

# Deep Well Ranch – Research Insights

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NM  
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# How do we deal with livestock management in extensive pastures?



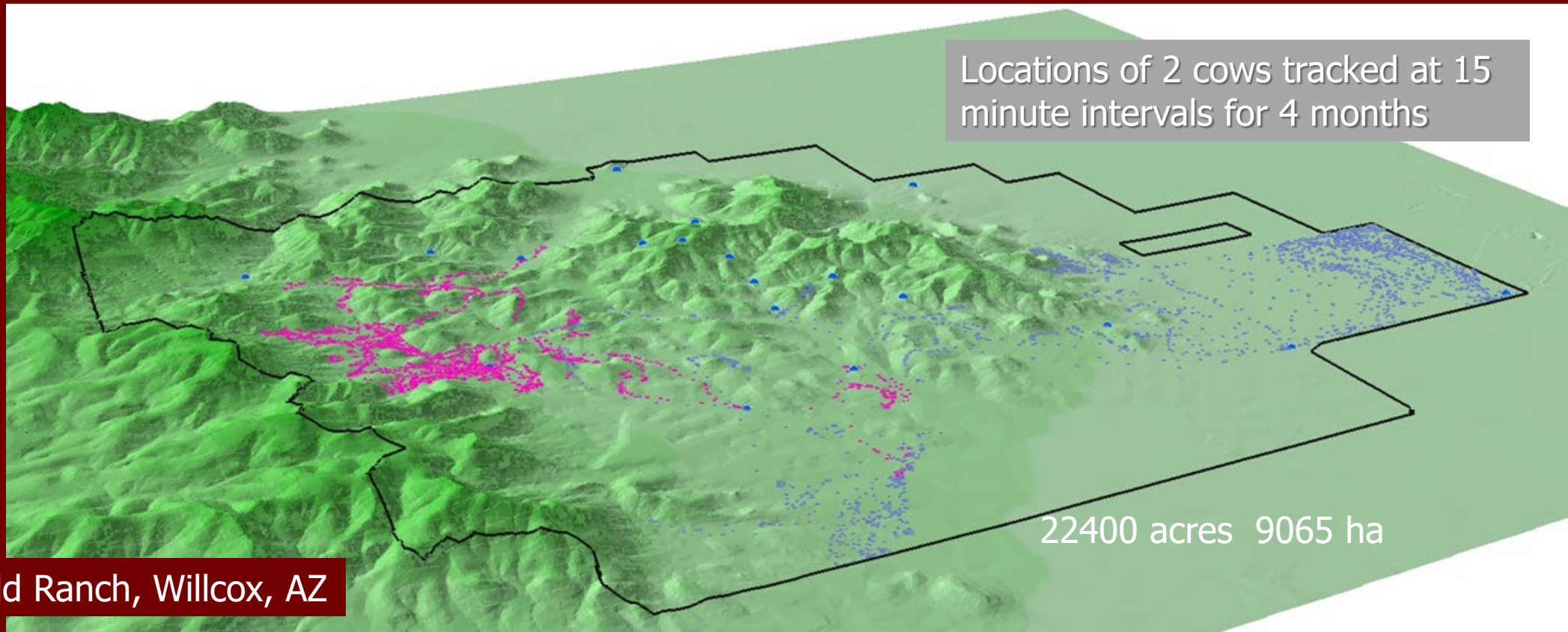
Todd Ranch, Willcox, AZ

Horseback observers are sometimes the best approach to monitor cattle and grazing impacts



Cattle use vast areas and they are difficult to observe and monitor

- Fun, but time consuming to check cattle on horseback
- Ability to monitor health and welling of livestock is limited
- Remote monitoring would
  - Improve animal welfare
  - Improve productivity
  - Reduce labor



Todd Ranch, Willcox, AZ

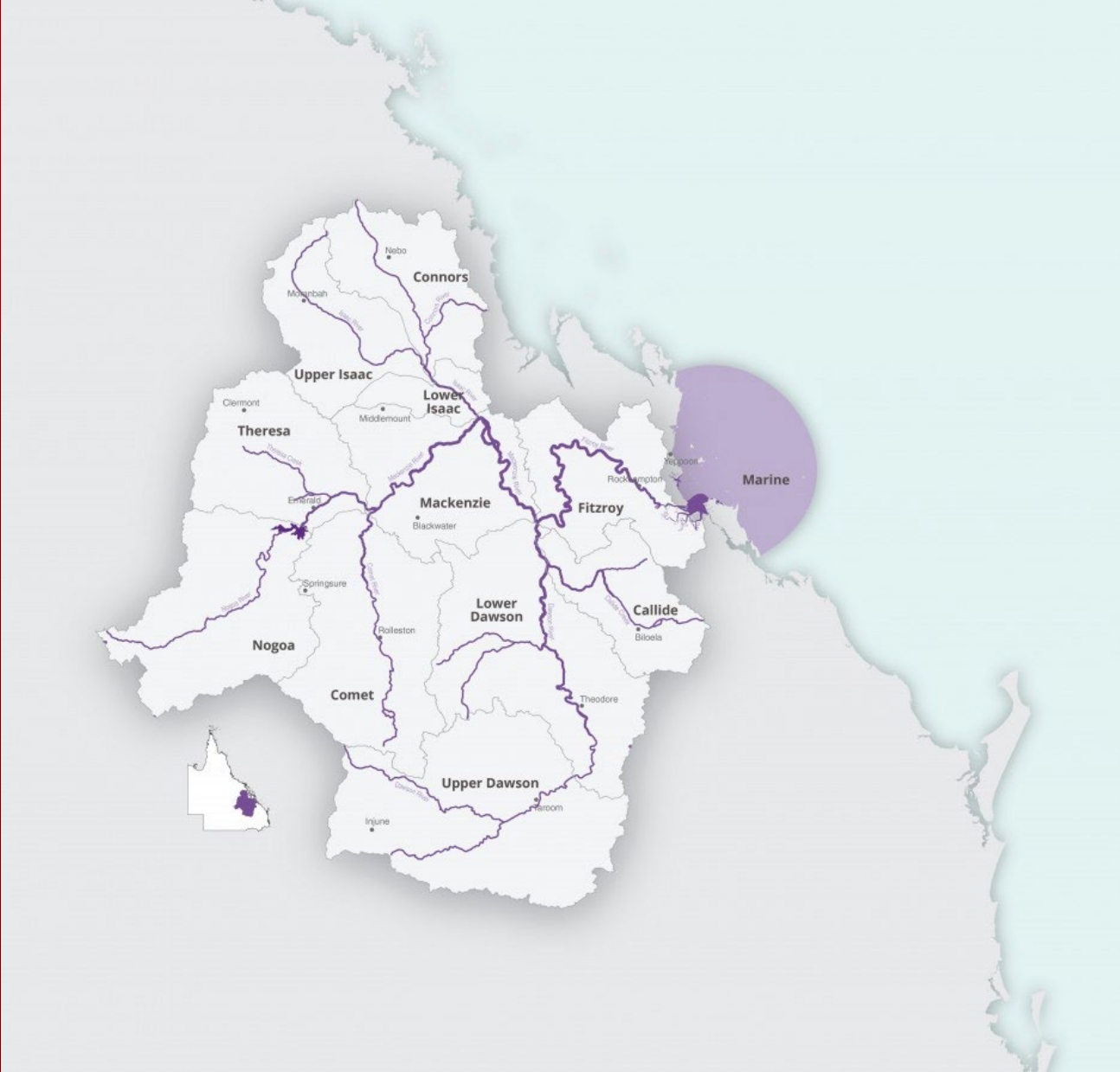
A second issue is monitoring livestock impacts on vegetation, soils and other resources



In riparian areas, livestock impacts can occur quickly









# Answer:

## Precision Livestock Management

- What is Precision Livestock Management?
  - Continuously monitor all the factors that might influence animal productivity and welfare to develop sustainable management strategies (di Virgilio et al. 2018)
  - A management system based on the continuous automatic real-time monitoring and control of production/reproduction, animal health and welfare, and the environmental impact of livestock production (Berckmans 2014)



Since 1998, we  
have been  
monitoring cows  
with store-on-board  
GPS collars,  
primarily Lotek

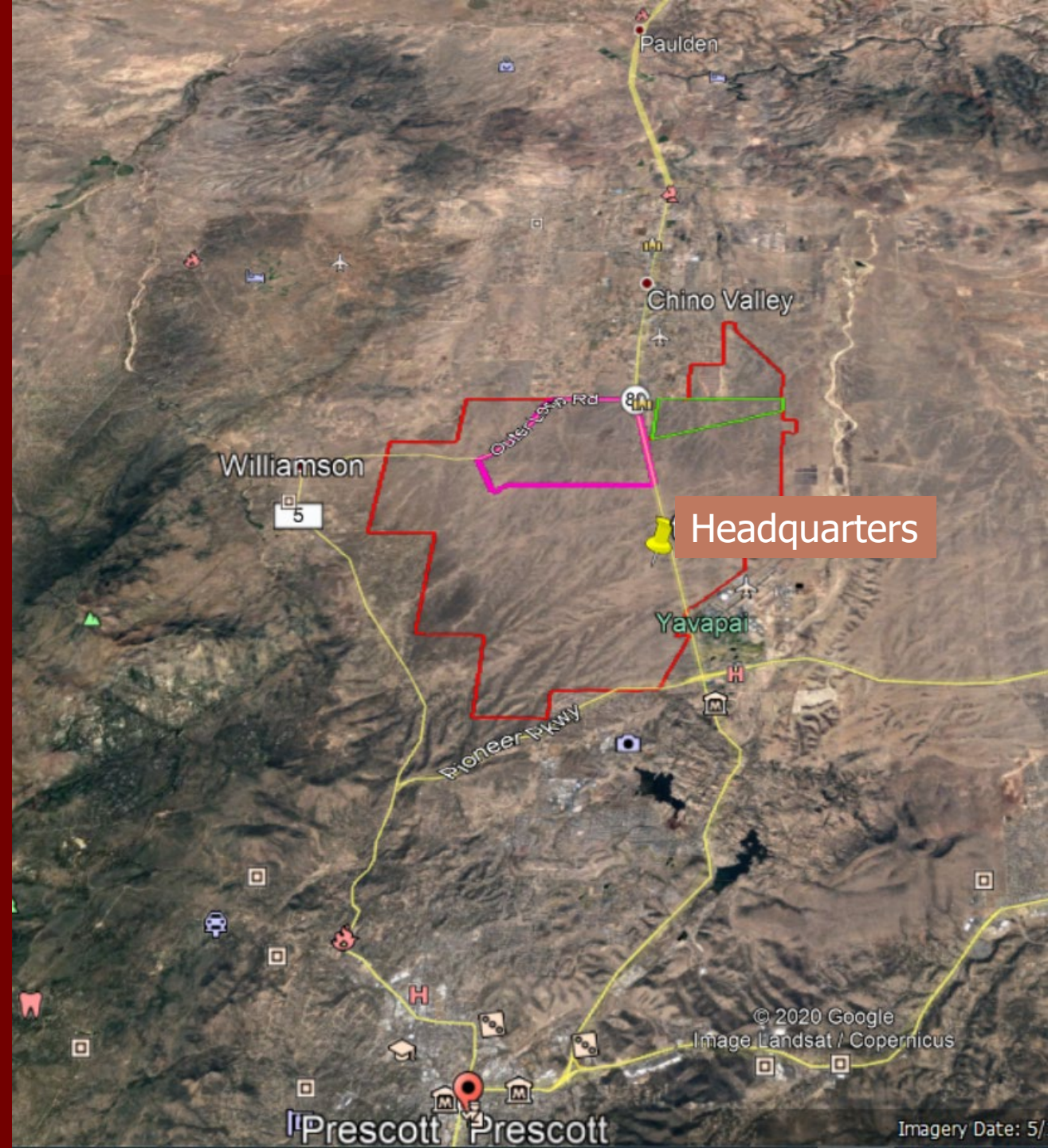
# Evaluation of Precision Livestock Management Technologies and Techniques at Deep Well Ranch

Funding from the Harold James Family Trust

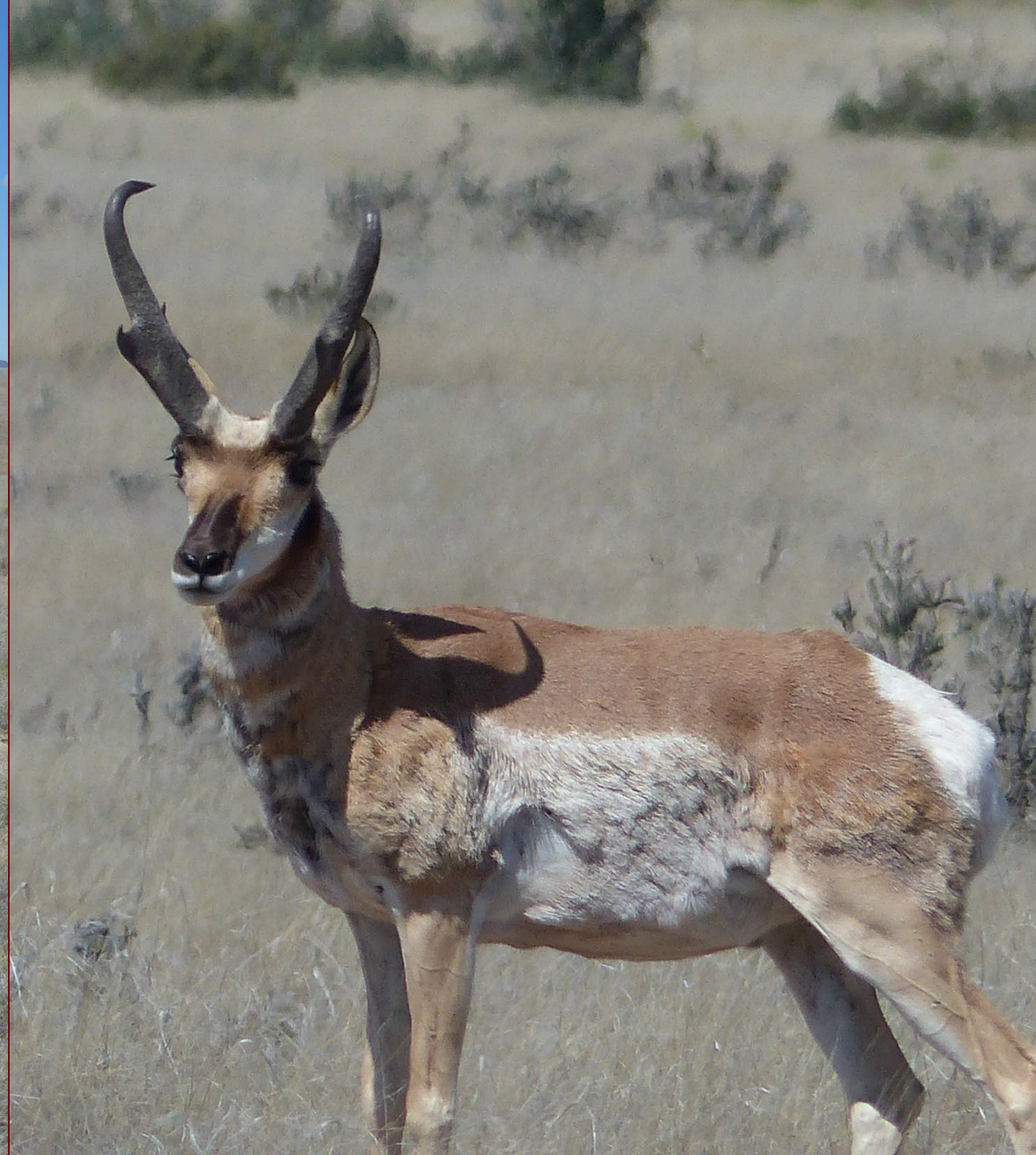


# Deep Well Ranch

- ~ 18,000 acres
- 4700 to 5450 feet elevation
- 17.7 inches annual precipitation
- Dominant vegetation, black gramma
- 200 to 250 Corriente cows
- Sales
  - Roping cattle
  - Beef
- Manager Bob Burris



Rangeland is in great condition



# Equipment to Monitor Livestock Well-Being on Rangelands

- GPS
- Accelerometers
- Thermistors



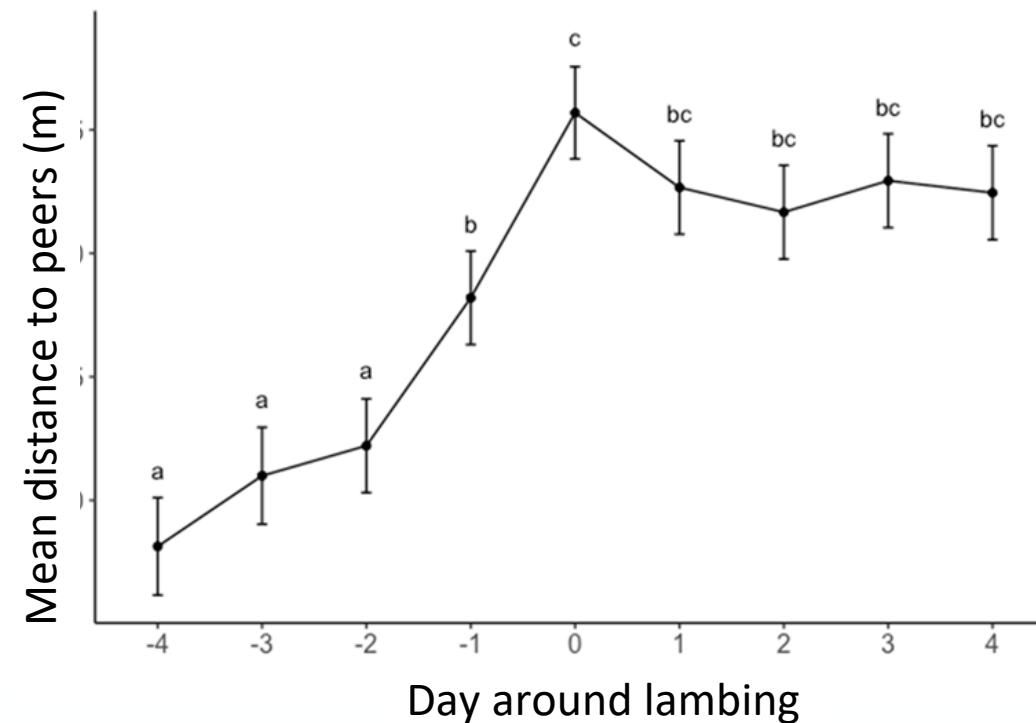
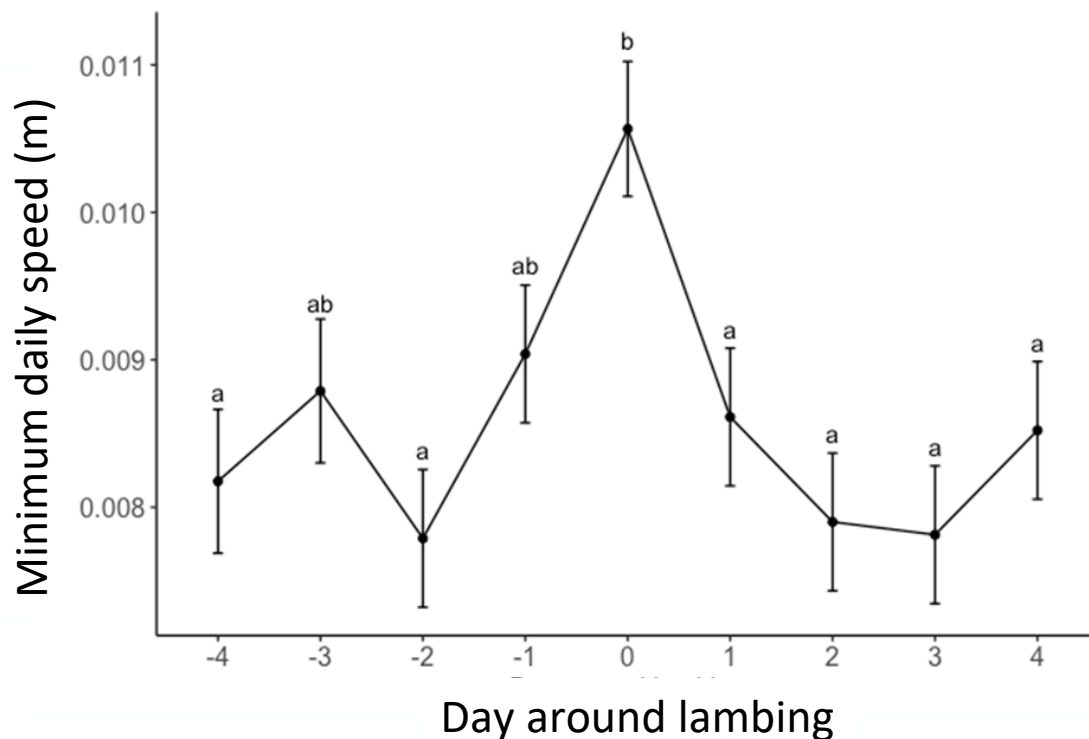
GPS Tracking as  
a Tool for  
Remotely  
Monitoring  
Livestock  
Welfare

Initial studies  
leading to  
current work at  
Deep Well  
Ranch



## Fogerty et al. (2020) Lambing Study

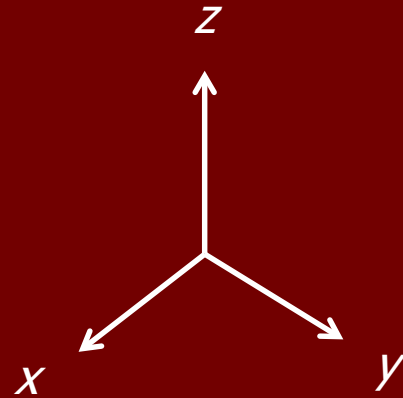
- Increase in minimum daily speed
- Separation from peers
- GPS unable to distinguish hour of lambing



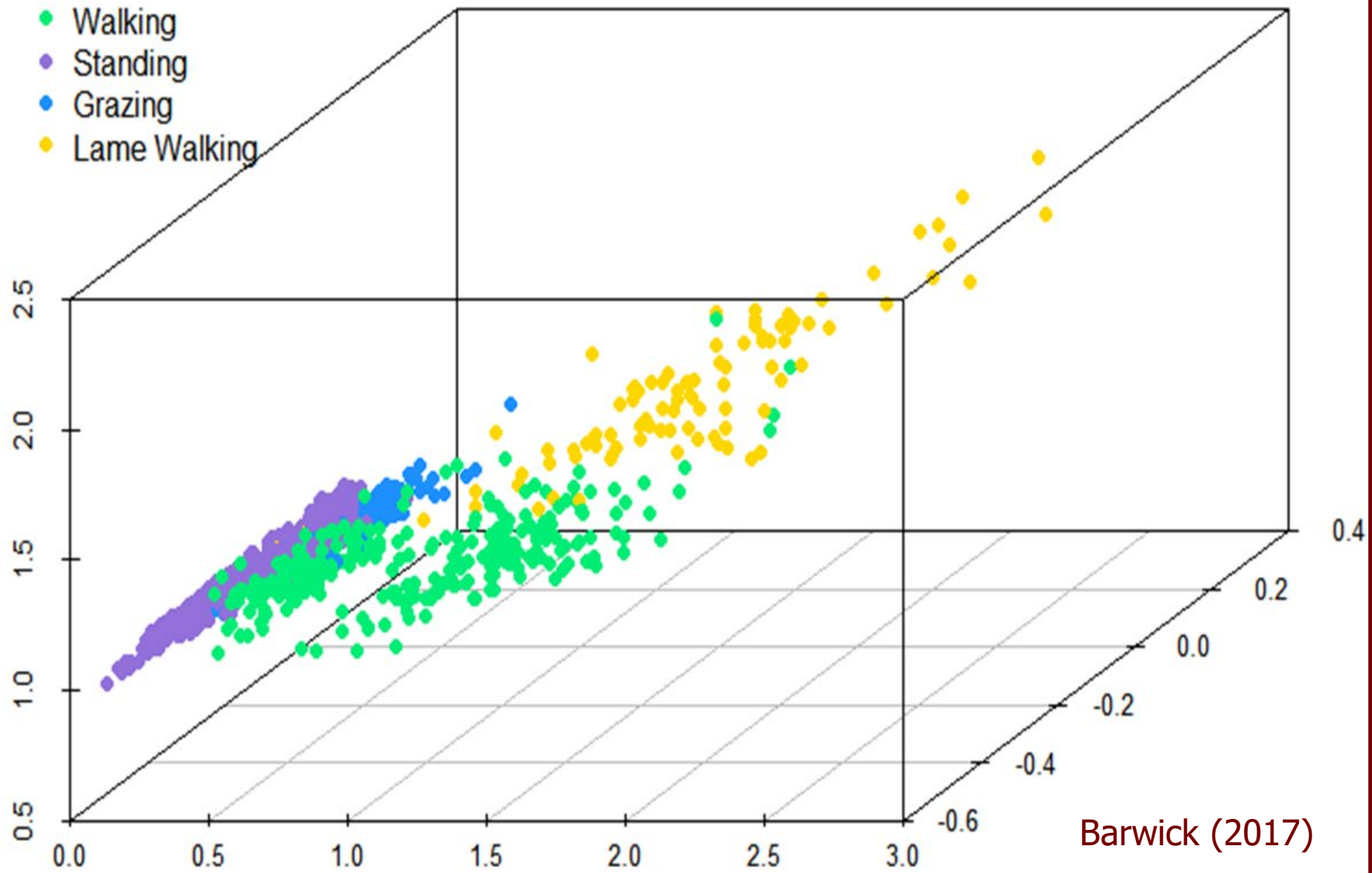


# Accelerometers are motion sensors

- Detect motion
- 3 axes  $x$ ,  $y$  and  $z$



# Potential for accelerometers to predict sheep behaviour including lameness



# NMSU Penned Sheep Study

- Random Forests used for classification
- Behaviors: Active and Inactive
- 10 second epoch
- Variables
  - Range of x
  - Range of y
  - Standard Deviation of x
  - Minimum of Signal Magnitude Amplitude



Observed Behavior (%)	Predicted Behavior (%)		
	Active	Inactive	Total*
Active	<b>79.9</b>	20.1	492
Inactive	8.9	<b>91.1</b>	928
			1420

**Accuracy = 87%**

# NMSU Penned Sheep Study

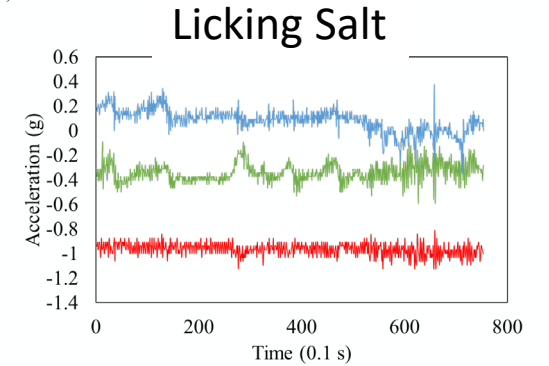
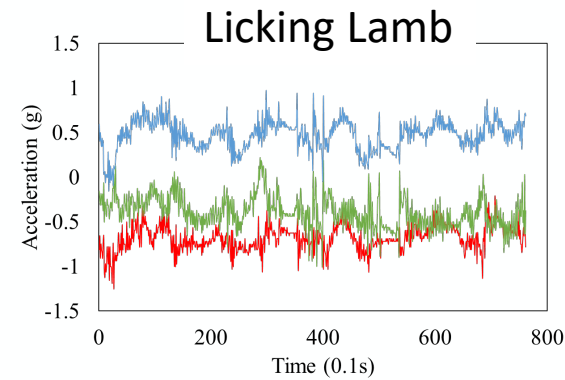
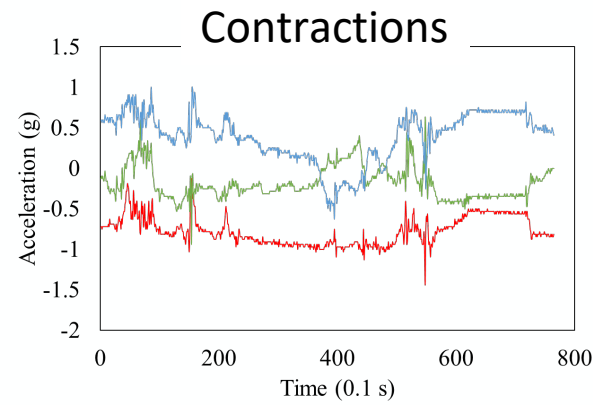
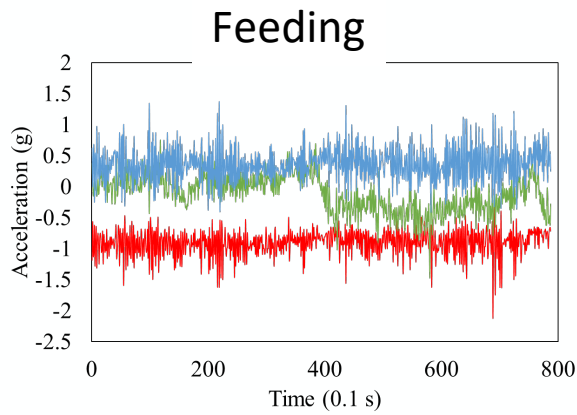
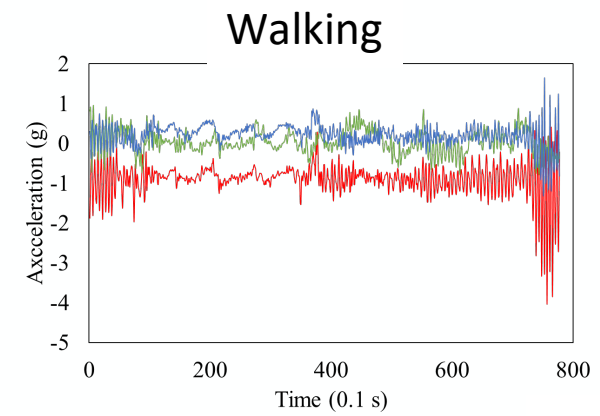
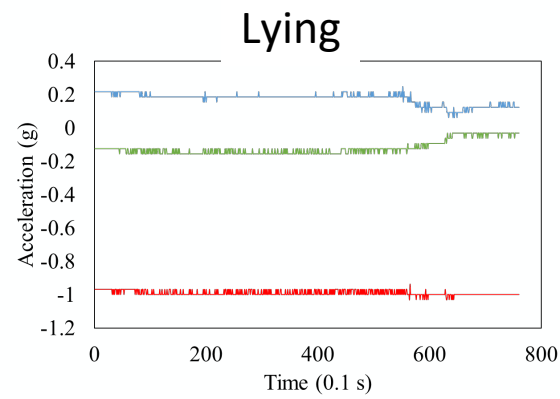
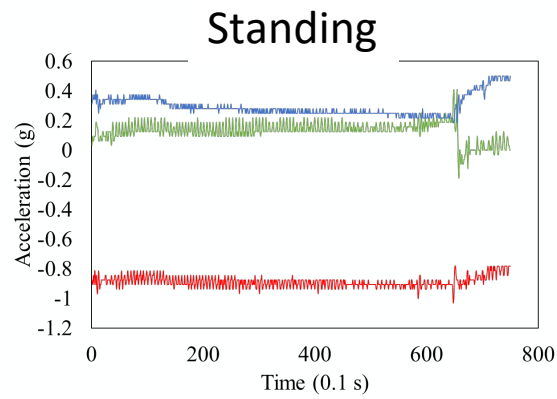
## Random Forests Classification of Behaviors

### Validation Results



Behavior	Accuracy (%)
Feeding	76
Lying	84
Licking Lamb	36
Licking Salt	29
Contractions	24
Standing	56
Walking	33

**Overall Accuracy – 67%**



80 seconds of raw accelerometer data from known behaviors of ewes

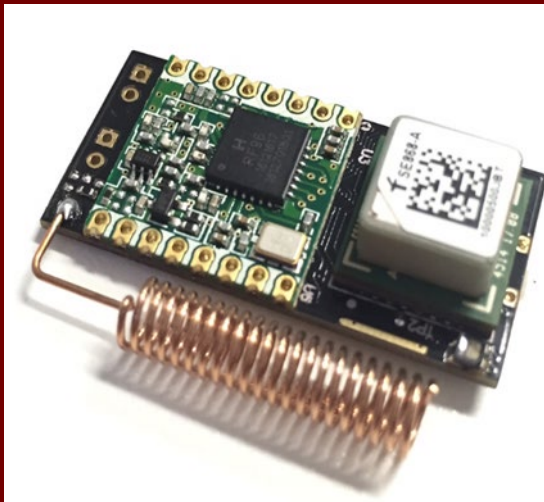
— X axis    — Y axis    — Z axis



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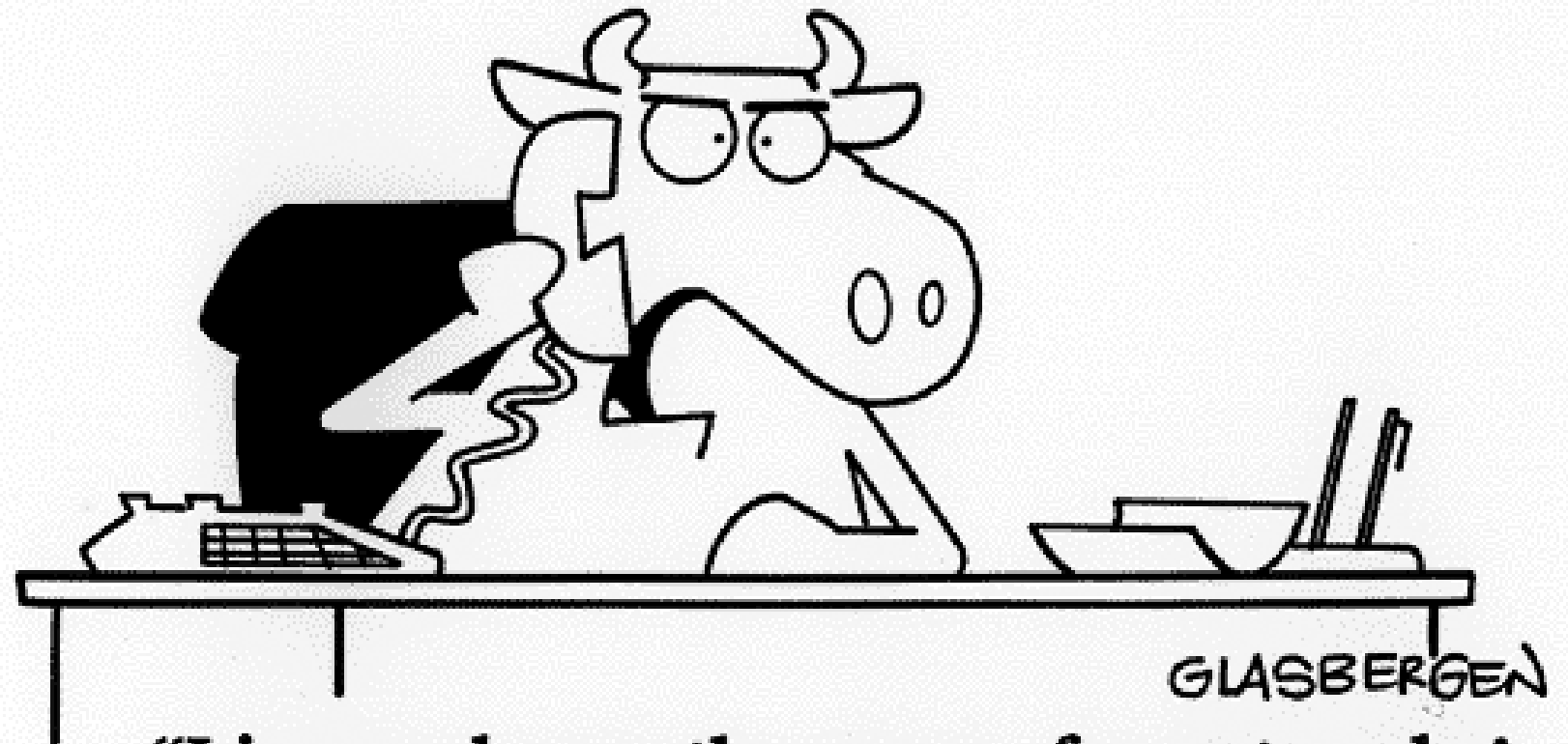
Transition from "Store on Board"  
to  
"Real-Time" or "Near-Real Time"



LoRa chipset for real time tracking of livestock



We are never  
satisfied!

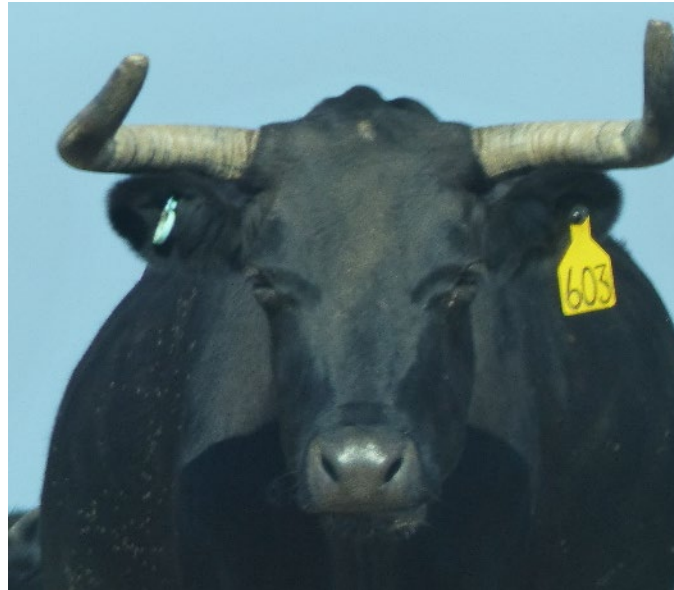


**“I jumped over the moon, for pete sake!  
I should be swamped with endorsement offers,  
but all I got was a stupid nursery rhyme!  
You’re a lousy agent, Bernie!”**

# Real-Time and Near-Real Time Monitoring

## GPS Tracking

- Movement (LoRa)
  - NMSU - Bailey
- Digital Matters Oyster 2 (4 G cellular)
  - Texas A&M - Walker
- Abeeway (LoRa)
  - NMSU – Cibils
- CQ University (LoRa)
  - CQ University – Trotter
- CERES (IoT)
  - CSIRO Australia
- MOOnitor (satellite)
  - Israel and USDA-ARS



## Accelerometer

- Herddogg (Bluetooth)
  - NMSU – Bailey
  - CQ University – Trotter
- MOOnitor (satellite)
  - Israel and USDA-ARS



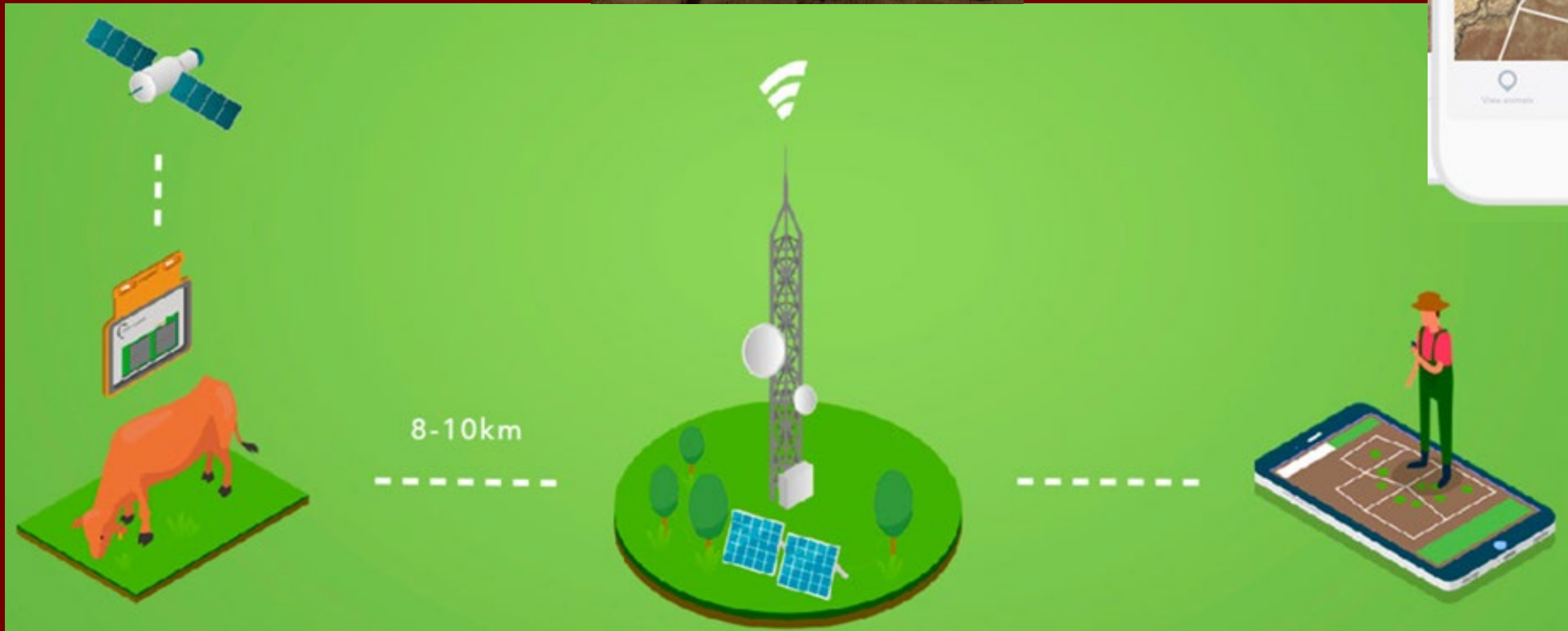


Moovement  
"real-time"  
GPS ear tag



## Moovement system uses

- GPS tracking
- LoRa transmitter
- LoRa receiver
- Cell phone technologies
- Smart phone app





## Moovement tags

- Commercially available
- \$60 USD / tag
- Position recorded every hour

### 2019 NMSU Study

- Deep Well Ranch
- Prescott, AZ
- Rolling terrain
- 1 LoRa antenna
- 8 tags tested

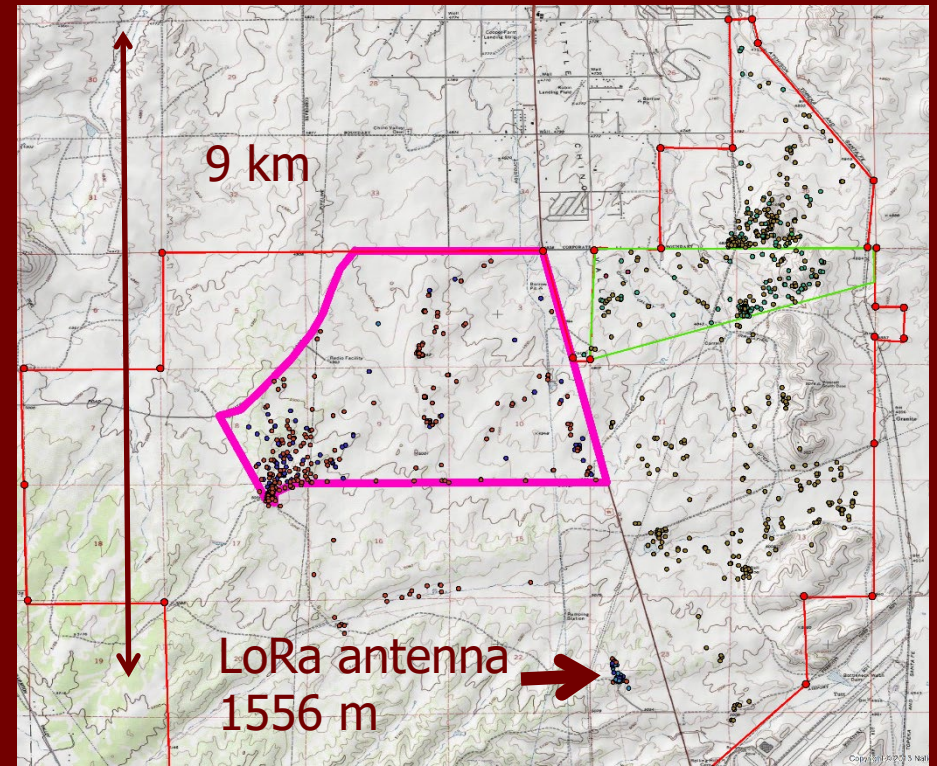
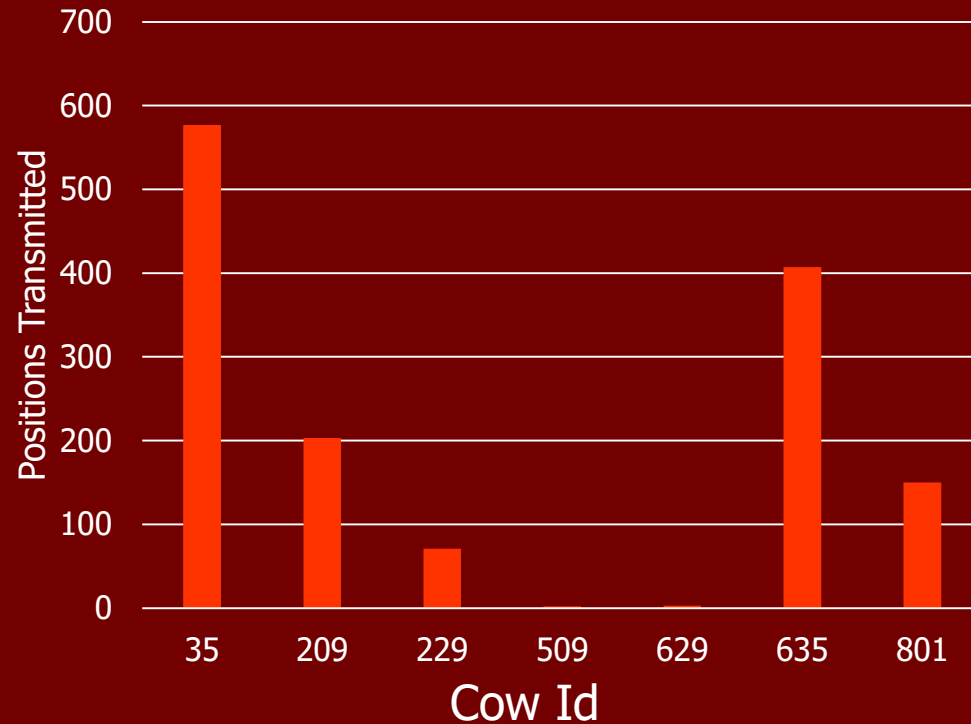


# Positions from Movement tags (June – October 2019)

Big reason why we got few fixes

Average elevation of fixes: 1511.4 m  
Minimum elevation of fixes 1443.8 m  
Elevation standard deviation 27.3 m

For cow 35:  
 $4.4 \pm 3.2$  SD positions / day  
Range 1 to 16 positions / day



## Potential for Precision Livestock Management to Improve Welfare: Examples

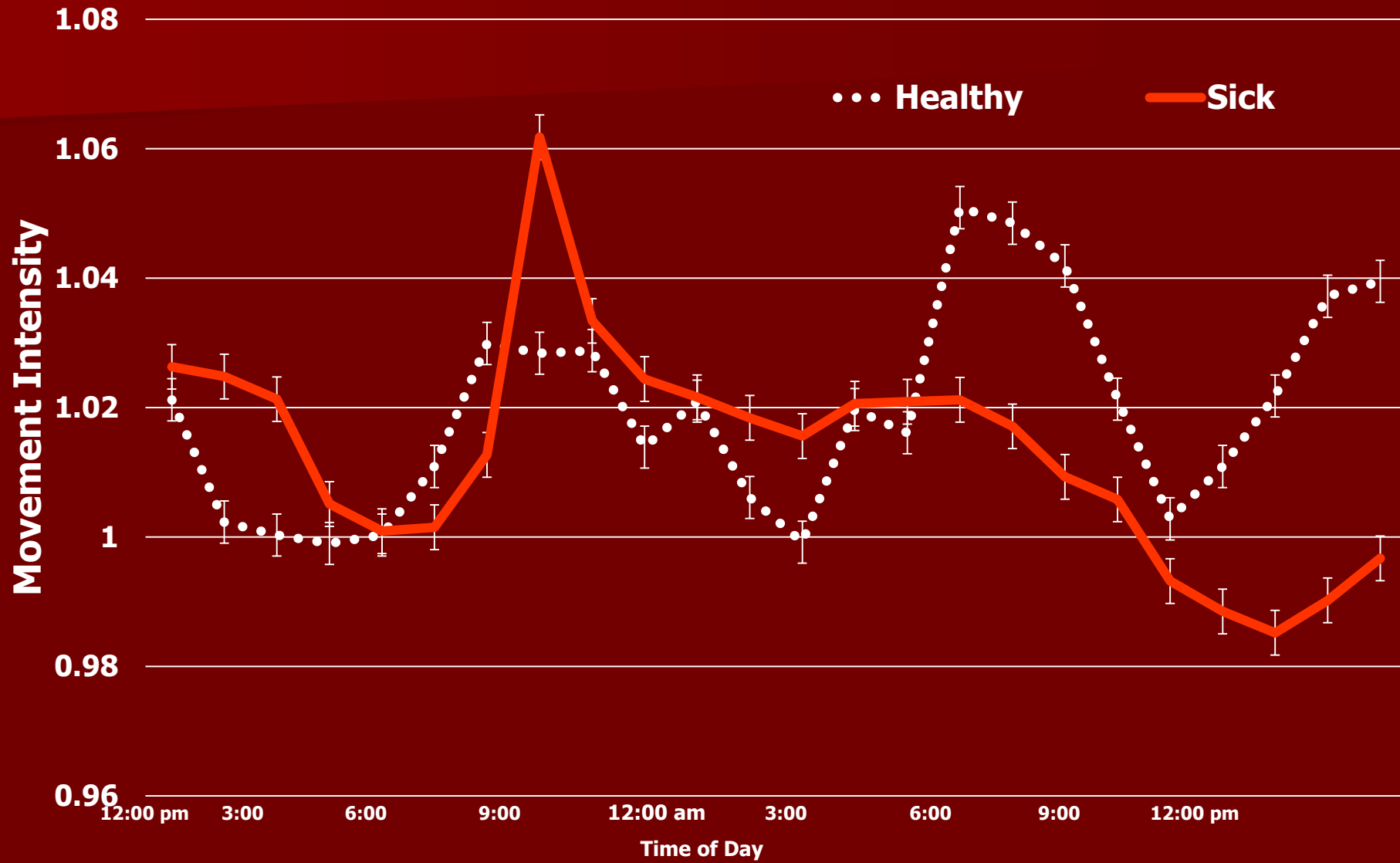


# 3-Day Sickness

- Viral disease of cattle and buffalo
- Mosquitos and other biting insects are vectors
- Sudden onset of high fever
- Shiver, stiff and may be lame
- Stop eating and drinking
- Depressed
- Illness lasts for only a few days

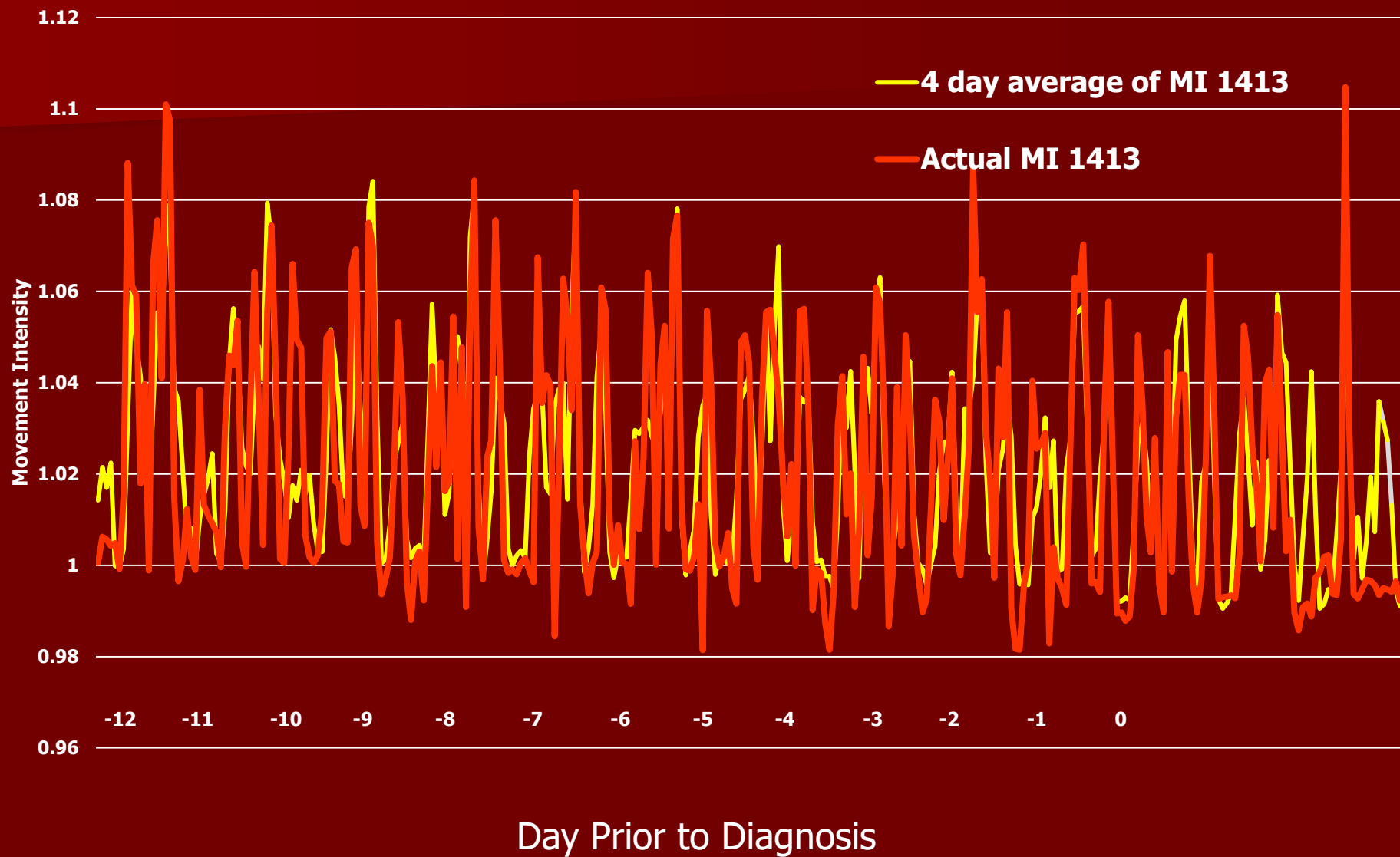
# Diurnal activity pattern of heifers the day prior to the diagnosis of BEF for affected and control animals

Accelerometer – Based Index of all 3 Axes



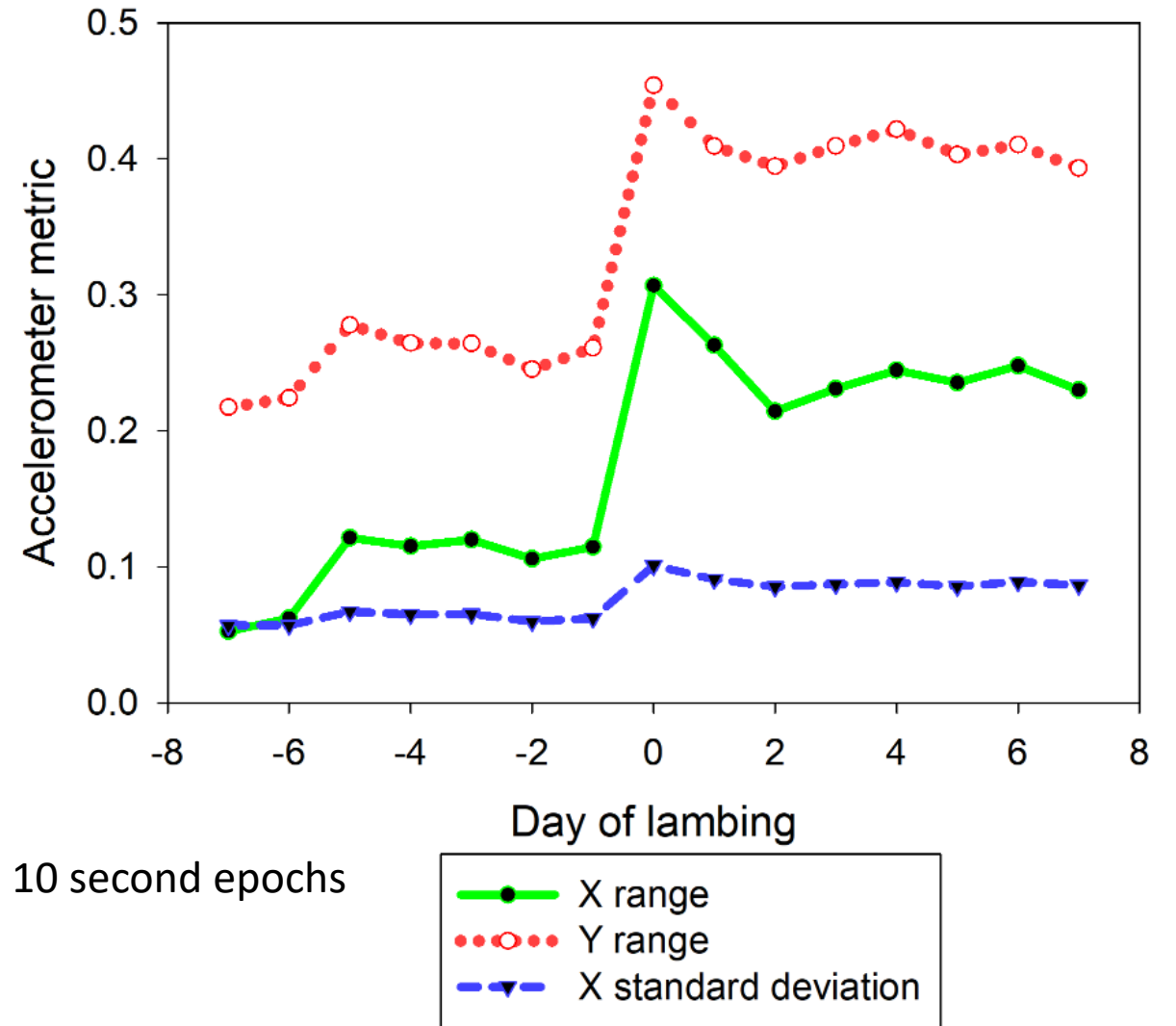
# How can we detect an illness in "real time"?

Accelerometer – Based Index of all 3 Axes



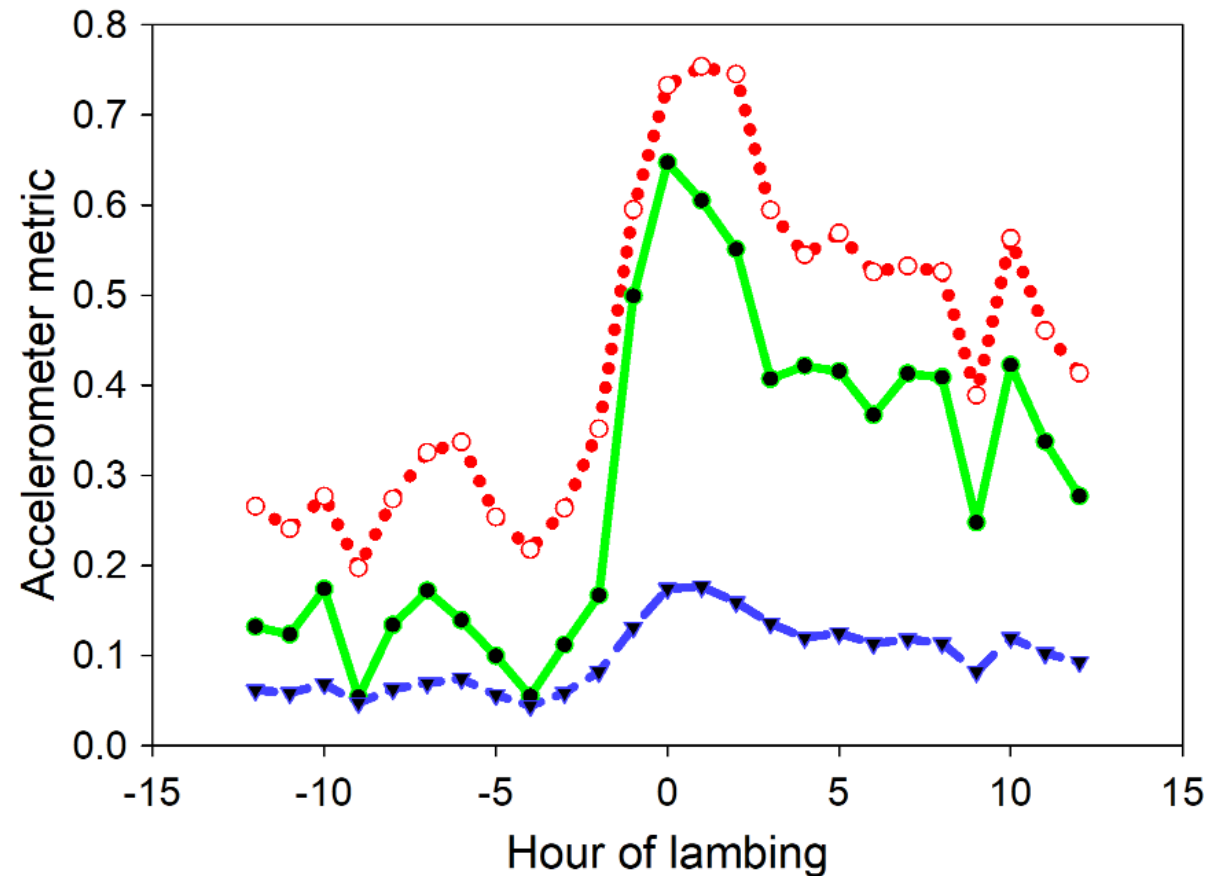


# Detection of Lambing NMSU Pen Study

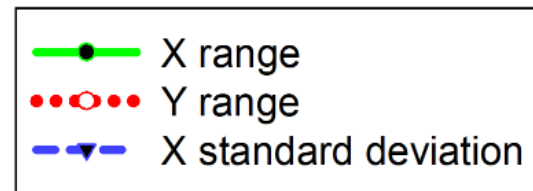


Clear indications of lambing from metrics derived directly from accelerometer,

but not from predicted behaviors using “random forests” machine learning



10 second epochs



Water is the most critical nutrient!

Ranchers must check water systems frequently.

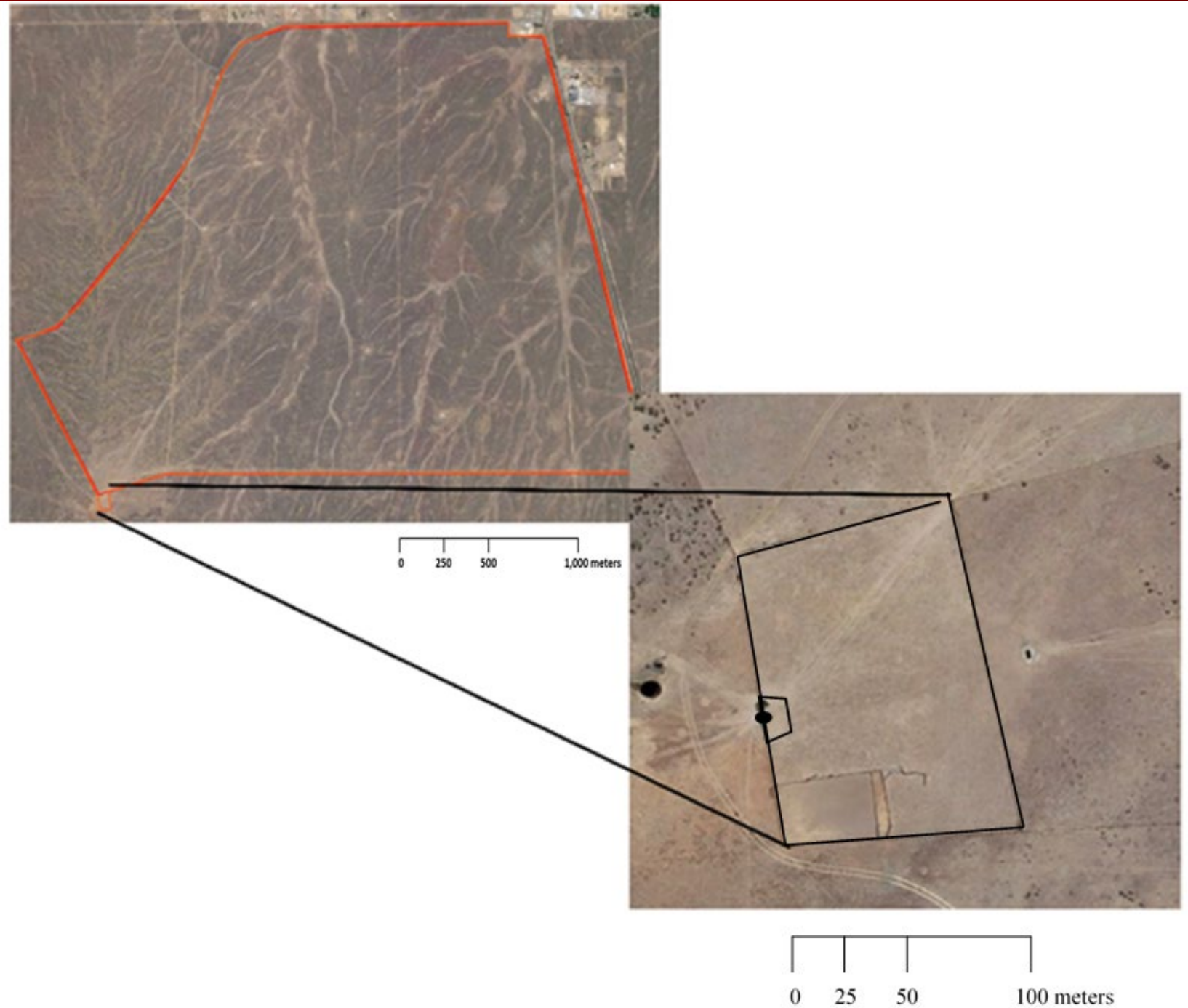
A large labor requirement

Water system failure is a major animal well-being concern!  
- Especially in the summer



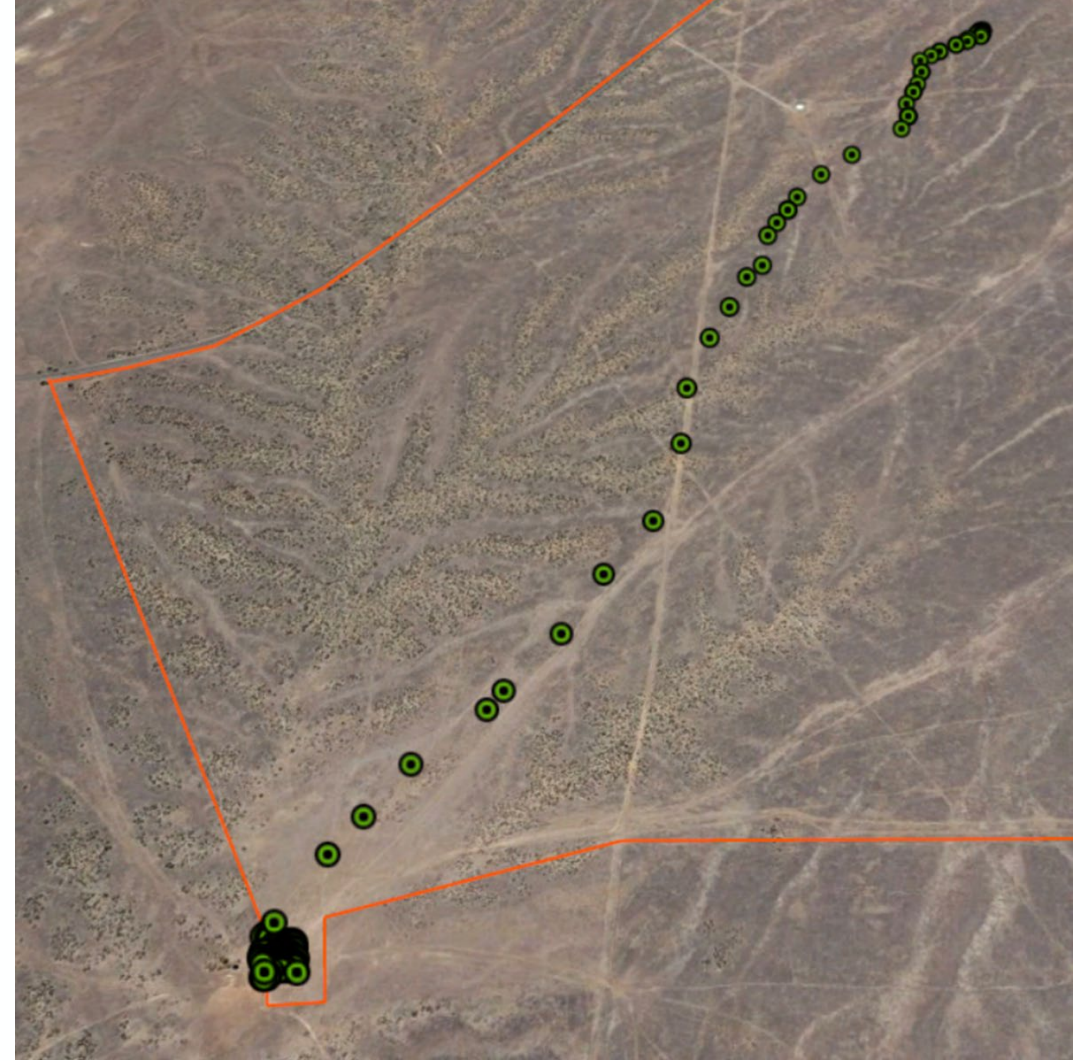
# Study Site

- Deep Well Ranch
- North Pasture
- 2700 acres
- 130 cows
- Simulated water failure for 4 hours
- Comparison to previous day





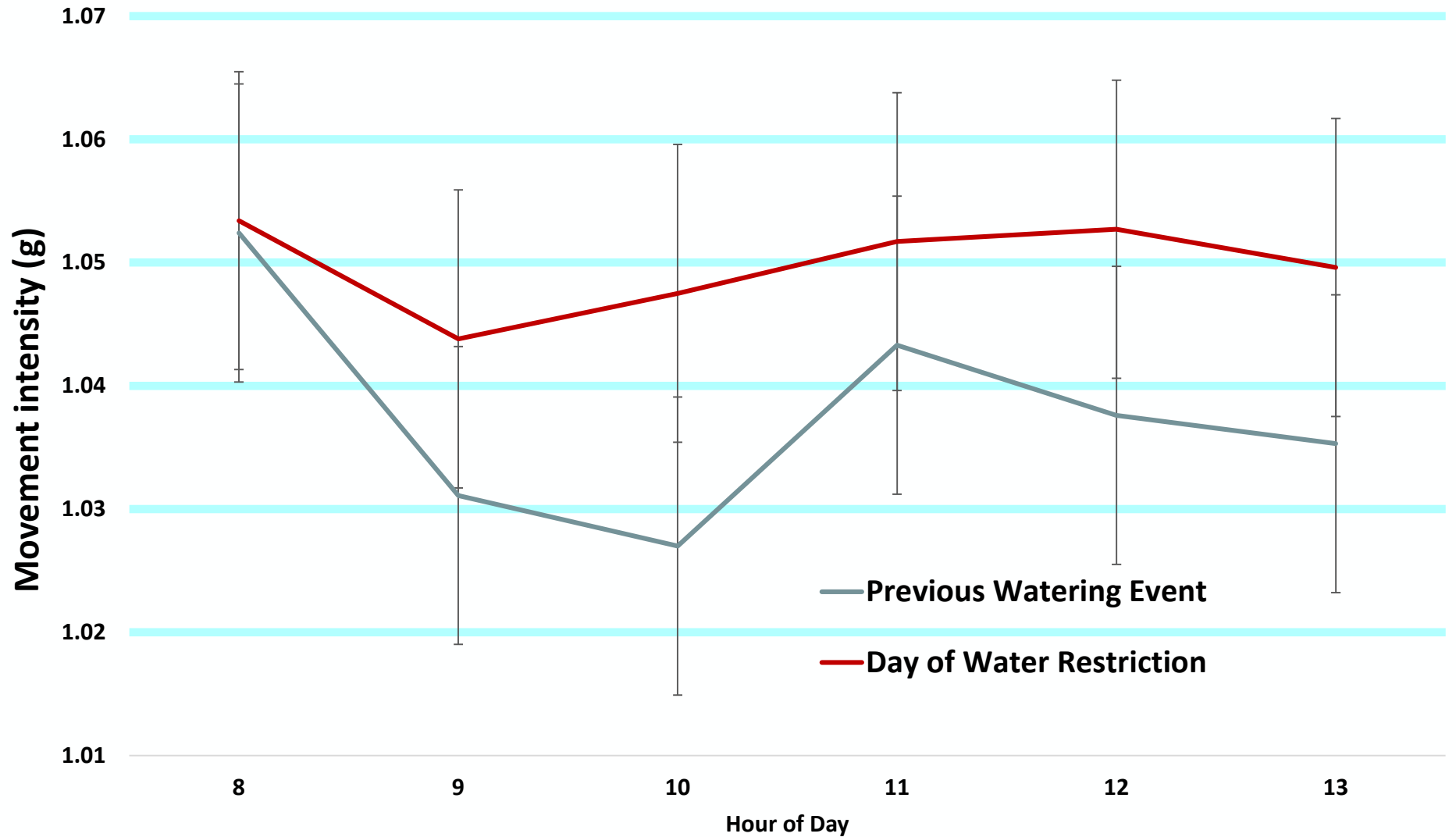
Typical watering event



Simulated water failure

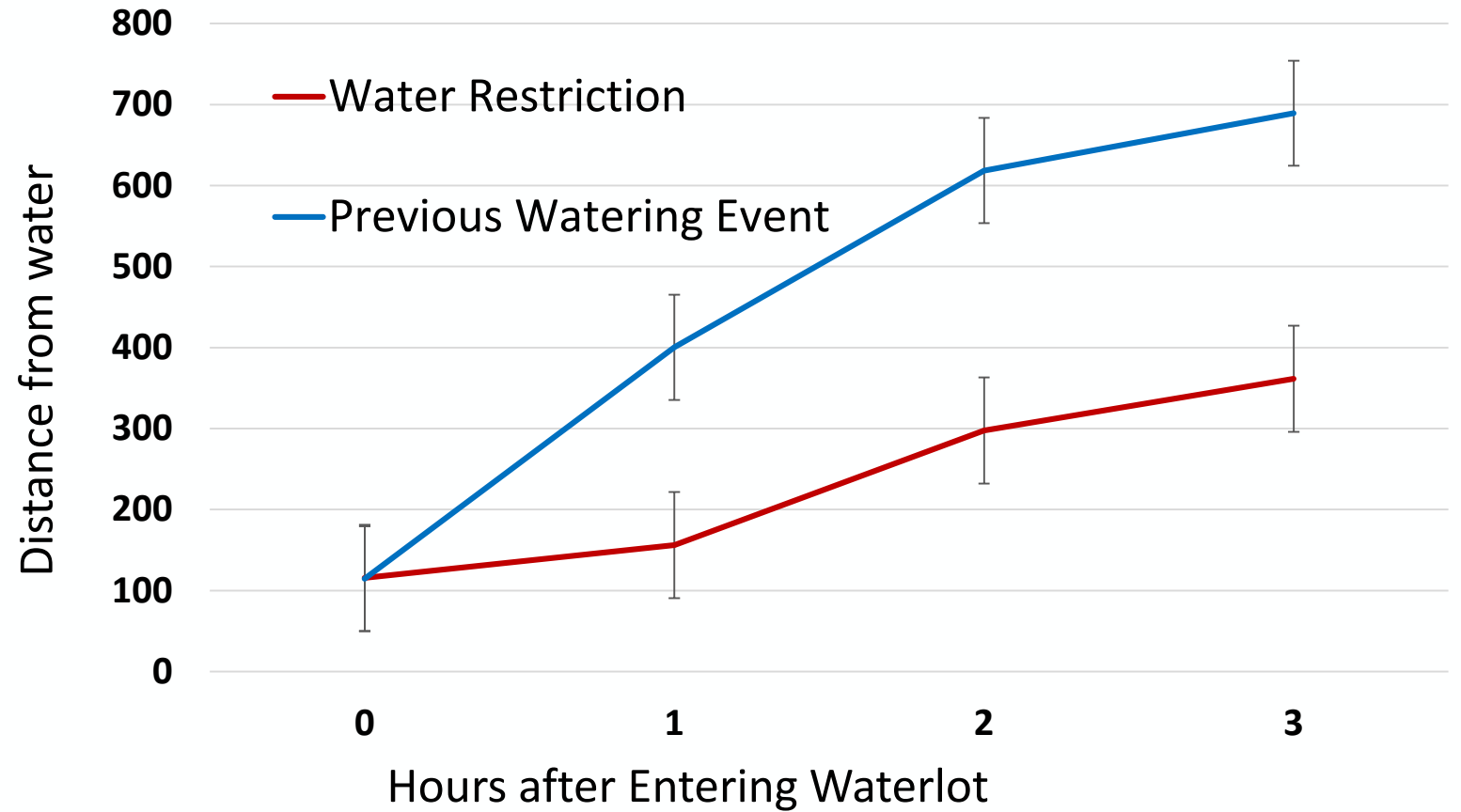
Cows were more active (agitated??) when water was restricted

Accelerometer – Based Index of all 3 Axes



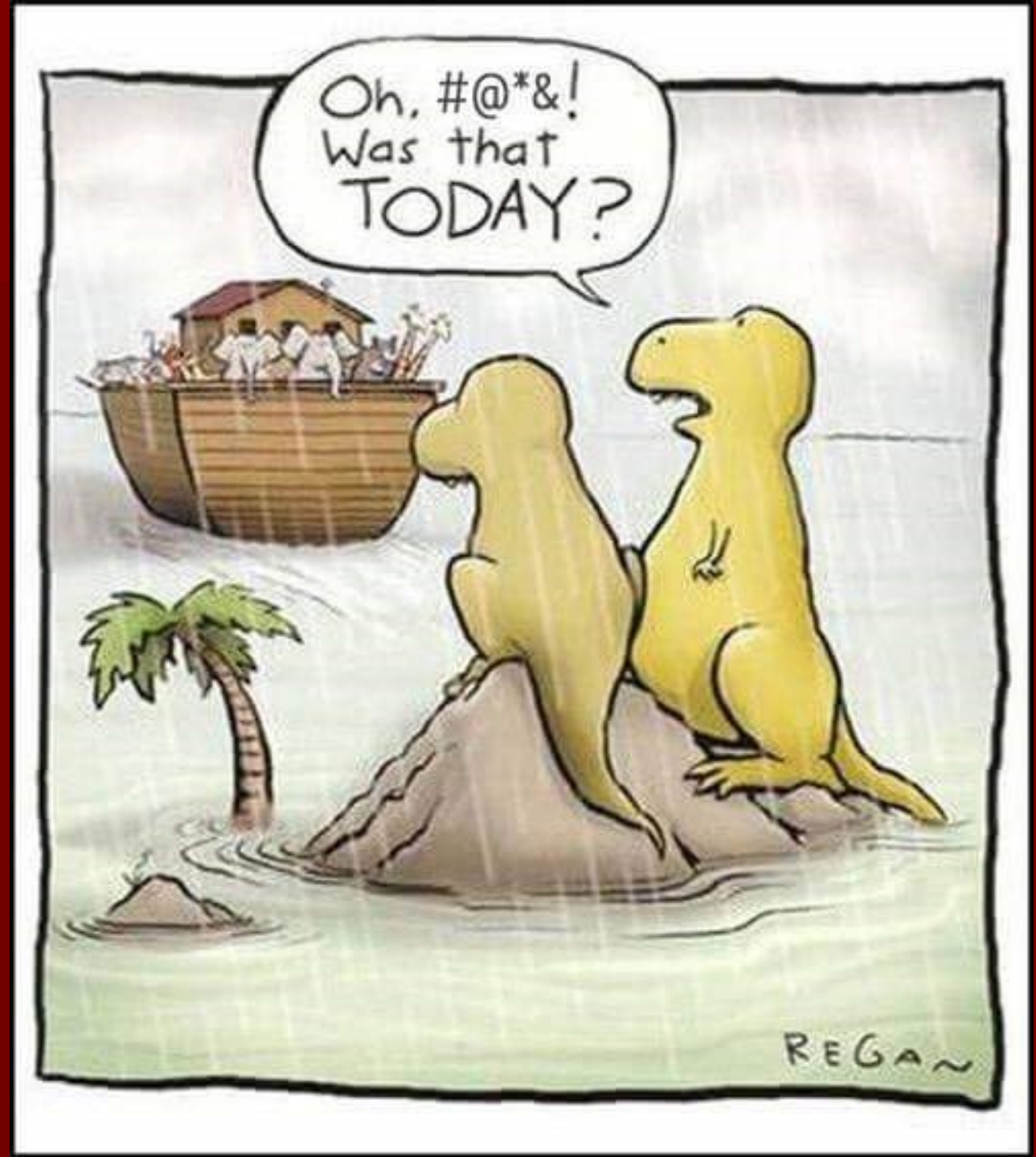
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# Real time GPS tracking can detect simulated water failure



Grazing levels are critical  
and time sensitive

Real time or near real  
time tracking has  
potential to identify  
problems before  
defoliation levels are  
excessive





# Social Interactions

Time spent within  
75 m of another cow -dyad

Time spent within  
500 m of another cow -dyad

Positions within 200  
yard of water were  
excluded



Two pastures

- 2700 acres North Pasture
- 770 acres North Ditch Pasture

Similar number of cows

135 cows in North Pasture

130 cows in North Ditch Pasture

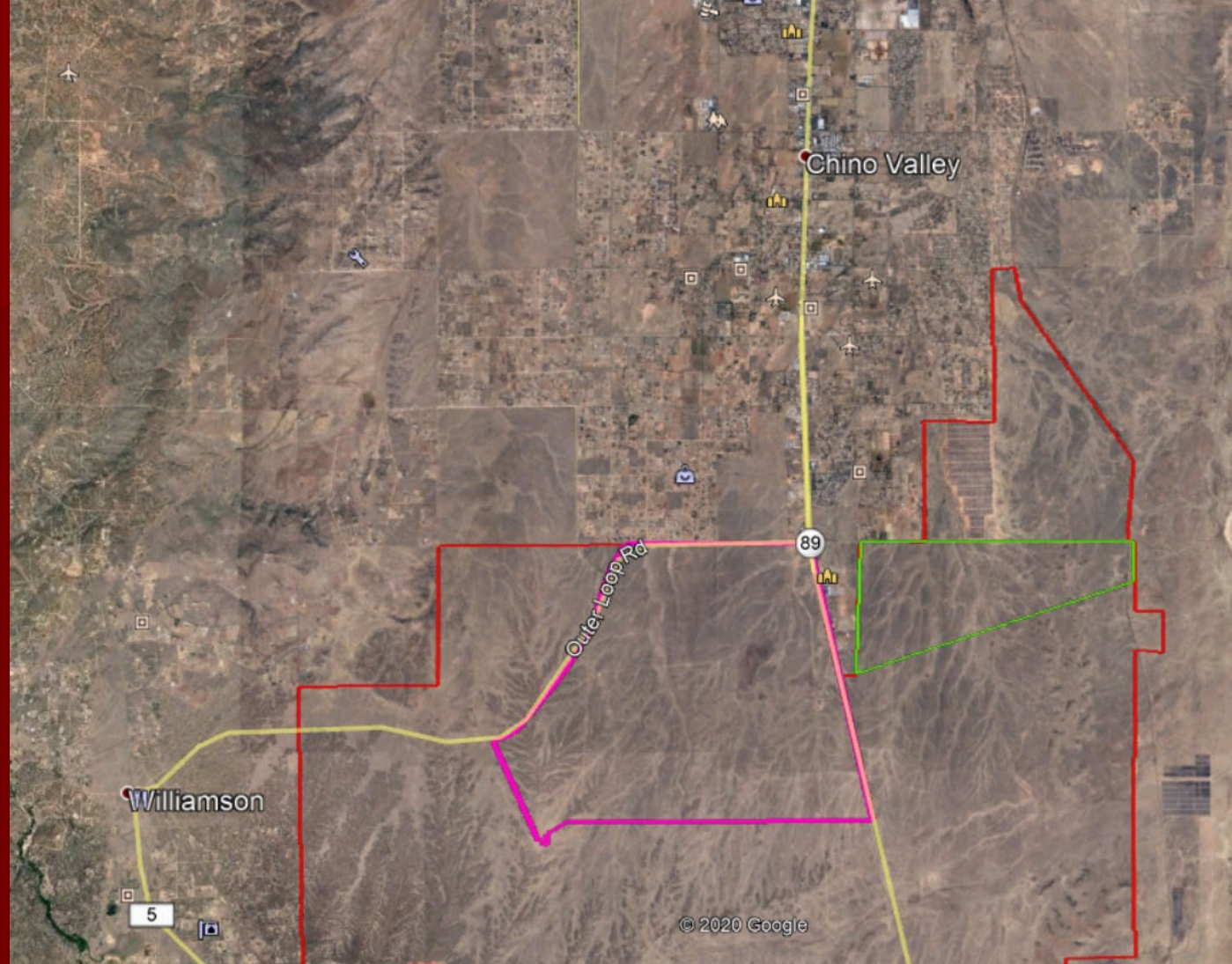
Two Stocking Densities

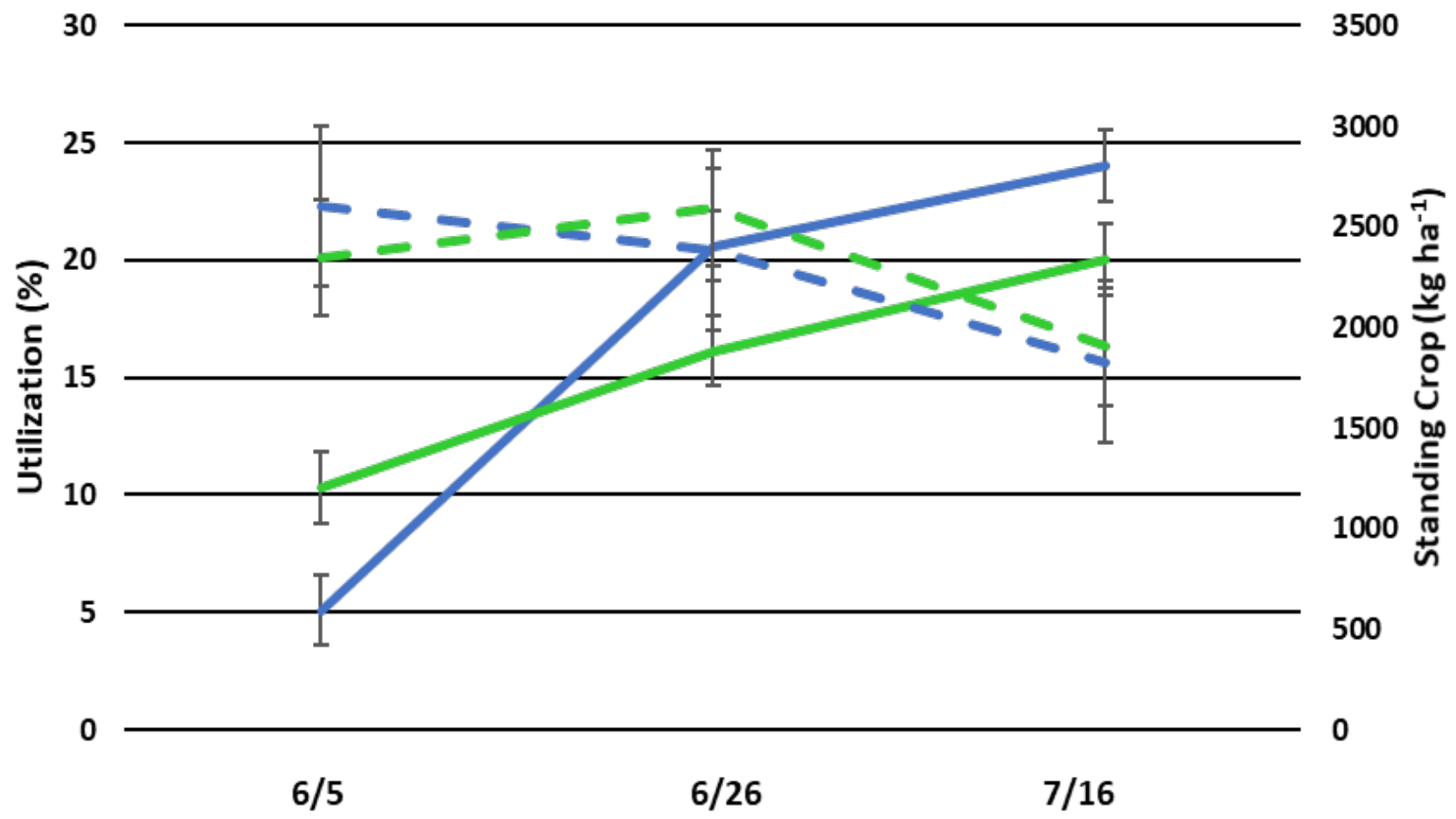
- Light North Pasture
- Heavy North Ditch Pasture

35 cows tracked in Light Stocking Density

32 cows tracked in Heavy Stocking Density

Cows tracked from June 6 to July 16

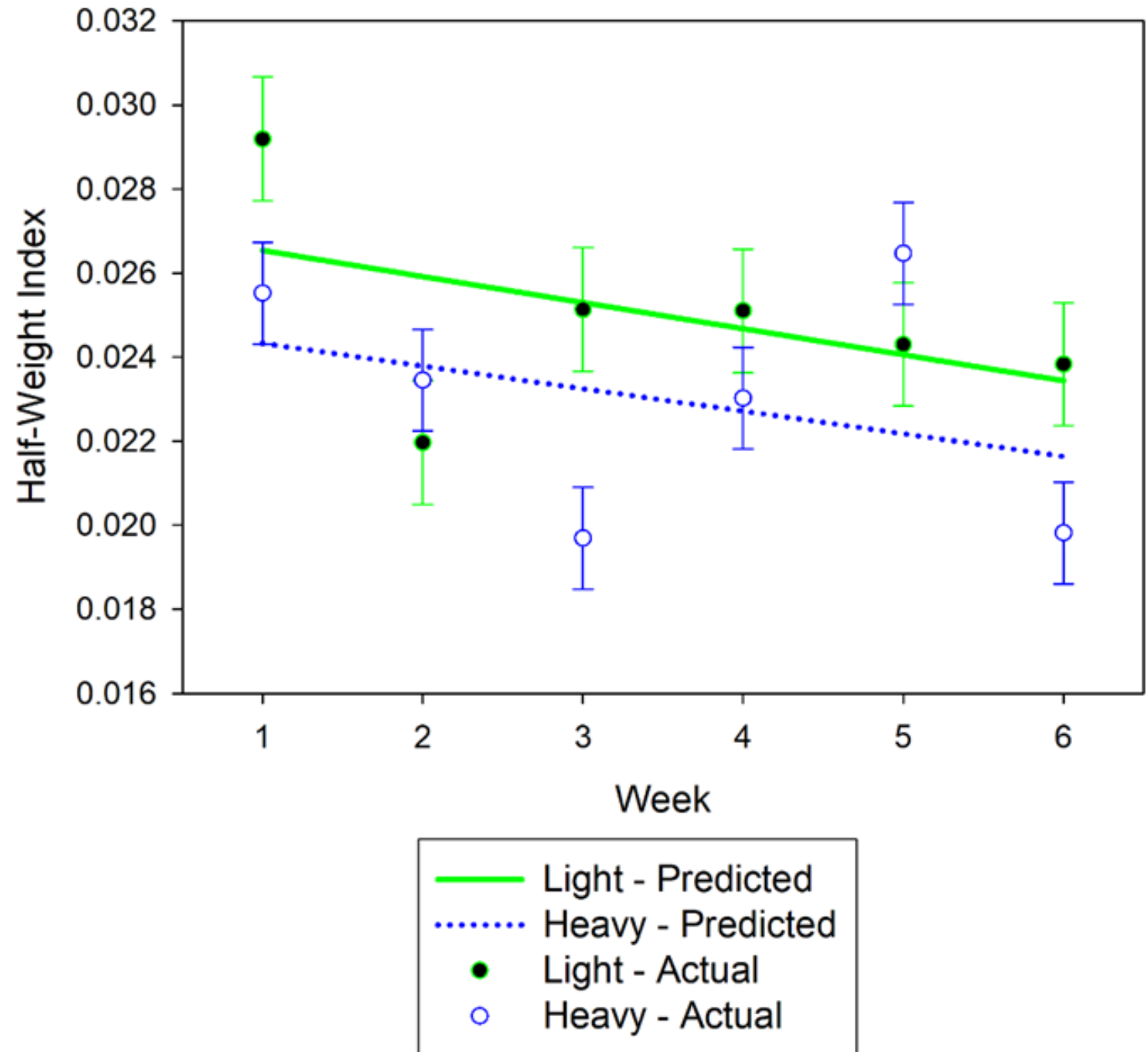




— Heavy Utilization Rate     — Light Utilization Rate  
- - Heavy Standing Crop     - - Light Standing Crop

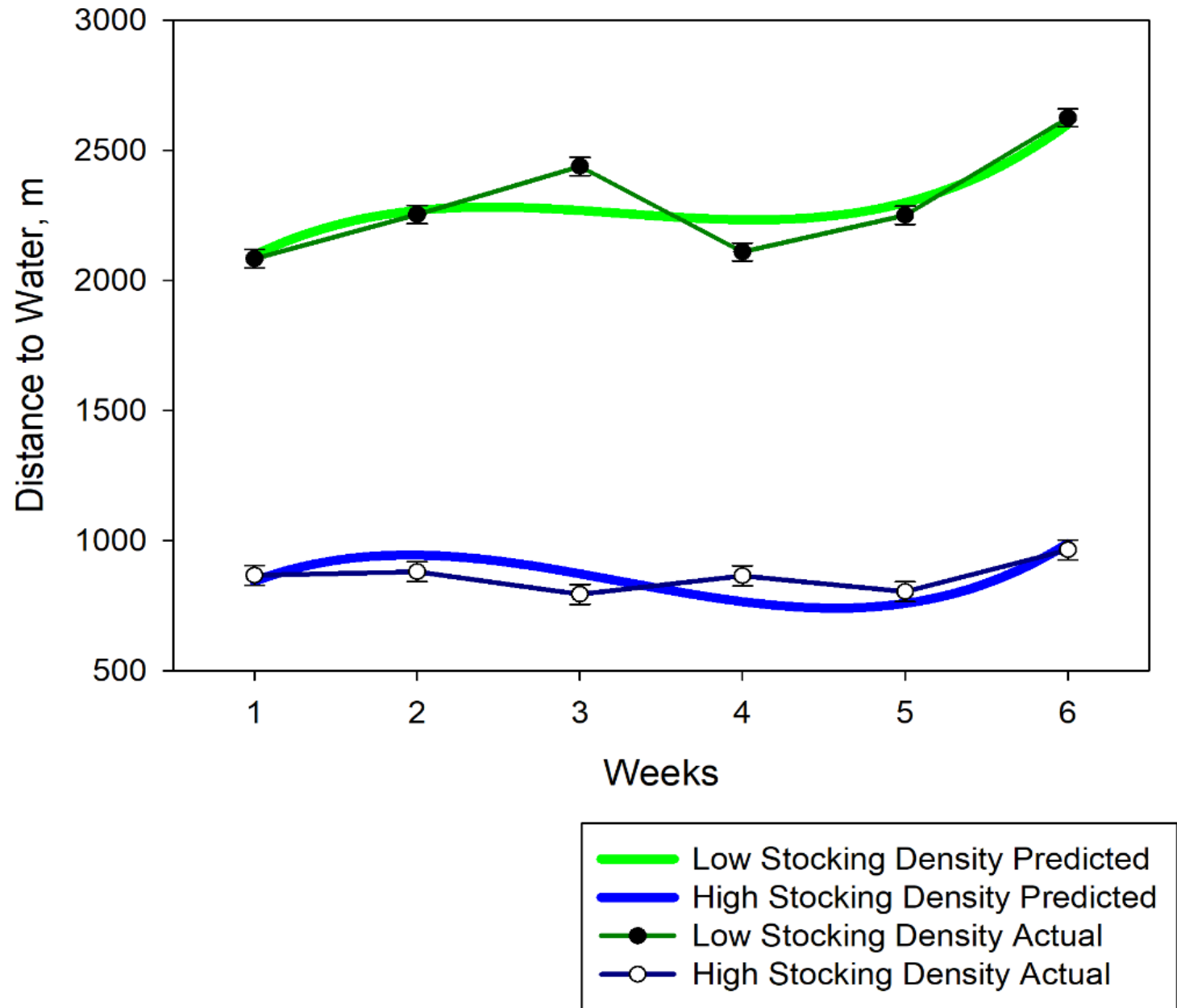
Spatial associations at 75 meters declined as cows began to disperse to find forage

Half-weight index is the proportion of time that two cows were with 75 meters



As cows defoliated the pastures they traveled farther from water

However, cows in the smaller pasture (High Stock Density) could not travel as far



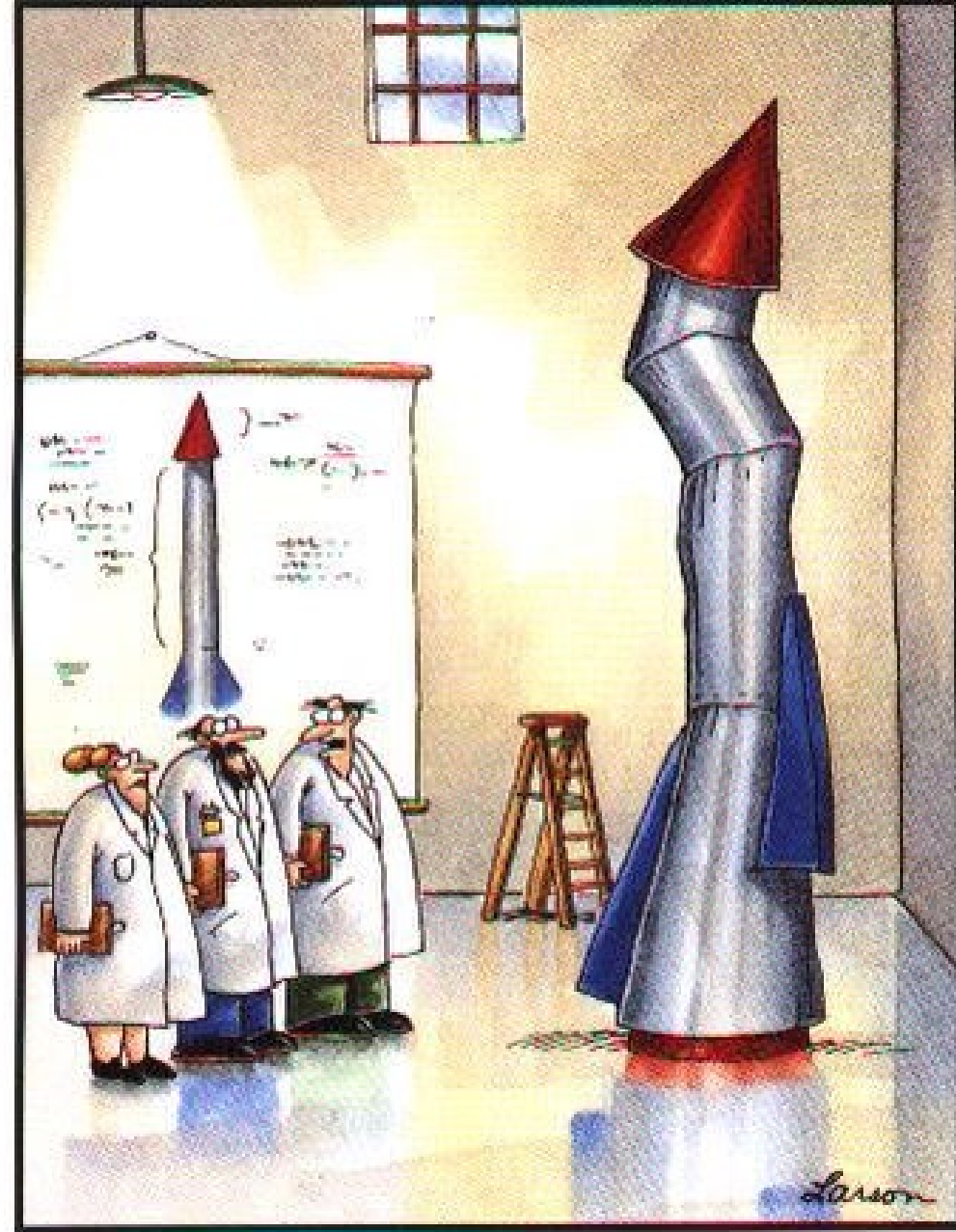
## The concept of “cow buddies” is overrated

- Our data and other studies (Stephenson et al. 2016, Stephenson and Bailey 2017) show that cows do not hang out with the same cow or cows all the time.
- In this study, cows spent less than 10 % of their time within 75 m of any tracked cow (excluding time with 200 meters of water)
- The most associated two cows were on average
  - 789 meters apart in the North Pasture (Light SD)
  - 1049 meters apart in the North Ditch Pasture (Heavy SD)



"Satisfied? ... I warned you not to invite the cows in for a few drinks."

# Monitoring Grazing Patterns in Real Time Will Require More Research



"It's time we face reality, my friends. ...  
We're not exactly rocket scientists."

# Challenges of Real Time Tracking and Monitoring on Rangelands



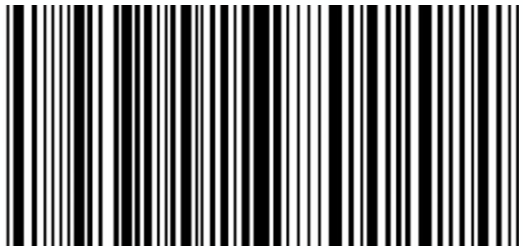
- Large pastures
- Remote areas
- Mountainous terrain
- Lack of cell service



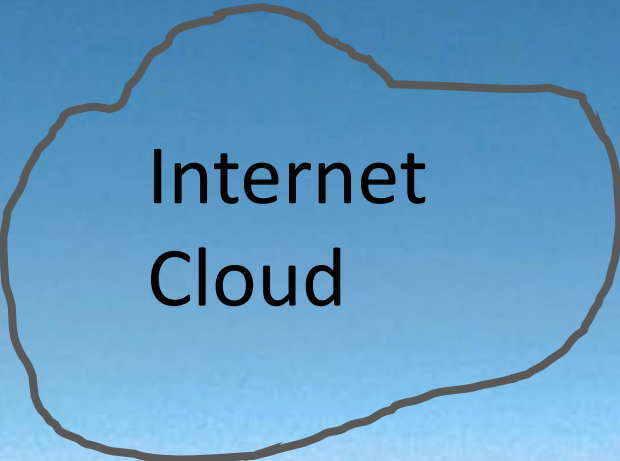


To identify differences in cattle grazing patterns:

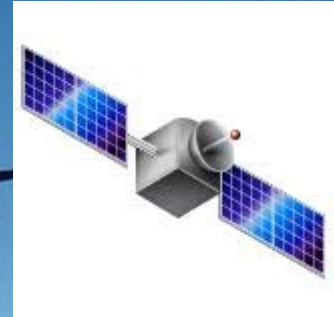
Place barcodes on cows and record locations using drones or planes



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Internet  
Cloud



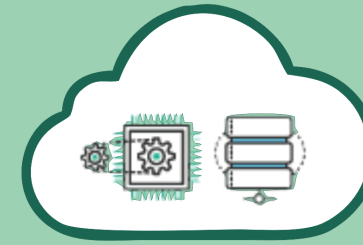
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# Edge Computing

- Process data on the tag
- Develop algorithms to calculate metrics
- Reduce the size of transferred data packets
- Reduce battery requirements
- Artificial intelligence research

## CLOUD

Big Data processing  
Business Logic  
Data Warehousing



INTERNET

## EDGE

Realtime data processing  
At source/on premises  
data visualization  
Basic analytics  
Data caching, buffering  
Data filtering, optimization  
M2M communications



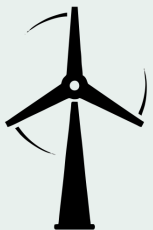
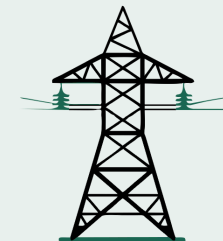
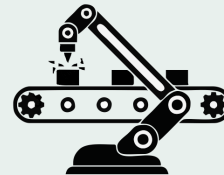
LEC-3031



HTCA-6200



LAN/WAN



## SENSORS AND CONTROLLERS



**BE BOLD.** Shape the Future.



Harold James  
Family Trust



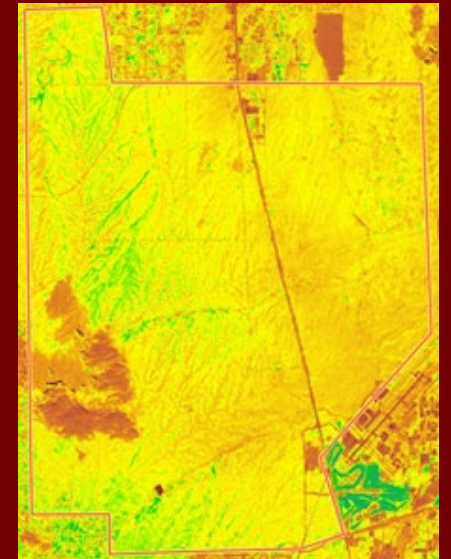
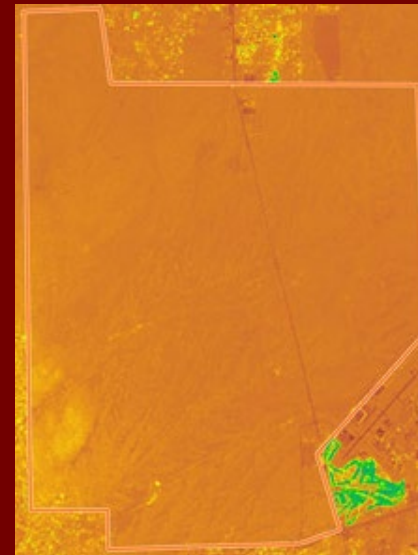
## Continuing research at Deep Well Ranch



Test bed of new technologies

June 2018

August 2018



NDVI maps

# Questions?

