

Supplementary Information

Beef Production in the Southwestern United States: Strategies toward Sustainability 10.3389/fsufs.2020.00114

Supplement 1

Precision ranching is a promising approach for agricultural adaptation to a changing climate. The Sustainable Southwest Beef Coordinated Agricultural Project is developing a precision ranching system in close collaboration with rancher partners throughout the American West. Figure 1 shows a dashboard tracking three cows grazing an extensive rangeland pasture, in close-to-real time at the Chihuahuan Desert Rangeland Research Center (CDRRC) in southern New Mexico. Cows were wearing LoRa WAN-enabled sensors configured to monitor GPS locations at 15-minute intervals via a LoRa WAN network, and data were collected using a single LoRa WAN gateway and antenna located approximately 5 miles from the pasture. Benefits observed from the monitoring system in the project's first year include time savings in locating livestock for routine monitoring and sampling, signals of impending or recent calving, detection of an injured animal, and finding an animal that escaped a pasture.

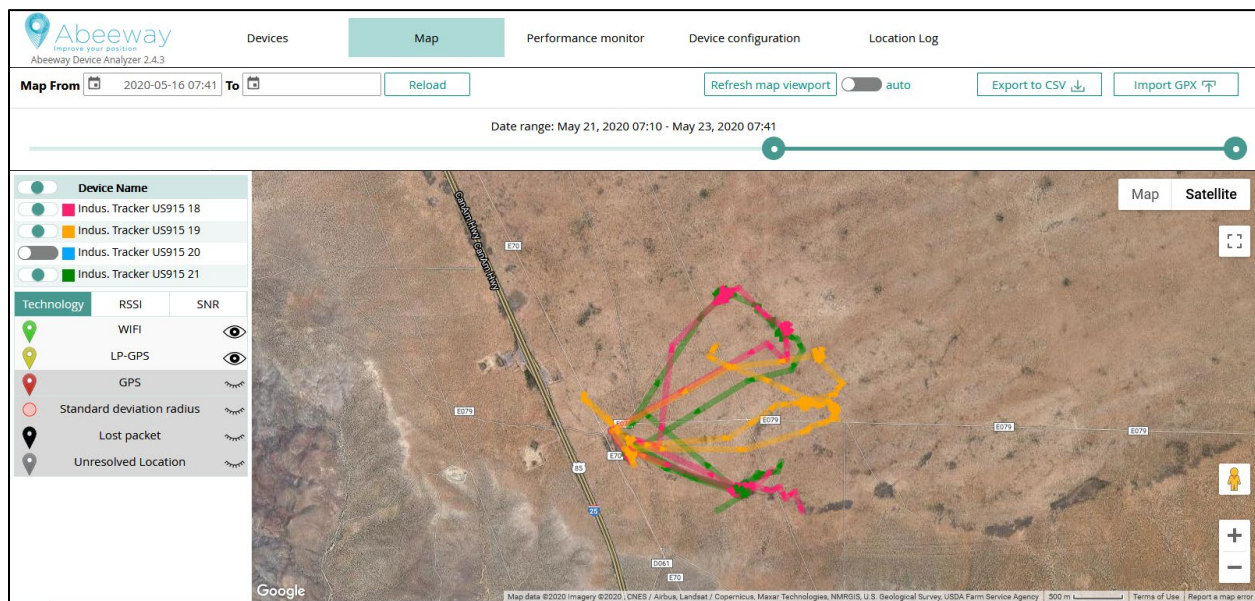


FIGURE 1. Tracking three cows in close-to-real time using the LoRa WAN network.

Supplement 2

The Sustainable Southwest Beef Coordinated Agricultural Project is using a pericoupling approach (Liu, 2017) to understand the social and ecological effects of the current, dominant beef supply chain vs. a plausible supply chain of the near future, in which locally-produced and/or grass-finished products have a greater share of the overall beef market of the Southwest. An initial step entails quantifying the flows of resources among four regions pericoupled through beef production in the United States: 1) the Southwest, 2) the Ogallala Aquifer region, 3) the Northern Plains, and 4) the Upper Midwest Corn Belt. Flows include cattle, money, manure nutrients, and grain with embodied water and fertilizer (Table 1 in the main article).

We began by quantifying current flows of cattle from the Southwest to the Ogallala Aquifer region for feedlot finishing, with an initial focus on flows into Texas, as the state contains a major share of the nation's largest feedlots (National Cattlemen's Beef Association, 2019). Interstate movements of cattle are recorded at the state level via Interstate Certificates of Veterinary Inspection (ICVIs), state brand inspection departments, or both (see Shield and Mathews, 2003; Buhnerkempe et al., 2013; Beck-Johnson et al., 2019). As of the writing of this article, we are working to acquire ICVI and brand inspection data collected by states in the project's coverage area (Figure 1 in main article). Here we report preliminary results and describe knowledge gaps and needs for future research.

The state of Texas does not have a brand inspection system; it records interstate cattle movements via the ICVI system. Partners at Texas A&M University provided ICVI data comprising the count of "non-breeding" beef cattle imported to Texas from respective states of origin, monthly in 2015-2017 (Texas Animal Health Commission, 2020). Non-breeding beef cattle inspected in the Texas ICVI system are imported mainly for the purpose of feedlot feeding (Shield and Mathews, 2003). Notably, the following classes are exempted from veterinary inspection upon entering the state for feedlot feeding: *beef breed steers, spayed heifers and beef breed female cattle, under 18 months of age, delivered to a feedlot for feeding for slaughter by the owner or consigned there with an owner-shipper statement* (Texas Animal Health Commission, 2019).

The New Mexico Livestock Board Brand Inspection Department provided data about exports from New Mexico to other states (New Mexico Livestock Board, 2019). Per New Mexico state law, movement of beef cattle from New Mexico to another state requires 1) an inspection and form issued by a New Mexico Livestock Board livestock or brand inspector, and 2) all entry requirements of the destination state (New Mexico Statutes Chapter 77: Livestock Code, Article 9). Notable exceptions to this inspection system include exports from American Indian Tribal Lands and exports from auction barns (e.g., Clovis Livestock Auction). The New Mexico Livestock Board estimated that its inspection data account for ~85-90% of the cattle exported from New Mexico (personal communication, Julie Gauman, Records Custodian, New Mexico Livestock Board). We analyzed data that spanned 2015-2017 and comprised the following variables: New Mexico Livestock Board origination district (n=26), destination city/state, date of movement, and the number of head exported for purpose of feedlot.

Per the Texas ICVI import data, in 2015-2017, on average, 1.1 ± 0.19 million non-breeding beef cattle were imported into Texas each year, with the five Southwestern states accounting for $28\% \pm 4\%$ of the annual average. Imports from Arizona accounted for the largest share at $17 \pm 3\%$ ($201,609 \pm 67,576$ head), and New Mexico accounted for $4\% \pm 1\%$ ($41,831 \pm 7068$ head). In contrast, during the same period, New Mexico Livestock Board data indicated an annual average of $227,472 \pm 15,305$ head exported from New Mexico to Texas feedlots. Therefore, the New Mexico export estimate was approximately five times greater than the Texas import estimate. The discrepancy was apparently due to differences in data collection in New Mexico vs. Texas – for example, the exemption in italics above – however, that exemption alone would likely not explain the entire discrepancy.

Looking ahead, we plan to work with the New Mexico and Texas agencies to understand the reasons for the discrepancy in estimates of exports vs. imports. As we expand our analysis by quantifying flows between additional states of the Southwest and Ogallala Aquifer region, we recognize that an accurate pericoupling assessment (Table 1 in the main article) will require a full understanding of each state's requirements for interstate cattle movements, and their correlated approaches to data collection.

References

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