded to another party without the intervention of the disclosing party. The fact that data are disclosed to another party does not mean it cannot be protected as a trade secret; if that were the case, there would be little need for much of trade secret law. Rather, the question is how and to whom the information is disclosed. As noted in the Restatement (Third) of Unfair Competition's comments on the Uniform Trade Secret Act, ". . . the owner is not required to go to extraordinary lengths to maintain secrecy; all that is needed is that he or she takes reasonable steps to ensure that the information does not become generally known." [39]

The question becomes what constitutes "reasonable steps" to keep continuously uploaded data protected, or data that is voluntarily shared with a Big Data ATP. Almost certainly this means there must be some form of agreement in place between the disclosing party and the receiving party regarding how the receiving party must treat the received information, including to whom (if anyone) the receiving party may disclose that information. Such agreements are discussed in greater detail below. However, there is some question as to whether any agreement could protect the trade secret claim for data that was disclosed to an ATP. When one discusses farm data privacy, one often consider the concept of remaining anonymous. However, in the Big Data world anonymity is no longer achievable, at least in the same manner as it once was. Mayer-Schönberger and Cukier describe how even sanitized data can reveal the identity of individuals by combining additional layers of (probably publicly available) data. Given the prevalence of public geospatial data, data from USDA, and plat maps, it is possible in many circumstances to use those data layers with a sanitized community of farm data to reveal all the data that were intended to remain anonymous. As a result, one could argue sharing data with an aggregator essentially renders it ineligible as a trade secret (regardless of a nondisclosure agreement with the aggregator) since the receiver cannot make a reasonable guarantee that the data can be kept secret.[40] This concept has implications not only for the potential application of trade secret principles to agricultural data, but to broader privacy policy concerns as well.

Assuming for the moment that trade secret protection can be obtained for agricultural data, one should consider the use of a "non-disclosure agreement" when sharing data with an ATP. While an explicit written "non-disclosure agreement" (or "NDA") is not necessary to claim trade secret protection, such an agreement is almost certainly a good idea if an agricultural producer wishes to retain a protectable ownership interest in their data if such an interest exists. Not only can such an agreement clarify a number of issues unique to the relationship between the disclosing and receiving parties, but also can address numerous novel issues in the current information environment that trade secret law have not yet reached.

The concept of NDAs as separate agreements may be practicable for one-on-one relationships, such as those between agricultural producers and smaller consulting firms, negotiating separate agreements with multiple entities poses significant transaction costs. This problem is particularly magnified when one considers larger corporate service providers who would face the issue of negotiating tens of thousands of NDAs. Unsurprisingly, such entities choose to create standard agreements in their form contracts. While certainly understandable, this in turn creates the "opt-out problem" wherein a farmer who believes the form contract does not adequately protect his or her interests is forced to either agree to the form or do without the product or service—which may be the only product or service compatible with a significant portion of the very expensive equipment he or she already owns or uses. This then provokes the discussion of whether such contracts are enforceable or are, instead, adhesion contracts. There is yet to be found consistency among Federal courts as to the enforceability of such software use agreements.[41]

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[38] *See* B. Upbin, FORBES (Tech business blog), "Monsanto Buys Climate Corp for $930 Million," October 2, 2013. *http://www.forbes.com/sites/bruceupbin/2013/10/02/monsanto-buys-climate-corp-for-930-million/*.

[39] Smith, *supra* note 4, *citing* Restatement of Unfair Competition (Third) § 757 (1995).

[40] Griffin and Shanoyan, *supra* note 20.

[41] The asymmetry of EULA's has led to allegations they represent "adhesion contracts" and should not be enforceable as a matter of policy. However, some courts have found insufficient evidence of adhesion and held such agreements enforceable. *Compare* cases finding EULAs en-

Continued

To conclude the trade secret analysis, colorable arguments exist both for and against the proposition farm data poses an "ownable" and protectable trade secret. That said, this option provides the best doctrinal fit among the traditional intellectual property forms, and farmers wishing to preserve whatever rights they do indeed have in that data seem best advised to use the trade secret model to inform the their protective measures. Even so, use of trade secret doctrine as a protective measure for agricultural data has drawbacks in the lack of consistency among states in trade secret law (although the UTSA has done much to add consistency to the field) and the fact it is often a "backward looking" and costly solution since trade secret must frequently be used to seek damages (which are often difficult to both prove and quantify) through litigation after a disclosure has already been made.

4. Current Legal Framework for Privacy Rights in Agricultural Data

Those concerned about the disclosure of personal data can certainly cite a number of damaging data breach examples. Recent history suggests many of the real threats in data transfers come from insufficient controls to prevent the disclosure of personally identifiable information ("PII") to outside parties and inadequate agreements on the uses of data by parties to whom it is disclosed.

To the extent producers regard agricultural data as proprietary, their concerns about its disclosure naturally invite a review of the release or theft of proprietary information in other sectors. One need not look far into the past to find numerous examples of the disclosure of PII, whether merely inadvertent or the result of targeted hacks. Attacks on companies' payment systems have resulted in the credit card information of hundreds of millions of customers from Adobe Systems (150 million customers), Heartland Payment Systems (130 million customers), TJX (parent company of TJ Maxx and Marshalls, 94 million customers), TRW Information Systems (credit reporting company, 90 million customers), Sony (70 million customers) each of which dwarf breaches attracting more media attention such as Home Depot (56 million customers) and Target (40 million customers).[42] Perhaps the most troubling data breach in recent history, though, was the 2017 Equifax data breach, which exposed a large array of personal and financial data for over 143 million.[43] The Equifax breach is especially troubling for many consumers, as Equifax was entrusted with the most sensitive personal information consumers could provide, and was supposed to serve as a secure repository for that information. It is reasonable to surmise that particular breach was a significant setback for the trust of agricultural producers in systems that could collect their financial data.

To some extent, there may be a very limited reasonable "expectation of privacy" in agricultural data since a significant segment of such data is available from public sources or sources obtainable from public vantage points (such as aerial or satellite imagery). Nevertheless, there remains an also-significant segment of data for which an argument could be made that a privacy interest exists. The challenge may be figuring out who has the best ability to protect that data from disclosure.

The greatest risk of data breaches for agricultural producers may be attacks against aggregators, since attacks against individual farm systems pose very high barriers relative to the amount of data such an attack could obtain. Theoretically, a hacker could tap into the tractor/implement network (also called the tractor/implement bus) using a number of commercially-available technologies allow farmers to plug into the network and access Controller Area Network ("CAN") messages directly; for example, one could purchase a CAN message reader ("CAN sniffer") to read machine diagnostic codes for repairs.[44] Someone wishing to "steal" data would likely not want to be present to retrieve the data from the device, though, and would likely prefer to use a CAN data logger coupled with a device to wirelessly transmit the data. Many data loggers are available to the public as well; for example, the "Snapshot®" device used by Progressive Insurance for some insurance programs is

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forceable: *Ariz. Cartridge Remanufacturers Ass'n v. Lexmark Int'l, Inc.,* 421 F.3d 981 (9th Cir., 2005); *ProCD, Inc. v. Zeidenberg,* 86 F.3d 1447 (7th Cir. 1996); *Microsoft v. Harmony Computers,* 846 F. Supp. 208 (E.D.N.Y. 1994); *Novell v. Network Trade Center,* 25 F. Supp. 2d. 1218 (D. Utah, 1997) *with* cases finding EULAs unenforceable: *Step-Saver Data Systems Inc. v. Wyse Technology,* 939 F.2d 91 (3rd Cir. 1991); *Vault Corp. v. Quaid Software Ltd.* 847 F.2d 255 (5th Cir. 1988); *Klocek v. Gateway, Inc.,* 104 F. Supp. 2d 1332 (D. Kan. 2000).

[42] J. Pepitone, "5 of the Biggest-ever Credit Card Hacks," (2013) CNN Money, available at *http://money.cnn.com/gallery/technology/security/2013/12/19/biggest-credit-card-hacks/* (last visited November 8, 2017).

[43] Federal Trade Commission, "The Equifax Data Breach: What to Do." *https://www.consumer.ftc.gov/blog/2017/09/equifax-data-breach-what-do* (last visited November 8, 2017).

[44] Interview with Dr. John Fulton, Ohio State University Department of Food, Agricultural, and Biological Engineering, July 6, 2015.

simply a CAN data logger plugged into a vehicle's On-Board Diagnostic (OBD–II) port.[45] Alternatively, of course, if one wanted to steal large amounts of agricultural data at once, one could attempt to hack a cellular network provider used by an equipment manufacturer to carry their data signals. Further, it should be noted the equipment manufacturer likely has no ability to specify or enforce the security protocols used to safeguard such cellular transmissions.

While such an approach would work for standard messages transmitted over the bus, it would not work for proprietary messages. To decode such messages, the prospective hacker would have to develop a system for decoding the information being provided from the task controller for the implement, and that task would take almost as much work (if not more) than the work in developing the task controller system in the first place.[46] Note, that several companies now provide means for reverse-engineering proprietary CAN messages (such as those related to crop yield) so farmers can automatically transfer yield data to the cloud. Such technology could also be used to decode other proprietary information.[47] Perhaps ironically, the growth of proprietary data network protocols that lead to complaints about the lack of interoperability of farm equipment systems could also provide greater protection against data breaches.

Additionally, the Global Positioning System "GPS" receiver in most systems connects directly to the implement's task controller. As a result, a "bug" might receive information about the commands sent to the implement but without the associated location data, rendering it meaningless. The bug would require its own GPS receiver along with implement data (the configuration and dimensions of the implement), which today could be done for a modest equipment cost.[48] Obtaining agronomic data via a physical connection to an implement poses a task manageable for someone knowledgeable in SAE J1939 and ISO 11783[49] technology.[50] However, building and deploying such a device poses a significant amount of effort (to say nothing of the potentially-criminal trespass involved in deploying it) in relation to the prospect of collecting data on only one farm.

As illustrated from this discussion, a number of factors in the configuration and operation of farm data networks limit the opportunities for hackers to take agricultural data directly from the agricultural producer. Admittedly, most producers put little thought into their systems being physically hacked but worry instead about their data being accessed through an intercepted cellular signal. They might also worry about a bad actor hacking the system to implant false data. First, virtually all cellular signals are encrypted when transmitted and decrypted at the cellular tower;[51] without the decryption key, interpreting any data transmitted would be difficult (although not impossible for a sophisticated hacker; recent news has highlighted the ability of some groups to do so[52]). The use of data encryption through a secure sockets layer ("SSL") protocol by the farmer and his or her service provider

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[45] *See* Progressive Corporation, "Snapshot® Terms and Conditions," *https://www.progressive.com/auto/snapshot-terms-conditions/* (last visited November 8, 2017).

[46] *See* interview with Dr. Marvin Stone (June 10, 2015).

[47] Interview with Dr. John Fulton, Ohio State University Department of Food, Agricultural, and Biological Engineering, July 6, 2015.

[48] A relatively quick search of Google will yield many GPS receiver units for less than $50.

[49] SAE International, "The SAE J1939 Communications Network: An Overview of the J 1939 Family of Standards and How they are Used," 5 (white paper), available at *http://www.sae.org/misc/pdfs/J1939.pdf* (last visited November 8, 2017). *See also* INTERNATIONAL ORGANIZATION FOR STANDARDIZATION, ISO DRAFT INTERNATIONAL STANDARD ISO/DIS 11783: TRACTORS AND MACHINERY FOR AGRICULTURE AND FORESTRY—SERIAL CONTROL AND COMMUNICATIONS DATA NETWORK (2012). The ISO 11783 standard is often referred to as the "ISOBUS standard" and defines how the on-board computer networks on most agricultural equipment works and how their individual components work together. Combined, SAE J1939 and ISO 11783 govern much of how the data-collection network on any agricultural equipment works.

[50] M. Miettien, "Implementation of ISO 11783 Compatible Task Controller," XVI CIGR (International Commission of Agricultural and Biosystems Engineering) World Congress, Bonn, Germany (2006), available at *http://users.aalto.fi/~ttoksane/pub/2006_CIGR20062.pdf* (last visited November 8, 2017).

[51] For a primer on the process of encoding and decoding cellular signals, *see* How Stuff Works, "How Cell Phones Work," *http://electronics.howstuffworks.com/cell-phone.htm* (last visited November 8, 2017).

[52] *See* C. Timberg & A. Soltani, *By Cracking Cellphone Code, NSA Has Ability to Decode Private Conversations,* THE WASHINGTON POST, December 13, 2013. Online edition, available at *http://www.washingtonpost.com/business/technology/by-cracking-cellphone-code-nsa-has-capacity-for-decoding-private-conversations/2013/12/13/e119b598-612f-11e3-bf45-61f69f54fc5f_story.html* (last visited November 8, 2017).

in data transfers adds another difficult-to-break security barrier to interception of the data.[53]

Most agricultural data disclosed to a service provider is likely in the form of telematics data, raw data regarding crop production, GIS information about the farm, and other similar types. Conversely, hackers frequently go after large concentrations of data with easily-converted financial value, such as credit card information. Thus, it may be difficult for hackers to make a "quick buck" from agricultural data making it a less-appealing target of attack. Nevertheless, an adage in computer security is "where there is value, there will be a hacker."[54] As a result, systems storing agricultural data are less likely to be directly attacked, but farmers are understandably concerned that PII may be stolen if, for example, their vendor account information is somehow linked to their agricultural data or if their account information is stored with a third party that is a more appealing target. Depending on the type of computer at issue and its common use, the Federal Computer Fraud and Abuse Act ("CFAA")[55] may provide a means of prosecuting unauthorized access of the computer in the event agricultural data linked to PII is compromised. Discussed below, the Federal Electronic Communications Privacy Act (ECPA)[56] could also be used as a potential prosecutorial tool for those attempting to intercept agricultural data during the data transmission process.

The theft of PII by criminals is one threat posed by data transfers, but so too is the inadvertent, or perhaps intentional but misinformed, disclosure of data by the party receiving that data. Take, for example, the disclosure of thousands of farmers' and ranchers' names, home addresses, GPS coordinates and personal contact information" by EPA in response to a Freedom of Information Act (FOIA) request regarding concentrated animal feeding operations (CAFOs) which prompted a lawsuit from the American Farm Bureau Federation and National Pork Producers Council alleging the agency overstepped its authority in doing so.[57] While this event represents the disclosure of information by an enforcement agency, many farmers fear the converse—that an enforcement agency could compel a data-receiving party to disclose information even if such disclosure were not legally required. Another concern is whether an adverse party in litigation (or even a party contemplating litigation) could persuade a party holding a farmer's data to disclose the data as an aid to their case, again even if such disclosure was not legally required.

Much work remains to be done on defining governmental safeguards against disclosures, and even more work remains to be done in defining how the government can obtain electronic data. Although laws such as the ECPA (heavily modified by the USA Patriot Act) govern the acquisition of information through intercepted communications, there is little law to prevent a government agency from simply requesting data from a service provider. Anecdotal evidence suggests service providers and their legal counsel continue to struggle in defining parameters for how to respond to non-subpoenaed requests for data by government agencies.

All these issues surround restrictions on the taking of information by some unauthorized (or at least questionable) means. While there are at least some laws potentially applicable in these circumstances, there are no laws defining an inherent privacy right in agricultural data.[58] For example, the Federal Health Insurance Portability and Accountability Act ("HIPAA")[59] provides privacy rights and restrictions against disclosure of health information; the Gramm-Leach Bliley Act (also known as the Financial Modernization Act of 1999)[60] and Fair Credit Reporting Act[61] protect financial information from disclosure; the Privacy Act of 1974[62] restricts disclosures of personal information by held by the Federal government. As of now, though, there are large categories of agricultural data that may fall between the

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[53] *See* C. Heinrich, *Secure Socket Layer (SSL),* in ENCYLOPEDIA OF CRYPTOGRAPHY AND SECURITY 1135 (Henck C.A. van Tilborg, Sushil Jajodia, eds., 2011)

[54] S. Sammataro, "Cybersecurity for Small or Regional Law Firms," paper presented at American Agricultural Law Association Annual Symposium, Charleston, South Carolina (October 23, 2015).

[55] 18 U.S.C. §§ 1030 *et seq.*

[56] 18 U.S.C. §§ 2510 *et seq.*

[57] S. Wyant, "Farm Groups File Lawsuit to Stop EPA Release of Farmers' Personal Data." Agri-Pulse (2013), available at *http://www.agri-pulse.com/Farm-groups-file-lawsuit-to-stop-EPA-release-of-farmers-personal-data-07082013.asp* (last visited November 8, 2017).

[58] T. Janzen, "Legal Issues Surrounding Farm Data Ownership, Transfer, and Control," paper presented at American Agricultural Law Association Annual Symposium, Charleston, South Carolina (October 23, 2015).

[59] 42 U.S.C. § 300gg, 29 U.S.C. §§ 1181 *et seq.* and 42 U.S.C. §§ 1320d *et seq.*

[60] 15 U.S.C § 6803.

[61] 15 U.S.C. §§ 1681 *et seq.*

[62] 5 U.S.C. § 552a.

cracks of these laws with no Federal (and in most cases, no state) protections against its disclosure.

5. Potential Policy Responses to Address Agricultural Data Issues

Having reviewed the current legal environment surrounding the ownership rights and privacy protections relevant to agricultural data, what can this Committee and Congress do to enable U.S. farmers and ranchers to take maximum economic advantage of Big Data tools? As referenced above, Big Data cannot be Big Data without "buy-in" to the system from large numbers of agricultural producers. In these beginning years of agricultural data systems, there are many ATPs vying for farmers and their acreages to enroll in their systems. As the system matures, this relationship will likely shift, and there will be few (or perhaps only one) ATP and the vast majority of farms may be participating. Nevertheless, for the maturation process to begin, agricultural producers must "buy in" to the system. At a fundamental level, that buy-in requires trust in the system from those producers. That trust, in turn, likely requires answers to the questions of ownership and privacy in agricultural data.

None of the Federal intellectual property laws directly address who holds a protectable intellectual property right in agricultural data. Arguably, the most appropriate fit may be found in state law under the UTSA, although the applicability of that law is questionable as well. The UTSA may provide a useful map to any Congressional efforts to help define ownership rights in agricultural data. Passage of statutory law defining ownership of "agricultural data" may be a daunting task given the complexity of the current Federal and state intellectual property framework (which also draws from centuries of common law). Thus, it may be advisable instead to use a consensus-driven approach among agricultural producers and service providers to define agricultural data rights. The coalition led by the American Farm Bureau Federation and its "Privacy and Security Principles for Farm Data"[63] represents a tremendous step forward on this issue. Other groups, such as the Open Ag Data Alliance, continue to build coalitions on the technical side of the Big Data issue to develop systems and standards embodying the principles of interoperability, security and privacy.[64] The next step is to see continued cooperation among groups such as these in integrating their principles in legally-binding service agreements.

Another collaborative effort to help agricultural producers evaluate the data policies and protections of data service providers has been the Ag Data Transparency Evaluator, coordinated by the American Farm Bureau Federation, which requires service providers to undergo a ten-factor review (based in part on the Privacy and Security Principles, with the review self-reported by the service provider) with a satisfactory review resulting in the "Ag Data Transparent" seal.[65] Congressional support of this and other efforts to equip farmers and ranchers in evaluating the data tools available can help foster trust, encourage Big Data participation, and drive many of the potential advantages Big Data services have to offer.

Modern agricultural producers are expected to be proficient in a broad array of the disciplines of science and business, but few have a background in intellectual property law. Support of educational programs to help these producers understand the legal issues at play in Big Data service agreements could do much to help increase trust, advance the consensus process, and empower producers to make informed decisions about the cost-benefit analysis of sharing their data under those service agreements. The consensus process may also provide a vehicle for developing an understanding among all stakeholders as to the privacy protections necessary and appropriate to protect agricultural data, which occupies a unique space between purely personal and business information. Such information does not readily fit into the existing framework of Federal privacy laws, and as business information, may not belong in such a framework.

One matter in which Congressional action may be directly applied is the development of clearer guidelines regarding the production of agricultural data held by private data aggregators, more robust safeguards against inadvertent disclosure or intentional hacking by outside parties, and clear guidance on when disclosure of government-held data is, and is not, required under the Freedom of Information Act[66] or other circumstances.

Finally, although outside the direct scope of a discussion of legal issues in agricultural use of agricultural data tools, rural access to wireless broadband services is

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[63] American Farm Bureau Federation, "Privacy and Security Principles for Farm Data," November 13, 2014 (revised April 1, 2016). Available at *https://www.fb.org/issues/technology/data-privacy/privacy-and-security-principles-for-farm-data* (last visited November 8, 2017).

[64] Open Ag Data Alliance, "Principals and Use Cases," *http://openag.io/about-us/principals-use-cases/* (last visited November 8, 2017).

[65] *See www.agdatatransparent.com* (last visited November 8, 2017).

[66] 5 U.S.C. §552.

crucial to fully utilizing the potential of agricultural data systems. Before the rapid adoption and usage of agricultural data technologies will occur, the lack of this enabling technology must be addressed. The expansion of connectivity across the U.S. has been a priority, but access has grown slowly. This is especially true in the major crop producing regions. The majority of data transfer occurs over cellular systems, but there are worldwide initiatives to provide wireless connectivity via satellite, balloons, and other platforms. Regardless of platform, the agricultural industry relies upon wireless connectivity to support big data systems.

Telematics allows data to be wirelessly uploaded and downloaded between farm machinery and online servers. However, limited connectivity is a barrier to adoption leading to potential economic losses.[67] Whitacre *et al.* addressed the current connectedness of agricultural production areas.[68] It was these areas that were impacted by the United States Federal Communications Commission (FCC) updated definition of connectivity that could be considered broadband in January 2015. The definition changed from 4 Megabits per second (Mbps) download and 1 Mbps upload to 25 Mbps download and 3 Mbps upload. Although broadband speeds did not instantly change, the level of connectivity that service providers could advertise as 'broadband' changed. The faster speeds required to be considered broadband brought light to connectivity barriers, especially with respect to connectivity gaps in rural areas where agricultural production occurs. Specifically, the 25 Mbps download speed requirement negates the majority of United States wireless connections from being classified as broadband.

However, the vast majority of data being passed between farm equipment and online servers is uploaded rather than downloaded; and upload speeds are typically only a fraction of download speeds. For some types of data such as machine diagnostics and prescriptions, current speeds may be adequate. However, yield data and specifically imagery data may require connectivity speeds in excess of what is currently available. In summary, a concerted national policy effort must be made to expand broadband access in rural areas for a number of important rural development purposes, not the least of which is to facilitate the potential economic advantages to be gained by integration of agricultural data technologies on farms and ranches.

Concluding Remarks

The application of Big Data to agricultural production holds the potential to improve the profitability of U.S. agriculture and to better prepare its farmers and ranchers to handle the inherent risks of the industry. Additionally, Big Data could play a vital role in the further development of tools and techniques necessary to feed an ever-growing, hungry world. I commend this Subcommittee for its foresight in addressing these issues, and sincerely thank the Subcommittee, Chairman Moran, and Ranking Member Blumenthal for the opportunity to address you today.

Senator MORAN. Thank you very much, Doctor.

Mr. Janzen, welcome.

STATEMENT OF TODD J. JANZEN, PRESIDENT, JANZEN AGRICULTURAL LAW LLC

Mr. JANZEN. Thank you, Mr. Chairman, Ranking Member Blumenthal, and members of the Subcommittee. My name is Todd Janzen. I'm an attorney, a private practice attorney, in Indianapolis, Indiana. And the firm that I work at, Janzen Agricultural Law LLC, specializes in helping farmers, ag technology providers, and also agribusinesses.

But I speak here today not only as an attorney, but also as somebody who grew up on a farm in south-central Kansas, a grain and livestock farm. And so I'm particularly attuned to the issues that farmers are facing on a legal front.

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[67] Griffin, T.W., and Mark, T.B. (2014). "Value of Connectivity in Rural Areas: Case of Precision Agriculture Data." International Conference on Precision Agriculture. July 20–23, 2014. Sacramento, CA.

[68] Whitacre, B.E., Mark, T.B., and Griffin, T.W. (2014). How Connected are Our Farms? Choices. Online: *http://www.choicesmagazine.org/choices-magazine/submitted-articles/how-connected-are-our-farms.*

Let me start, though, by talking about the types of data that are being collected by the various ag data platforms that are out there because I think that's helpful in understanding the framework here.

So there are various streams of data I like to say that come off of fields and farms, and this can include land data, agronomic data, weather data, management data, machine data, and also livestock data, which would be information about genetics or feed consumption by animals.

But what's really changed in the last 5 years is not just that farmers are generating this information, but now farmers are taking this information and storing it in cloud-based servers that are not located on the farm. And so this transfer of information off the farm I think is a pretty monumental transition in history for U.S. agriculture.

But with this transfer of information, there have also been some groups that have started to raise concerns, you know, about farmers losing out on the benefit of knowing all this and having all this information on their farm.

A poll by American Farm Bureau in 2016 identified a number of issues that farmers faced, but I classify them into three big categories. One is a lack of trust with a lot of these ag technology providers that are on the market today. Second would be a loss of control to these companies. And then the third would be something that some other panelists have already mentioned, which is just the overall complexity of the agreements that farmers are being asked to sign. I heard a farmer yesterday describe this as the aggressive fine print.

So to address these problems, American Farm Bureau, National Farmers Union, and the commodity groups from a number of national organizations came together and said, "Let's create a set of core principles that we can all agree on." So in 2014, they introduced a document called the "Privacy and Security Principles for Farm Data," which really outlined some core principles that they wanted to see adopted by the industry.

And 37 different companies and organizations signed onto these core principles by pledging that they would incorporate them into their contracts, but here we are today, and we don't yet have all 37 of those who have really met the challenge that they agreed to take on years ago.

So as a follow up to this effort, American Farm Bureau, Farmers Union, and others came together and said, "Let's create some sort of certification process where we can recognize companies that are adhering to these core principles for agricultural data." And so out of that came this Ag Data Transparency Evaluator process, which I've been fortunate enough to be a part of. And I want to just briefly describe how that works so that it's clear to the Subcommittee.

Companies that want to be certified as "Ag Data Transparent" can submit their contracts and answer a 10-question form about how they use farmers' ag data. That is then reviewed by an independent third-party administrator, and currently Janzen Agricultural Law is that administrator. So we take that information and we review it, and we ultimately determine if companies are being transparent with how they are using agricultural data or if they're

not being transparent, in which case, we send them back and ask them to do it over.

But if they are transparent, then they are awarded the "Ag Data Transparent" seal of approval. And you may see this on some companies' marketing materials. And I'll mention Farmobile, one of the very first companies to go through this process and has been awarded the "Ag Data Transparent" seal of approval.

So we review these questions, such as, "What data is being collected?" Does the company obtain consent before the data is transferred in or out of that platform? And then also, "Can a farmer delete their data if they're finished using that platform?" And then we post the results of this question-and-answer to the *AgData Transparent.com* website so that farmers can review this and make informed decisions before they go down the road of sending their data to one of these companies.

So here we are today. We've had nine companies go through this evaluation process and be certified "Ag Data Transparent." There is still a lot of work to do because there are a lot of companies that have said they want to do this process or maybe they've committed to it, but yet they haven't followed through and become certified.

So, Mr. Chairman and members of the Subcommittee, I'm honored to be here today, and I look forward to your questions. I think this is a very important issue for farmers, and I hope that we can address them.

Thank you.

[The prepared statement of Mr. Janzen follows:]

PREPARED STATEMENT OF TODD J. JANZEN, PRESIDENT, JANZEN AGRICULTURAL LAW LLC

Good afternoon Chairman Moran, Ranking Member Blumenthal, and members of the Subcommittee. My name is Todd J. Janzen, I am the president and attorney with Janzen Agricultural Law, LLC, a law firm based in Indianapolis, Indiana that serves the needs of America's farmers, ag technology providers, and agribusinesses.

One of the reasons we founded Janzen Ag Law in 2015 was that we wanted to be at the forefront of the changes that have been occurring on the farm for the past few years. Farms are becoming more digital every day, and together with that digitalization is a movement of agricultural data stored on computers in the farm office to cloud-based data storage devices. Agricultural data (ag data) can be many things, including yield data, soil data, planting information, weather data, financial data, etc. This marks the first time in history that the majority of the information that farmers generate and use on their farms has been moved into the hands of companies outside the farm.

As a result, we are seeing a digital land-rush occurring across the United States. The past few years have seen millions of dollars pour into ag data startups from Silicon Valley, to Kansas City, to North Carolina. Historic legacy agricultural companies, such as John Deere, are also at the forefront of this movement by expanding their product offerings to include cloud-based data storage platforms. All of these companies are scrambling to get the most acres of data into their platforms so that when consolidation of ag technology providers (ATPs) begins, they are in the strongest position.

In the race to the cloud, we must also be cautious so that the American farmer is not left behind. Today I will address the issues facing farmers as digitalization occurs and how the industry has begun to address these issues.

Issues Facing Farmers as Ag Data Moves into the Cloud

American Farm Bureau Federation (Farm Bureau) conducted a poll of over 400 farmers in 2016 to understand their issues concerning ag data privacy, security, and control. The poll highlighted what are essentially three issues that continue to come up when asking farmers about ag data concerns:

1. Lack of Trust

Seventy-seven percent (77 percent) of farmers expressed concern about which entities can access their farm data after the data is uploaded to cloud-based servers. The same percentage expressed concern about whether uploading the data could cause it to be used for regulatory purposes.

Sixty-seven percent (67 percent) of farmers said they consider how outside parties will use their ag data when deciding whether to entrust their data with a certain ATP.

A farmer's lack of trust can come from many sources, but I speculate it originates in two places. Many ag data companies are new. Ag data startups lack the goodwill that older agricultural companies have spent years building. They have new sales associates who are strangers to the farm, or in some instances, strangers to agriculture. They are viewed as outsiders.

Older, long-established agricultural companies do not suffer from a general lack of trust with the farmer, since they have spent years building that relationship. But when a seed company, equipment manufacturer, or ag retailer begins offering an ag data platform to store the farmer's ag data, farmers often are skeptical about whether the storage provider is trying to help the farmer raise a better crop or using the ag data to sell the farmer more or higher-priced goods and services. This skepticism may erode a farmer's trust.

2. Concern with Losing Control

Farmers are also concerned that uploading their ag data to cloud-based platforms means they will lose control over downstream uses. Sixty-six percent (66 percent) of respondents in the Farm Bureau poll believe farmers should share in the potential financial benefits from the use of their data beyond the direct value they may realize on their farm.

Farmers raised concerns that ATPs could use their ag data to gain an unfair advantage in the marketplace. Sixty-one percent (61 percent) of farmers expressed worry that ATPs could use their data to influence market decisions.

These concerns arise from a fundamental legal truth about ag data—there are no laws that specifically protect farmers' privacy and security concerns. Ag data is not typically "personally identifiable information," such that it would be protected by state laws which prevent misuse of personal information like name, address, and phone number. Nor does ag data fit into a class of data that Congress has chosen to protect legally, such as medical information (HIPAA). Finally, ag data does not neatly fit into existing legal protections for intellectual property, such as patents, trademarks, or copyrights. Ag data ultimately may be deemed a trade secret under existing state and Federal trade secret laws, but that will depend upon whether courts interpret existing statutes to include information such as agronomic data.

These uncertainties mean that the contracts between farmers and ag tech providers are very important. These contracts will determine farmers' rights in the ag data their farms create.

3. Frustration with Complexity of Current Legal Agreements

Fifty-nine (59 percent) percent of farmers were confused about whether current legal agreements allowed ATPs to use their ag data to market other services, equipment, or inputs back to them. Zippy Duvall, president of Farm Bureau, said: "This indicates a higher level of clarity and transparency is needed to secure grower confidence. One of the topics I hear most about from farmers on the data issue is having a clear understanding about the details of 'Terms and Conditions' and 'Privacy Policy' documents we all sign when buying new electronics. You should not have to hire an attorney before you are comfortable signing a contract with an ag technology provider."

Our experience as a law firm working in this area confirms that this is a real problem for farmers and ATPs. There is no standard agreement that governs ag data transfer, use, and control by ATPs. Instead, technology companies have adapted other forms of legal agreements to try to address the issues associated with moving ag data into cloud-based platforms, but with limited success. A farmer seeking to compare two similar products today might find that they are governed by two very different sets of contracts.

This only adds to a farmer's confusion. If we want to make technology easy to embrace and use—and we do—then we need to simplify the contracts farmers sign when implementing new ag data technology on the farm. Contracts that no one reads and understands set the stage for problems down the road.

How the Ag Industry is Addressing Farmers' Concerns

1. The Privacy and Security Principles for Farm Data

Farm Bureau, National Farmer's Union, and national commodity organizations for corn, soybeans, wheat, and sorghum, led an effort in 2014 to establish fundamental principles for companies working in the ag data space. These organizations held a series of meetings where roundtable discussions occurred among industry stakeholders, such as John Deere, CNH Industrial, AGCO, Monsanto, DuPont Pioneer, Beck's Hybrids, Dow Agrosciences, Farmobile, and other ag technology providers. The culmination of these efforts was the drafting of the "Privacy and Security Principles for Farm Data," also known today as ag data's "Core Principles."

The Core Principles address thirteen key elements related to ag data. These include:

- Education
- Ownership
- Collection, Access and Control
- Notice
- Transparency and Consistency
- Choice
- Portability
- Terms and Definitions
- Disclosure, Use, and Sale Limitation
- Data Retention and Availability
- Contract Termination
- Unlawful or Anti-Competitive Activities
- Liability & Security Safeguards

After releasing the Core Principles in 2014, Farm Bureau asked companies to voluntarily "sign on" to the document. As of October 2017, the following organizations and companies have agreed to implement the Core Principles into their contracts with farmers.

AGCO
Ag Connections, Inc.
Agrible, Inc.*
AgSense
AgWorks
Ag Leader Technology
American Farm Bureau Fed.
American Soybean Assoc.
Beck's Hybrids*
CNH Industrial
Conservis*
Crop IMS
CropMetrics
Dow AgroSciences LLC
DuPont Pioneer
Farm Dog
Farmobile LLC*
Granular*
Grower Information Services Cooperative
GROWMARK, Inc.*
Independent Data Management LLC*
ohn Deere
Mapshots, Inc.
National Assoc. of Wheat Growers
National Barley Growers Assoc.
National Corn Growers Assoc.
National Cotton Council
National Farmers Union
National Potato Council
National Sorghum Producers
North American Equipment Dealers Assoc.
OnFarm
Raven Industries
Reinke Manufacturing Co., Inc.
Syngenta
The Climate Corporation—a division of Monsanto
USA Rice Federation
Valley Irrigation
ZedX Inc.

*Company certified to be Ag Data Transparent. For more information, visit *www.agdatatransparent.com*

A copy of the Core Principles is attached as *Exhibit A.*

2. The Ag Data Transparent Effort

Having the Core Principles in place was a great starting point for the ag data industry to address farmers' concerns with ag data privacy, use, and control. However, the Core Principles are only guidelines, and only valuable if companies incorporate the Core Principles into their contracts with farmers. Therefore, following the release of the Core Principles, several farm groups and industry stakeholders worked together to create an independent verification tool that could help farmers determine if ag tech providers are abiding by the Core Principles. This tool is called the Ag Data Transparency Evaluator. It is a simple three-step process:

- Participating companies must answer 10 questions about how they store, use, and transfer ag data.
- The 10 question answer form is reviewed by an independent third party for transparency and completeness.
- If the evaluation is acceptable, the company is awarded the "Ag Data Transparent" seal of approval for use on its future marketing materials.

Participation is voluntary, but all companies that signed onto the Core Principles have been asked to participate in the Ag Data Transparent effort as well.

a. The 10 Question Evaluation. Here is a list of the 10 questions that each participant is asked to answer as part of the evaluation:

1. What categories of data does the product or service collect from me (the farmer)?
2. Do the Ag Technology Provider's (ATP's) agreements address ownership of my data after my data is transferred to the ATP?
3. If the ATP contracts with other companies to provide data related services, does the ATP require these companies to adhere to the ATP's privacy policies with me?
4. Will the ATP obtain my consent before providing other companies with access to my data?
5. After I upload data to the ATP, will it be possible to retrieve my original complete dataset in an original or equivalent format?
6. Will the ATP notify me when its agreements change?
7. Will the ATP notify me if a breach of data security occurs that causes disclosure of my data to an outside party?
8. Upon my request, can my original dataset be deleted when my contract with the ATP terminates?
9. Do the ATP's agreements establish how long my original datasets will be retained?
10. Do the ATP's agreements address what happens to my data if the ATP is sold to another company?

Answers to all questions except for question 1 are "yes" or "no," but companies are also given space to explain their answer.

b. Reviewing the 10 Question Evaluation.

After an ag tech company completes the 10 question evaluation form, the company submits its answers to an independent third party evaluator to determine compliance. Janzen Agricultural Law LLC is the law firm that has been selected to conduct the evaluations. After reviewing a company's answers, we typically go back to that company with suggestions for improving its contracts and policies to bring into compliance with Core Principles. Companies then make those revisions to their contracts and policies and resubmit their 10 question form. Once a company's answers align with the Core Principles, we send an official letter designating the company as "Ag Data Transparent" and authorizing use of the seal of approval.

The final, approved 10 question answer forms are posted on the Ag Data Transparent website at *www.AgDataTransparent.com* Farmers can research and review companies' answers online. The website requires no log in and is free to use. An example of the home page is attached as *Exhibit B*.

c. The Ag Data Transparent Seal of Approval

Companies that undergo evaluation and are approved as "Ag Data Transparent" may then use the seal of approval on their websites and marketing materials. To date, nine companies have completed the evaluation and been approved as "Ag Data Transparent." These nine companies are:

- AgDNA
- AgIntegrated, Inc.
- Agrible, Inc.
- Beck's Hybrids
- Conservis Corporation
- Farmobile
- Granular
- GROWMARK

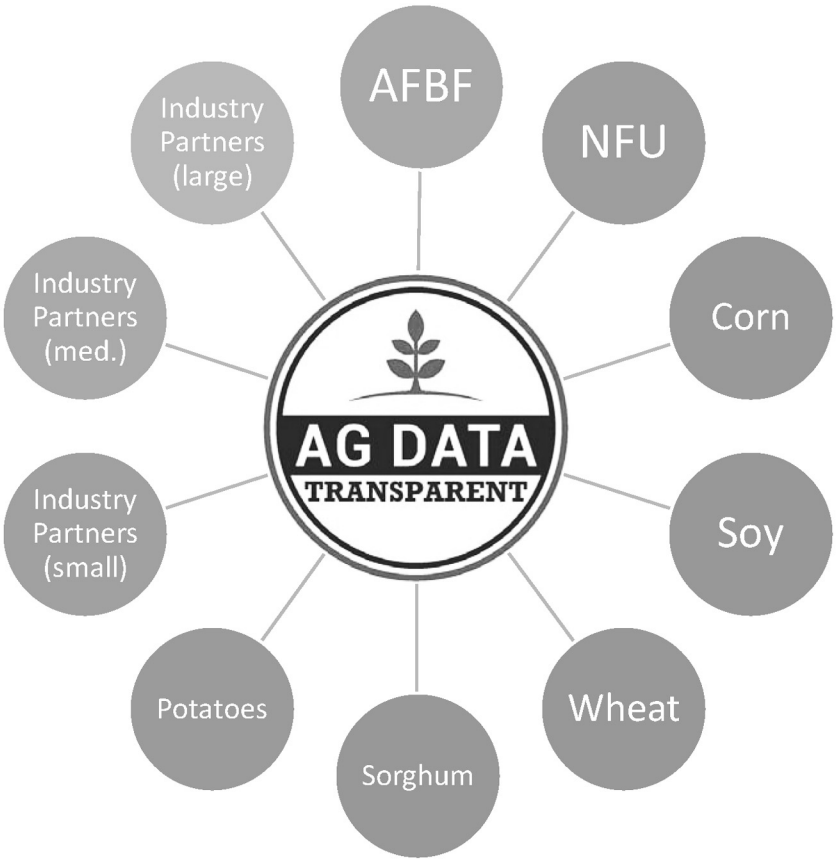
- Independent Data Management LLC

The participants are diverse, from a Silicon Valley ag tech startup, to a Midwestern seed company, to one of the Nation's largest farm cooperatives and ag retailers. These companies may use the Ag Data Transparent seal on their websites, denoting their compliance with the Core Principles. Farmers who see the seal of approval will know the company went through the time and effort to certify its contract.

The Ag Data Transparent process addresses farmers' three main concerns with ag data. First, the process instills trust. No company submits its contracts to a voluntary evaluation unless the company is willing to revise its contracts, as necessary, to bring them into compliance with the Core Principles. Second, loss of control is addressed by requiring tech providers to obtain farmer consent before transferring data to third parties. Finally, farmers' complexity frustration is addressed by condensing all of a tech provider's contracts into a 10 question form that answers the questions farmers want to know. The Ag Data Transparent process makes contracts better.

d. Who is behind the Ag Data Transparent effort?

The Ag Data Transparent effort is governed by a non-profit corporation, the Ag Data Transparency Evaluator Inc. The corporate bylaws create two classes of directors: (1) farm organizations that are made up of farmer-member organizations; and (2) diverse ag technology providers, referred to as "industry partners." The farm organizations are American Farm Bureau Federation, American Soybean Association, National Corn Growers Association, National Farmers Union, National Sorghum Producers, National Association of Wheat Growers and National Potato Council. The industry partner board members are ag technology providers ranging from large corporations, medium-sized companies, and ag tech startup organizations.



Janzen Agricultural Law LLC, which serves as the administrator of the program and conducts the evaluation reviews, is not a board member.

3. The Ag Data Use Policy

Our law firm also drafts terms of service, license agreements, privacy policies, and other contracts for ag technology providers. This work has confirmed many concerns facing farmers today when it comes to ag data. We see how companies struggle to communicate clearly how they intend to store, use, and transfer ag data.

For these reasons, we have encouraged companies to draft "data use policies" or "data use agreements" for their farmers. In a typical data use contract, the technology provider addresses all of the issues raised by the 10 questions and the Core Principles. For example, a data use policy will explain what information the provider collects and what permission is required before the provider transfers that data to another party.

From our standpoint, the Ag Data Transparent effort has helped drive more technology providers into creating data use policies. Thus, the effort has paid dividends even for some companies that have not participated in evaluations because it has caused them to rethink how they are contracting with farmers.

Conclusion

The Ag Data Transparent effort is great step towards bringing transparency to ag data contracts between farmers and their technology providers. Wider participation would certainly help the effort, but that is up to the industry. Out of the dozens of ag tech providers with cloud-based platforms on the market today, only nine have completed the certification process. A few companies are in the process of certifying, but uptake could be better.

Farmers should ask their technology providers why they have not earned that Ag Data Transparent seal. This Subcommittee should ask technology providers this question as well when they come before you to testify in future hearings.

Thank you, Mr. Chairman and Ranking Member for your time and attention to this important issue. I look forward to answering any questions you may have for me.

EXHIBIT A

PRIVACY AND SECURITY PRINCIPLES FOR FARM DATA

(AG DATA'S CORE PRINCIPLES)

November 2014

The recent evolution of precision agriculture and farm data is providing farmers with tools, which can help to increase productivity and profitability.

As that technology continues to evolve, the undersigned organizations and companies believe the following data principles should be adopted by each Agriculture Technology Provider (ATP).

It is imperative that an ATP's principles, policies and practices be consistent with each company's contracts with farmers. The undersigned organizations are committed to ongoing engagement and dialogue regarding this rapidly developing technology.

Education: Grower education is valuable to ensure clarity between all parties and stakeholders. Grower organizations and industry should work to develop programs, which help to create educated customers who understand their rights and responsibilities. ATPs should strive to draft contracts using simple, easy to understand language.

Ownership: We believe farmers own information generated on their farming operations. However, it is the responsibility of the farmer to agree upon data use and sharing with the other stakeholders with an economic interest, such as the tenant, landowner, cooperative, owner of the precision agriculture system hardware, and/or ATP etc. The farmer contracting with the ATP is responsible for ensuring that only the data they own or have permission to use is included in the account with the ATP.

Collection, Access and Control: An ATP's collection, access and use of farm data should be granted only with the affirmative and explicit consent of the farmer. This will be by contract agreements, whether signed or digital.

Notice: Farmers must be notified that their data is being collected and about how the farm data will be disclosed and used. This notice must be provided in an easily located and readily accessible format.

Transparency and Consistency: ATPs shall notify farmers about the purposes for which they collect and use farm data. They should provide information about how farmers can contact the ATP with any inquiries or complaints, the types of third parties to which they disclose the data and the choices the ATP offers for limiting its use and disclosure.

An ATP's principles, policies and practices should be transparent and fully consistent with the terms and conditions in their legal contracts. An ATP will not change the customer's contract without his or her agreement.

Choice: ATPs should explain the effects and abilities of a farmer's decision to opt in, opt out or disable the availability of services and features offered by the ATP. If multiple options are offered, farmers should be able to choose some, all, or none of the options offered. ATPs should provide farmers with a clear understanding of what services and features may or may not be enabled when they make certain choices.

Portability: Within the context of the agreement and retention policy, farmers should be able to retrieve their data for storage or use in other systems, with the exception of the data that has been made anonymous or aggregated and is no longer specifically identifiable. Non-anonymized or non-aggregated data should be easy for farmers to receive their data back at their discretion.

Terms and Definitions: Farmers should know with whom they are contracting if the ATP contract involves sharing with third parties, partners, business partners, ATP partners, or affiliates. ATPs should clearly explain the following definitions in a consistent manner in all of their respective agreements: (1) farm data; (2) third party; (3) partner; (4) business partner; (5) ATP partners; (6) affiliate; (7) data account holder; (8) original customer data. If these definitions are not used, ATPs

should define each alternative term in the contract and privacy policy. ATPs should strive to use clear language for their terms, conditions and agreements.

Disclosure, Use and Sale Limitation: An ATP will not sell and/or disclose non-aggregated farm data to a third party without first securing a legally binding commitment to be bound by the same terms and conditions as the ATP has with the farmer. Farmers must be notified if such a sale is going to take place and have the option to opt out or have their data removed prior to that sale. An ATP will not share or disclose original farm data with a third party in any manner that is inconsistent with the contract with the farmer. If the agreement with the third party is not the same as the agreement with the ATP, farmers must be presented with the third party's terms for agreement or rejection.

Data Retention and Availability: Each ATP should provide for the removal, secure destruction and return of original farm data from the farmer's account upon the request of the farmer or after a pre-agreed period of time. The ATP should include a requirement that farmers have access to the data that an ATP holds during that data retention period. ATPs should document personally identifiable data retention and availability policies and disposal procedures, and specify requirements of data under policies and procedures.

Contract Termination: Farmers should be allowed to discontinue a service or halt the collection of data at any time subject to appropriate ongoing obligations. Procedures for termination of services should be clearly defined in the contract.

Unlawful or Anti-Competitive Activities: ATPs should not use the data for unlawful or anti-competitive activities, such as a prohibition on the use of farm data by the ATP to speculate in commodity markets.

Liability & Security Safeguards: The ATP should clearly define terms of liability. Farm data should be protected with reasonable security safeguards against risks such as loss or unauthorized access, destruction, use, modification or disclosure. Polices for notification and response in the event of a breach should be established.

The undersigned organizations for the Privacy and Security Principles of Farm Data as of April 1, 2016.

AGCO
Ag Connections, Inc.
Agrible, Inc.*
AgSense
AgWorks
Ag Leader Technology
American Farm Bureau Federation
American Soybean Association
Beck's Hybrids*
CNH Industrial
Conservis*
Crop IMS
CropMetrics
Dow AgroSciences LLC
DuPont Pioneer
Farm Dog
Farmobile LLC*
Granular*
Grower Information Services Cooperative
GROWMARK, Inc.*
Independent Data Management LLC*
John Deere
Mapshots, Inc.
National Association of Wheat Growers
National Barley Growers Association
National Corn Growers Association
National Cotton Council
National Farmers Union
National Potato Council
National Sorghum Producers
North American Equipment Dealers Association
OnFarm
Raven Industries
Reinke Manufacturing Co., INC.
Syngenta
The Climate Corporation—a division of Monsanto
USA Rice Federation
Valley Irrigation
ZedX Inc.

*Company that has also certified its policy is compliant with the Ag Data Transparency Evaluator. For more information, visit *www.agdatatransparent.com*

EXHIBIT B

AG DATA TRANSPARENT HOMEPAGE

www.AgDataTransparent.com

Senator MORAN. Thank you very much.
Dr. Haman.

STATEMENT OF DR. DOROTA HAMAN, PH.D., PROFESSOR AND CHAIR, AGRICULTURAL AND BIOLOGICAL ENGINEERING, INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES, UNIVERSITY OF FLORIDA (UF/IFAS)

Dr. HAMAN. Chairman Moran, Ranking Member Blumenthal, and members of the Committee, thank you very much for this invitation to talk about technology in agriculture and data-driven farming.

My name is Dorota Haman, and I am Professor and Chair of Agricultural Engineering at the University of Florida, and I have been working there since 1985. Agriculture is a major economic driver in Florida. Florida agriculture is very diverse and focused on specialty crops with most farms smaller and complex, and they are much more complex than large Midwest farms dedicated to crops like soybean, corn, or wheat.

This diversity makes introduction of new technologies more complicated, and data collection is also more complicated, and analytics are more complicated. Many Agricultural Technology Providers are

focused on agronomic crops, not on specialty crops, such as citrus, tomatoes, strawberries, blueberries, and other fruit and vegetables produced in Florida.

Data-driven farming is the future of agriculture. Furthermore, it is becoming clear that the future of agricultural operation will embrace the concept of Internet of Things, a system of interrelated computing devices, machines, robots, sensors, actuators, and network connectivity. Many technologies are needed to bring agricultural operation to this new level, and many of them have been available for some time, but they are now becoming economical to introduce in agriculture. Farmers will need to accept these technologies to be competitive.

New farm technologies and monitoring equipment are already producing enormous amount of data at a wide variety of spatial and temporal scales. Raw data are not very useful, but become very valuable if appropriate algorithms are developed and applied. Process data used by farmers are also valuable to others, including insurance companies and commodity markets.

A level of data standardization will be necessary for optimal sharing and utilization, including a common pool infrastructure to facilitate transfer and integration of data from different sources. Common pool infrastructure would also facilitate collection of information for the USDA National Statistics Service.

There is no doubt that standardization and openness of platforms would accelerate solution development and innovation. However, data ownership and privacy and security of information in relation to agricultural Big Data analytics must be addressed.

It can be argued that access to high-quality farm data gives large agribusiness advantage over small farmers with limited resources. Open source analytics developed by public institutions, such as universities and Cooperative Extension Service using public funds, for example, USDA funds, NSF funds, would provide the solution for those farmers.

These are exciting times for agriculture. Scientists and engineers have been focusing on research in the area of robotics, remote sensing, machine vision, machine learning, for many years. Progress has been made on early estimation of yields for specialty crops, such as citrus, strawberries. This was done using autonomous vehicles and machine vision. These techniques need to be adapted for other specialty crops.

Extensive weather data and crop models help growers evaluate climate change adaptation strategies. We have developed technology to remotely diagnose citrus "greening," a devastating citrus disease. Data-driven technologies can also improve farm safety through use of alerts and wearable sensors, and save lives.

I want to thank you for your time. I'm happy to answer any questions you might have.

[The prepared statement of Dr. Haman follows:]

PREPARED STATEMENT OF DR. DOROTA HAMAN, PH.D., PROFESSOR AND CHAIR, AGRICULTURAL AND BIOLOGICAL ENGINEERING, INSTITUTE OF FOOD AND AGRICULTURAL SCIENCES, UNIVERSITY OF FLORIDA (UF/IFAS)

Chairman Moran, Ranking Member Blumenthal and Members of the Committee, thank you for the invitation to talk about technology in agriculture and data-driven farming. My name is Dorota Haman. I am a Professor and Chair of Agricultural and

Biological Engineering Department (ABE) at the University of Florida (UF) in Gainesville, Florida.

I was educated as an agricultural engineer at Michigan State University and I have been living in Florida and working at the University of Florida since 1985. My research, teaching and extension work has been focused on water management in irrigated agriculture. Since 2007, I have been in a leadership position in Agricultural and Biological Engineering at UF and have been working with an interdisciplinary group of scientists and engineers. I have also been involved in the American Society of Agricultural and Biological Engineers (ASABE) for over 30 years, serving on various technical committees and on the Board of Trustees and I am Fellow of this organization. This testimony represents my view on the emerging, and rapidly growing area of data-driven agriculture.

Technology is rapidly changing the way we live, work and interact. This is also true in agriculture. The way we farm and produce food and fiber is experiencing a rapid change and it will only undergo more dramatic change in the near future. Agricultural operations and machinery are becoming more automated, computerized and data-driven. The future of agricultural operations will include the Internet of Things (IoT), defined as a system of interrelated computing devices, machines, robots, sensors, actuators and network connectivity. The transfer of data in this system does not require human-to-human or human-to-computer interaction.

More and more sensors are introduced every day to agricultural operations and monitoring systems. Increasingly, these sensors are connected through wireless communications to the internet, making data available in farm databases and mapping systems, and, more importantly, for enabling analysis of what affects what, why, when and how.

Many technologies that are needed to bring agricultural operations to this new level have been available for some time, but they are only now becoming economical for introduction into agriculture. The convergence of technologies in other fields is rapidly bringing down the cost of devices and sensors, and therefore making agricultural applications economically feasible. For example, sensors built as components of costly medical devices are now economical for farmers. The medical sensor may cost several hundred (if not thousands) of dollars but a simplified, maybe less accurate form, but totally adequate for the agricultural application, is becoming available for a small fraction of the price. The use of unmanned aerial vehicles (UAVs or Drones) in agricultural operations is another good example of technology becoming affordable. A drone that costs a few hundred dollars today, was sold for thousands of dollars a few years ago.

Agriculture is a major economic driver in Florida. Agricultural research and extension at the University of Florida (UF) provides knowledge, innovation and technology transfer that supports 2.2 million agriculture-related jobs and direct industry output of $148 billion in Florida (2014). Florida agriculture is very diverse and focused on specialty crops with most farms smaller and more complex than large Midwest farms dedicated to crops like soybean, corn or wheat. This diversity of production often makes introduction of new technologies more complicated for data collection and analytics. Many Agricultural Technology Providers (ATP) are focusing on agronomic crops not on specialty crops such as citrus, tomatoes, strawberries, blueberries and many other fruits and vegetables produced in Florida.

Florida is also a significant milk producer. Many modern dairy farms are highly computerized and data-driven to optimize their operation. Last week, I visited one of the dairies in North Florida. Each calf is tagged at birth and monitored throughout its entire life on the farm. Calves are fed by robots that adjust the formula of their feed based on need at their individual stage of life. The feed, health, milk production, milk quality, location etc. of every cow are monitored and available when needed. Solid waste is converted to high quality compost sold to the ornamental industry and the liquid waste is recycled through field irrigation to produce more feed for the cows. This is just a glimpse where modern agriculture is now and where it is going.

A successful peanut grower in Levy County, remotely controls center-pivot irrigation systems in response to soil moisture probe data, from anywhere in the world where there is internet, saving time and labor. Remote video systems on center-pivots allow visual monitoring for security and system operation. Enhanced GPS controlled auto-steering systems on tractors on this farm are accurate to less than an inch and virtually hands-off. They precisely map the location of planting, for precise and efficient harvesting several months later. Such precise operations eliminate over-application and overlap of pesticides and fertilizers. Soil can be sampled automatically and indexed to GPS coordinates to regulate a variable fertilizer spreader. These efficiencies save water, fertilizer and money and reduce adverse impacts on the environment.

Responding to Florida growers' needs, scientists and engineers have been focusing on research in the area of robotics, remote sensing and machine vision for many years. Early yield estimation is critical for harvest planning and marketing. Great progress has been made on estimating the yields of various specialty crops such as citrus and strawberries using autonomous vehicles and machine vision. These techniques need to be adapted to other specialty crops.

Huanglongbing (HLB)—commonly called "greening" is a devastating disease that has had significant impact on citrus yield and quality in Florida. Unfortunately, so far, no cure has been reported for HLB. The first critical step for successful control of HLB is its detection and diagnosis. It has been demonstrated that high-resolution aerial imaging using a low-cost UAV or drones can detect the disease. Recently, a vision sensor was introduced and successfully tested at UF for early detection of HLB. Since the majority of Florida citrus is already showing symptoms of the disease, research emphasis is shifting to genetic solutions to the HLB problem.

Sensor-based management of water delivery through irrigation has been implemented on many farms across the U.S. and in Florida. Precision irrigation offers the potential for improving irrigation efficiency through localized water delivery based on plant needs, weather predictions and soil moisture sensors. Reported water savings due to sensor control of irrigation and precise application of water are on average 60 percent. This results in money savings to a farmer and reduced use of precious water resources.

Data-driven technologies can also improve farm safety. Wearable sensors, now under development, can save lives and reduce harm to farm workers. Alert systems that can detect personal overheating, or inform about approaching thunderstorms and lightening (typical in Florida), will also increase safety in the fields. Nine out of the 10 hottest years on record have occurred in the past decade and, according to the Centers for Disease Control and Prevention, farmworkers are more than 20 times at risk for heat-related deaths compared to other occupational groups. Wearable sensors can also alert workers to chemical exposure through direct contact during application, contact with residue on plants, or through drift from nearby applications. The wearable sensors can be also used on various machines, drones and robots to provide immediate safety intervention.

Weather data systems have been essential for efficient management of agricultural systems. A system of automatic weather stations and satellite data provide excellent management tools for Florida growers. The cost of a sophisticated blue-tooth-enabled weather station is now less than $1000. This monitoring will become more critical as climate change leads to increased changes in seasonal temperatures, rainfall patterns, and the frequency and severity of storms. For example, in the last few winters, Florida growers have been affected by insufficient chill-hours to optimize production of temperate fruits such as blueberries, peaches, and strawberries. Adapting to these changes, Florida blueberry growers are experimenting with "evergreen" production of blueberries that does not require chilling. Agriculture in Florida is not only sensitive to the manifestations of climate change mentioned above, but also to the salt water intrusions in coastal irrigation wells as a result of sea-level rise.

Data quality has always been a key issue in farm management information systems, and is more challenging in an era of Big real-time data. Intelligent processing and analytics of Big Data is challenging because of the large amount of often unstructured, heterogeneous data which requires a smart interplay between skilled data-scientists and domain experts. At present, new farm technologies and monitoring equipment are producing enormous amounts of data at a wide variety of spatial and temporal scales. Raw data sets are cumbersome and not directly useful, but become very valuable if appropriate algorithms are developed and applied. Data analytics, frequently provided by ATPs, are being developed for agricultural applications and are a necessary step to make these data valuable to growers. These processed data are also very valuable to others including insurance companies and commodity markets. A level of data standardization will be necessary for optimal sharing and utilization, including a common pool infrastructure to facilitate transfer and integration of data from different sources/companies.

New technologies are introducing new problems and issues that need careful consideration. There is no question that openness of platforms would accelerate solution development and innovation. However, data ownership, and related privacy and security issues are problems that are frequently discussed in relation to Big Data and analytics. These concerns need to be addressed, realizing that enforcement may slow down innovation.

It can be argued that access to high quality data, that allows for predictive business modeling of every aspect of farming, gives large agribusinesses advantage over

farmers, especially small farmers, who do not have sufficient resources to pay for data analytics.

Leveling the playing field for smaller farmers, such as Florida farmers who produce specialty crops, through the use of open source analytics developed by public institutions such as universities and Cooperative Extension Service using public funds (*e.g.,* USDA, NSF) is an option, providing data processing though utilities (apps), interactive models and maps.

In summary:

- Agricultural operations and machinery are becoming more automated, computerized and data-driven. It is becoming clear that the future of agricultural operations will embrace the concept of Internet of Things (IoT).
- Technology is becoming less expensive, and economical in agricultural operations. Farmers will need to adapt to be competitive.
- Farmer-collected raw data become valuable if appropriate algorithms are developed and applied. Data analytics, frequently provided by ATPs, are necessary to make data valuable to growers.
- The processing and analytics of agricultural Big Data is in its infancy, and is challenging because of the large amount of often unstructured, heterogeneous data which requires a smart interplay between skilled data-scientists and domain experts. A common pool infrastructure should be developed to enhance sharing and integration.
- Land-grant universities and Cooperative Extension Service may provide a public platform for data processing though utilities (apps), interactive models, and maps.
- Data ownership, and related privacy and security issues, are problems that are frequently discussed in relation to Big Data and analytics. These concerns need to be addressed.

I want to thank you for taking the time to focus on technological innovations in agriculture. Thank you for inviting me to testify today. I would be happy to answer any questions that you might have.

Senator MORAN. I want to thank you for your time. Thank you very much. And there will be questions.

I think I'll turn now to the Ranking Member for purposes of his questions, and we'll then deal with the other Members of the Senate who are here, and I'll go toward the end.

So, Senator Blumenthal.

Senator BLUMENTHAL. Thanks, Mr. Chairman.

And thank all of you for your testimony. And I think that you have all identified one of the key issues here, "How do we enable farmers to maintain control, either through some kind of opt-in consent or some other means?"

And I just want to call your attention to the fact and ask your comment on the vote that the Senate took not so long ago on a resolution to overturn the Federal Communication broadband privacy rules, which I found extraordinarily regrettable. These rules were repealed, which constituted, in my view, an attack on consumer rights to privacy, but also these rules underlay the potential for protection of privacy in your industry as well.

So I want to ask each of you whether you've considered that all of these efforts may be undermined by the repeal of the FCC's broadband privacy rules because they leave no baseline protection, privacy protection, in place, and broadband providers can sell and share farmer data just as they can other consumer data, and whether you might recommend that we and principally the FCC reinstate those rules? And I'll ask that question of all of you.

You look like you're ready to answer, Dr. Ferrell.

Dr. FERRELL. Well, and the lens through which I've examined a lot of the protections for agricultural data is interesting because there is not really a specific existing statute that would address the type of data that we're discussing here.

If my tractor uses a cellular signal and basically makes a phone call to a service provider, there are Federal rules governing telephone communications that would protect that transmission. If I e-mail a file to my crop consultant, there are protections for that as well.

But if we're just talking about the transmission of telematics data, that really doesn't fall comfortably into any realm, especially when we start to combine and package that agricultural data with other things.

One example I sometimes give is that if my data service provider has raw agronomic data about my farm, but they also have a customer relationship management software program that pairs with that data, well, now there might be protectable, you know, personally identifiable information that is now coupled with my farm, that's a very different privacy issue than if we're just talking about agronomic data.

And so I think one thing that we may have to do is—I kind of agree that we need more robust consumer protections for data generally, and I think specifically when we talk about agricultural data, we've got a lot of work to do definitionally in defining what this kind of data looks like. It's not health data under HIPAA, it's not financial data under the Fair Credit Reporting Act, it's something unique unto itself that I think may deserve some efforts to actually define individually and define what those protections should be.

Senator BLUMENTHAL. You are certainly correct that there are lots of different kinds of data, even within farming, but the principles I think have to be framed in a way that they're applicable to all of these kinds of data. And you're right also, there may not be a specific statute here, but the principles have to be embodied at some point in regulations or rules or statutes, and the authority is there for the FCC to adopt protections.

So I would just invite you to think about what those protections should be, because right now a provider could paint an extraordinarily detailed picture of a farmer's business practices, from the type of feed he may use, the type of crops he grows, the type of fuel he uses, how many workers, how many livestock.

And I recall well a lunch I had, referring back to my early experience, with my grandfather, who had a farm—by the way, Senator Fischer, just south of Omaha—and the lunch was at the stockyards, and I was asking someone having lunch with us, one of my grandfather's friends, how many cattle he was feeding. And my grandfather nudged me and gave me that look of disapproval that grandfathers do when they are not enamored of the line of questioning, and he explained afterward that's like asking somebody how many dollars he has in his bank account. And that sense of privacy is broken, I think, by many of these practices, and farmers are very, very respectful about their privacy, with good reason.

Thank you.

Senator MORAN. Senator Blumenthal, thank you.

The Senator from Nebraska, Senator Fischer.

STATEMENT OF HON. DEB FISCHER,
U.S. SENATOR FROM NEBRASKA

Senator FISCHER. Thank you, Mr. Chairman.

And thank you, Ranking Member Blumenthal.

As a cattle rancher, I thank you for your respect to my privacy.

I would like to thank both of you for calling the hearing today so we can focus on managing that Big Data with new technologies for our Nation's farmers and ranchers. Not only will this help boost productivity, but advancements in digital analytics can improve how we feed our communities and conserve our natural resources. In fact, Tim Hassinger of Lindsay Corporation, from Omaha, Nebraska, noted at last week's Internet of Things hearing that the combined yield enhancement and resource savings from new technologies can increase the American farmers' profits by an average of $40 per acre.

And I would like to please submit for the record follow-up materials that Lindsay has provided regarding its research on data analytics and irrigation management, Mr. Chairman.

Senator MORAN. Without objection.

Senator FISCHER. Thank you.

[The information referred to follows:]

FOR IMMEDIATE RELEASE—November 8, 2017

LINDSAY CORP PRESIDENT AND CEO SPEAKS TO U.S. SENATE COMMITTEE

Tim Hassinger Addresses the Need for Improved Access to Rural Broadband Service

(OMAHA, Neb.)—November 2017—Tim Hassinger, president and CEO of Nebraska-based Lindsay Corporation, offered testimony during a hearing yesterday conducted by the U.S. Senate Committee on Commerce, Science and Transportation. The hearing, titled *Advancing the Internet of Things in Rural America,* focused on the benefits of the Internet of Things (IoT) in rural communities and the infrastructure needs necessary to advance the IoT market to ensure rural America has access to products and devices that are driving the digital economy.

"Like all business owners, farmers in rural communities need the ability to go online," Hassinger said. "The Internet fuels the innovative, advanced technology that will help America's farmers meet the food, fuel and fiber needs of our rapidly growing global population."

Hassinger's testimony contends that with reliable, high-speed Internet access, farmers can take advantage of tools that deliver hyper-local weather forecasts, real time data on soil moisture conditions and GPS for planting and irrigation management. They can also take advantage of a myriad of emerging technologies available from Lindsay Corporation and other American manufacturers. The testimony further explains that these innovations enable efficiencies through remote data collection, transfer and analysis from connected devices like soil moisture sensors, weather stations and cloud-based tools.

"At Lindsay Corporation, we are developing and deploying technologies to help growers produce more with less. For example, our FieldNET® and FieldNET Advisor™ remote irrigation management and decision support tools help farmers decide precisely when, where and how much to irrigate—to help them maximize yields while reducing overwatering and related input costs and nutrient losses," Hassinger said. "But we know the technology is only as good as the farmer's ability to access it."

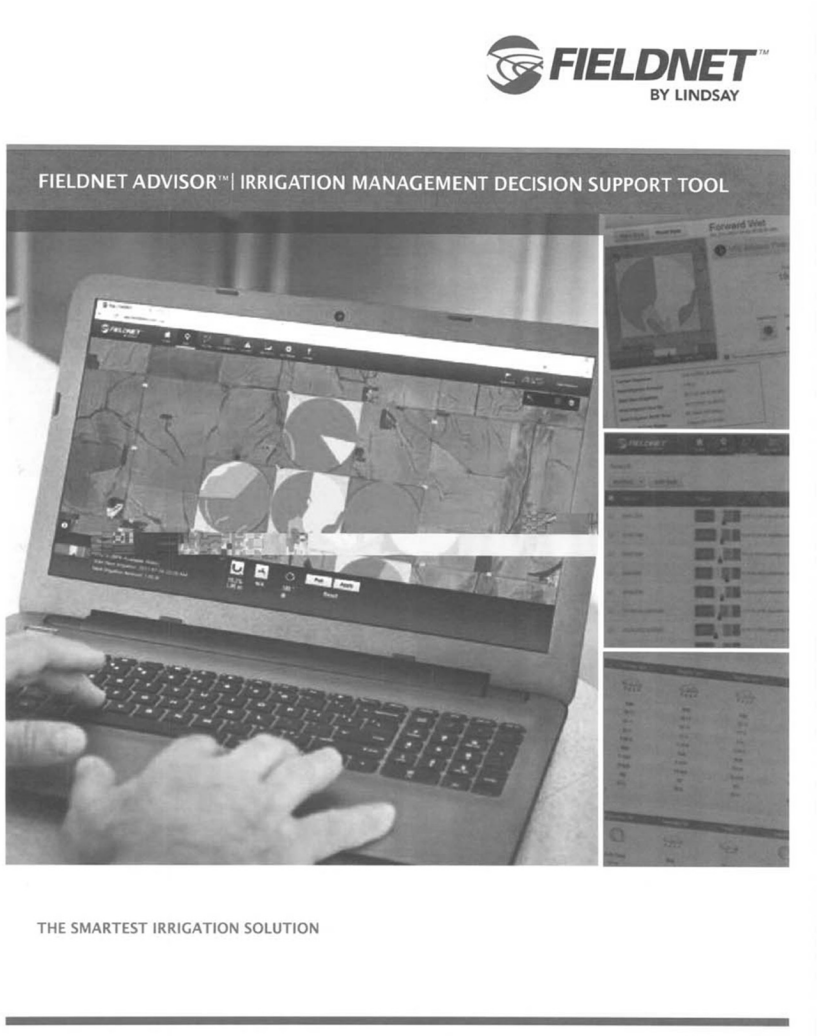
According to the Federal Communications Commission Broadband Access Report, an estimated 39 percent of the rural population (23.4 million Americans) lack access to broadband that meets today's benchmark speeds of 25 Mbps for downloads and 3 Mbps for uploads. By contrast, only 4 percent of urban Americans lack access to 25/3 Mbps broadband.

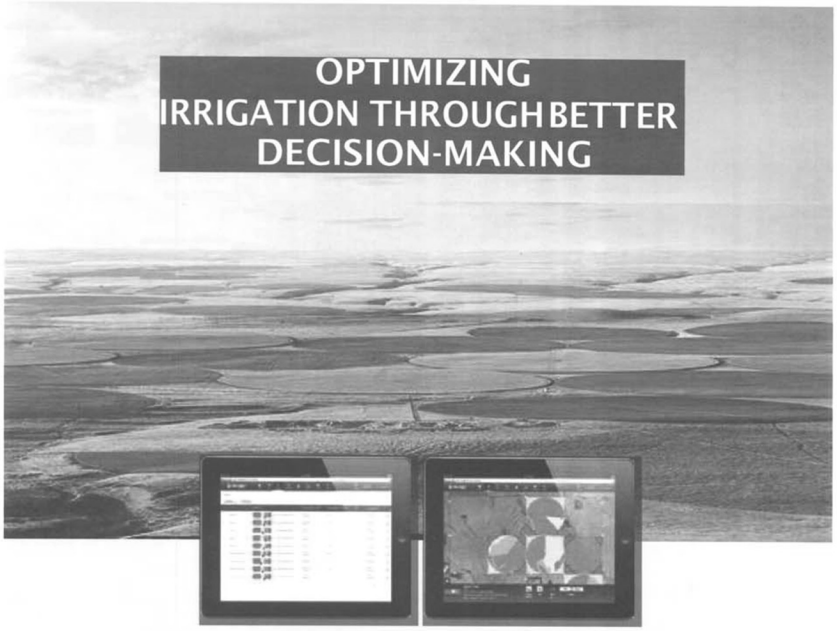
"While cities and municipalities typically have access to several high-speed Internet service providers, that access often ends at the city limits. Those living in rural

communities must depend on radio networks, satellite or cell service—all of which typically operate at lower speeds, limiting connectivity," Hassinger said. "All farmers are faced with the pressure to increase yields while conserving resources. The lack of reliable broadband hinders their ability to adopt the new technologies that will help them optimize their operations and compete in the global marketplace."

Hassinger's full testimony can viewed at *https://commerce.senate.gov. (https://commerce.senate.gov.)*

REPORT



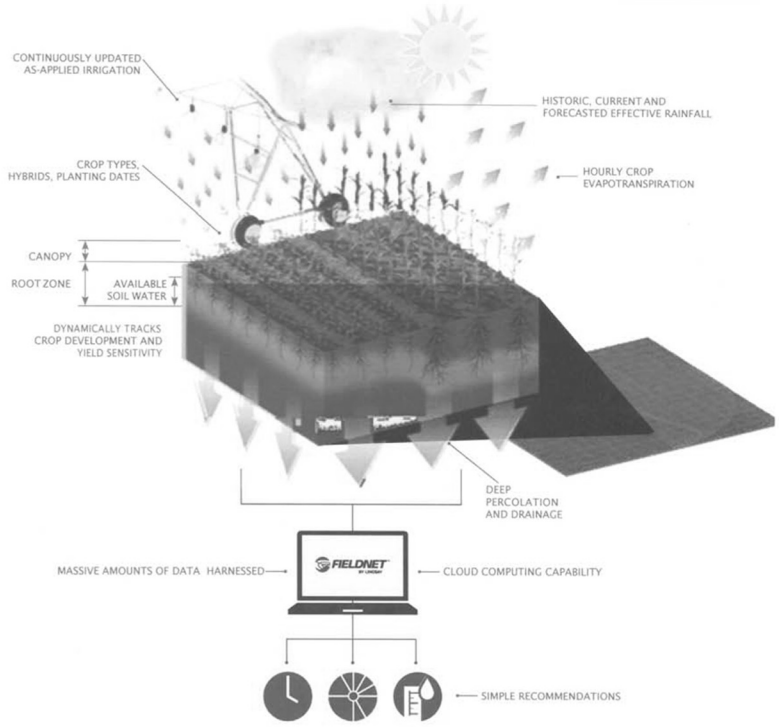


In a single map or list view, you can see the most critical information across all your fields, including current soil water depletion, recommended next irrigation start date and application depth recommended to avoid crop stress.

HOW FIELDNET ADVISOR CAN BENEFIT YOUR OPERATION
Saves time – Provides quick and easy-to-understand irrigation management recommendations and alerts
Improves yield output and crop performance – Tools to help avoid crop water stress and nutrient leaching
Increases profits and sustainability – Tools to reduce overwatering, saving related input costs and wasted resources

For growers who have relied on visual inspection of their crops or less scientific methods for irrigation management, FieldNET Advisor is the revolutionary tool that provides highly accurate information for better decision-making.

SCIENCE + DATA + TECHNOLOGY = SIMPLE RECOMMENDATIONS



WHEN, WHERE AND HOW MUCH

Using technology to simplify irrigation science

FieldNET Advisor combines more than 40 years of crop and irrigation research into FieldNET® by Lindsay's proven technology platform to simplify your irrigation management decisions and equipment operation.

You'll no longer have to rely exclusively on visual inspections of your field, use complex calculations or juggle multiple tools to track your crops' water needs.

FOUR POWERFUL TOOLS IN ONE

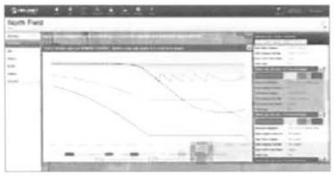
FIELDNET IRRIGATION ADVISOR™

The core of FieldNET Advisor, this tool compiles critical inputs related to the soil water balance (e.g. crop water usage, effective rainfall, actual as-applied irrigation history, and past deep percolation) to track the current soil water depletion and forecast the upcoming crop water requirements across your entire field. It's like having thousands of virtual soil moisture sensors placed throughout the field.

View current soil water depletion map and current pivot operational status, plus a summary of key actionable information with availability to directly select manual or VRI mode and control irrigation equipment.

FIELDNET CROP ADVISOR™

Dynamic, proprietary crop growth models track the development of each hybrid, including development stages and root growth, and continuously update the crop's forecasted maturity date. This tool also provides an estimate of any yield loss to date due to water stress – plus a projection of potential yield loss through crop maturity if no additional irrigation is applied.



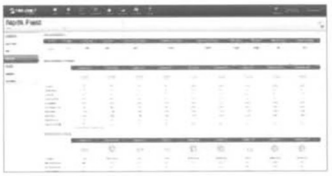
Crop Advisor continuously tracks the allowable soil water depletion to help avoid crop stress with customizable buffers throughout the season, plus the crop's forecasted irrigation needs through maturity.

FieldNET Advisor streamlines irrigation management and features all of your key information in one place. For example, the dashboard view provides a summary of the most critical details on one page, including current maximum field depletion, date next irrigation must be started, and amount of irrigation required.

Fully integrated remote irrigation monitoring and control means that you can stay informed with customized alerts and take immediate action from anywhere.

FIELDNET WEATHER ADVISOR™

A critical input is weather data, which is why the Weather Advisor uses hyper-local, hyper-accurate field-specific weather data, including hourly data for the current season-to-date plus a 15-day hourly forecast and historical norms to project the remainder of the season. This tool also provides the ability to set customized weather alerts, so you're aware of changing conditions and are able to react quickly. For fields where an optional Growsmart® weather station is installed, the data can be seamlessly fed into FieldNET Advisor as well.



Weather Advisor provides the valuable weather info you really need, including crop-specific daily ET (rather than reference crop ET), daily growing degree units (GDUs), and daily plus hourly wind speed, peak wind gust speed, forecasted likelihood of precipitation and amount, and more.

FIELDNET VARIABLE RATE IRRIGATION (VRI) ADVISOR™

Gone are the days of using the same plan throughout the season, as VRI Advisor provides continuously updated water prescriptions based on the dynamically changing field conditions. This is accomplished by leveraging the high resolution soil water depletion data across the field to generate VRI prescriptions that are dynamically optimized in real time to apply the required amount of water across every zone in the field. VRI Advisor can create both Precision VRI and basic sector VRI plans.

VRI Advisor allows you to review the current recommended dynamic VRI plan and make modifications if desired, or create and save new or modified plans.

HOW IT WORKS

1. Enter your crop types, hybrids and planting dates.
2. FieldNET Advisor automatically combines this data with soil maps, hyper-local weather info, and as-applied irrigation history across your field.
3. By tracking crop growth stage and root depth to monitor the amount of moisture available in the soil, FieldNET Advisor forecasts your crop's future water needs.
4. FieldNET Advisor then makes recommendations on when, where and how much to irrigate, helping you optimize your water use efficiency and maximize your profitability.

Since this information is seamlessly integrated into FieldNET's powerful remote monitoring and control platform, FieldNET Advisor gives you the ability to immediately put the recommended plans into action and track your progress from virtually anywhere.

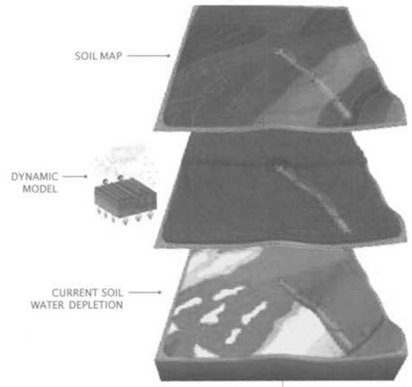
CROP DEVELOPMENT

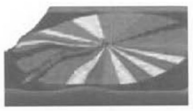
Before FieldNET Advisor, growers typically had to manually track the critical variables at each growth stage. FieldNET Advisor automates this process and removes much of the guesswork from irrigation decisions, which helps maximize yields while reducing water usage and other input costs.

CROP WATER USAGE

ROOT DEPTH

VRI OPTIONS WITH FIELDNET ADVISOR

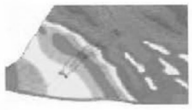




SECTOR VRI

Divides the field into 360 "pie slices" and adjusts the pivot speed over these sectors to change the application depth. (Does not control individual sprinklers.)

Works on Zimmatic pivots with BOSS or VISION panels. Also works on Zimmatic pivots with a BASIC panel or on other electric pivot brands by adding FieldNET Pivot Control™ or Pivot Control Lite.



PRECISION VRI

A virtually unlimited number of flexible application areas provides exactly the right amount of water by controlling individual sprinklers.

A Growsmart Precision VRI™ package is required.

What is FieldNET remote irrigation management?

Irrigation with industry-leading FieldNET is like having a remote control for all your irrigation related equipment. FieldNET hardware can be retrofitted on virtually any brand of irrigation equipment. Once installed, the FieldNET website and mobile apps allow you to monitor and control your systems from virtually anywhere.

With FieldNET, you get advanced features, such as variable rate irrigation, real-time shut-down alerts, and much more. It all adds up to less time in the field, less spent on valuable resources and more confidence.

FieldNET Advisor is a cloud-based irrigation management tool within FieldNET's remote monitoring and control platform. It's an add-on option that requires no additional hardware and provides seamless integration so you can immediately put recommended plans into action.

FieldNET Advisor also sends real-time text or email alerts to notify you when irrigation is required, providing you peace of mind.

INDUSTRY-LEADING CAPABILITIES

Talk to your local Zimmatic® dealer or visit myfieldnetadvisor.com to see which crops are currently available and to see if FieldNET Advisor is available in your region.

LINDSAY™

THE LINDSAY ADVANTAGE

DURABLE · RUGGED · EASY TO USE · INTEGRATED TECHNOLOGIES · BROADEST LINE OF SOLUTIONS

ZIMMATIC BY LINDSAY · FIELDNET BY LINDSAY · GROWSMART BY LINDSAY · WATERTRONICS A LINDSAY COMPANY · LAKOS A LINDSAY COMPANY

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Lean, Clean and Green. Lindsay Corporation is committed to developing environmental awareness and implementing sustainable practices to reduce the use of and protect energy, water, and all other resources.

FN ADVISOR BRO
ENG-2047 2500 0417

Senator FISCHER. Mr. Knopf, in your testimony, you describe your farm management operations. And what benefit do you see on your farm from implementing Big Data technology? How do you analyze it? Do you have input from your nutritionists, your equipment dealer, local co-op? How do you get it all put together?

Mr. KNOPF. That's a good question. There's a lot of information to try to analyze. And so in our farm—that answer is going to look different for each individual farm, of course, on the strengths and talents and the passions of that individual farm operator. Some farmers are very passionate about their data, very passionate about precision agriculture, and they want to be very hands-on in that process. And those are also I think the guys that are very passionate about the ownership and transparency of that data. They want it on a server in their office.

There's the other spectrum of farmers—and we're kind of in the middle, let me say that—there's the other spectrum of farmers, and sometimes it changes based on age demographics as well. I've noticed in my community, in my experience, and thinking about our own farm, the older generation is much more private about their data, very unwilling to share it. The younger generation is—you know, they grew up with smartphones, and Google is tracking them all the time and telling them things about themselves that they didn't know already, and so they're more used to that. So there's a generational change there as well.

For us, we're kind of in the middle of—I have an agronomic background from Kansas State. I have a young man that works—we have one full-time employee that also is an agronomist. And we do most of our data analysis in-house. But our data is stored in a software system that is web-based, and it's subscription-based. And that was a big change for us about 2 years ago, 3 to 4 years ago, is transitioning our data from being stored in-house to web-based, which is somewhat of an uncomfortable step because you feel like you're losing control, and that's why the transparency is so important. But we are still processing a lot of the data and analyzing a lot of it in-house. But there is a growing amount of service providers dealing with that. We collaborate a lot with our land grant with Kansas State University, and a lot of their research we collaborate with and host on our farm. So that's a very important collaboration. And I appreciate two representatives here from universities as well.

Senator FISCHER. And as you noted in your testimony, the ag economy is in a downward cycle right now, it's hurting. I also know that there's a lack of access to broadband, and we have a lot of slow downloading speeds. And how does that affect your bottom line——

Mr. KNOPF. That has a——

Senator FISCHER.—when you have this slow access?

Mr. KNOPF. Yes. Excuse me. That has a very significant impact. In fact, the county that we live in is just now receiving fiber optics ran to farms. In fact, it's not even hooked up yet, it's just being ran right—right now, being buried, because a lot of my peers that live in more—we have a community of about 40- to 50,000 within our county, but yet there is still a lot of rural part of the county. So a lot of my colleagues that live in rural counties in Kansas quali-

fied for grants from the government to help build that initial infrastructure.

Well, our county happened to not qualify because of the urban center that we had within that county, and we have some broadband antennas on top of elevators and towers and so forth, but it is very unreliable and fairly slow. So that has limited our utilization and access of data, particularly in web-based software platforms, and been an economic disadvantage in utilization of data because we're kind of caught in the middle of that process.

Senator FISCHER. Thank you.

Thank you, Mr. Chairman.

Senator MORAN. You're welcome.

Senator Klobuchar.

STATEMENT OF HON. AMY KLOBUCHAR,
U.S. SENATOR FROM MINNESOTA

Senator KLOBUCHAR. Thank you, Mr. Chairman. Thanks for allowing me to go, too. And just to follow up with Senator Fischer, and we've worked on some of these broadband issues, I, like Senator Fischer, have heard many stories from my state about the need for better broadband access. And I always remember a precision ag company out of Willmar, Minnesota, that actually told farmers to go to the restaurant parking lot because they would get better Internet.

And when you think about it, you know, way back about 10 years ago people were just trying to get Internet so they could write their grandkid an e-mail or something, and it has changed so much that if they don't have that ability, they're just not going to be able to do their work basically, and that's everything from Jennie-O in Minnesota measuring the temperature in barns for turkeys—I mention turkeys, we are number one in turkeys in Minnesota, and Thanksgiving is upon us—and other things that we've seen that it's just really a must-do for these farmers.

Mr. Ferrell, most broadband connections provide faster download than upload speed. Why is upload speed important for ag data? And how are reliability and bandwidth needs of farmers different than the average consumer?

Dr. FERRELL. Well, you're very right, Senator, in that we've seen tremendous gains in terms of what rural broadband access has been able to offer in terms of download speeds, and that's been good for farmers acquiring information. But as the witnesses have mentioned today, we're gathering tremendously more data that has to be uploaded. And in certain cases, in some applications, we need that data to be uploaded in real time.

And so even if you're in a broadband-connected accessible area, your farm equipment needs to be able to access wireless broadband speeds as well to upload that data and receive real-time updates about things like cropping prescriptions, like Mr. Knopf was mentioning.

As you're doing intensive management of a specific field, you need to have advanced broadband upload speeds to be collecting that information, getting real-time recommendations back, so you can make on-the-fly adjustments to things like seed population, fertilizer application, pesticide application, and things of that sort.

So the download speeds are good, but as the ag data revolution continues, upload speeds I think will be even more important because of the amount of data that we're pushing to the cloud rather than receiving from it.

Senator KLOBUCHAR. Thank you.

Dr. Haman, I just recently visited, in fact, just a week ago, Aker Technologies in Winnebago, Minnesota. You may not have been there before, but they're developing this innovative drone technology to help farmers be more efficient when applying fertilizer, pesticides, and water. It saves money. It leads to more sustainable farming because they're going to be able to see where they need the water, where they need the pesticide, and not do one-size-fits-all for their whole fields, nor do they have the resources, especially small farmers, to be able to walk through every row.

The FAA recently introduced a pilot program to explore the use of drones far beyond the line-of-sight operations in limited cases. For farmers managing large tracts of land, this could be a valuable option in the future. And in your testimony, you mentioned the use of drones to combat citrus diseases in Florida. Could additional drone monitoring help prevent the spread of diseases?

Dr. HAMAN. Absolutely, yes. They absolutely. We already are using drones, for example, in forestry. And in forestry, the drones can detect the areas where the disease is likely, where the plants are stressed. Using different spectra, you can detect stress which is from water or stress which is due to disease, and separate that. And we are right now doing research to detect specific stresses due to specific deficiencies of different nutrients and different—so possibilities are enormous, and as the cameras are getting smaller, it makes also big difference because they can be carried on small drones.

Senator KLOBUCHAR. Exactly. And that's what this concept is going on at this company.

Dr. HAMAN. Yes.

Senator KLOBUCHAR. Last question, Mr. Knopf. The Minnesota Corn Research & Promotion Council has been working with local farmers to test innovative conservation approaches, pilot new technology applications, by promoting the adoption of precision ag technology, like drone monitoring, smart irrigation, that I was just talking to the doctor about how we can help farmers with conservation.

Could you talk about how Federal research initiatives or landgrant universities partner with industry to further advance innovation? Quickly.

Mr. KNOPF. I really appreciate that question, and it is invaluable and becoming increasingly invaluable to both economic sustainability and environmental stewardship. We host yearly on our farm between four to a dozen experiments in collaboration with Kansas State. Their resources are limited more as time goes on because of budgets, so farmer-private university collaboration is increasingly important.

Senator KLOBUCHAR. Thank you very much.

Thank you, Mr. Chairman and Senator Blumenthal.

Senator MORAN. You're very welcome. Thank you, Senator Klobuchar.

Senator Lee.

STATEMENT OF HON. MIKE LEE,
U.S. SENATOR FROM UTAH

Senator LEE. Thank you very much. Thanks to all of you for being here. We're witnessing a technological revolution. It's very significant. I think it's going to soon be the case we'll look back at what we're experiencing today and realize that this was just the tip of the iceberg. And it's one that I think has the ability to allow farmers and ranchers enjoy cutting-edge technology and make their operations more effective, more productive, so that they can feed more people and do what they do.

I want to focus today a little bit on the application of unmanned aerial vehicle technology, drone technology, as we sometimes refer to it, to agriculture.

Mr. Knopf, I want to follow up on some questions Senator Klobuchar asked you about. Tell us what—how this has potential application in your field?

Mr. KNOPF. We happen to be 15 miles from the Polytechnic campus of Kansas State University, which is in Salina, and they are one of the leading institutions for UAS and UAV programming. For the last couple years, they have been carrying out a pilot project alongside the FAA with a grant they received on some extended line-of-sight operations for drones, which was already brought up, and looking at some of those regulations and how that can work.

So specifically what that means to our farm, other collaboration that we're doing with Kansas State from the Agronomy Department is looking at things such as being able to sense NDVI ratings, which is a plant health greenness index, and across the field in real time to very quickly pick up any problem areas in the field, to quickly address issues that need to be addressed before they make more significant impact. And it's just a better, more efficient, precise way to collect data across a wide scale. So there are a lot of implications in that, and I think satellite imagery is also an increasing area of data that is going to be easily accessible as well that will have a lot of applications.

Senator LEE. Thank you. And following up on that, Dr. Ferrell, you mentioned in your testimony that drones are one technology, one useful piece of technology, that can be used to gather agronomic data. Can you explain how important this is for farmers, why it's important?

Dr. FERRELL. Yes. I think it's incredibly important because it's constantly being called upon for farmers to do more with less, and that's not just in terms of input, sometimes it's in terms of labor as well. You know, we've talked about the use of UAS and drones to scout crop conditions, and certainly that enables one farmer to cover potentially thousands of acres in a day whereas if they were trying to do that on the ground by scouting, that might take days out of their schedule, and they just don't have the manpower to handle that.

But another important aspect of UAS use that we haven't talked about much is actually in livestock operations, especially if you're talking about large, you know, pasture-based operations, sometimes using drones to check cattle can save a tremendous amount

of time and resources, and enable us to identify cattle that are in poor health, get them treated quickly, and get them back to health.

So I think there are unprecedented opportunities there for us in the agricultural sector.

Senator LEE. It could help a lot of people in their operations.

Now, Mr. Janzen, your law firm represents people in regulatory compliance and registration. What can you tell us about what the largest regulatory barriers are to farmers and ranchers using drone technology, or for drone technology more broadly being implemented in the United States?

Mr. JANZEN. Thank you, Senator. I think right now probably some of the largest barriers for farmers would be the cost of the drones and also the ability to use the data and get real results back that they can put into practice on their particular farms. And I think that there was a lot of hype when drones first started to become very popular, and, you know, now here we are today, and we're trying to figure out how to best use that information today. So I don't know currently that there is an enormous regulatory hurdle for use of those drones on the farm.

Senator LEE. What about the FAA's restriction on the use of drone technology beyond line of sight?

Mr. JANZEN. Oh, yes.

Senator LEE. Has that had an impact on people's adoption of this technological platform?

Mr. JANZEN. That's a very good point. Yes, it probably is creating some restrictions on people wanting to use the technology because that is a barrier to, you know, a single farmer who may want to use this technology on their farm.

Senator LEE. OK. It's one of the reasons why I've been a big believer in and an advocate for legislation that would help provide clarity on drone regulation. This is a technology that has tremendous promise, not just for the U.S. economy, but for humanity, but because the technology is developing in the way that it is here in the United States, it can offer some real benefits to the United States specifically.

As we've seen in other areas, one of the things that can hold back technological innovation is stifling government regulation, and so that's why I've been an advocate on that.

Thank you, Mr. Chairman. I see my time has expired.

Senator MORAN. Thank you, Senator Lee.

Let me start I think with Mr. Tatge, although I'm happy to have a response from any of you. The promise, or a promise, from data collection and its usage is its increasing value, and, therefore, added profitability to production agriculture.

So in your testimony, Mr. Tatge, you estimated that a billion dollars of annual revenue could be returned to rural communities from multiple sales of that information.

Mr. TATGE. Yes, sir.

Senator MORAN. So how do you envision Mr. Knopf earning additional income as a result of collecting data on his farm?

Mr. TATGE. So we create what is called an electronic field record. An electronic field record is a map basically of what happened on what part of the field, whether it be seeding rates that are being planted, whether it be application rates from sprays that may have

been applied to the crop, and then from harvest as well. And once you get those—that data in a state where it's in a standard, and we call this electronic field record, we can make that available for sale.

So when we make that available for sale, companies come to us, and we've already sold data for farmers, will come to us and say, "I would like to buy that layer of data, and this is what I'm willing to pay." And then we go back to the farmers and we tell them who the buyer is of that data and how much they're willing to pay, and the farmer chooses if they want to—let's think of it as licensing a copy of that data to that company. And if they do, we split the revenue with the farmers.

So we've turned it into a profit center for basically taking digital exhaust and packaging it to get it to go to the people who have a desire to acquire it.

Senator MORAN. So you're the market. You're the intermediary between those who have something to sell and those who have something they want to buy?

Mr. TATGE. Yes, sir. We're also helping with the collection of the data in the first place to get it standardized in a way that makes it easily portable or interoperable. Because our job is not to do any analytics on data, our job is to help farmers get the best dataset that they can get in one place and in a format that it can move wherever they direct it to go.

So when our focus is exclusively on being able to focus on how can we get the best dataset into a database, and then how can we get that data to flow into whatever system the farmer directs us to send it? If they're working with their local agronomist, we've got several examples where a farmer is automatically sending data to their agronomist without having to do anything. The day they get done spraying the field, this file is going directly to their agronomist, and there's no charge for that.

The farmer can choose to share that data with anyone they want. It's when you get enough of this data packaged together, though, that's when you bring the opportunities for monetization of the data, just like a brand-new commodity.

Senator MORAN. That's not much value to individual data in and of itself, an individual farmer's data, but if you can combine it with broad data, bigger data——

Mr. TATGE. Yes, there are values to it on the farm itself for your operations, making sure you're running your machines as efficiently as you can, fuel usage, idle time. It's a different value prop to the farmers. Then there's a value to sharing that data with trusted advisers, and it adds increased service opportunities and increased ability to react during the in-season mode to make some changes to hopefully put down any threats that come up or minimize their impact.

And then to the market, there's a greater opportunity to really start to identify and make these datasets available for us to understand best practices. Are we planning—how come when the farmer rips open the bag, we are—we lose all this genetic yield potential? Is it because they're planting the seeds too deep? Are they planting them too shallow? Are they planting them at the wrong time? Are they planting them too early? Are they planting them too late?

There are all of these things that get opened up with the data for us to identify what the best practices are and what the best pieces of equipment are to help drive efficiencies. It's very exciting. But that is how you can create a revenue stream going back there because the major ag companies that you see today, they could easily change their marketing budgets. Instead of buying commercials and hats and jackets and boots—right?—we could change that into let's be open and honest with our customers, let's buy their data from them so that we have the opportunity to service them better.

Senator MORAN. Who are the purchasers of data today? And who do you expect them to be in the future?

Mr. TATGE. They range from a wide range of data analytics companies as well as insurance and reinsurance companies trying to identify risk levels and some of that. They're also equipment manufacturers. So there are a bunch of people that are trying to figure out and benchmark data against each other, and they're getting access to data that they've never had before.

Senator MORAN. Is this function that you're helping create, is it similar to what USDA does as they collect data and then make it public for purposes of farmer decisionmaking——

Mr. TATGE. Yes, it can be. You know, the USDA has got the—I mean, they are the gold standard of data, and they are the ones—when you see the markets move a lot, a lot of times it's because a USDA report came out, and it wasn't what the market was anticipating, and that causes a lot of the volatility there.

Traders love the volatility, and I was one for several years. But farmers traditionally, and the companies that use that raw commodity as the base for their product, like a flour mill, does not care for the volatility. So getting that volatility out of the market and getting that information to the market quicker is a huge opportunity to help reduce, I think, overall volatility in the markets.

Senator MORAN. In the billion dollars that you estimated, does that include all three—the value of all three components of that data that you described?

Mr. TATGE. That includes—no, that is the value of the marketplace side of the data only.

Senator MORAN. And you base that estimate on what?

Mr. TATGE. We base that estimate on 25 percent of the acreage in the four major row crops—which would be corn, beans, wheat, and cotton—and being able to monetize that data four to five times on a turn. Once one person buys the data, the others want to buy it as well.

Our problem right now is the fact that we don't have enough data. And when you go into a new market like this, when you're creating a new marketplace, supply brings demand. So that's one of the things that we're working very hard with right now to address.

Senator MORAN. And this is a question for again maybe you, Mr. Tatge. So when a farmer buys a piece of equipment, at what point in time—what year, what model year, of equipment collects the data? Where did we start? How recent of a development is this?

Mr. TATGE. So I think in 2011 is when most of the new equipment started coming with a modem in it. I think it was a 2G modem at that time. So I would say from 2011 and newer, most

of the equipment that is sold today has a modem in it. But we have an aftermarket solution that allows you go to back to roughly 2002 on most of the pieces of equipment. So as long as there are sensors on it, we have a piece of hardware that can allow us to make that older piece of equipment more modern in its form of collecting data.

Senator MORAN. So when you say there's a shortage of data, is it because farmers are using equipment that's older than that, the technology isn't utilized on their farm, or they don't know or utilize the information, the data, that they have?

Mr. TATGE. It's the second one more so. I would estimate that 80 percent of the data generated in cabs of equipment today does not make it out of the cab ever, and that's a roadblock. The industry lacks—I'm going to use a navigation app for me. So Google Maps is something that I use just about everywhere. I used it to get here.

And when I went to buy my new pickup, I couldn't get it without the electronics in it, without the navigation system. I wanted to because it was expensive and I didn't need it. But I couldn't buy that truck without it. My wife has a car as well that we've had the same challenge on not buying the navigation system. But we ended up buying two of them that we don't use. And the reason we use Google Maps is because of the interface and it is portable and it can move with me.

The ag industry lacks a common interface of that nature to be able to get this data out of the cab. So when you only plant once a year, I mean, you kind of forget how the technology works until next year. And that's one of the challenges that we have, and we have the opportunity with the technology available today to make those tools smarter and easier for digital immigrants.

Senator MORAN. Thank you very much.

Do any of you have anything to add in regard to how this use of data, the monetization of information, means money returning to rural America?

Well said, Mr. Janzen?

Mr. JANZEN. Yes. I would add a little bit to that. I always tell people, because we get asked this question a lot, "What is the real value of the farm data?" Right?

And I always say imagine that you had two 80-acre parcels of land that you had grown corn and soybeans and wheat on for the last 20 years, and, you know, one of those you have accurate data records for how things were planted, when they were fertilized, when you applied pesticides, and one you did not. You know, how much more would somebody be willing to pay for that information at the time of sale than the parcel that's identical that doesn't have any of this that goes along with it?

And so I think the answer is certainly something, right? I mean, it's certainly worth something. Is it worth $20 an acre? $50? $100? I don't think we really know that yet because it's such a young industry. And I also think we haven't done a good enough job of collecting that information year after year after year to really see the value. But we will get there and there will be a time when that is a valuable commodity and certainly people are willing to pay more for it.

Senator MORAN. Mr. Knopf?

Mr. KNOPF. Mr. Chairman, I may quickly mention that I think it's important to keep in mind that the value may not always be just monetary. I think one of the things we're seeing in private industry right now is there is tremendous competition to grasp and collect that digital acre. Sometimes the value going back to the farmer is in benchmarking against other farms on our performance from a yield standpoint or a sustainability standpoint. Other times, the value coming back to the farmer by sharing his data is access to a model that that data can be implemented to that has been designed by Big Data that a private industry has paid to capture.

And so it may be access to a model or access to something other than monetary value, it may also be the nugget given back to farmers for sharing data.

Senator MORAN. When Mr. Tatge says that 80 percent of the information collected from a piece of farm equipment is not being utilized, is that by the farmer? Is the information still being utilized by the manufacturer, the seller of the farm equipment?

Mr. KNOPF. From my perspective, in most of our equipment, it is not automatically, as far as I know, automatically being sent somewhere even though there are modems in the machine. And, yes, I think most of it is that it's not being utilized by the farmer.

You know, we only have so much time. I think a lot of this data utilization is going to have to be, with the exception of very large farms, more of it's going to be outsourced to service providers, which is a new economic opportunity for rural America, and the drone industry as well.

Because the farmer just literally doesn't have the time to manage all of this data to take it out of the cab and, you know, I can't—my dad, we know the age of farmers, and this is going to be an important transition, as that generational change happens, there is going to be a lot of change as we see that transition happen, but the current generation of farmers, it's a big technological hurdle to cross for most farmers.

Senator MORAN. Because of the access to this information, farmers can be more efficient and, therefore, more profitable is the theory, and I think the facts I think will demonstrate that. Does that increase the chances that farms get larger, or does it make it more likely that the medium-sized farm becomes more efficient and, therefore, more sustainable economically?

Dr. Ferrell, you look interested.

Dr. FERRELL. We've actually speculated about that in some of the academic research. And there's definitely the argument to be made that says there are efficiencies to be had, and those efficiencies might be magnified at the larger scale of farms. And so from one perspective, that could actually accelerate the growth and the scale of farming, and that's one thing that's true.

It depends on what we talked about earlier, which was, "How do we go about sharing the value and the gains from those technological advances between the aggregators and the individual farmers?" It might actually be that this technology might enable our medium and smaller producers to capture some of the efficiencies that heretofore were only available to those larger producers and might actually keep them more viable. I think there are probably more macroeconomic trends that are going to still push toward

larger operations, but I think this could be an important source of invigoration for those small and medium producers as well.

Senator MORAN. That's encouraging.

Senator Blumenthal has some additional questions. We'll have more one more round. Senator Blumenthal will ask his question, I'll ask mine, and we'll try to wrap this up.

Senator BLUMENTHAL. Thank you.

I think, Dr. Ferrell, you were the one who used the term "aggressive fine print." Or Mr. Janzen, sorry.

[Laughter.]

Senator BLUMENTHAL. And let me address this question to the panel, but first to you. What do you worry about in those contracts, performers in the fine print, and is one of those worries mandatory arbitration clauses, which, as you know, deprive any potential party and litigant of the right to go to court under some circumstances, often very broad circumstances, and often contained in the fine print?

Mr. JANZEN. Thank you. Yes. Well, as an attorney, I worry a lot about this, and I get asked to draft these types of contracts by ag technology providers that hire our services. And so we think about this a lot. And, you know, what I always tell my clients is you want the contract to be something that the farmer can understand when they read it. And that's very different than I think the traditional route that we've gone in this country.

I mean, we all get the updates on our cell phones all the time, and nobody reads those, you know, and that's a problem, and it's a real problem when the information is not just, you know, the stuff that you're clicking on your cell phone, but it's actually proprietary information that belongs to a farmer.

So, you know, I worry a lot about the complexity of these agreements, and I worry a lot that the industry adopts standard form contracts for these new agricultural technologies when it's like putting a square peg in a round hole and it really doesn't work.

Regarding arbitration provisions, I haven't seen that as widely used as probably in some other areas, but they are definitely in there. And, yes, that certainly could be a problem. You know, as somebody whose Equifax data was breached, I can certainly relate to that issue.

I would say the other thing that I concern myself with is a choice of forum provision in a contract because if anyone has to go to New York City to adjudicate a dispute, and they live in Wyoming, you already know the outcome of that, right? So that's the other thing that I worry about in these standard form contracts.

Senator BLUMENTHAL. Any other responses?

Dr. Ferrell, you're nodding.

Dr. FERRELL. Oh, I would just agree. We've seen those in lots of contracts. I've seen a lot of those in some of the ag data contracts. And interestingly enough, I've seen those a lot in oil and gas contracts, wind energy contracts, solar contracts, and there is some limited empirical evidence that shows that those arbitration clauses really work to disfavor the landowner in those circumstances because not only is the choice of forum usually a remote urban location as opposed to the home court of the producer, but also the arbitration process usually kind of tends to stack the

deck in favor of the more—and I don't want to call these unsophisticated, that's not what I intend to say, but corporate entities tend to see arbitration more, are very familiar with that process, and use it to their advantage I would say generally.

Senator BLUMENTHAL. They're more experienced in it.

Dr. FERRELL. Yes, sir.

Senator BLUMENTHAL. Especially if it's mandatory.

Dr. FERRELL. Yes, sir.

Senator BLUMENTHAL. Thank you.

Senator MORAN. Mr. Knopf, does K-State Extension, for example, have any ability to educate you and other farmers in regard to data? Is that happening?

Mr. KNOPF. K-State Research and Extension has data specialists. I'm very impressed with Dr. Ferrell's knowledge. Come north a little bit if you——

[Laughter.]

Mr. KNOPF. So, yes, we have precision agricultural specialists, but, again, it's—again, it's another—it's a whole other realm that they have historically not dealt within, and the amount of capital and things to just fund positions is I think limited in how extensively they can take on that roll.

Senator MORAN. Is there anyone who is vying for your data? Does somebody want to buy it?

Mr. KNOPF. Nobody has offered me any money for it yet.

[Laughter.]

Mr. KNOPF. But, yes, certainly private companies are not as much directly, but very indirectly competing for access to my data, and they don't really know, I think in many instances, yet what they're going to do with it because it's the amount that they can collect. The bigger the amount is, the more value. Whatever that value is, it's about scale. And so I think my perception as a farmer is a lot of times they don't know or aren't letting on what they're going to do with it, but once they have a bigger scale of it, there's inherently going to be an incredible amount of value there. And the competition for me to just hand over my data card is very high.

Senator MORAN. Is it possible that a monopoly could arise owning the data, that the information is available only to a select few? Could an exchange end up being the purchaser of data and know more than others who are interested in the markets?

Dr. Ferrell.

Dr. FERRELL. That's a perfect opportunity for me to loop in the fact that Dr. Terry Griffin at K-State, their precision cropping systems economist, actually taught me a lot about this issue specifically. And if you look at the trends that we've seen in other technology providers, take, for example, operating systems for personal computers, you start with lots of those systems out there, and over time, through acquisitions, market share, and the fact that, as Mr. Tatge said, we want to see interoperability, that's why so many of us either have a Mac or a PC, is because eventually those two operating systems kind of boil down, and I can create a Microsoft Office document and share it with everybody who's on the Committee with me here fairly easily.

And so lots of factors, economic and practical, tend to drive us toward that, either monopoly or monopsony, that small group of providers that are eventually going to take over.

There are lots of reasons to suspect you would probably see that in the data space as well, and that's why I think that the dialogue between the producers and the aggregators is so important, is to make sure that as that consolidation occurs, that we maintain some parity in the bargaining position between the users and those aggregators.

Senator MORAN. That could be a potential difference between USDA information and data that's collected through this process we're talking about. The access could be much more limited in this setting?

Dr. FERRELL. I think so. And the interesting hypothetical situation is, you know, we have USDA data trying to provide us information about crop conditions, acres planted, things of that sort, and, you know, as the other witnesses mentioned, that's a huge driver of both market information and volatility as well. What happens if someday USDA is, for lack of a better word, outmoded by private aggregators of that information that have much better, much more rapid market intelligence? How would that influence markets?

Senator MORAN. Right. I mean, that's not a question I thought of until I was hearing the panel today. Information is valuable, but there can be a corner on the market, which then changes the nature of the market.

Mr. TATGE. So I talk about this and debate this a lot. I traded commodities for several years. The interesting thing is that if a farmer opts-in to sharing their data or selling their data, let's say licensing their data, to a commodity brokerage house, they're getting their profit, they're taking the risk off the table right away because they're getting a piece of it, regardless of where the market goes.

So I would argue that the data flowing to the market quicker is going to reduce volatility and give the farmers additional reasons and ways to monetize that data that they haven't probably thought of in the past.

The farmer is the first consumer of that data, if you will. When you're driving through your combine, you're the first consumer of that data. OK? So you might think, "Oh, my yields are much better than I thought. I should hurry up and sell some." Right? He—that's a good use of that first—that first, you know, consumer of that data. The problem is you're not quite certain enough if it's just that field or if it's just your area. But if we can have a larger pool of that data, suddenly that becomes really relevant for you in your marketing decisions as well as the market at a whole.

I absolutely have no—I have no doubt that getting information—once you get something faster, you never go back. OK? And I believe that will be the same in the markets and the information that we're collecting as well.

Mr. KNOPF. Mr. Chairman, I may—you've been a—you understand regulation and how that impacts farming systems, and I think that's one important note that hasn't been perhaps mentioned, is we also need to recognize the risk of—as access of data

increases, I think we need to be cognizant of the risk that that—the risk that that presents in utilizing that data down to the farm level perhaps to regulate a farmer on specific practices even though we're working within a biological system.

There are going to be large swings across years based on rainfall, on how much nitrogen we use per bushel of wheat per se. So this year is going to look very different than last year. And when folks don't understand a biological system and weather variation and just look at a dataset, it can be an easy thing to immediately think, well, how can we get them to always just use this much nitrogen per bushel of wheat? So I think that's an important thing to think about as well.

Senator MORAN. These markets, of course, are international. And is the market for data international? Is the same thing we're talking about here happening in Brazil and Argentina and Europe?

Mr. TATGE. I think hypothetically, absolutely. There is going to be a lot of different regulations and rules, and it's going to take a while to understand how each country wants to deal with their data that's collected. But I absolutely think this is a global opportunity for sure.

Senator MORAN. Let me just ask a few questions that I think can be quick. Is my understanding correct that there really is not an agency of the Federal Government that protects farmers or regulates the collection of data? Is that the conclusion of what I heard you all say?

Dr. FERRELL. That's correct, sir.

Senator MORAN. And I guess I should ask the next question: Should there be?

Dr. Haman?

Dr. HAMAN. I think that it is very important, one thing is very important, that the data is standardized because the closer the formats of the data, the possibility of comparing that is extremely important. Right now, we are getting a lot of data which is really not very good. And even farmers would admit that the data, raw data, is something which they cannot process.

I have mentioned that we are moving toward Internet of Things or Internet of agriculture. At that point, we remove the factor of human being in a lot of situations because machines talk to each other and the computers talk to each other. Sensors are talking directly to the computers.

So some kind of standardization will become reality anyway. That's also true of the data which is coming from the satellites because all of that has to be downscaled because it's on a scale which is not really practical for farmers. But there's a lot of work going on, on downscaling the data which is coming from satellites.

But all these databases have to talk to each other, and that's very difficult to do if there are a lot of small—it seems to me if there are a lot of small entities, small companies, which are organizing the data differently, then there is a problem. Of course, sooner or later, the Microsoft or an Apple is going to emerge and just take over. This is probably what's going to happen, but the sooner we make this data comparable, the easier it will be for everybody.

That also creates kind of a positive situation for very small farmers and for farmers with specialty crops because the big companies are not interested in data on specialty crops, and this is where farmers don't have such large farms, but there is a lot of very good data going on there.

And I just recently heard that in Brazil they are tagging individual trees in the orchard and collect data on individual trees. We are not doing that right now, but maybe somebody else is doing. So the interest is all over the world. Germany is investing a lot of money into data as well.

Senator MORAN. Thank you very much.

Dr. HAMAN. Thank you.

Senator MORAN. I can see USDA is the agency or the department that would be involved in the standardization of data.

Dr. HAMAN. Probably.

Senator MORAN. That's a slightly different question than where I was going, but an important one. And ultimately that could be of great value to FSA and to RMA, risk management and to farm programs, if the Federal Government actually had the information in which they're basing payments, crop losses, or crop production, standardized. My question, slightly different than that, is no one is out there protecting the farmer.

And, Mr. Janzen, my understanding of what you do is related to transparency, not related to privacy, not related to standardization. You've got a—I mean, "niche" makes it sound less important, but you have an area that you're dealing with related to transparency, which is important, but nothing broader than that, and no one else is doing what you're doing in those other areas, right?

Mr. JANZEN. That's essentially right. I would say we do deal with privacy issues because the Transparency Evaluator does ask questions that really get at privacy as well and protecting that.

Senator MORAN. OK.

Mr. JANZEN. And going back to your question about regulation, I think that the Transparency Evaluator really is sort of an attempt at the industry to police itself so that Congress doesn't have to step in. Now, for that to work, we need full buy-in from the industry, and right now I would say we have a good first step, but we need wider buy-in from other players.

Senator MORAN. When you indicated earlier that there is uncertainty as to who owns the data, whose job, whose responsibility is it to clear up this issue of data ownership?

Dr. FERRELL. Well, it's interesting, we've actually tried to explore this. There is not really a way to trademark it, patent it. You really can't copyright data because copyright requires an element of creativity, and data is raw facts, which we have a Supreme Court and President that says you cannot copyright true facts.

So that leaves us in the realm of trade secret, and this is something that Mr. Janzen and I have talked about quite a bit. We think there's a colorable argument to be made that farm data is a trade secret. If it is a trade secret, there are a lot of strings that come with keeping it a trade secret. And trade secret is also a function a state law, not Federal law. So you run into some problems with that being consistent across states.

Now, we do have the Uniform Trade Secret Act, which the last time I had checked, 48 states had adopted, and the remaining 2 states were considering it. But there might be an advantage toward a Federal protection there to keep that consistent across states and to allow, in a way, more interoperability as well because we would have a consistent application of those principles no matter where you were.

Senator MORAN. Senator Blumenthal and witnesses and audience, this is I think my last question, to give you hope.

[Laughter.]

Senator MORAN. So my question was going to be about, what are the risks and consequences of data breach, data security, insecurity? And this question of about, "Who owns data?" causes me to ask, so if someone steals your data, is there a question about whether that's a theft because who owns it? So is it that uncertain?

Dr. FERRELL. There's a very valid question with that because if you are claiming that your ag data is a trade secret, number one, that means it has to derive independent economic value from not being known. In other words, the data actually has to be more valuable because people don't know it rather than people are—you get value from it, but so does someone else as well.

And the argument there is to say, you know, if I have data about Mr. Knopf's farm, that doesn't do me any good on my farm because I don't have his farm, I have mine. And so the one side of that argument is that, well, so what if ag data gets disclosed because that's data that's incredibly location-specific to your farm, and it gets out there?

But the other argument is, well, if you know more about my farm, you might be able to bid resources away from me. You might go to my landlord and say, "Wow, Ferrell is doing a terrible job of farming your place, I could do a much better job, and I've got the data to back it up."

So there's an argument there that disclosing the data might actually reduce its economic value. But the point of that is it's really nebulous, and you would spend a lot of time trying to make a very legal argument about whether or not you even had that ownership in the absence of something more carefully defining what ag data ownership really meant.

Senator MORAN. So in today's world of cyber breaches, cyber attacks, and data breaches, is there something we should worry about in the realm of agricultural production data?

Mr. JANZEN. It seems to me—oh, go ahead. I was going to say it seems to me like the most likely candidate for hacking into and obtaining disclosure of agricultural data from someone that shouldn't have it would probably be some form of corporate espionage or, you know, a competitor of one company thinking that if they could get their hands on that information, it may give them a leg-up in the marketplace. And, you know, I don't think we would see that from a United States company, but it's very possible that it could be from a foreign company that wants to get their hands on information to give them a leg-up.

Senator MORAN. I can see some production facilities who would love to keep their information private.

Mr. TATGE. I think one of the big questions that's yet unanswered is the companies that have data, and they've had it, collected it for years, what happens to that data when those companies are sold? That's the question that is looming out there as far as if we've collected data for a long time, and we go to sell our company, part of the value of that company is based upon the data that you've collected. And did you obtain it in ways that were described and really covered under some form of agreement? And I would say for the most part today that doesn't exist.

Senator MORAN. Justin, Mr. Knopf, if you sold your farm in the future, I don't imagine you have enough data at the moment to make the data itself valuable, does the data go with the farm, or that's a separate commodity?

Mr. KNOPF. Well, that's a fair question. I haven't really conceived that question.

Senator BLUMENTHAL. Why is it not like any other property——

Mr. KNOPF. I think——

Senator BLUMENTHAL.—the grain that remains in the silo or the gas in your tractor or——

Mr. KNOPF. Yes.

Senator BLUMENTHAL. Now, the interesting question, though, is—and we haven't really talked about it—mentioning the word "copyright," what about the software in your tractor? When you sell your farm and you sell that equipment, you're also selling the tractor, but the software belongs to GM or John Deere or whoever made the machine, and you can get in trouble if you start tinkering with the software even on your car, let alone your tractor. So this is a common problem in terms of who owns what when we're talking about Big Data.

Mr. KNOPF. Yes, two questions there. Chairman Moran's question, I think a lot of it is the value is still very much being defined, and it's rapidly changing every day in the marketplace because I think as we're—right now, farmers are still struggling to know what the value is in that data and how to use it, and there's a lot of personal intuition about looking at that data from your farm that has to—that another person from outside your farm that doesn't have the understanding that you do of your farm is not going to see the same value that you do in your data. But as models develop and software develops to better automate that process, that data will become more valuable and an independent value proposition.

And, Mr. Blumenthal, that's a very appropriate question, and perhaps you all talked about this as the right—the right to repair, and that's a whole other realm of, you know, when our tractors break down with some—a sensor or a piece of software that's running something mechanical, we get a code, the tractor stops moving. We have to call out the service repairman from the implement company that has the only access to that software to be able to reset that code. There is no third-party competition within the access of that right to repair that specific code.

Now, I understand protecting intellectual property rights and innovation and being able to collect and based on your—recoup value and innovation and protecting that, but there is some—there is also a balance there between at some point in that machinery al-

lowing third parties to enter that software and to be able to access it for repairs as well.

Mr. TATGE. One example, just to add on to that, that I've heard quite a bit is if you were to buy a piece of land in your general area, how many years does it take you to get it to perform the way it was performing for the individual before? On average, I hear it's probably 3 or 4 years for you to really get to know that piece of dirt.

When you think about that, when you go to resell or when you go to market a piece of land, having that history and giving the formula as to what was used before I think could greatly allow the new acquirer to be able to bring that up to the same production standards much faster than it would be on their own.

Mr. KNOPF. And we've always had that, you know, we've always had soil samples and more kind of raw non-digital data on our farms in the past, and that typically, depending on the transaction, if it's a friendly transaction, sometimes it will just be given over, but as that value increases, that becomes more of a very appropriate question.

Senator MORAN. Senator Blumenthal, I take no offense at you indicating now this is the more interesting question, I guess because truth is a defense.

[Laughter.]

Senator MORAN. Thank you for an interesting question.

Senator BLUMENTHAL. Thank you all for your participation today. And I want to thank the Chairman for having this hearing.

Senator MORAN. Mr. Blumenthal, thank you very much. Thanks for your participation.

The hearing record will remain open—let me—I always ask this question, Does anyone, any witness, have anything they want to say before we close today's hearing? Anything we missed?

[No audible response.]

Senator MORAN. Great. The hearing record will remain open for 2 weeks. During this time, Senators are asked to submit any questions for the record. Upon receipt, the witnesses are requested to submit their written answers to the Committee as soon as possible.

That concludes today's hearing. I thank you all for your presence.

[Whereupon, at 4:07 p.m., the hearing was adjourned.]

A P P E N D I X

PREPARED STATEMENT OF HON. BILL NELSON, U.S. SENATOR FROM FLORIDA

Thank you, Mr. Chairman, and thank you for holding this hearing to discuss a topic that is certainly of paramount importance to the State of Florida.

Mr. Chairman, agriculture is one of the most important pillars of Florida's economy, with an annual economic impact of over $120 billion dollars. We have over 47,000 farms and ranches, which employ over 2 million people. Many people know about Florida Oranges, which by the way make up 60 percent of the total U.S. value, but in addition to oranges, we are also ranked #1 in value of production for snap beans, cucumbers, grapefruit, sugarcane, fresh market tomatoes, and watermelons.

So I am very pleased to be holding a hearing that discusses how we can make farming more productive, more efficient, and more sustainable through the use of data. Human activity is drastically changing our world's climate, and not for the better, and we will have to use data and analysis to adapt agricultural practices and protect workers.

In Florida, farmers use precision agriculture to monitor the health and development of beef cattle and dairy cows. They use it to assess soil health in peanut and cotton fields.

And if a fascinating experiment continues to show promise, citrus growers might soon be using lasers to inject pesticides directly into the leaves of citrus trees. Last January I visited with researchers from the University of Florida Citrus Research and Education Center in Lake Alfred, to see this incredible technology in person. A laser makes a tiny incision in the leaf of an infected citrus tree, and then a machine sprays a bactericide directly into the laser cut to get it into the tree's system more effectively.

Research like this couldn't come at a more crucial moment for the citrus industry. Last week, the U.S. Department of Agriculture updated its estimate for the 2017–2018 season, lowering the expected harvest to 50 million boxes. The initial prediction for this season was already a decades-low 54 million boxes.

And that was before Hurricane Irma swept through the state in early September. Farmers and ranchers are still trying to calculate total losses and figure out how to salvage the season. The initial reports are devastating: $760 million in losses for citrus growers, and $2.5 billion in total agriculture losses in Florida. I'm working very closely with Senator Rubio and others to make sure that the next supplemental package includes disaster aid for these farmers so that they don't go out of business.

In the meantime, this hearing can explore how precision agriculture is playing a role in our fight to find a cure for citrus greening, canker, laurel wilt, and other pests and diseases.

Lastly, this committee has a long history of examining the issues of "big data" and how it affects consumers and our economy. Whether it's a consumer shopping online, or a farmer tending to his or her fields, companies are collecting information and monetizing that information for their purposes. Just as I have long advocated for consumers when they are using their smartphone or shopping at the mall, they should have a say in if and how their information is collected and used.

Lastly, I'd like to welcome our distinguished witness panel today, but I want to particularly recognize Dr. Dorota Haman (Door-OH-tah HAH-man). Dr. Haman is Professor and Chair of the Department of Agriculture and Biological Engineering at the University of Florida. She is a renowned expert as an agricultural engineer in advanced irrigation management and technologies. I look forward to hearing Dr. Haman and the testimony from all of our witnesses today.

Mr. Chairman, I am excited to see the new ways in which technological advances can increase agricultural productivity and efficiency in my state and in the rest of the country. Thank you for holding this important hearing.

PREPARED STATEMENT OF TIMOTHY HASSINGER, PRESIDENT AND CEO, LINDSAY CORPORATION

Thank you Subcommittee Chairman Moran, Ranking Member Blumenthal, Senator Deb Fischer and all of the members of the subcommittee for this opportunity to submit this written testimony.

My name is Tim Hassinger. I am the president and chief executive officer of Nebraska-based Lindsay Corporation—a leading manufacturer of center pivot and lateral move agricultural irrigation systems. For more than 50 years, Lindsay Corporation has been at the forefront of research and the development of products and services designed to meet the world's rapidly growing agriculture and transportation needs.

As you may know, it's estimated that by 2050, the global demand for food will be 60 percent higher than it is today. To meet this daunting challenge, it's imperative that we develop and deploy technologies that will help growers produce more with less, while preserving water and other natural resources.

Data-driven farming is the key to allowing growers to meet the food, fuel and fiber needs of the rapidly growing global population. With the touch of a button or swipe of a finger, farmers who have broadband access can:

- Receive commodity price information;
- Monitor and respond to changing weather conditions;
- Use GPS for planting and irrigation management;
- Get real time data on soil and moisture conditions;
- Connect with other farmers and agriculture experts, and
- Store and analyze data to increase sustainability and productivity.

They can also take advantage of a myriad of new technologies now available from Lindsay Corporation and other American manufacturers. Among other things, these innovations enable remote data collection, transfer and analysis from connected devices like soil moisture sensors, weather stations and cloud-based support tools. Farmers are using this information to streamline their operations, maximize efficiency and increase productivity.

We work with farmers every day, so we know the power that comes with the ability to leverage big data. We now offer technology that helps farmers decide precisely when, where and how much to irrigate—maximizing yields while reducing overwatering and related input costs and nutrient losses.

In recently conducted field studies, our researchers found that remote telemetry streamlined growing operations in several key ways, including:

- 3 percent increase in corn *yield* (driving profit of $25 per acre);
- 17 percent reduction in *water usage* (saving more than 9.25 million gallons on a 130 acre field);
- $10/acre reduction in *energy costs;* and
- 75 percent reduction in *time* spent going back and forth to the fields (another $5/acre saved).

This combination of yield enhancement and resource savings can increase American farmers' profits by an average of $40 per acre—profits that can be reinvested in their operation and in their local economy.

Data-driven technologies allow growers to increase yields while conserving water and other natural resources. These technologies are no longer luxuries. Rather, they are critical tools needed to increase the overall operational efficiency and productivity needed to complete in the global marketplace.

PREPARED STATEMENT OF DEERE & COMPANY

Deere & Company ("John Deere") respectfully submits these comments for the record as part of the Subcommittee's November 14, 2017 hearing on the subject of "Technology in Agriculture: Data-Driven Farming."

John Deere is a global leader in the manufacture of agricultural, construction, turf and forestry equipment. Deere provides advanced agricultural and other equipment and services to customers that cultivate, harvest, transform, enrich and build upon the land to meet the world's dramatically increasing need for food, fuel, fiber and infrastructure. Deere has been providing innovative equipment and services to customers since 1837, and today is pioneering state-of-the-art data and information solutions designed to greatly enhance productivity and sustainability.

The Value of Data-Enabled Agriculture

John Deere believes that the growth of data-enabled agriculture is as transformational today as was the introduction of mechanization to the farm almost one hundred years ago. Insights generated from producer data will be critical to meeting the goal to produce enough food and build the infrastructure required to sustain a growing global population. Properly used, producer data has the potential to greatly improve precision, productivity, profitability, and sustainability on the farm.

American farmers face constant pressure to improve efficiency, environmental stewardship, and output. For this purpose, farmers look to advanced smart farming technology solutions, including solutions that take advantage of mobile and fixed broadband access. Today, producers are able to farm to within a few centimeters of accuracy thanks to innovative GPS-enabled positioning systems that are now standard on virtually all modern farming equipment, as supplemented with data available from satellite signals. Using these high precision techniques, advanced agricultural equipment and services now include technology that provides real-time agronomic data that can be analyzed to optimize the precise amount of seed, fertilizer and pesticides needed, reduce costs for fuel, labor, water, and identify best practices for fields in a given location. (Deere's Precision Ag Technologies, for instance, gives farmers access to detailed agronomic information in the field essential for improved decision-making with respect to managing costs and recourses.)

Where possible, producers use data and communication technologies to interact with customers and vendors, follow commodity markets, obtain real-time information on field conditions, weather and other environmental factors, and manage fleets and regulatory compliance. Farmers can also employ innovative machine-to-machine ("M2M") operations in the field and machine-to-farm ("M2F") from the field that enable producers to make significant improvements in real-time productivity and cost management.

Today, these technologies are making an enormous contribution to improved use of limited resources, regulatory compliance and ag sustainability. Precision technologies are enabling more efficient, prescriptive use of soils, water, fertilizer, herbicides and fuel by allowing producers to tailor farming practices and applications to the specific conditions of an individual field.

For example, when the farmer leaves his field in the fall, he is able to share harvest yields directly and immediately with trusted agronomist advisors. This helps the advisor to prescribe the appropriate amount of nutrients to be added back to the soil, based only on what the farmer took off at harvest, and ensure those nutrients are added and incorporated before winter. The farmer can also make decisions on which seeds to buy for next year, taking advantage of early order price discounts. By reducing inputs, improving resource management, minimizing land impacts and lowering costs, these technologies are delivering the promise of sustainability on the farm.

The economic impact of these technologies is significant. According to recent reports, data-driven decisions about irrigation, fertilization and harvesting can increase corn farm profitability by $5 to $100 per acre, and a recent 6-month pilot study found precision agriculture improved overall crop productivity by 15 percent.[1]

The Importance of Data Privacy

In addition to offering a full line of innovative, high-quality agricultural equipment to producer customers worldwide, John Deere provides data and data application services that support customer business needs and the optimal utilization of Deere machines. These services are provided through Deere's proprietary data management platform, the John Deere Operations Center.

John Deere believes that all involved in the generation and use of data and data services should have effective processes in place to ensure privacy, security and ultimate control for the producer. Deere has been actively engaged with individual customers, grower organizations, ag service providers, agronomists and many others to develop practices and processes that ensure producer privacy and control, while making data processing, analysis, and use as seamless as possible. Deere believes that the market participants across this value chain—through collaboration, private agreement and mutual trust—are best able to develop and implement the necessary practices and protocols that protect producers and serve commercial needs. To this end, Deere has developed a set of business data principles that govern its use of production data, machine data and administrative, and are incorporated into every customer's John Deere Operations Center services contract. These principles are de-

[1] *See* Kurt Marko, Forbes, Precision Agriculture Eats Data, CPUC Cycles: It's a Perfect Fit for Cloud Services (Aug. 25, 2015), available at: *http://www.forbes.com/sites/kurtmarko/2015/08/25/precision-ag-cloud/*.

signed to give the customer the ability to control whether and how his/her data can be used, by whom, and for how long.

These principles are:

1. Deere provides data and end-user application services for one reason: to support the business needs of its producer customers and improve the use of Deere equipment and technologies.
2. The producer's data should be differentiated into machine, production, and administrative data, and each data subset should be managed in accord with these important distinctions.
3. Deere utilizes customer data only with the customer's consent, in order to improve grower productivity and profitability, and to optimize the utilization of John Deere products and services in the customer's farming operations.
4. The producer customer retains control of his business data including whether, what and how his data is used and shared. The customer may withdraw this consent or request that data be deleted from his account at any time.
5. Any disclosure of explicit customer business data is determined solely by the customer's designated account preferences and through contractual agreements with John Deere.

Farming is a complex, dynamic industry and this makes the notion of farm data ownership complex as well. Farmers use Deere's tools and offerings in many different ways, which further complicates the issue of ownership. Expectations, relationships, contracts and laws regarding data control and ownership vary from place to place, operation to operation and even on a single farm. Companies that assert that farmers own their data are not being transparent—it is not as simple as that, which is why John Deere is focused on efforts to ensure that farmers control their data.

Real-world circumstances that make data *ownership* complicated and uncertain include:

- Custom harvesters or equipment operators who may have the right to share production data.
- Landlord and/or tenants who may have the right to share some or all production data from a farm.
- Agronomists and other consultants who may have the right to share data.
- A farmer who may buy licenses to use commercial prescription files, other technologies, or seed hybrids that the farmer does not own.

This is why Deere believes that customer *control* of the data is the most important issue. Deere's data management services and applications are designed to ensure customer control of their farm's data.

There are important distinctions between the types of data that are generated through integrated ag technologies, and Deere and its customers agree to manage these differentiated data sets accordingly. John Deere segregates customer data into three subsets—Machine Data, Production Data, and Administrative Data.

- Machine Data are data that generally relate to how equipment is functioning (fuel consumption, vehicle diagnostic, engine performance). This data may be utilized, with the customer's consent, in original or aggregated, anonymized form to proactively address equipment issues and improve the customer's experience with the machine.
- Production Data relate to the work being performed by the customer, and enable Deere to administer services the customer has opted into, such as field tasks, location history or wireless data transfer. By using our systems, customers agree to allow Deere to create aggregated and anonymized Production Data sets. These anonymized data sets are proprietary to John Deere. John Deere is free to use and disclose the anonymized data, and John Deere may promote information and services derived from anonymized data. Anonymized data is never traceable back to a specific customer.
- Administrative Data is information that helps Deere support a customer's account and activities in our system. Examples of administrative data are: data sharing permissions, account users, machines and licenses connected to accounts, acres or file sizes.

These distinctions are a critical part of the data management process. They preserve customer control while distinguishing the sensitivities associated with certain data sets. They are reflected in the contractual agreements between John Deere and its customers.

It should be noted that the marketplace for technology around data collection, transmission, storage and use is evolving rapidly and will continue to evolve in the years to come. Producers will continue to be presented with new options and product offerings that can deliver even greater value, while rewarding the most innovative technology and service providers at the same time. This can best happen through the collaborative private sector efforts of market participants, without the specter of more rigid standards or codes imposed from outside that could stifle innovation. The Ag Data Transparency Evaluator, created and managed in conjunction with the American Farm Bureau Federation, is a good example of this private sector effort. John Deere played an integral part in the creation and implementation of this tool. We are actively working with this group to achieve its "seal of approval." Initially, discussions around the requirement to recognize farmers' ownership, rather than control, of data slowed our progress. After much discussion, Deere believes we have greater alignment with this group and look forward to adding our name to the list of companies that have gone through the transparency process.

Finally, it should also be noted that, without essential broadband connectivity in croplands, many of the potential benefits of data-driven agriculture can never be realized. Real-time ag services using data generated on the farm are dependent on reliable, high-speed wired and wireless connections to the Internet—connections that in turn depend on a robust rural broadband infrastructure that is currently lacking in many parts of the country. More attention must be given at the Federal level to ensure that the build-out of wireless broadband infrastructure, including connectivity in the fields where farmers and equipment operate, is achieved.

At the heart of John Deere's efforts and principles around data-enabled agriculture lies our history of, and commitment to, helping those linked to the land. Since 1837, John Deere has been building lasting relationships with agricultural producers based on our core values of integrity, quality, innovation, and commitment. Deere believes that the trust we have established with producers, built up over these 180 years, is exponentially more important than the value we might derive from producer data.

Deere & Company appreciates this opportunity to share its views, and looks forward to working with the Subcommittee on these important issues.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JERRY MORAN TO JUSTIN KNOPF

Question 1. Your testimony described the usage of data as a "driver of economical sustainability and environmental stewardship." As a Kansas farmer focused on both being a good steward of the land and making a living to provide for your family, could you please further describe your efforts to balance sustainable farming practices with improving efficiencies to increase profits? Can the two goals go hand in hand?

Answer. Yes, often the two goals can go hand in hand. I believe most "sustainable farming practices" will have positive impacts on profit in the long term. The challenge is "the long term" might be ten years, or twenty, or a lifetime. There are numerous examples of sustainable farming practices which evidence would point to having a long term positive impact on profit, yet be a possible net cost in the short term. These types of practices will tend to have slower adoption curves. An example of one of these practices on our farm would be cover crops. They are crops planted between our main grain crops solely intended to provide environmental benefits to soil protection and health. The seed and investment in time and machinery to plant them is a significant cost and we have yet to document a yield or economic benefit to the subsequent grain crop. However, evidence and agronomic principles predict that across time, the environmental and biological benefits from cover crops in our climate and soils will improve the resiliency of our farm and perhaps the productivity, and therefore profit. In the meantime, we utilize data from both on farm research trials and field scale to evaluate what cover crops in which part of our cropping sequence will have the most impact with the least amount of cost. We then start with limited acreage and hopefully scale the practice to broader implementation as we learn and begin to reap some benefits over time.

There are other examples of sustainable farming practices that will also improve efficiencies to increase profit as well in the short term. An example from our farm is zone management. We utilize various sources of data, typically multi-year yield maps, satellite imagery, and soil maps, to divide a field into zones based on productivity. Then, the more productive zones of the field receive the right amount of fertilizer to sustain that productivity while fertilizer rates are cut on less productive zones. Right away, we have improved the efficiency of our fertilizer which increases

our return on that investment, plus reduces fertilizer carryover and loss into the environment.

Question 2. How does data collection and sharing specifically assist farmers in striking the appropriate balance, including innovations in live-time monitoring of crops and measurements of surrounding conditions?

Answer. Data collection and sharing improves our understanding of how crops are impacted by certain factors such as weather events, management decisions, soil types, etc. Obviously some of these factors are outside of the farmer's control, but access to improved live-time monitoring of crops and measurement of surrounding conditions can help farmers be more proactive in predicting crop response to these factors or events and lead to more timely and improved decision making. One quick example, this past summer we had a summer hail storm that significantly reduced soybean stands in its path. We utilized satellite images of the impacted fields that were available several days after the storm to fine tune our scouting and decision making about where to replant and where we could salvage the stand of soybeans.

Question 3. Your testimony divides the data that your farm specifically uses into three categories: microdata, service provider data, and macrodata. Will you please describe how farmers and their operations benefit from each category of data?

Answer. Microdata-this is data a farmer collects from his own operation and is specific to his operation. This likely helps better characterize specific aspects or management factors unique to his farm, leading to improved decision making.

Service provider data-this is data that is produced by a service provider outside of the farm. Likely, there will be data from the farm shared with or collected by the service provider, but then the service provider will utilize data from that farm and perhaps integrate it with data from other farms and/or a proprietary algorithm or internal data set to provide analyzed data back to the farm in order to help with improved decision making by the farmer.

Macrodata-this is "big data" collected from many farms likely across a broad geography. The farmer may or may not have contributed data from his farm, however, there are insights gained from the sheer volume of data that may not be possible if the data set was not so large. The insights may be more universal in nature yet still applied by many farmers to improve decision making.

Question 4. In a 2016 poll conducted by the American Farm Bureau Federation, regarding the loss of control over downstream uses of data, sixty-six percent of the farmers polled expressed concern about not being compensated for the potential benefits from the use of their data beyond the direct value they may realize on their farm. Meanwhile, sixty-one percent of the farmers were concerned that agricultural technology providers (ATPs) could use their data to influence market decisions. Which of the two concerns do you believe is the greatest threat to farmer profitability and well-being, and what should be done to alleviate these concerns?

Answer. I don't know which of these two concerns is the greatest threat to the farmer. As the statistics indicate, both are of significant concern to many farmers. Farmers are accustomed to dealing with concrete things we can put our hands on tractors, soil, grain. Data is very abstract and therefore more difficult for farmers to quantify the value of, although most of us certainly recognize it does have value. As was mentioned in the hearing, I believe one of the most important steps to reducing the threat of non-compensation is transparency and understandable communication up front before data transactions and agreements take place. It is important the farmer can quickly and easily understand what is happening with his data and the parameters of any data agreement he is considering. I also believe it's important to recognize that farmers may be compensated for their data in forms other than money. Compensation may be access to insights gleaned from the larger data set they are contributing to, or access to a proprietary decision making tool.

I believe most would agree that there is power in data and recognize the consolidation in agricultural companies, which is likely why farmers feel concern about their data being used to influence market decisions. Consolidation and concentration of data is perhaps something that should be monitored.

Question 5. With connectivity being crucial to the successful implementation of the technology we have discussed today and almost 30 percent of farms not receiving adequate broadband connection according to the USDA's Farm Computer Usage and Ownership August 2017 report, what role can this Committee play in closing the gap to make sure all of our farms are able to benefit from broadband and innovative technologies? Do you see a role for advanced wireless networks in achieving that goal?

Answer. Our farm is one of the 30 percent not receiving adequate broadband connection. We do have a broadband connection, but to date it is slow, not very reliable, and with only one provider choice, there is no competition to drive improvement.

Nearly all data management software has now become web based so as the amount of data on the farm needed to be uploaded and downloaded exponentially increases, effective utilization of data and implementation of technology becomes impossible without reliable and high speed data transfer technology. My time as a farmer is very limited as it is, especially during the growing season, so I cannot afford to sit and wait on a slow data connection. There have been numerous times I've had to abandon a project because of slow data transfer. However, I am hopeful as a local communications company has undertaken the project of running new fiber optics to rural residences and farms in our community. This will help with effective data transfer from our farm office, but it will take advanced wireless networks to achieve this goal in the field from mobile devices. It is my hope this committee would have a renewed commitment to learning where these gaps still exist and assisting small local companies, such as Home Communications, Inc. in Galva, Kansas, along with wireless network providers in closing those access gaps to fast and reliable data networks.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. CATHERINE CORTEZ MASTO TO JUSTIN KNOPF

Question 1. Obviously in the west we have some greater agriculture challenges than other regions, and wildfires are one of them that we've seen have detrimental effects over and over again. In many cases, these fires have a multiplier effect on production and for things like future flooding. And, in general, water is also another constant challenge. Are there technologies that can help measure and account for drought conditions, or measure the volatility of fires within parched forests or grasslands *before* we have fires that potentially get out of control? Are there any associations with improving broader weather prediction or forecasts? And are there other specifics where you foresee this data and technologies helping us get a better handle on our climate change crisis?

Answer. It has and continues to be heart breaking to see and hear reports from the west on the devastation caused by these wildfires. We've had devastation in Kansas as well from wildfires recently. Thousands upon thousands of acres of grassland have been burned, countless cattle and miles of fencing lost, and homes and barns that have been passed down through families on the prairie for generations destroyed. There are certainly technologies that can provide data to help measure and account for drought and predict risk of fire. While I'm certainly not the best person to speak to these technologies, I can give you an example from Kansas that is helping. Since 1986, Kansas State University has managed a network of high tech weather stations, called the Kansas Mesonet. Through recent efforts to grow the number of stations in the network, they now have coverage across the state. These stations are not only monitoring and recording typical weather data, but also soil moisture, which is of course helpful in characterizing drought, and when used in conjunction with relative humidity and wind speed, has been a helpful proactive warning for high risk of grassland fires. I believe increased number of weather stations such as these that are available for farmers, ranchers, emergency preparedness personnel, and the public to access will hopefully help quantify and characterize more extreme weather, in turn leading to increased preparedness.

There are technologies being implemented on farms that are scalable enough to help mitigate climate change. Two specific examples are improved fertilizer management through using the right source, rate, time, and place for plant nutrient applications, which significantly reduces Nitrous Oxide emissions, and also no-till farming practices which sequesters Carbon Dioxide from the atmosphere in the soil. With the help of Dr. Charles Rice, soil microbiologist at Kansas State University and world-renowned soil Carbon expert, I recently calculated that through building soil organic matter by implementing a no-till based cropping system, our family farm has offset the average Carbon emissions for roughly 4000 Americans. The soil is one of the biggest Carbon sinks on the planet and practices such as no-till that increase the organic matter of the soil not only offsets Carbon Dioxide, but also improves the ability of the soil to capture and hold water, reduces erosion, and allows soil biology to thrive, all leading to a more productive and resilient system.

Question 2. There were many references to the environmental benefits of agricultural data. Are we in a position yet where we can authoritatively quantify the environmental benefits experienced by the use and attention to these technologies and data analysis? For example, is this science proven to the point that we should be creating incentives in the farm bill conservation title for their utilization to keep pristine watersheds like Lake Tahoe, or water quantity in drought areas, solidified

for the decades to come? Or is there a place for this use in connection with the Federal crop insurance program?

Answer. Yes, we are now able to much better quantify environmental benefits experienced through utilization of technology, data, improved decision making, and effective conservation practices. However, the challenge becomes as geography, climate, soils, and numerous other things change from state to state, region to region, and even farm to farm, the outcomes and impacts of practices will vary widely. Therefore, the "right" decision for meaningful and long lasting environmental impact on my farm may be the "wrong" decision for a farm 100 miles west of me. Farmers are operating within an incredibly complex biological system with an infinite number of relationships all impacting each other. This is why it becomes so difficult to legislate effective change to a biological system. That being said, I do believe incentives can be incredibly effective at driving long lasting and meaningful change if they are flexible and tailored to a local level by local experts and advisors whom farmers trust. I have personally utilized the Conservation Stewardship Program in the farm bill to help offset some of the risk and short term costs in utilizing cover crops, which has allowed me to implement the practice on more acres. And I do believe crop insurance could be an effective avenue to offer incentives for implementing conservation practices, but they must be practices that are proven to be effective, economic, and increase reliance at a local level. As you know, the devil is always in the details.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JERRY MORAN TO DR. SHANNON FERRELL

Question 1. In your testimony, you state that as participation in the data community increases to a critical mass, farmers' bargaining power with the data service providers likely will be greatly reduced and a majority of the value will be enjoyed by the providers. You then state that for farmers to take maximum economic advantage of Big Data tools, large numbers of farmers must "buy-in" and participate in the data community. Where is most of this value enjoyed by the data service providers derived from? What can be done to mitigate the disparate levels of value received, especially for producers?

Answer. Witness response to Question 1, part A: Where is most of this value enjoyed by the data service providers derived from?

Before discussing the source of the value enjoyed by data service providers through data compilation and deployment of Big Data tools, it is important to discuss the value of data at the farm level in the form of Small Data. At the individual farm level, farmers may take advantage of today's data collection and analysis tools to run on-farm experiments with respect to seed varieties, fertilizer applications, moisture management, and so on. They can also use data to calculate crop shares for rent, look for improved efficiencies in equipment, management, conservation practices, and so on. In these uses, farmers capture all of the data's value on-farm in the form of increased returns or reduced costs.

While these "micro" level benefits can be considerable for the individual producer, there can also be significant value derived through the use of Big Data systems and analytical techniques at the "macro" level when data from hundreds or even thousands of operations are aggregated. As mentioned in the written testimony, Big Data analytics can be used to much more rapidly develop hybrids by running trials across multiple soils and environmental conditions, developing more accurate and robust models for predicting risk factors such as weather patterns and production numbers, and development of improved agricultural equipment. All of these items can be derived from the aggregation of data from farmers and provide value back to those farmers.

When one examines the potential economic values of data for the data service providers, there are five primary sources to consider:

(1) Data service providers can derive revenue from the services they provide directly to the farmer that provided the data. This could be in the form of service fees for things like data collection and validation, creating a repository of the farmer's data that can be easily shared with other parties to whom the farmer would like to provide access (such as a crop consultant, landlord, etc.), or in the case of a data service provider that also serves another role such as a crop consultant, providing reports, prescriptions, or recommendations to the farmer based upon the data.

(2) The data service provider could derive revenue from using the data to market goods or services to the farmer. For example, if the data service provider is

a subsidiary of a seed company, the farmer's data could help the seed company make seed recommendations that are a good fit for the farmer's operation. This form of focused marketing can sometimes benefit the farmer as well. For example, consider purchasing a mixing bowl for your kitchen on Amazon. Based on that purchase, Amazon suggests a whisk and baking sheet that are commonly purchased with your mixing bowl that have gotten favorable reviews from people who purchased all three items simultaneously. If you also make the suggested purchases and enjoy them, it is a "win-win" transaction for both you and Amazon. Similarly, purchasing a seed variety that performs well for your farm and increases profits creates a win-win for you and the seed company. However, companies can also use a farmer's data to provide recommendations while extracting more profit from the producer. As another example, seed companies already use information about producers to know which seed varieties are better suited to the farmer's land and charge them more for that variety than they would charge another producer. With increasing access to producer data, input suppliers could continue to derive more precise information about a producers willingness to pay (or ability to pay) for their inputs and adjust their pricing accordingly.

(3) Data service providers might provide data products or services based on farmers' data to other companies. For example, data service providers might sell reports or predictive models to insurance underwriters might help them price crop insurance products. These reports or models might be derived from farmers' data but their sale would not necessarily involve the transfer of the farmers' data.

(4) Data service providers can function as data aggregators and then sell the farmer's data to third parties, deriving revenue from those sales. In some cases, such data service providers may pay the farmer for their data, but in other cases they may charge the farmer a fee for their data collection services (while providing some analytical services or reports back to the farmer) and also derive a fee from the sale of the data to other entities.

(5) Eventually, if and when enough farms join data networks, a fifth use could come of that data—use of that information for significant transactions in commodities markets. A hypothetical example would be a data service provider who had access to a sufficiently large sample of farms to make accurate predictions of eventual U.S. crop yield who then takes positions in the commodities markets well before anyone else would be able to access that information.

A potential sixth value source is from the data service provider positioning itself as an acquisition target with the purchasing company getting either the data it holds and/or the subscription relationships with the farmers it serves. Economic theory and historical precedent both suggest that we will see an evolution in the agricultural data industry starting with a large number of service providers vying to engage farmers because, as Metcalfe's law suggests, the value of their data networks will increase as a square of the number of their network participants. Better-capitalized firms or firms with another competitive advantage will acquire other firms until eventually only a handful of dominant service providers—or even a singular monopolistic provider—emerges. In the course of this evolution, the more farmers and data a company can acquire, the more attractive they become as an acquisition target. While some firms are certainly pursing the strategy of becoming one of the dominant providers, it is equally certain that other firms are seeking simply to be acquired.

Witness response to Question 1, part B: What can be done to mitigate the disparate levels of value received, especially for producers?

Answer. Research continues to determine both the value of agricultural data in the aggregate and what proportion of that value is captured by the farmer relative to others in the value chain. As with the current USDA estimate that farmers capture 15.6¢ of the food dollar, it is likely farmers will not capture a large proportion of data values since they are relatively small, "atomistic" players in the market with little bargaining power and face significant barriers to the kind of collective action necessary to increase that bargaining power.

Having said that, farmers' bargaining power may be at a maximum right now. As mentioned in the response to Part A of Question 1, most data service providers recognize they are in a race to acquire access to the data of as many farmers and their acres as they can, as quickly as possible. Some are approaching this with the strategy of a telemarketer telling a prospect "sign up today, because this offer will be gone tomorrow!" However, farmers should be thinking like economists, and carefully weighing the benefits presented by any particular service provider with the

value they can receive from that provider's services (or, indeed, the payment the provider is offering to secure the farmer's data). To that end, farmers should ask five questions of any prospective data service provider:

(1) How many growers/farms/fields/acres are in the data service provider's data community? The higher the number, the greater the value it can potentially provide to the individual farmer.

(2) What analytics conducted on the community will benefit my farm? This aims at the direct ability of the data service provider to increase the farmer's ability to make profitable decisions, regardless of any external benefits.

(3) What data quality control standards are being used? If the data service provider is not taking strong measures to ensure the quality of the data in their community, it cannot provide reliable insights to the producer. To quote the age-old computer principle: "garbage in, garbage out."

(4) What uses will be made of my data? This question has a number of implications discussed in the responses to other questions below, but here its purpose is to help the producer gauge what potential values the data service provider may be trying to capture that will not directly benefit the producer (or may actually increase costs for the producer).

(5) What assurances can the data service provider make that the farmer's data will not be provided to third parties without the ability of the producer to share in the revenues from that transaction? Consider the analogy of a farmer giving an unrestricted easement to an oil pipeline company. The farmer may get a payment for the easement, but the oil pipeline company may be able to sell co-located easements to a natural gas company, a telephone company, a fiber optic company, and so on, without the farmer having any ability to capture the value realized from those transactions. Similarly, if a farmer does not have an agreement restricting "downstream" uses of his or her data, they only have one opportunity to capture the value of that data.

While farmer's negotiating power may be at a peak, it may also be a matter of timing to make sure farmers do not completely miss out on the ability to capture the value of their data. As the industry continues to evolve, we will likely see a progression going from a) farmers paying data service providers for their services, b) data service providers realizing they need more and more farmers in their network and thus reducing their costs, potentially to nothing, to join, c) companies actually paying farmers for their data, but then d) companies securing a critical mass of farms or acres to have sufficiently robust data networks that they no longer need additional farmers to join.

In the end, the most effective means of helping farmers secure the maximum amount of their data's value may be educational efforts to help them determine the value of their data, evaluate data service providers and their agreements, and make informed choices about their data sharing relationships.

Question 2. You note the irony in the growth of proprietary data network protocols that lead to complaints about the lack of interoperability of farm equipment systems also providing greater protection against data breaches. What measures can be taken to continue improving the interoperability of data collection without sacrificing security?

Answer. Witness response to Question 2: There are two primary reasons computer viruses are far more problematic for computers using a Windows operating system than an Apple OS system: first, far more machines use Windows, and second, the nature of Windows architecture permits more access points to its code than Apple OS. At the same time, one could also make the argument that all computer users have benefitted from consolidation in the computer industry in that so many programs are now interoperable and data can be shared among what is now billions of other users with relatively little friction. By analogy, farmers and data service providers may both benefit from consolidation in the industry and the increased interoperability it provides.

Such consolidation may also "consolidate" security concerns as more eggs are kept in fewer baskets. This is the Windows problem again—since there are far more Windows-based computers in the world, virus writers devote more resources to viruses that target them. Thus, as consolidation continues in the agricultural data sector, increased research and development efforts will be needed to make sure that these "fewer baskets" are guarded by increasingly robust security tools. Congressional support of these research efforts would benefit not only agricultural producers but a vast number of Americans who rely on data security to keep their personal information secure.

The increasing automation of agricultural data collection and transmission tasks might actually serve as a means of increasing data security. The second reason Windows computers suffer from so many security issues is the Windows operating system was not built with security as one of its primary concerns, since its foundations were built before networked computing was a primary use of PCs. As a result, there are far more access points to its code that virus writers can use to insert malicious instructions. Conversely, there are fewer access points in Apple OS—a system built from the ground up for networked, multi-user applications that thus requires explicit user permission for code to be activated. The analogy in agricultural data is that the tighter integration of data networks across agricultural equipment creates fewer intervention opportunities for third parties. The market will likely continue to drive this integration. With that said, the issue of user's data security needs to be continuously brought to the attention of hardware and software developers so they can keep security as a foundational principle in their designs.

Another tool that might aid the security of farm data networks may not seem to be directly connected to the security issue, but certainly is: the expanded development of broadband cellular networks in rural areas. Cellular transmissions are encrypted by the nature of the processes that make cellular communication work; this has the most beneficial side effect of adding to the security of the transmission. However, in many rural areas, sufficient cellular signal or bandwidth is not available to make use of many current agricultural data technologies, requiring farmers to manually download and transmit their data using much less secure methods. Expansion of rural broadband cellular access would have the dual benefit of making agricultural data tools more accessible and profitable for farmers while also reducing the security risks associated with collecting and transmitting agricultural data.

Question 3. In your testimony, you note that the current legal framework for ownership of agricultural data is inadequate for the transfer and aggregation of agricultural data. Is the agricultural data space unique enough to require specific legislation regarding ownership and property rights, or is a novel combination of existing property ownership laws more appropriate and adequate?

Answer. Witness response to Question 3: One of the first questions farmers always ask about their data is "do I own it?" It is a natural question to ask, since farmers depend on access to land whether it is owned or leased, and thus are closely attuned to property rights. However, traditional notions of ownership break down to some extent with agricultural data. Thus, the better question for the farmer to ask may be "what rights do I have with respect to my data, and what rights to others have with respect to it. The most critical element of this may be what rights (and abilities) does the farmer have to exclude others from access to the data.

If one thinks about it, the notion of "privacy" is really a function of one's ability to exclude others from access to information. For example, HIPAA's provisions regarding health information naturally couples with the notion of privacy in one's health matters, as they pertain to matters of one's own body. Thus, HIPAA provides a legal right to exclude others from access to health information without explicit consent for the disclosure of that data. The Fair Credit Reporting Act (FCRA) covers matters of financial information, which also couples with traditional notions of privacy and the right to exclude others from access to one's financial records.

However, the barriers start to blur a bit with the FCRA in that financial transactions mean reaching out to and communicating with another party; we recognize that others may have some limited right to access our financial information if that information is relevant to their financial risk in some respect, such as loaning us money. Therefore, we allow credit bureaus to collect financial information and to disclose that information to others so they may make credit decisions about us.

The credit reporting analogy is important to understanding whether we need a specific legal framework for agricultural data. Whenever someone requests credit, they are required to ask if the potential borrower will give consent to the lender to access a credit report. Thus, for a third party to make use of the financial data, they must have the consent of the person about which the data is collected. Conversely, though, in many farm data agreements, the farmer may not have the right to approve or deny access to their data to "downstream" users.

One could argue that agricultural data is significantly different from HIPAA-protected health information (about the workings and condition of one's own body) or financial data, but one should also consider the fact that farmers lack the ability to protect their information from disclosure. Put another way, it would be impossible for farmers to try and keep confidential much of their production information and practices because they can literally be seen from aerial or satellite imagery. With relatively little effort one can tell how many acres a particular farmer owns and what proportion of it is in what crop for a given year (compare this to a bicycle maker or a coffee shop—it would be extraordinarily difficult to determine the vol-

ume or nature of their business, or to even tell one business from the other without continuous monitoring of the business at high image resolutions, simply because their businesses have roofs and farms cannot). It could be argued then that perhaps farmers should be given more protections than other businesses because one could derive a significant amount of financial information about them from publically available resources, to say nothing of the improved ability to do so if one coupled data sources from a data service provider that transferred that information without the farmer's consent.

However, if one did desire to provide enhanced protections for agricultural data and allow farmers to exclude others from their data without explicit consent, two significant barriers loom. First, one would have to define the type of agricultural data subject to the protection. This would be challenging, given the broad diversity of data that can be collected and transmitted on farms today. Second, it would be difficult to define when such consent would be needed. Would the farmer have to give consent to any data transfer to another party? There would be significant transactional costs in such an approach. Further, there are doubtlessly data uses that will be available in the near future that might not even be conceivable today; it would be quite challenging to give informed consent in an up-front data use agreement when one doesn't know what data uses might be possible in the future.

The current legal framework might be serviceable as an interim tool to help provide farmers some grounds for the excludability of agricultural data, and enhancements to that framework may be possible. In the near term, though, perhaps one way to help farmers maintain control of their data is additional research into encryption algorithms that give farmers a key that would be required to access the information—this would put more control over downstream uses back in the hands of the farmers, and also give them an increased ability to participate in the value received for data transactions.

Question 4. As more and more firms enter the agriculture-technology space and interact with data used by and/or generated by farmers, the need for clarity and consistency on privacy principles is growing. For these new entrants, can you suggest any best practices these firms should engage upon to ensure their data privacy procedures properly convey the data's expected use?

Answer. Witness response to Question 4: Much use is made in the agricultural data industry of the word "transparency" but there can often be much ambiguity in what that term means. The greatest value of that term, in the witness' opinion, is to err on the side of disclosure to the farmer when discussing the internal and external uses that the data service provider will be making of the farmer's data. Those uses should be disclosed clearly in language that is understandable by farmers with a wide range of experiences and educational backgrounds. One such example may be a Truth in Lending Act (TILA) disclosure. Though an agricultural data use agreement might not bear a clear analogy to a lending transaction, TILA makes clear the potential impacts of the lending transaction and the borrower's rights and remedies. Data service providers could benefit from making sure their data use agreements have similar levels of clarity.

Another principle beyond the clarity of the disclosure is its frequency. Using another financial analogy, individuals can use credit monitoring services to receive notifications when someone makes a credit inquiry about them. Data service providers could also provide notices when an external entity has made a request to access the farmer's data, or when a new internal use is made of the data. Robust notification procedures can also help farmers take protective actions in the event of a data breach.

As mentioned in the response to Question 3, there arises the issue of informed consent when a new data use arises that was not contemplated by the original data use agreement. Though it might increase transactional costs, the simple answer to this problem is to require disclosure of a potential new use and secure the farmer's consent to the use before it is implemented. The counterpoint to this approach, however, is that its increased transactional costs might make companies implementing it less competitive than those who do not.

Finally, as new companies enter the agricultural data sector, they would do well to avail themselves of the efforts of farm groups, existing data service providers, and equipment manufacturers to develop consensus on the principles that should govern agricultural data management. The Privacy and Security Principles Farm Data developed by the American Farm Bureau Federation and the Ag Data Transparency Evaluator are two good starts for companies to use in developing their operating policies and procedures. Both of these tools continue to develop, and the dialogue can provide greater benefits to the agricultural industry with increased participation from more farmers and data firms.

Question 5. While much of the data we discussed in the hearing is generated on farm and captured by farmers or their equipment, significant quantities of data is publicly available and critically important to inform risk modeling, yield prediction, etc. in both the public and private sector. How can we encourage the continued use of this type of data, and even grow our sources, while ensuring that farmers understand their role in this process?

Answer. Witness response to Question 5: Perhaps the best steps that can be made toward this goal are to continue funding of research and extension efforts through our Land Grant universities to help producers understand the value of the data resources to their decision making processes. For example, the witness is currently the principal investigator on a Southern Risk Management Education Center grant funded through USDA–NIFA to develop a handbook and decision tools that can help producers understand the value of agricultural data tools and help them make informed choices about their uses (SRMEC Agreement 21667–19).

Additional research on how agricultural data systems can be made more robust, reliable, and accurate can also add to the volume and quality of publically-available data. For example, the most commonly-logged seed variety on planter data systems is the variety that comes first alphabetically on the system's drop down list. This means that producers sometimes inadvertently (although potentially carelessly or intentionally) select data inputs that are inaccurate, which in turn affects all downstream uses of their data. Research of tools to help improve data accuracy will not only increase profitability for producers, but will also improve the data and decision tools available to the industry.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. CATHERINE CORTEZ MASTO TO DR. SHANNON FERRELL

Question 1. Ranching is a part of the fabric of rural Nevada's frontier. We have operations under generations of family management. While we heard many of the virtues of row crop farming and big data during the hearing, can you outline the advancements and prospects for animal agriculture? Is there also an advantage of agricultural data in ensuring a higher bar of food safety as well, for farmers, ranchers and consumers?

Answer. While most of the discussion around agricultural data and Big Data in agriculture has revolved around applications for crop systems, the data revolution holds tremendous implications for livestock producers and the consumers of their products. Space does not permit a full exploration of all the potential avenues by which new data technologies could impact the livestock industry, but below are a few examples.

Animal traceability: One example of how data technologies are being used right now in other countries is to provide robust animal traceability from farm to fork. For example, the bovine spongiform encephalopathy (BSE, sometimes called "mad cow disease") outbreak in the U.K. during the late 1990s spurred the implementation of an animal identification system that can trace an animal throughout its life from birth to the retail packaging in which its cuts are sold. Put another way, a steak could be traced back to the retailer, wholesaler, meat processor, feedlot, and cow-calf operation at which the calf was born. That level of traceability has the potential to prevent losses that could reach billions of dollars in the event of a BSE discovery in the United States by quickly isolating every other animal with which a diseased animal came into contact and drastically reducing the number of animals that would have to be quarantined or destroyed to prevent spread of the disease. It could simultaneously determine the wholesaler and retailer location of any potentially dangerous food products. Quick and accurate disease traceability thus has important implications for both livestock producers and consumers.

Disease traceability is an important example of the loss-prevention capability of data technologies, but there are also important value-added applications as well. The same technology can enhance the ability of livestock producers to provide age and source verification of beef products, enhancing their ability to market their beef as a branded product rather than a commodity. Traceability also allows ranchers to show compliance with certifications and standards to demonstrate to consumers that given affinity traits have been maintained throughout the beef supply chain.

Keeping of such traceability information is possible with manual technologies, but is made faster, easier, and much more accurate and reliable by automation technologies such as radio frequency identification (RFID) tags for animals coupled with automated readers and loggers. Those technologies, working together with an already robust supply chain data system in the wholesaler and retailer sector, have significant potential to rapidly improve traceability within the U.S. beef system.

Managing production inputs: One of the reasons the use of data technologies has received so much attention in crop production is that it is relatively easier (though one hates to apply the term "easy" to the significant work in technological research and application that has occurred there) to deploy sensors and data collection/transmission systems on tractors, planters, sprayers, and combines than it is to cattle. However, advancements in sensors and computers continue to make it easier to use these advanced data technologies in livestock applications.

In addition to the traceability systems mentioned above, we continue to see advances in sensor systems allowing ranchers to learn more and more about their production input use. The corn farmer cares about seed variety, water uptake, fertilizer inputs, and disease pressure as variables in determining their crop yield. A robust genetic database and traceability system coupled with wearable sensors could help a rancher track a cow's water and feed intake and health. We already have technologies allowing for feed and water tracking in closed environments like a feed yard or dairy, but advancements continue toward wearable sensor technologies that would allow similar tracking in open pasture environments.

Beyond tracking these factors, such sensors could also be coupled with other data systems to provide significantly enhanced management information for ranchers to see what production variables yield the greatest financial returns. An example of this is a program here in Oklahoma called the Oklahoma Quality Beef Network (OQBN). Through a number of manual protocols, producers participating in the OQBN have the information needed to show compliance with a number of value-added programs giving them access to premiums in the marketplace for their cattle. Participation in the program also gives ranchers the ability to analyze the costs and returns of their production practices. OQBN represents another system that could be enhanced by the deployment of data technologies and a strong animal traceability system. For example, as an animal is given the OQBN vaccine regimen, each vaccine could be scanned as administered to the cow after the cow's RFID scan; those vaccines would then be part of the cow's OQBN record to show compliance with its vaccination requirements, and that information could be displayed at the auction as the cow comes into the ring.

Managing range cattle production: At the risk of stating the obvious, managing range cattle production is hard, and those challenges are multiplied in Nevada by the significant size and/or rugged topography of ranches. Many of the sensor technologies referenced herein require cattle to be close to a collection point such as a watering point or feed area, but those points are difficult to come by in range production. Even if a rancher could put a transceiver near common watering points or feeding areas on a range, those transceivers depend on cellular data networks to collect and transmit data. The expansion of rural broadband cellular coverage could increase the opportunities for producers to take advantage of these technologies, however. Broader and stronger networks would allow many more opportunities for range cattle producers to take advantage of these data technologies.

Another technology that could be of great benefit to range cattle producers is unmanned aerial systems (UAS or "drones"). In their most straightforward application, UAS could be used to help ranchers check on cattle much more quickly than they could by ground vehicle or horseback. This could include everything from taking pictures or video to count cattle, inspect fences, or check on water availability. This is particularly true in rugged, mountainous terrain that is difficult to access.

If the UAS were equipped with data transceivers backed by a strong rural broadband network, the UAS could even collect and relay the sensor data mentioned above, or could alert a rancher to a cow that was ill and in need of immediate treatment. While some current UAS technologies could already help in this regard, current FAA regulations only allow most UAS to be operated by "direct line of sight" which means the pilot must have direct visual contact with the UAS. That rule makes some of these applications impractical, particularly in mountainous terrain. Continued improvements in camera and transmitter technologies could soon make a "point of view" camera mounted on the UAS an acceptable substitute for direct visual contact, though, permitting amendment of the FAA regulations to allow longer flight ranges.

Consumer-side data: Much has been discussed in terms of how Big Data technologies can create models to help crop production, but there is also significant potential for those technologies to impact beef production, and indeed, consumption. We already have large volumes of universal product code (UPC) scanner data from retail outlets that can tell us much about where and when certain food products are consumed. However, if the beef industry were to couple that data and supply chain information with the traceability elements mentioned above, the amount of data available for analysis would grow exponentially, and tremendous insights could be derived about beef demand, consumption patterns, and other factors. Big Data could

also provide significant insights into the effectiveness of food policy such as the use of SNAP EBT benefits for certain types of foods, the nutrient profile of those purchases, and consumer incentives.

Question 2. There were many references to the environmental benefits of agricultural data. Are we in a position yet where we can authoritatively quantify the environmental benefits experienced by the use and attention to these technologies and data analysis? For example, is this science proven to the point that we should be creating incentives in the farm bill conservation title for their utilization to keep pristine watersheds like Lake Tahoe, or water quantity in drought areas, solidified for the decades to come? Or is there a place for this use in connection with the Federal crop insurance program?

Answer. The most concise answer is "we're not there yet, but we're getting closer rapidly."

At the "micro" or farm scale, we may indeed be getting close to having the technology in place to help producers demonstrate compliance with environmental requirements. For example, say a producer has a feedlot that meets the definition of a Concentrated Animal Feeding Operation (CAFO) under the Clean Water Act and wants to show their compliance with the CAFO's nutrient management plan (NMP). A grid-sampled soil test of the field to receive animal waste could create a precise prescription for how much of each macronutrient should be applied to that field. Sensors on the tractor used to inject liquefied animal waste to crop ground, coupled with a nutrient analysis of the waste, could show the amount of nitrogen, phosphorous, and potassium applied using variable-rate technologies to comply with the prescription. Later, the crop harvested from the ground where the wastes were applied is reported using a combine's yield monitor data, which can show the nutrient uptake of the crop and thus the nutrient balance for the soil.

This scenario demonstrates the technologies available to manage agricultural environmental factors on the input side, but if we want to reliably automate environmental compliance efforts, we must also have strong sensor networks in and around environmental receptors such as streams and lakes, particularly at points where watersheds connect. This will require continued development of environmental sensors and again, strong rural broadband networks over which to transmit the data.

The discussion to this point has focused on farm-level compliance, but what about compliance at a "macro" or regional level, such as demonstrating compliance of a watershed with an agriculturally-based total maximum daily load (TMDL)? We may have a bit to go before we can reliability show compliance on a regional level, simply because doing so would require 1) the continued penetration of sensor and transmission technology into more agricultural implements and 2) the interoperability of those systems to "speak the same language" so insights could be derived across multiple farms, rather than on a farm-by-farm basis. However, with that said, these factors continue to advance rapidly, and we may cross that threshold soon. Such technologies could soon facilitate the ability of farmers to manage nutrients in impaired watersheds. For example, in a TMDL-limited watershed with a "cap and trade" system, producers could validate how much of each nutrient they have applied to show their compliance with the nutrient limitations they received or traded.

In any of these scenarios, it is important to note that the accuracy of any compliance system depends on the proper calibration and operation of the sensors used. While automation may make compliance much easier, if automation is ever used to demonstrate compliance with a regulatory program, it should also be paired with the opportunity for a producer to review their submissions and explain anomalies. If a sensor suffers a malfunction, it could show a producer applied far more than their allocation of a nutrient, even though the proper amount was actually applied. Conversely, a third party might try to "hack" a tractor system or the data collection to implant false data. Any compliance system created in the future should make allowances for how to handle these anomalies.

With respect to the crop insurance program, there are tremendous opportunities to hone the actuarial models for the system and to facilitate produce's demonstration of compliance with insurance program requirements afforded by both Small Data and Big Data systems. Big Data analytics can continue to drive gains in accuracy for models in setting premiums and cost management, while Small Data can help producers accurately report yields (again, presupposing proper calibration and operation of the equipment sensors).

Question 3. Obviously in the west we have some greater agriculture challenges than other regions, and wildfires are one of them that we've seen have detrimental effects over and over again. In many cases, these fires have a multiplier effect on production and for things like future flooding. And, in general, water is also another constant challenge. Are there technologies that can help measure and account for

drought conditions, or measure the volatility of fires within parched forests or grasslands *before* we have fires that potentially get out of control? Are there any associations with improving broader weather prediction or forecasts? And are there other specifics where you foresee this data and technologies helping us get a better handle on our climate change crisis?

Answer. There are indeed a number of technologies that can help address these concerns. One present example of a weather and climate monitoring system that has provided tremendous benefits for my home state is the Oklahoma Mesonet. The Mesonet is a system of weather stations spread throughout the state, with at least one (if not more) such stations placed in every county. These stations fill in the significant geographic gaps between NOAA weather monitoring stations, and allow us to collect data on dozens of weather and climate parameters. These observations are fed into a number of models that help us keep close tabs on a number of factors for everything from fire weather hazards to drought monitoring and evaporative losses. The Oklahoma Mesonet has already helped our meteorologists and climatologists refine their predictive models and led to a tremendous output of research into Oklahoma weather and climate issues. The application of similar technologies in Nevada could provide significant improvements to prediction of fire weather conditions with the potential to issue advisories and reduce the risk of ignition sources. Similarly, the evaporation, soil moisture, and mesoscale models could help refine the use of scarce water resources. To help illustrate the applications of the Mesonet and our models, such as the fire-weather model, I have attached a summary prepared for you by Mr. Al Sutherland, coordinator of Mesonet Agricultural Data and Products, with the assistance of Dr. J.D. Carlson, lead investigator on the OK–FIRE model.

Further, in the future, the reduction in cost of reliable weather sensors could mean individual landowners could have their own weather stations (as an increasing number of Oklahoma farmers and ranchers do) that could be interoperable with Mesonet stations. This would have the effect of filling in even more gaps in the network, increasing the precision of its observations and providing even better information for predictive models. Indeed, weather monitoring is an arena in which there is tremendous opportunity for improved sensor systems and Big Data to have a positive impact in climate management.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JERRY MORAN TO TODD J. JANZEN

Question 1. As administrator of the Ag Data Transparency Evaluator, you are familiar with the lack of trust and confusion that many farmers experience in identifying what exactly is done with data collected from their land. Can you please describe considerations among industry stakeholders that led to publishing the "Core Principles" that are incorporated into the Evaluator?

Answer. The main drivers behind the "Core Principles" for ag data were the concerns from farmer-members of national farm organizations, such as American Farm Bureau Federation, National Farmers Union, National Corn Growers, National Association of Wheat Growers, American Soybean Association, and National Sorghum Producers. These organization spearheaded the effort to develop the Core Principles because their members wanted a basic framework around how ag data is collected and shared.

Question 2. Your testimony states that only nine companies (including Farmobile) are currently approved as "Ag Data Transparent" according to the Ag Data Transparency Evaluator's formal process. Why have not more companies voluntarily completed the evaluation, especially given the fact that nearly 40 companies participated in drafting the "Core Principles?"

Answer. This is a question best addressed to those companies that have not participated. I can only speculate as to their delay in participation. My belief is that these companies want more control over farmers' data than they are willing to publicly admit. Therefore, it is easier to remain quiet and say nothing than subject themselves to the Ag Data Transparent process.

Question 3. How can we incentivize more active participation by industry stakeholders to complete this evaluation?

Answer. I think the fear that Congress might step in and regulate the privacy and collection of ag data is something that will drive more companies to participate. As the value of the Ag Data Transparent brand increases over time, that will drive more participation as well.

Question 4. As agricultural data becomes more valuable to entities outside of the farmers that collect it, data security concerns are likely to grow exponentially while criminals with all types of motives seek to illegally gain access to and capture privately-owned data. How do you foresee data security practices in the agricultural industry evolving as a result?

Answer. Data security in the ag data space must progress at the same rate as data security in the non-agricultural space. Ag tech companies should not think that they are immune to security challenges.

Question 5. Are there any specific security traits to agricultural data that need to be accounted for steps going forward?

Answer. Ag data can contain proprietary information, which makes it different than other types of consumer-type data that may not be proprietary.

Question 6. In a 2016 poll conducted by the American Farm Bureau Federation, regarding the loss of control over downstream uses of data, sixty-six percent of the farmers polled expressed concern about not being compensated for the potential benefits from the use of their data beyond the direct value they may realize on their farm. Meanwhile, sixty-one percent of the farmers were concerned that agricultural technology providers (ATPs) could use their data to influence market decisions. Which of the two concerns do you believe is the greatest threat to farmer profitability and well-being, and what should be done to alleviate these concerns?

Answer. I believe the greatest threat to the farmer is that ATPs will be able to influence the ag markets by using ag data, but without making that same g data available to farmers. That would put certain holders of information in a superior position to the average farmer.

Question 7. As more and more firms enter the agriculture-technology space and interact with data used by and/or generated by farmers, the need for clarity and consistency on privacy principles is growing. For these new entrants, can you suggest any best practices these firms should engage upon to ensure their data privacy procedures properly convey the data's expected use?

Answer. New firms in the ag data space should do two things when they begin to collect data. First, they should determine their guiding principles for how they intent to treat ag data. Second, they should develop easy to understand data use policies that they can share with farmers that explain how the firm intends to use the farmer's data.

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Question 9. While much of the data we discussed in the hearing is generated on farm and captured by farmers or their equipment, significant quantities of data is publicly available and critically important to inform risk modeling, yield prediction, etc. in both the public and private sector. How can we encourage the continued use of this type of data, and even grow our sources, while ensuring that farmers understand their role in this process?

Answer. Witness did not respond.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. CATHERINE CORTEZ MASTO TO TODD J. JANZEN

Question 1. Given the dramatic benefits of agricultural data that were outlined in the hearing, are we addressing these advancement in our high school agricultural education and training efforts? Or at the technical or community college education level? And much of what we heard about, and what we think about in the innovation sector, requires more students and a workforce who can work with the technology, data analytics, and various other computer science skill sets. Is that accurate from your perspectives? Are there ways in your mind we can better incentivize and be developing the workforce we'll need to see the great promise of what we're talking about today? Including the cyber security needed to protect agricultural and ag-related business in this sector?

Answer. I am not involved with high school or secondary education and cannot therefore directly speak to this question. From my personal experience, more could be done to drive more students into science and technology focused careers, including agriculture. National and state FFA organizations do a lot to help foster growth in this area, but these are non-profit organizations that rely on donations and volunteers.

Question 2. There were many references to the environmental benefits of agricultural data. Are we in a position yet where we can authoritatively quantify the environmental benefits experienced by the use and attention to these technologies and data analysis? For example, is this science proven to the point that we should be creating incentives in the farm bill conservation title for their utilization to keep pristine watersheds like Lake Tahoe, or water quantity in drought areas, solidified for the decades to come? Or is there a place for this use in connection with the Federal crop insurance program?

Answer. The data collection and analytic tools today are already smart enough to make meaningful differences in environmental protection. For example, we could measure fertilizer use on farmland and fertilizer run-off from field tiles and other pathways to determine proper fertilizer application rates, assuring that as little as possible is lost. Likewise, we can compare fertilizer usage and yield across fields to determine proper application rates and timing to maximize fertilizer and soil resources.

There could certainly be more use of data in the Federal crop insurance program. Deb Casurella at Independent Data Management LLC is an expert on this subject and would be the right person to testify on this topic.

Question 3. So if we acknowledge the virtues of agricultural data, and that small data can even be used to market the sale of land or an operation, what safeguards in place to verify this information so a potential land buyer isn't defrauded by skewed land performance data or analytics that inflated the profitability of the land?

Answer. The best way to verify that ag data is not fraudulent would be to insist on receiving the original raw data from a seller, or obtain a copy of the same data from a third-party source. Even then, there would still be a question whether the machine that produced the raw data was properly calibrated. One way to verify that would be benchmark the seller's data with other data in the same area. Any dramatic difference could be due to data manipulation.

Question 4. Have agribusinesses been utilizing varying strategies to collect big data in agriculture? What was the old typical procedure for companies to obtain information from farmers, or their customers, on the progress or performance of their product? And are there situations where the producers are forced into a data collection program by seed, fertilizer or equipment companies? Or can they opt-out?

Answer. Many of the larger agribusiness companies have been collecting agricultural data from customers for years. Often, they collected this information because they were providing services to farmers, such as fertilizer of pesticide application. They collected data during such activities and then retained it for their own records.

I am not aware of any specific situations where companies require ag data submission as a condition of using a machine or device, although I think that will inevitably happen.

RESPONSE TO WRITTEN QUESTIONS SUBMITTED BY HON. JERRY MORAN TO DR. DOROTA HAMAN

Question 1. One of the aspects of your background I found interesting is the work you've done with farmers in developing nations, specifically as it relates to irrigation. I chair the Senate Hunger Caucus and have worked for many years on the issue of reducing food insecurity in the world. I believe that agriculture development initiatives that help countries feed themselves is a key part of the long-term strategy to end global hunger. Can you elaborate on your work with farmers in developing countries, specifically as it relates to using water more efficiently, and how that work has reduced food insecurity?

Answer. I would like to take this opportunity to thank Senator Moran for asking this question and for his bipartisan leadership on the Senate Hunger Caucus. Food assistance, and other support provided by the U.S. all over the world, leads to reduction of global food insecurity.

My expertise is in agricultural engineering with a focus on water management and irrigation. As reported by the Food and Agriculture Organization (FAO) of the United Nations and by the World Bank, approximately 70 percent of fresh water

usage is for agriculture. Most of agricultural irrigations systems are poorly designed and poorly managed. Even the best irrigation systems, if not maintained and carefully managed, are inefficient. Most of the irrigation systems over-apply water and there is a potential to improve efficiencies through technology and education.

My major effort has been focused on Florida growers and specialty crop production in Florida. I have also been a university teacher working with the next generation of farmers, academics and irrigation specialists. I teach people how to design, manage and maintain irrigation systems. My work has been focusing on efficient systems such as microirrigation and sprinklers. These systems are usually used for higher value, specialty crops such as fruits and vegetables but can also be adapted for small farmers in developing countries.

My international work has been largely in education. I have worked for FAO in Zimbabwe designing curriculum and lab experiments for a six-months intensive course focused on planning, design, maintenance and management of irrigation for smallholder farmers. I have taught two 2-week courses in Egypt. I have spent 3 months in Mexico and 4 months in Chile investigating and teaching efficient methods of irrigation. In addition, my students have worked with farmers in India, Ecuador, Columbia and Poland.

As an example, one of my students, working in Jamaica on his Masters project, implemented a simple drip system for calaloo (Jamaican spinach) and cucumbers. The increases in yield and reduction in water usage were significant. After the experiment was finished, the farmer adopted the system on the entire farm.

Question 2. What opportunities exist, if any, to take the technology being used today by large-scale U.S. farmers and use it to help smallholder farmers in developing nations be more productive and sustainable?

Answer. New technologies can eliminate many maintenance mistakes through automation and sensor control. New technologies can provide inexpensive alerts, and in the future, automatic intervention.

Technology leapfrogging is likely in agriculture in developing countries. Use of cell phones in developing countries is often cited as an example of leapfrogging. Apps and advisory programs, built and available from the open sources, can be made available on the smartphones. Solar phone chargers are becoming available even in very remote locations without an electrical grid. Access to quality data is critical for development of Apps and tools that can be available to poor farmers. One of the examples of an open platform is the BioSense Institute in Serbia. This project was funded from the European program Horizon 2020.

Response to Written Questions Submitted by Hon. Bill Nelson to Dr. Dorota Haman

Question 1. In addition to improving crop yields, how can big-data be used to protect farm workers from heat-related injuries? Is the farming industry using technology and data to improve worker safety?

Answer. In collaboration with the *Farmworker Association of Florida,* Dr. Linda McCauley, Emory University in Atlanta (GA), has established the *Los Girasoles* heat stress study. Los Girasoles, funded by the National Institute for Occupational Safety and Health (NIOSH), is a four-year project (now in its third year) that aims to better understand how agricultural workers respond to heat stress and collect better data on the magnitude of heat-related illnesses like heat stroke in agricultural work.

The data have been used to develop the Heat Related Prevention Illness training for the PISCA (FSU–FWAF) project and the Farm Labor Supervisor Training (FLST) in IFAS/UF.

An APHA policy statement have been drafted and approved. A local representative is sponsoring local legislation to promote a regulation of heat stress. A pilot study has been conducted with FSU looking at alternative clothing. Data on kidney functions as related to heat stress have been collected by researchers last year and will be continued next year.

Large amounts of physiological data collected by Los Girasoles was presented at several conferences and meetings. This is a list of current publications on the topic:

1. Flocks, J., Mac, V., Runkle, J., Tovar-Aguilar, A., Economos, J., & McCauley, L. (2013). Female farmworkers' perceptions of heat-related illness and pregnancy health. *Journal of agromedicine,* 18(4), 350–358.
2. Mutic, A., Mix, M., Elon, L., Mutic, J., Economos, J., Flocks, J. Tovar-Aguilar, A., & McCauley, L. (2017). Classification of Heat-Related Illness Symptoms

among Florida Farmworkers. *Journal of nursing scholarship.*doi:10.1111/jnu.12355

3. Mac, V., Tovar-Aguilar, A., Flocks, J., Economos, E., Hertzberg, V., & McCauley, L. (2017). Heat exposure in Central Florida fernery workers: results of a feasibility study. *Journal of agromedicine,* 22(2), 89–99.
4. Hertzberg, V., Mac, V., Elon, L., Mutic, N., Mutic, A., Peterman, K., Tovar-Aguilar, A., Economos, E., Flocks, J., & McCauley, L. (2017). Novel Analytic Methods Needed for Real-Time Continuous Core Body Temperature Data. *Western journal of nursing research,* 39(1), 95–111.

Wearable sensors similar to Fitbit can measure temperature and heart beat (or other biometrics) to alert workers to dangerous conditions. Sensors that are built into the clothing are also under development. CorTemp *http://www.hqinc.net/* has been used for body core temperature, which also allows capture of heart rate signals, in addition to button temperature sensors in and outside workers' clothing, including ActiGraphs (medical-grade wearable activity and sleep monitoring solutions for the research community).

In addition to Florida, there are teams in California, Tennessee, and Sinaloa (Mexico) who are using similar equipment. To improve diagnostics, researchers are collecting blood, urine, BMI, HBP, body fat percentage, and temperature at workers' homes.

Question 2. Florida has faced both record droughts and record rainfall in the past few years. Can you describe how technology can help farmers prepare for and adapt to wild swings in weather?

Answer. Technology can help farmers prepare and adapt to wild swings of weather in several ways. First it can help inform farmers of upcoming weather conditions in a timely and user-friendly way. It can also help farmers monitor conditions on a farm to better track the risk of pests and diseases, soil moisture conditions, and other potential yield-reduction factors that may require control measures. However, collecting data in an efficient and cost-effective way is just the first step in the process. Data must be translated into information through the use of mathematical models, machine learning, artificial intelligence and other data analytics to infer information from this new "data rich" environment. Data and information only have value if used to drive a farmers' decisions. That is why we need to provide farmers with tools that are customized to their farming environment and conditions.

It is also important to highlight that we need to develop and promote technologies and management practices that help farmers become more resilient to climate variability and change: *http://agroclimate.org/fact-sheets/climate/*

To adapt to these extremes, systems should be designed to a higher standard than is currently normal. For example, drainage systems should be designed to handle extreme rainfall events. At the same time, to cope with extreme drought events, efficient irrigation systems and additional water supplies should be identified.

Question 3. How can big data help us prepare for and adapt to the effects of climate change?

Answer. Large-scale geo-reference data can be very helpful in identification of the long-term trends in weather patterns and climate change. With new ways of data collection through satellites, drones, robots and cheap sensors, there will be improved data collection and analysis.

Reliable and early prediction of both drought and rainfall based on climate models and global and local weather data (that are becoming more dense and precise) are critical for dealing with extreme weather events. Forecasting weather for the next few days or a week, the next rain front, the next heat wave, the path of the next hurricane and trends in climate change over the next decades use the same climate models which are build, tested and updated with billions of weather/climate data from tens of thousands of weather stations and sensors from land, ships, airplanes, ocean floats at various depths, research stations, and satellites. These are examples of big data already used and applied in daily life.

Increasing accuracy of weather event predictions is critical to the timeliness of preparations, decisions and interventions. For example, expectation of unusual rainfall may require lowering of the water table in the field or draining of water reservoir to create more space for upcoming rain. Timing of this operation is critical. For example, draining water storage in preparation for extreme rain cannot be done too early or the plants may be stressed to the point of yield reduction. The accuracy of prediction is critical to successful preparation and big data from numerous sensors, as well as remote sensing, can increase the accuracy of prediction.

Technology can also be helpful in managing scarce resources during drought and regulating water application to optimize incomes under drought conditions. Suffi-

cient lead-time is important for implementation of water storage to minimize the impact of drought on production.

It is important to remember that improved short-term forecasts (on the scale of days up to the entire season) can be very useful for management decisions and can mitigate the impact of an extreme event.

Big data may be able to help in analyzing reports of the impacts of extreme events. Currently, state climatologists and the National Drought Mitigation Center rely on somewhat subjective reports of drought impacts. Big data can help in analyzing diverse reports of impacts in a more objective manner.

Question 4. Can big data help us reduce greenhouse gas emissions from agriculture?

Answer. Big data allow us to see the patterns and fine-tune systems to make them more efficient. Well-known examples of the agricultural sources of greenhouse gas emissions are paddy-rice production and animal production. Another is oxidation of the organic material in cultivated soils.

To shift from the paddy-rice, scientists are working on increasing production of upland rice that is not flooded and this growing system contributes much less to atmospheric greenhouse gasses. Increased efficiency in animal production and waste management may be beneficial to reduction of methane emissions. Efficient management of these agricultural systems is critical and the information provided by big data can help us optimize the systems through mathematical modeling. For example, by increasing the land-surface area covered with plants and reducing deforestation we can increase removal of CO_2 from the atmosphere. New technologies, including robotics and low-energy LED lights for protected (indoor) plant production, are opening possibilities for vertical growth (in multistore buildings) of high value vegetables and fruits in urban areas. This production may benefit from CO_2 enrichment (using industrially produced CO_2) at the same time preventing its release into the atmosphere.

To reduce CO_2 in the atmosphere, numerous management strategies have been discussed including using plants to draw carbon out of the atmosphere and developing techniques to hold it in the soil. These strategies vary in effectiveness across different climates, soils and geographies. Sequestration of carbon is achieved through transferring atmospheric carbon into the soil via plant photosynthesis. Soil carbon must then be protected as effectively as possible from microbial activity that will release the carbon back to the air. Most, if not all, of the management techniques (operations) that promote carbon sequestration also improve soil aggregation, water retention, soil fertility, and food security.

Question 5. Should we be thinking about "big data" and how farmers control their information the same way we think about consumers using the Internet or conducting financial transactions?

Answer. I believe that these factors need to be carefully analyzed and a set of acceptable rules should be developed and established. I believe that it is important to make sure that sufficient high-quality data are available as an open source to allow for creating free access to critical information (or at very reasonable cost) especially for small, family farms and for farmers in developing countries. For example, in Europe, all the data created under the Horizon 2020 program are open access and the program includes a lot of agricultural big data. Another example of this type of platform is the BioSense Institute in Serbia.

Question 6. Can you describe how extension services like the one at the University of Florida help famers—particularly small farmers, new farmers, and specialty crop farmers—access the same type of information that corporate farmers have?

Answer. The University of Florida Institute of Food and Agricultural Sciences (IFAS) has been engaged in developing services and decision aids to help Florida farmers, including small farmers, improve resource use efficiency and reduce risk associated with climate variability and change. AgroClimate.org (*http://www.agroclimate.org*) for example provides climate related information and dynamic application tools that interact with a climate database system for the Southeastern U.S.A. Information includes climate forecasts combined with risk management tools for a range of crops, forestry, pasture, and livestock. It has been quite successful and adopted by farmers in Florida to decide when to apply fungicide to strawberry fields based on weather conditions or to track the accumulation of chill hours during the winter in farms growing temperate fruits such as blueberries and peaches. AgroClimate integrates weather and climate data from public sources such as the Florida Automated Weather Network (FAWN) and gridded weather data from NOAA that covers the entire U.S.A. and the globe. Several mobile phone apps have been developed based on the weather and climate database services provided by AgroClimate including the Smart Irrigation Apps *http://www.smartirriga*

tionapps.org) that help farmers in Florida and Georgia schedule irrigation of crops such as citrus, strawberries, cotton and turf; thereby saving water and reducing leaching of nutrients into the groundwater.

At UF, we are planning to create a similar portal for safety information and safety practices in agriculture. We are in the process of hiring a new faculty member to work on this project.

Question 7. Do you think that consumer concerns about genetic engineering and GMO crops might create a backlash against precision technology, particularly as it relates to our food supply?

Answer. I believe that this is unlikely. Precision agriculture is not directly linked to genetic engineering or GMO. In fact, due to precise management of resources (water, nutrients, pesticides and other chemicals, etc.), available technologies benefit the environment and reduce input costs. Precision technologies have been used for years in agriculture. Data availability, especially Big Data, makes these systems more precise, allows for faster and better decisions, and increases operation and production efficiency. These technologies do not introduce anything new or foreign into food chain. New genetic technologies, such as CRISPR (gene editing) seems to be less controversial and more likely to be accepted by the general public.

RESPONSE TO WRITTEN QUESTION SUBMITTED BY HON. CATHERINE CORTEZ MASTO TO DR. DOROTA HAMAN

Question. There were many references to the environmental benefits of agricultural data. Are we in a position yet where we can authoritatively quantify the environmental benefits experienced by the use and attention to these technologies and data analysis? For example, is this science proven to the point that we should be creating incentives in the farm bill conservation title for their utilization to keep pristine watersheds like Lake Tahoe, or water quantity in drought areas, solidified for the decades to come? Or is there a place for this use in connection with the Federal crop insurance program?

Answer. I do not believe that we are yet ready for inclusion of specific incentives, policies and regulations. Scientists are working on information that can improve crop insurance program but we are not ready to implement it yet. The new technologies and sensors are providing abundant and potentially high quality agricultural data that can be very beneficial (in the future) to evaluate the environmental impact of agriculture and hopefully optimize the entire system to reduce the impact on the environment. Massive data require the development of adequate models, and these are not yet mature but are rapidly evolving. At this point, model development is one of the major challenges in big data analytics. The concept of analyzing big data relies excessively on "blind" machine learning, where "black boxes" of data are "mined" in the hope that the process will "tell us what it contains". The problem is that these large data sets are of highly dimensional (complex) and there are many possible combinations of the drivers that could potentially produce similar results. Identifying the correct relationships requires experts with mature and relevant conceptual models to drive the search process. In addition, "dimension reduction" (selecting a smaller set of really *important factors suitable for management*) is a critical step.

Interdisciplinary approach is necessary to assure that big data are appropriately analyzed. Teams of subject-matter experts need to team up with machine-learning experts (from statistics and informatics) to identify the correct solutions to the problems. The challenge today is that because of high potential economic gains, sensors, data, and machine learning has progressed rapidly but has not teamed up with content experts for specific problems. This is particularly true in Agriculture and Environmental Sciences, which are particularly complex as they are based on open and largely uncontrolled systems (as opposed to other artificial or human-controlled settings).

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