Defining the Barriers to Telematics for Precision Agriculture: Connectivity Supply and Demand

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1. Introduction

The United States is a global leaders in food production and agricultural technology adoption. This is a result of the continuous innovation that takes place in the agricultural sector. Humans have advanced from being hunters and gatherers to the point where we are increasing the yields of primary commodities, such as corn, soybeans, wheat, cotton, etc. on an annual basis. The increases seen in crop yields is a function of technology adoption starting with improved management of these crops, the adoption of precision agriculture technologies, and genetic modification. To keep up with population growth it is expected that food production must double by 2050. To accomplish this, production agriculture will have to find ways to be even more efficient with inputs in order to maximize output per acre and limit the negative externalities created through production intensification. Success will depend on production agriculture efficiently and effectively turning the vast amount of data that is generated into information and knowledge in order to make real-time decisions and justify the utilization of inputs.

"Big Data" has the potential to change the fabric of agriculture as we know it today. "Big Data" is data whose size, scale, and unstructured nature require the usage of new analytical tools and frameworks to be developed and employed. These frameworks need to be flexible enough to weave together data from hundreds of thousands of acres and from various sources, such as weather data, yield data, satellite imagery, drone imagery, planting prescriptions, and equipment diagnostics just to name a few. If this can be done, it has the potential to be the next agricultural revolution of smart products utilizing precision planters, yield monitors, and other sensors, analogous to how smartphones changed popular culture, to a point where the system can be evaluated as a whole. However, this requires a new or different of mindset compared to the way most of our agricultural producers are operating today. Many producers today are rightfully only focusing on their operation and have reservations or concerns over several key questions. . Some topics of interest include:

- Data ownership: producer vs manufacturer vs landowner vs retailer;
- Data utilization, privacy, storage, and security: data access, utilization, sharing;
- Data value;
- Data transfer.

The primary focus of this paper is on the last topic of data transfer, specifically as an enabling technology to precision agriculture and especially telematics. Telematics could be broadly described as data measured and viewed remotely. Limited wireless internet connectivity impedes the full utilization and effectiveness of precision agriculture practices and the subsequent agricultural big data systems. In the absence of wireless data transfer for download and upload, precision agriculture technologies such as telematics cannot be utilized efficiently. According to Erickson and Widmar (2015), one of the largest changes between the 2011, 2013, and 2015 surveys of agricultural service providers is the usage of telematics for field-to-home office communications. In 2011, only 7% of service providers offered telematics data services but the percentage increased to 15% by 2013, and to 20% in 2015. There were slightly more dealerships offering telematics in the Midwestern US (17%) than in other states (12%) in 2013, potentially due to the lack of broadband connectivity outside the Midwest (Whitacre et al., 2014). Erickson and Widmar (2015) also report that two-thirds of service providers stated telematics is perceived to be an emerging technology with 30% suggesting an uncertain future and 37% suggesting a promising future; indicating a lack of understanding of the future of the technology. Until wireless internet is sufficient to transfer agricultural data, the impedance of telematics and precision agriculture are likely to capitalize into substantial farmland value differences for internet-connected and internet-deficit fields (Griffin et al., 2016).

An example of telematics would be JDLink.

> "This is Deere & Company's cloud system for telemetric data. Used in both construction and agricultural equipment, it allows machine owners to monitor a single machine or fleets from a single computer or mobile device. JDLink data is transmitted using the machine's modular telematics gateway and displayed in a web based portal. Types of data transmitted by machines include machine usage statistics (fuel consumption, utilization, idle time and more), machine health information (diagnostic trouble codes), and machine location information for location services. If properly configured, electronic alerts can be sent to take action such as notifying a dealer technician of a diagnostic trouble code or alerting law enforcement authorities that a machine has been moved outside the expected work area."
>
> (Bennett, 2016)

The realization of the "Big Data's" full value will not happen until this barrier is overcome. Expanding upon Whitacre et al. (2014) we have two objectives. First, given the new broadband definition, we update the wireless coverage for the United States similar to Whitacre et al. (2014). We focus on examining broadband availability for crop production regions. These high-production areas are also the areas where precision agriculture adoption rates are expected to be the highest and where telematics most likely to be employed; therefore where the value of big data is initially expected to be fully realized. However, without adequate access to wireless internet, the development of a big data system will lag behind potential development.

Additionally, insufficient connectivity could limit the value of a big data system if the technologies used to populate the system are inefficient in data transfer. Secondly, we examine the data transfer and bandwidth requirements to transfer data from representative farms.

2. Status of Broadband Connectivity in US

Broadband connectivity across the globe but specifically within the United States will have a significant impact on both big data utilization and telematics adoption. In the absence of broadband connectivity and wireless data transfer, the benefits of telematics services are limited. In general the industry is experiencing the effects related to network externalities. In addition to constraining the profitability of agricultural firms; lack of broadband connectivity limits the adoption and efficiency of precision agricultural technologies that make use of or rely upon near real time connectivity.

In the United States, the National Broadband Map (NBM, http://www.broadbandmap.gov/speed) provides data on wireless availability over a range of broadband speeds. Superimposing these data on top of publicly available crop production data from the United States Department of Agriculture (USDA) illustrates the need for increased wireless broadband in nonresidential areas.

Current Status of Broadband in US

The United States Federal Communications Commission (FCC) updated the definition of broadband in January 2015. The faster speeds required to be considered broadband brought light to connectivity barriers, especially with respect to broadband connectivity gaps in specific geographic areas such as agricultural production regions. Specifically, the 25 megabit per sec (Mbps) download speed requirement negates the majority of United States wireless connections from being classified as broadband. Figure 1 shows the discrepancy between the download and upload speeds required by the FCC to be considered broadband.

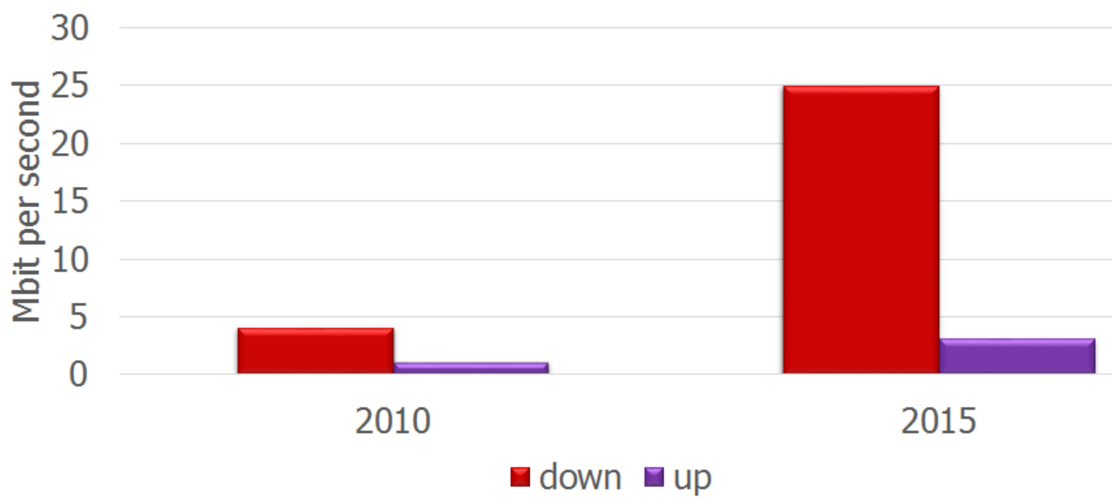

Figure 1. US FCC-defined broadband speeds

Recently passed legislation, such as Iowa's "Connect Every Acre" bill that was signed into law in June 2015, demonstrates the recognition of this topic by policy makers of today. In addition, recent congressional hearings on internet connectivity in general and another specifically on big data in agriculture both discussed the ramifications of internet on agriculture. Many producers' currently employing precision agriculture technologies do not have access to broadband speed wireless internet. Figures 2 shows the relationship between corn and wheat production and download speeds. The dark black blocks represent areas where greater than 75% of the population meets the 25 mbps download requirements and the majority of these blocks are located in close proximity to major cities and not prime agricultural areas.

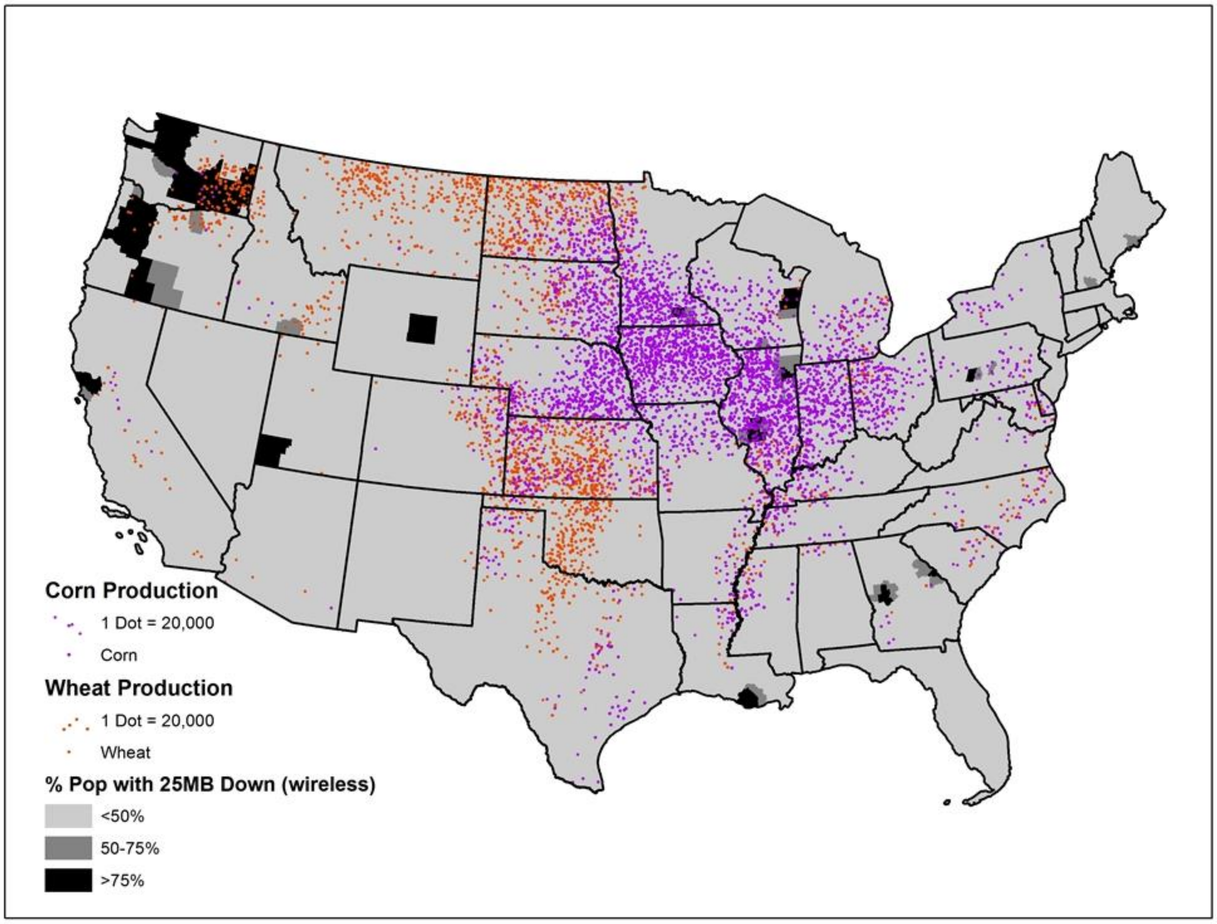

Figure 2: Wireless Download Availability for Corn and Wheat Production, 2015.

Figure 3 shows the relationship between corn and wheat production and upload speed broadband speed requirements. The low hurdle of 5 mbps results in significant parts of the country achieving the hurdle to be considered broadband. Shear (2014) points out that most precision agriculture data needs to be uploaded rather than downloaded; and given that upload speeds are substantially slower than download speeds, moving data such that real-time decisions can be problematic. For some types of data such as machine diagnostics, planting prescriptions, and the like the current speeds offered are probably adequate. However, yield data and specifically imagery data may require connectivity speeds in excess of what the industry currently offers.

More importantly, these connectivity requirements may not be a cost effective method of data transfer, given labor and connectivity costs.

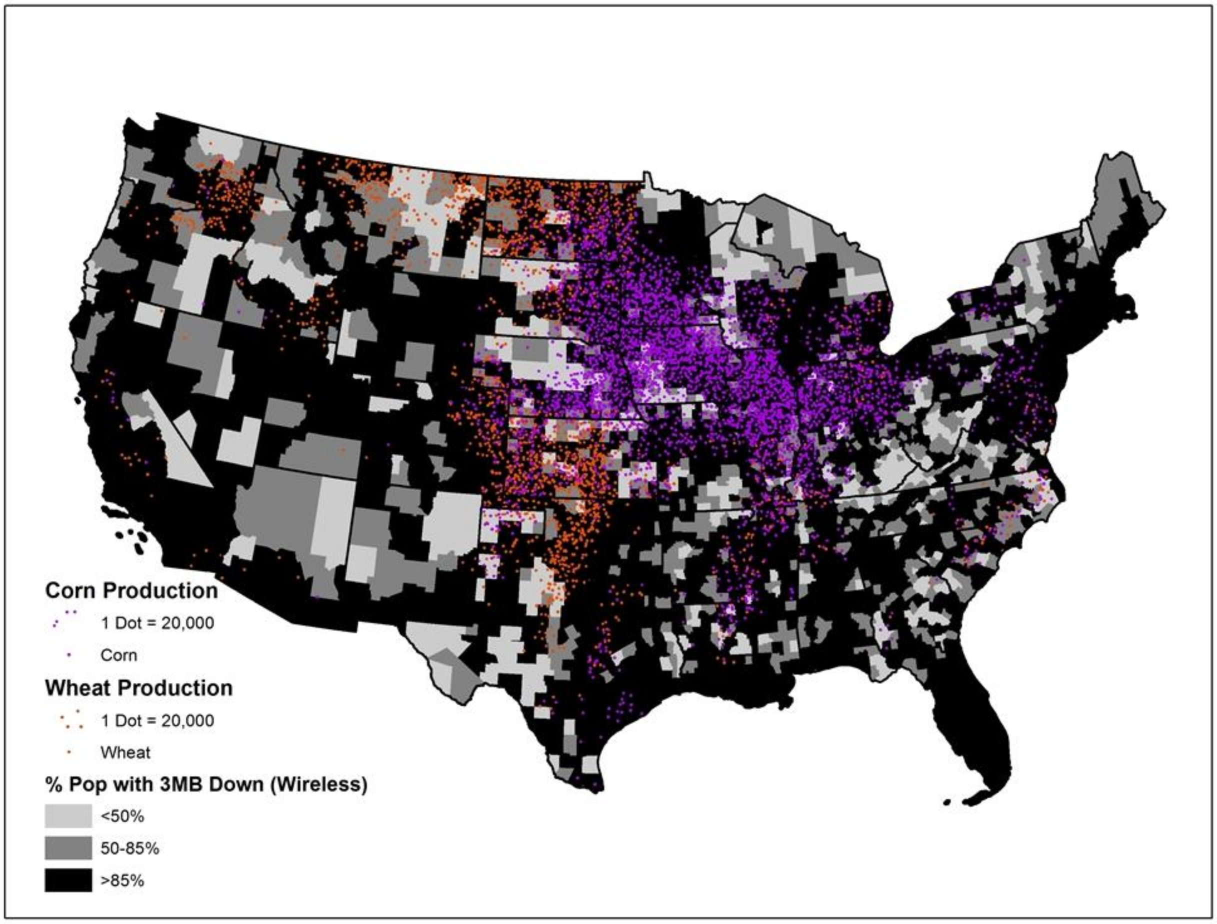

Figure 3: Wireless Upload Availability for Corn and Wheat Production, 2015.

2.1 Rest of World and Global Initiatives

The US is not unique across the globe in providing high speed internet. In Germany, the government is pushing a 50 Mbps target up from the currently 11Mbps for all users (Woods, 2015). This doubles the currently highest global average speed of South Korea of 24 Mbps

(Woods, 2015). Wireless internet providers have only started to provide wireless connectivity sufficient to move data from crop producing regions far from residential areas. These providers have been encouraged and supported by the efforts of Google and Facebook to connect the world's population. Facebook has been reported to evaluate drones (Lee, 2015), satellites, and high-altitude balloons (Patterson, 2015). Google has similar goals; to make internet connectivity ubiquitous for every per global citizen.

3. Data Transmission Needs

Current forms of data transmission (i.e. cellular, wireless, and satellite) are lagging behind the needs of production agriculture (Griffin and Mark, 2014). There has been a significant push to increase availability of broadband internet connectivity in rural areas, where the majority of agricultural production takes place. This has been a very slow process that is not keeping pace with demand to the point that connectivity is a barrier to the full utilization of current precision agriculture technologies or at least the internet is seen as an enabling technology. Cellular and hard-wired providers have been unwilling to expand their services in rural areas due to the lack of sufficient voice service customers needed to justify the investment. However, satellite based internet connectivity could provide an effective solution over larger geographic areas.

The typically setup for producers today involves utilizing cellular connectivity to transfer data or are still utilizing the status quo of manually transferring data. Current 4G cellular connections only allow up to a 10 Mbps download speed, and upload speeds that range from 2 to 5 Mbps. Historically, differences between upload and download speeds were several magnitudes different due to residential uses relied more on download than upload. This is evident if one considers watching streaming video via Netflix, i.e. downloaded data; however more recent phenomena such as uploading ‘selfies’ to Facebook require relatively more upload. This has increased wireless providers desire to improve upload speeds. Increasing the upload speed would provide the agriculture sector with a much needed boost in capacity.

Little information actually exists or is not publically available on file size by type. Additionally, precision agriculture provider has proprietary software used to package and move the data. However, Shearer (2014) estimated that row crop producers potentially generate 0.5 kilobytes of data per plant. In other words, a corn producer with a plant population of 30,000/ac could produce 15 megabytes of data per acre; and if this were a 1,000 acre corn farm, they could potentially produce 15 gigabytes of data per year that would need to be transferred. Extrapolating this out to the approximately 88.9 million acres of corn planted in 2015 there would be approximately 1,333.5 terabytes of data produced. This estimate does not include the usage of drone or UAV imagery data that is increasing in popularity in agriculture; the reliance on imagery from drones greatly increase these data transfer requirements. The amount of data generated from drones will depend on the type, frequency, and quality of images that are being taken (Buschermohle 2014).

A key for most producers will be deciding which data layers require real-time transfer and analysis is desirable. Data layers that might require real-time transfer are yield data and equipment diagnostics. While some data layers could be wirelessly transferred after the fact once a connection is achieved. Furthermore, without sufficient wireless data transfer service, producers rely on manual data transfer which may not happen until after the season is over. By then, opportunities to adjust management practices are missed, significantly affecting farm profitability, productivity, and environmental impact. In addition, real-time communication between farm equipment and online servers is not possible. Finally, land that lacks adequate connectivity leads to geospatial data not being sufficiently backed-up in a timely manner, therefore increasing the risk of this valuable data being lost or destroyed.

4. Discussion

These findings suggest that opportunities exists for the private and/or public sectors to increase wireless connectivity infrastructure. This could be in form of improved satellites, increased wireless infrastructure, or high altitude balloons. The primary criteria for their usage will be upload capacity and reliability. Improving wireless connectivity could be one of the primary drivers of the adoption of big data, or at least not to impede adoption. The increase in connectivity could also increase the adoption of precision agricultural technologies that can lead to input cost saving and decreased input usage. Without adequate connectivity to allow efficient and cost effective data transfer, the value of the big data system will be limited for both direct and indirect users, such as producers and consumers, respectively. In the US, internet service providers' especially wireless providers are all private sector firms as opposed to Australia where the federal government provides basic internet infrastructure for resale.

These results are of interest to public policy makers, environmental groups, private sector satellite internet service providers, and members of the agricultural industry including farmers, equipment manufacturers, and software companies. Quantifying the magnitude of the problem and providing guidance toward a feasible solution will aide in maintaining a sustainable production agriculture industry now and for years to come.

4. Moving Forward

It is expected that over the next five years increased desire and demand for producers to collect and analyze data in an effort to increase the efficiency of their operation. This will be evermore important during time periods of low prices and in this environment of increasing scrutiny of chemical and nutrient usage. If producers are able to track and verify usage of these it could help minimize environmental impacts and legal costs for producers. Wireless data transfer technologies including satellite, cellular, hard-wired, and potential balloon based systems are suitable candidates to fill the connectivity void and all need to be explored. All of these technologies have the potential to be used for the agricultural data transfer but none are universally perfect for the task. However, specific characteristics are sought to move forward with the increase in data collection requirements within the agriculture sector. The first and most important characteristic is reliable access. As seen in Figure 2 and 3 there are significant gaps in current broadband offering and most of these exist in prime agricultural areas. Currently, upload and download speeds are a significant bottleneck for farmers depending on the file type and size. If the upload or download speeds are too slow, field efficiency can be decreased and in turn decrease the number of acres covered in a given day. During planting and harvesting season slow internet speeds can mean the difference in getting the crop in before a weather event or suffering yield penalties for an untimely planting or harvest. Thus translating into decreased income for the operation. There have been substantial pushes by state governments to increase broadband access to help increase business development in rural areas. However, the expansion of broadband access has been very slow and is not keeping up with the demands of the industry.

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