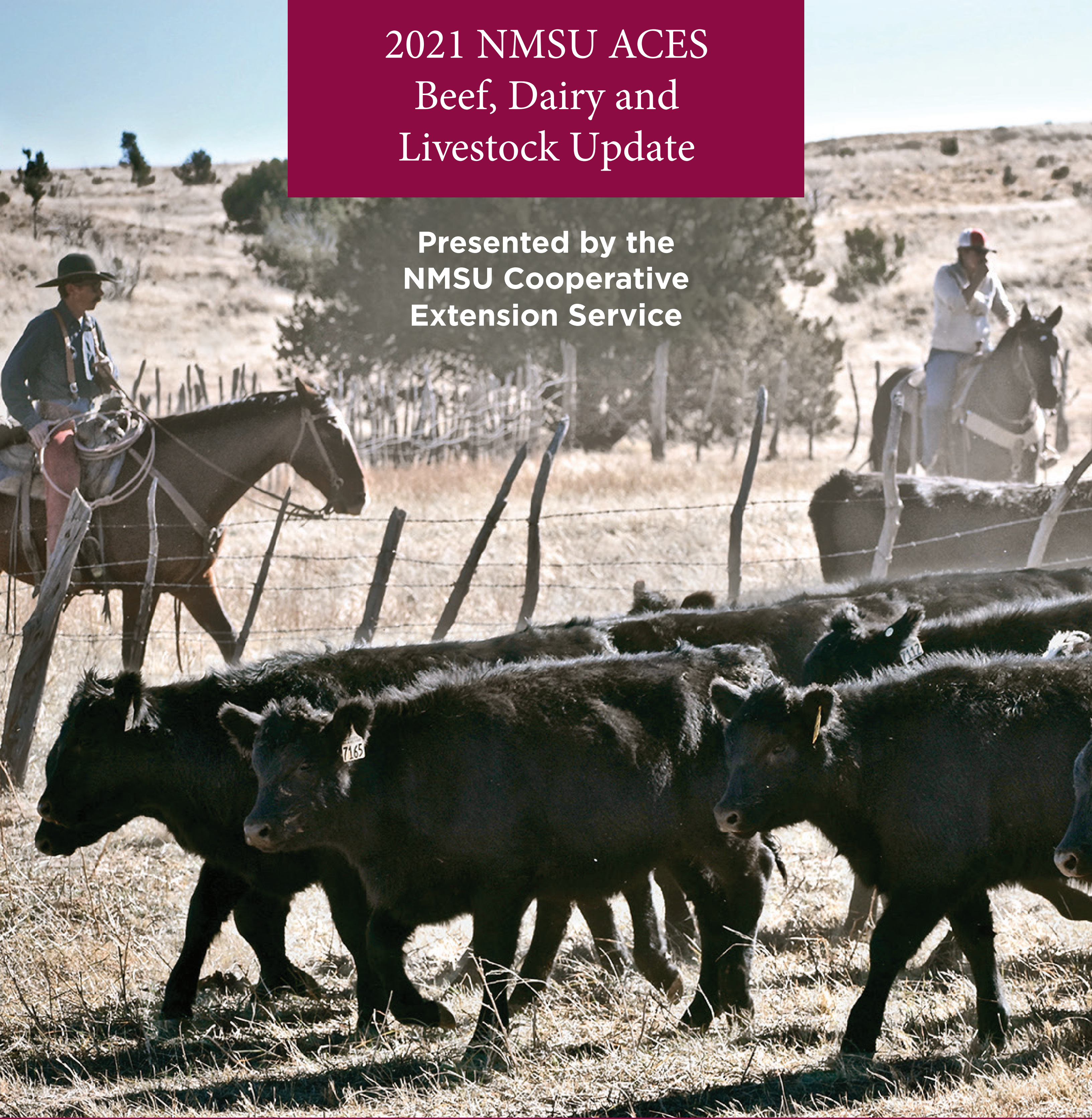
2021 NMSU ACES Beef, Dairy and Livestock Update



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College of Agricultural, Consumer and Environmental Sciences
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Testing of a LoRa-WAN digital ranching system on desert rangelands: some practical experiences

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Introduction

Precision livestock farming (PLF) is an emerging agricultural strategy that incorporates sensors and data analytics to inform management decisions (Neethirajan, 2017; Tedeschi et al., 2021). Though common in household and more intensive livestock and crop production systems, Internet of Things (IoT) tools are in earliest stages of development for extensive beef and sheep production systems on arid rangeland primarily due to limited infrastructure and lack of Wi-Fi, cellular (e.g. 3 and 4G), or satellite network access. Yet Long Range Wide Area Networks (Lora-WAN) could offer a high efficiency and low-cost solution to this hindrance as they promise near-real time long-range coverage (e.g. > 6 mi), a strong signal, long battery life, and customizable data collection units (e.g. widgets or sensors), compared to other conventional network types (Bocquier et al., 2014). Precision livestock technologies could provide New Mexican livestock producers novel tools for real-time monitoring of animal location and activity, asset tracking, and infrastructure monitoring in the face of a dwindling workforce and harsher climate (Spiegal et al., 2020).

This study aimed to test a PLF LoRa-WAN-based monitoring system across four pastures (12,000 ac) of Chihuahuan Desert rangeland. We report the installation protocol, maintenance, and practical applications associated with the system.

Materials and Methods

This PLF system consisted of a single Kerlink® LoRa-WAN iStation gateway, a remote 100-watt solar panel system (consisting of Renogy® components), a pair of Ubiquity® NanoBeam M2 airMAX Bridge Wi-Fi backhaul extenders, 43 LoRa WAN-enabled Abeeway® Industrial trackers, one Decentlab® tipping bucket rain gauge, and one Decentlab® water level sensor.

In this system, small packets of data can be transmitted from sensors to the LoRa WAN gateway on to the network server via one or more of a variety of backhaul systems including Wi-Fi, Ethernet, and 3G or 4G cellular GSM. The system we tested utilized a Wi-Fi backhaul, though it had GSM backhaul capability as well. Data transmission from the network server to the cloud or application endpoint was achieved via a secure payload transmission control protocol and coupled internet protocol (TCP/IP) or secure sockets layer (SSL; Figure 1). Flow of data was bidirectional such that sensor configuration could be modified using the applications server (a user-friendly internet dashboard) and transmitted via the cloud and network server back to the sensors to configure data acquisition frequency and precision.

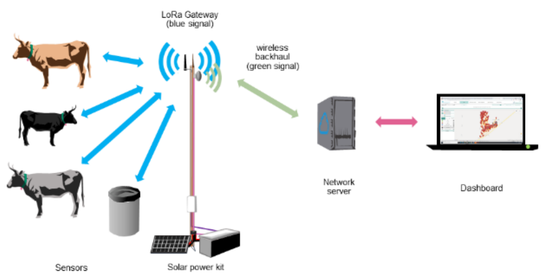


Figure 1. Dataflow between LoRa-enabled sensors, network gateway and antenna (tower with solar power kit), network server, and dashboard. Collars on cows represent LoRaWAN-enabled industrial tracking sensors used to monitor animal location in close-to-real time. Gray bucket represents a LoRaWAN-enabled tipping bucket rain gauge. The network server was a desktop computer connected to the internet via broadband. Cloud computing was used for data storage. The solar panel kit powered the gateway and Wi-Fi backhaul that transmitted LoRa data packets to and from the hard-wired internet connection at the ranch house. The applications dashboard is shown on a laptop computer with red points illustrating near real time cow location. Blue bi-directional arrows represent LoRa WAN signal, whereas a green bi-directional line represents Wi-Fi backhaul and a pink bi-directional line represents the TCP/IP SSL secure transmission of sensor payloads.

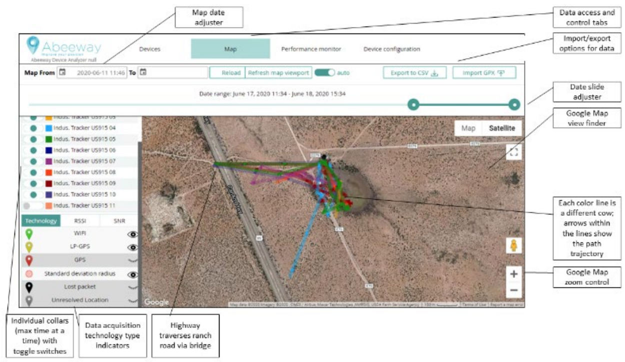
Industrial trackers equipped with global positioning system (GPS) were placed on custom collars on 43 rangeland beef cows and geo-positioning data was collected at 15-minute intervals for approximately 3 months from March 9 – June 9, 2020. The user dashboard was equipped for remote visualization of animal location, and offered several additional geo-positioning settings (e.g. time difference of arrival, Wi-Fi sniffing, and low power GPS) aimed at conserving battery life. The tipping bucket rain gauge and water level sensor settings were edited and visualized on a separate Decentlab® dashboard. All animal handling protocols were approved by the New Mexico State University IACUC.

Results and Discussion

The 100 watt solar and battery power system appeared adequate for the LoRa-WAN gateway and Wi-Fi backhaul, though there was only intermittent inoperability of the system as a whole, which may have been related to power, Wi-Fi backhaul, or other untraceable issues (e.g. weather and plant interference). The battery power of the industrial trackers was less than expected and dropped from 100 to ~35% over the three-month trial. The GPS data packets were recovered at 0 – 1.3 hour intervals and 46 ± 4% of GPS data packets were received on average, though for some weeks and pastures this data acquisition exceed 80% of expected GPS fixes. Power and Wi-Fi backhaul issues may have played a role in acquisition rates, in addition to upload channel and signal spreading factor settings, which were set to transmit over only one of six available channels. Battery life and data collection rates of precipitation events and trough water level were more consistent and reliable across the testing period (albeit these also timed out when the Wi-Fi system went down).

The system cost per cow is projected to range from ~$50 – 90 dollars per year depending on the level of features added. This system required new equipment and associated infrastructure, including cow trackers and other sensors, custom collars, Wi-Fi backhauling system, solar power and battery kit, and an annual subscription for licenses and use of dashboards. Current tests are being conducted to determine the reliability of utilizing 3 or 4G cellular backhaul as an additional data communication system, though this could add an additional data plan cost component.

Figure 2. Example of Abeeway® Device Analyzer dashboard and map viewfinder 'tab'.



Overall, the system, in its current state, provided several unique management tools. The rancher using the system quickly became accustomed to checking the online dashboard in the morning before heading out to visually inspect the animals. This resulted in less time invested in finding and tracking of animal locations and frequently grazed areas. In some instances, the system helped identify when cows had crossed a fenced boundary and ranch employees were able to quickly find and re-pen escaped cattle that were being tracked in near-real time. The rancher also became acquainted with cattle watering-bouts by watching daily return intervals on the dashboard, which resulted in reliable predictions of times when animals would be in watering corrals and could be gathered for evaluation.

The rancher checked the water level sensor daily to ensure animals in the pasture had access to fresh water. This process alone has merit for greatly reducing personnel and fuel costs associated with water monitoring, especially in hot summer months, in addition to enhancing peace of mind (Elias et al., 2020).

Data mining and calculation of animal behavior variables like minimum daily area explored also suggest promising application to identify and develop alerts to inform ranchers of potential problems with individuals or cohorts of cattle. Cows apparently reduced daily area explored around days of calving, so real-time monitoring of this and other variables could eventually be incorporated into this and similar systems to provide real-time signals of cow welfare to producers (Figure 3).

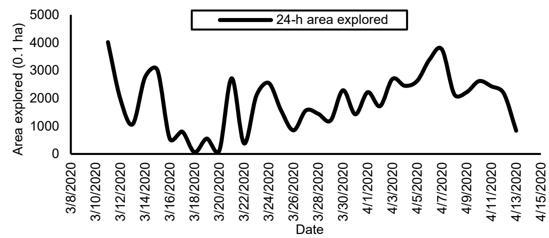


Figure 3. Example of GPS-derived behavioral metric and its relationship to parturition date. In this example, the cow gave birth on March 20, 2020 which coincided with daily area exploration nadir (0.1 ha).

Summary and New Mexico Impact

This case study revealed that mounting a real-time Lora-WAN system for PLF is possible on desert rangeland and could offer producers a user-friendly tool for close-to-real-time monitoring of animal location, activity patterns, as well as precipitation and trough water levels.

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