Development of Real-Time Livestock Management Strategies Using GPS Tracking and Sensor Technologies

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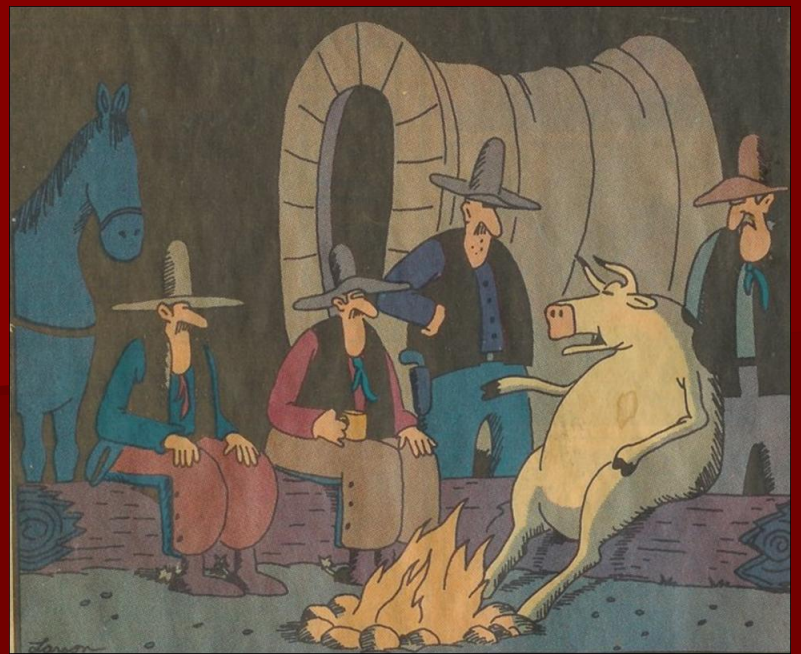


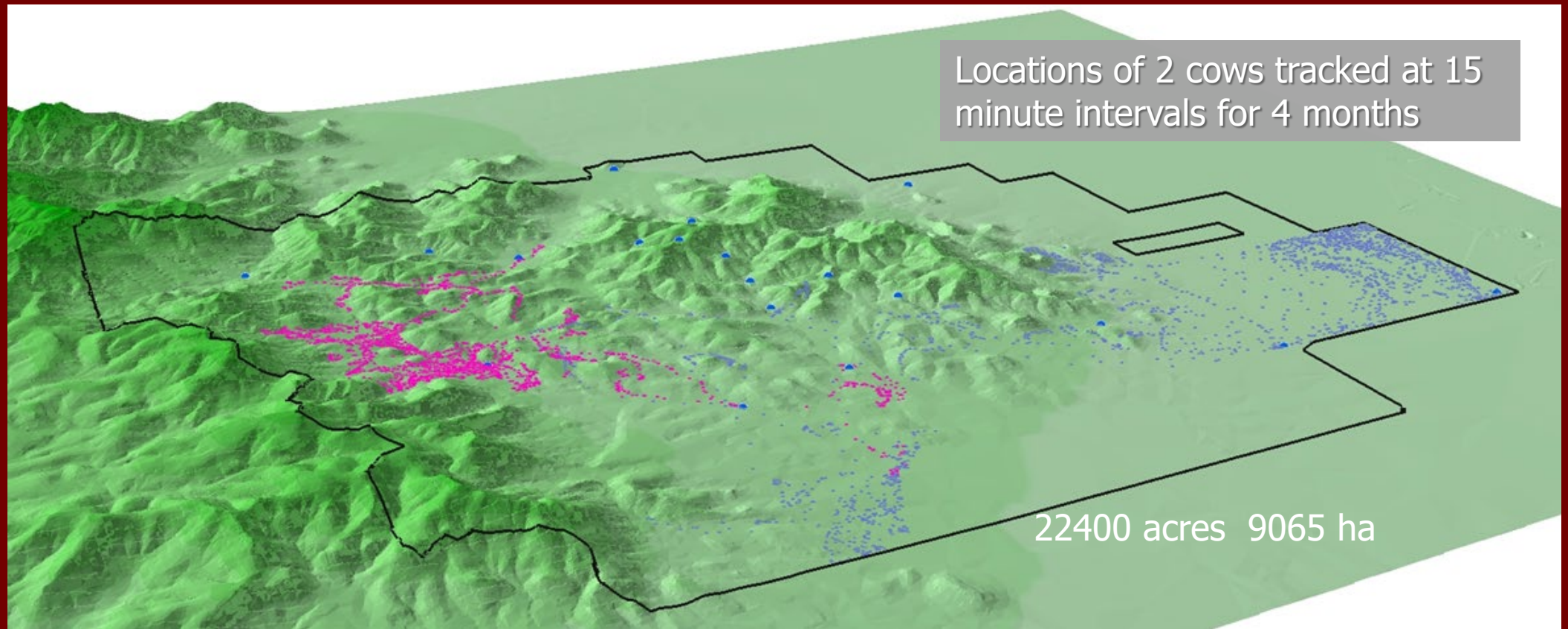
How do we deal with livestock management in extensive pastures?

Todd Ranch, Willcox, AZ

Horseback observers are often 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



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

In riparian areas, livestock impacts can occur quickly


Nebo
Connors
Moranbah
Upper Isaac
Lower Isaac
Clermont
Middlemount
Theresa
Emerald
Mackenzie
Blackwater
Fitzroy
Rockhampton
Marine
Springsure
Lower Dawson
Callide
Biloela
Rolleston
Nogoa
Comet
Theodore
Upper Dawson
Injune

Answer:
Precision Livestock Management

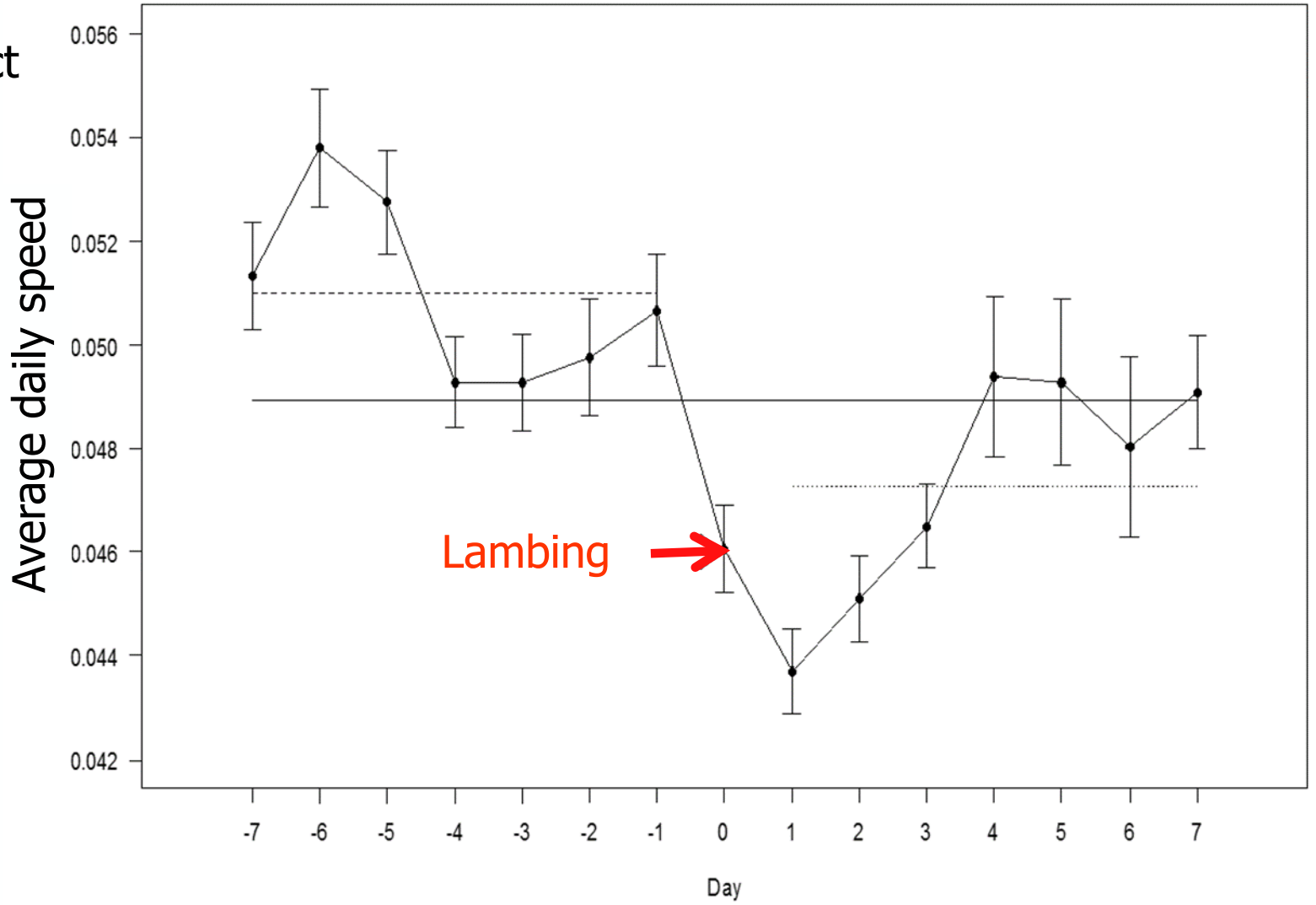
- What is Precision Livestock Management?
  - Continuously monitor all the factors that might influence animal productivity and welfare to develop sustainable management strategies (di Virgilio et al. 2018)
  - A management system based on the continuous automatic real-time monitoring and control of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

Global positioning system (GPS) collars can be used to track cattle, sheep and other animals

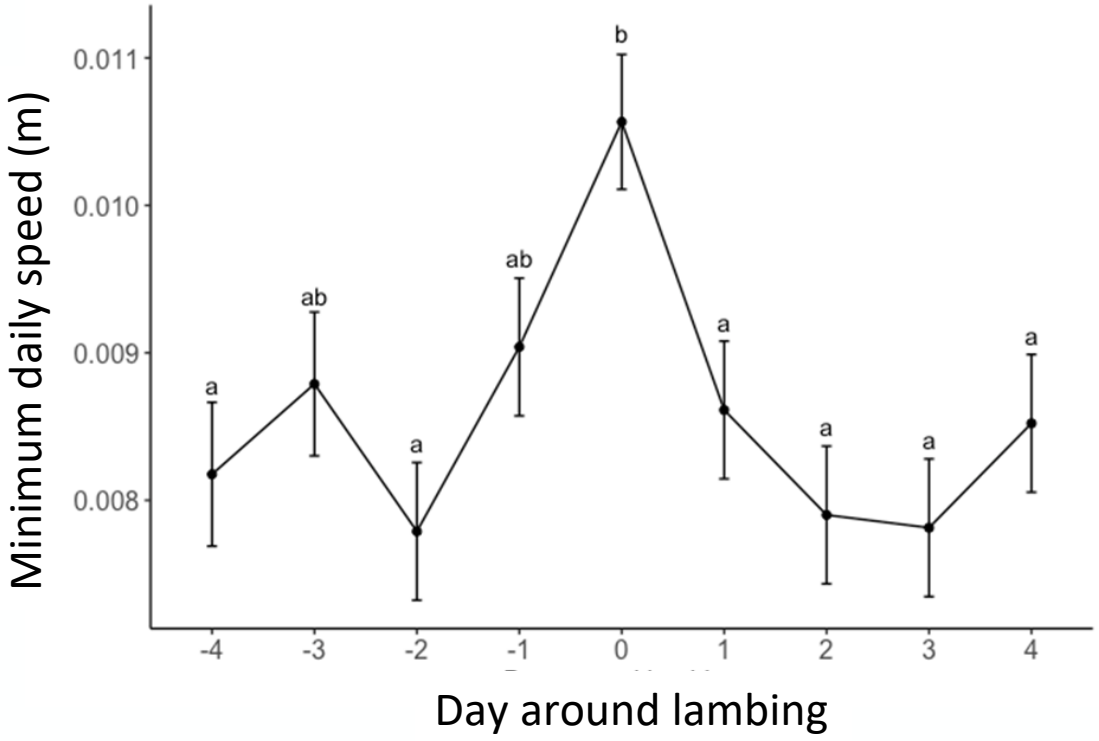
Spatial movements can be used to monitor behavior and potentially detect illness and animal welfare concerns

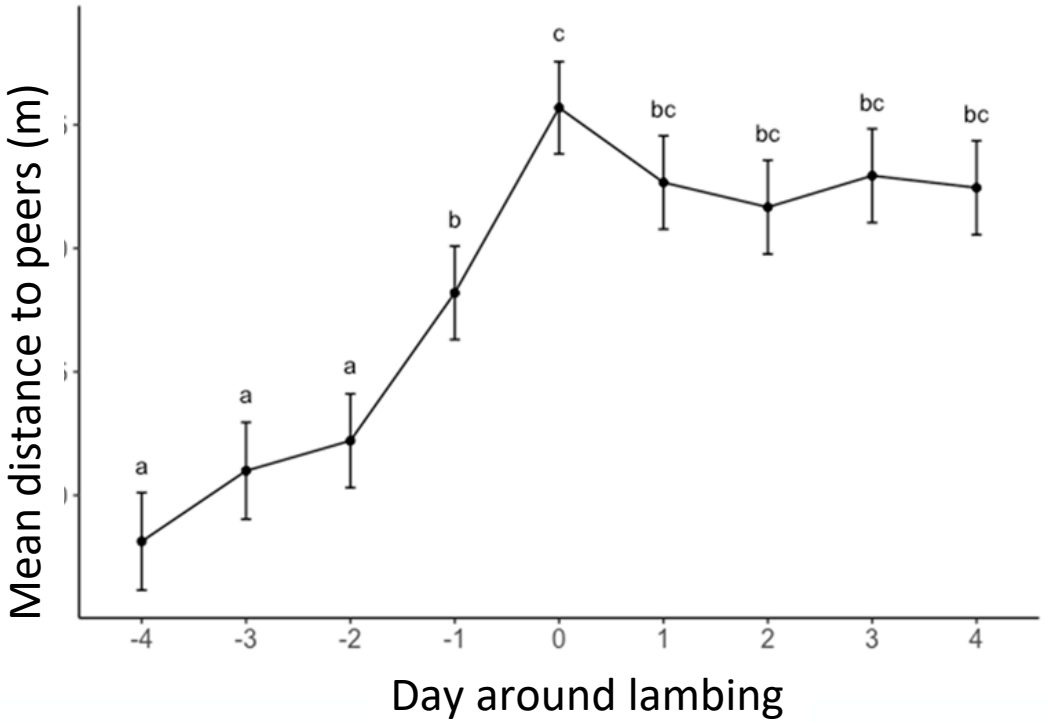
Potential for GPS tracking to detect lambing (Dobos et al. 2014)



Fogerty et al. (2020) Lambing Study

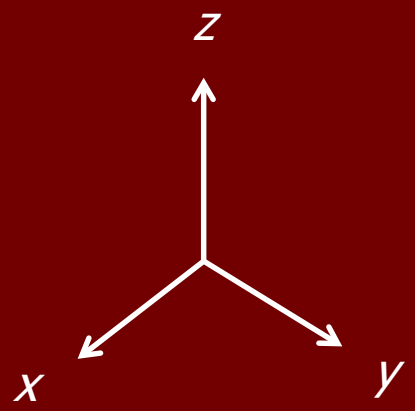
- Increase in minimum daily speed
- Separation from peers
- GPS unable to distinguish hour of lambing



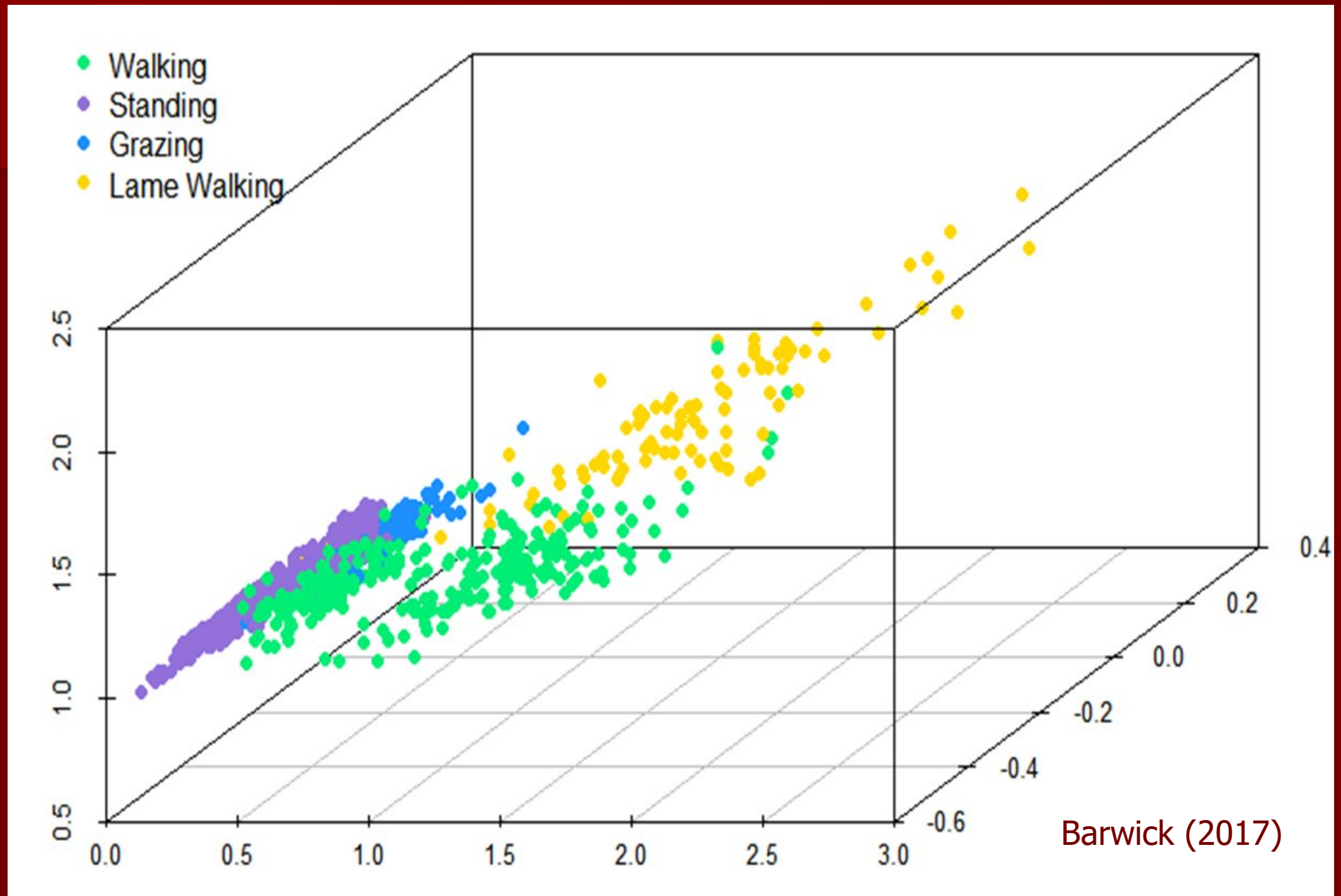


Accelerometers are motion sensors

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



Potential for accelerometers to predict sheep behaviour including lameness



Barwick (2017)

Fogarty et al (2020) Sheep Behavior Classification with Accelerometers

- For active and inactive behaviors (98% accurate)
  - 30 second epochs and Classification and Regression Trees
  - Variables:
    - Movement Variation
    - Standard Deviation of x-axis
    - Standard deviation of y-axis
    - Minimum of x-axis
- For behaviors - grazing, lying, standing and walking (78% accurate)
  - 10 second epochs
  - Variables
    - Movement Variation
    - Minimum of x-axis
    - Standard deviation of x-axis

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	**79.9**	20.1	492
Inactive	8.9	**91.1**	928
			1420

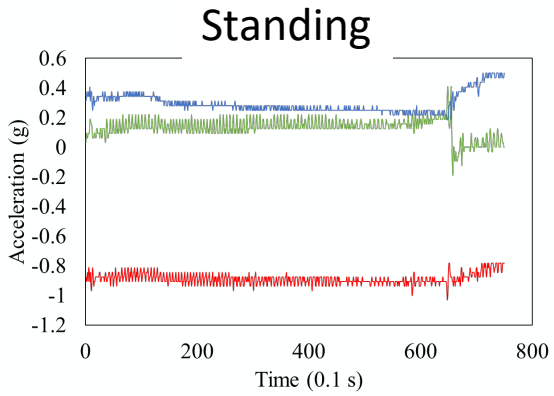
Accuracy = 87%

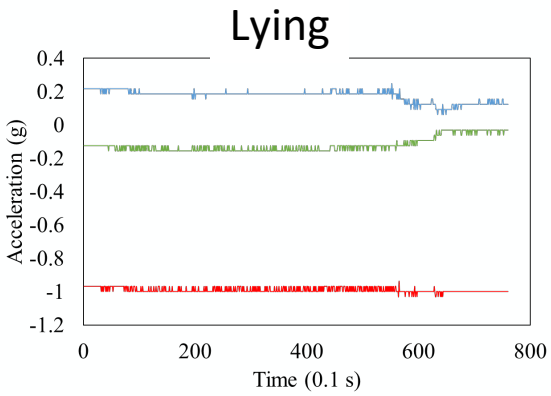
NMSU Penned Sheep Study
Random Forests Classification of Behaviors

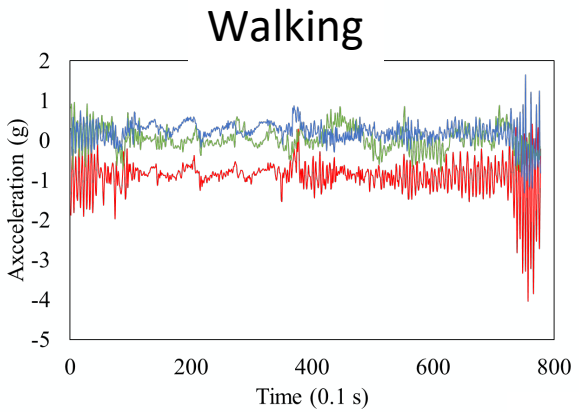
Validation Results

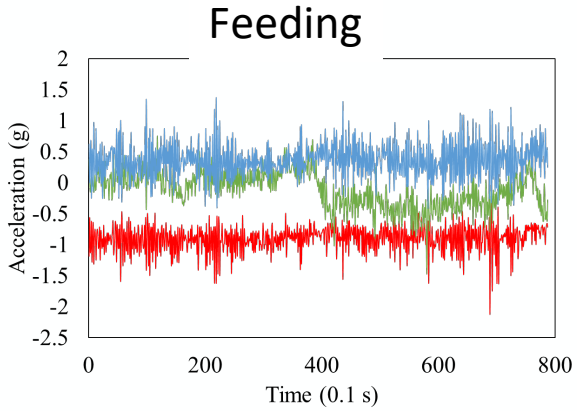
Behavior	Accuracy (%)
Feeding	76
Lying	84
Licking Lamb	36
Licking Salt	29
Contractions	24
Standing	56
Walking	33

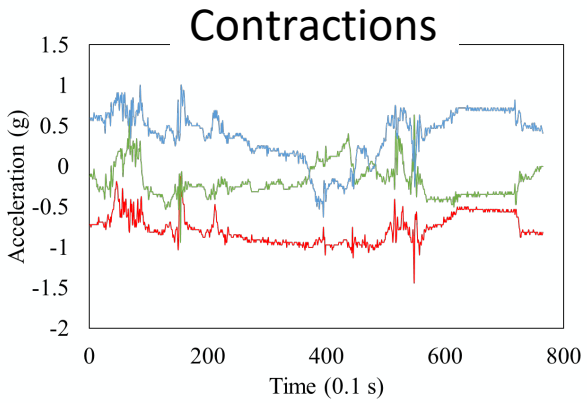
Overall Accuracy – 67%

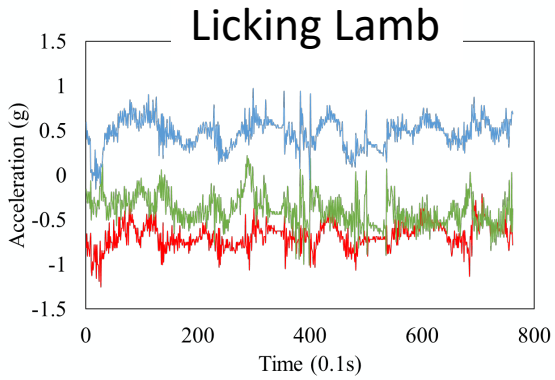


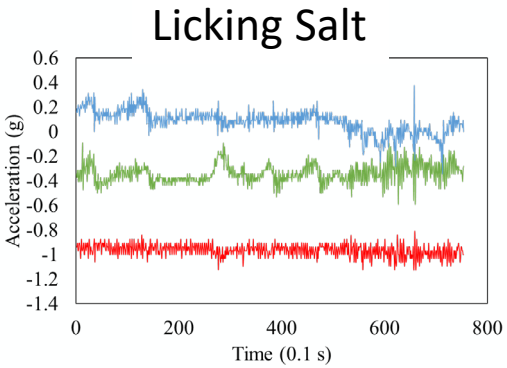








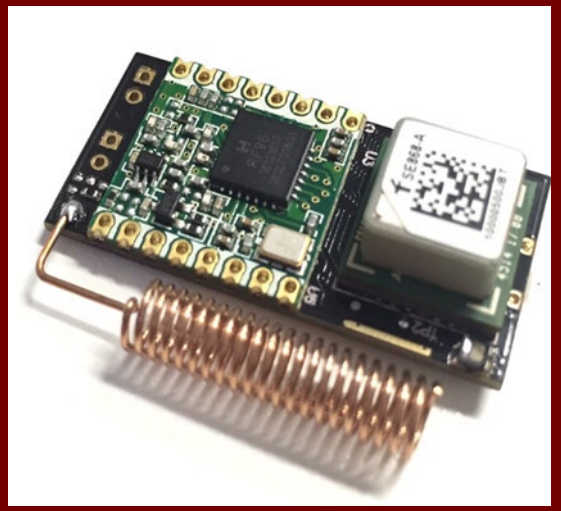




80 seconds of raw accelerometer data from known behaviors of ewes

X axis Y axis Z axis

Transition from “Store on Board” to “Real-Time” or “Near-Real Time”



LoRa chipset for real time tracking of livestock

We are never satisfied!

Real-Time and Near-Real Time Monitoring

GPS Tracking

- Moovement (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

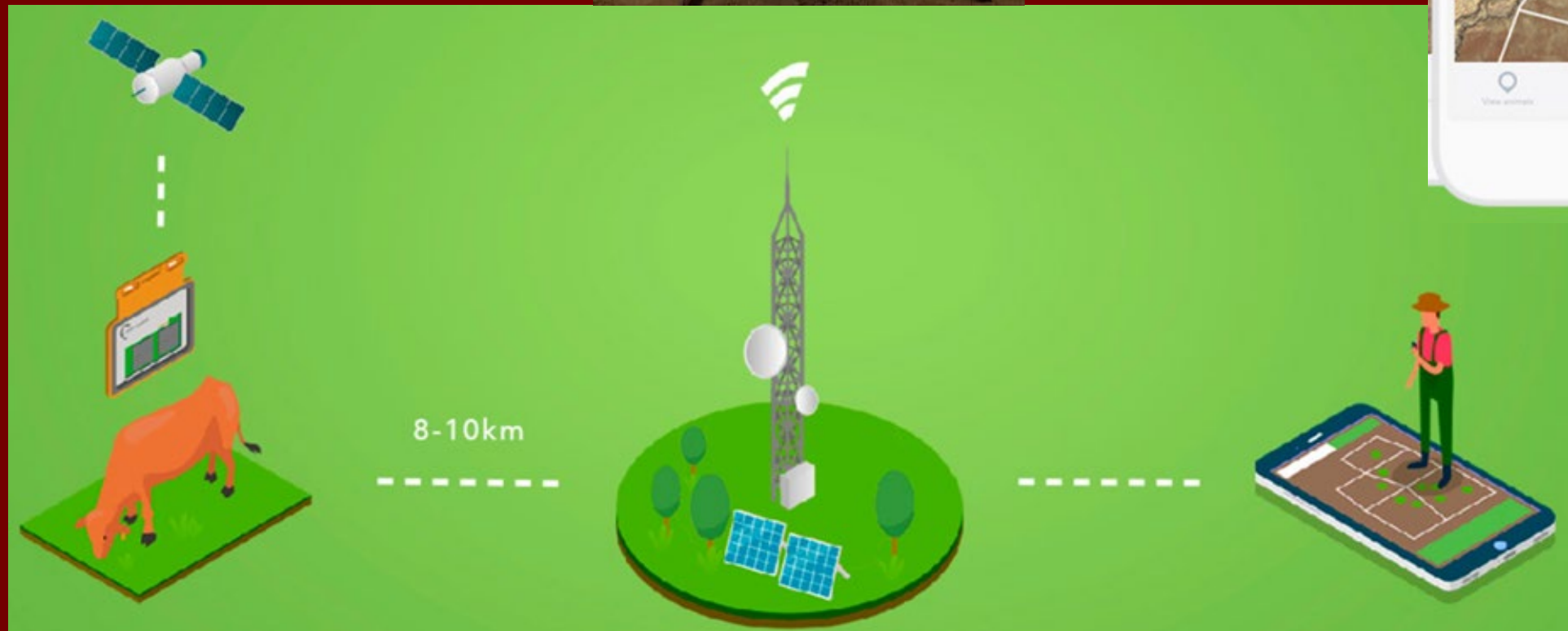
Accelerometer

- 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

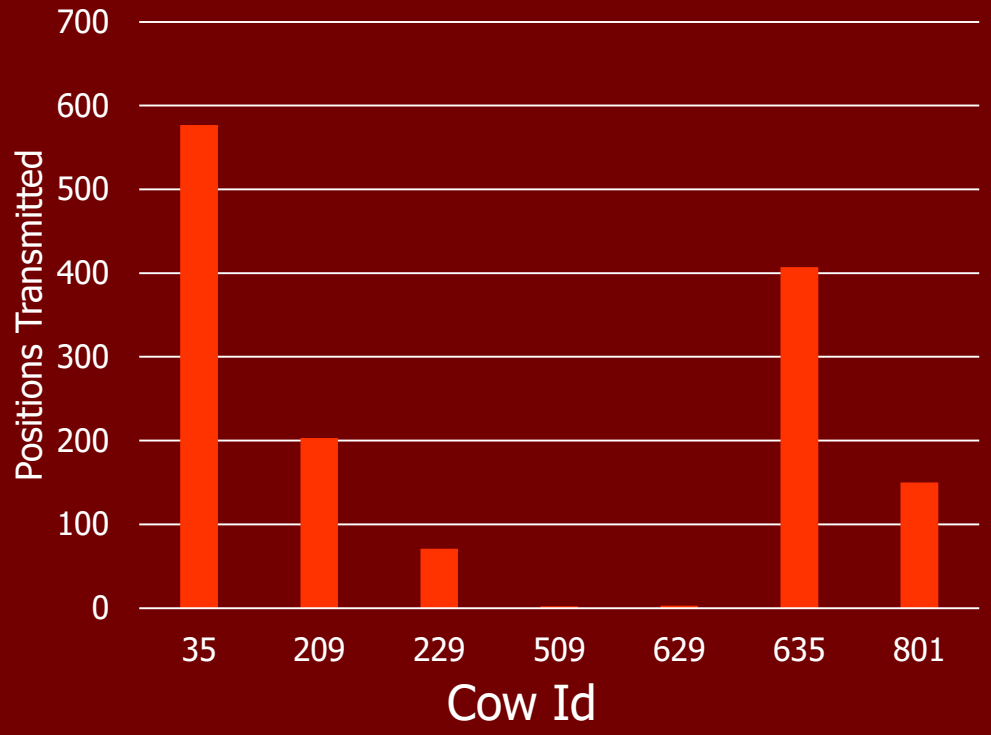
- Deep Well Ranch
- Prescott, AZ
- Rolling terrain
- 1 LoRa antenna
- 8 tags tested

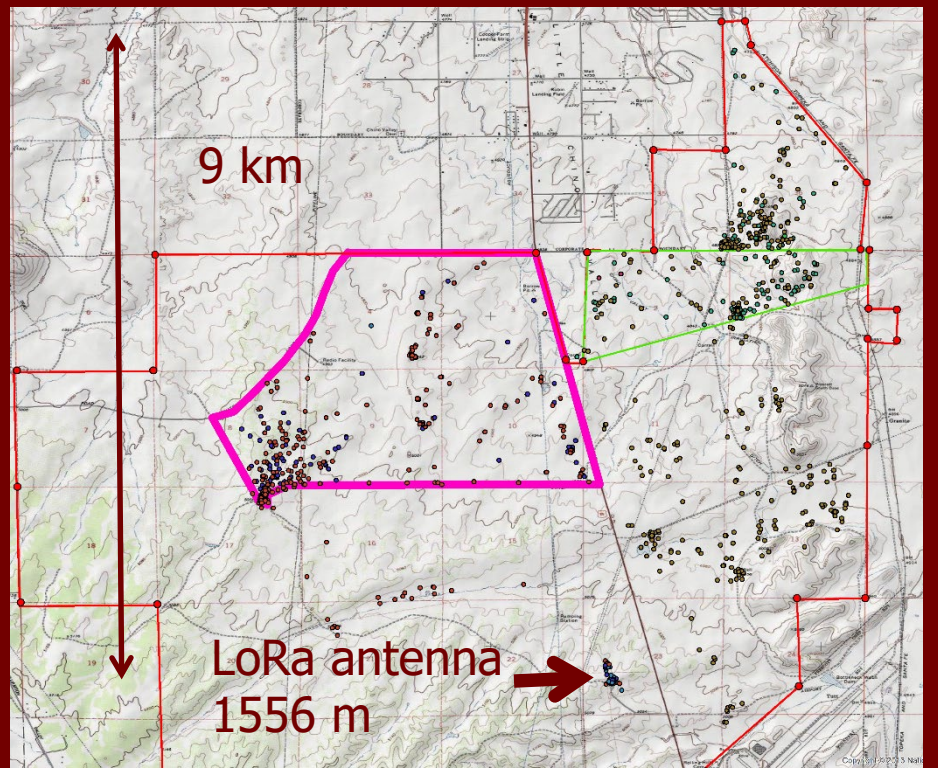
Positions from Moovement tags (June – October 2019)

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 ± 3.2 SD positions / day
Range 1 to 16 positions / day

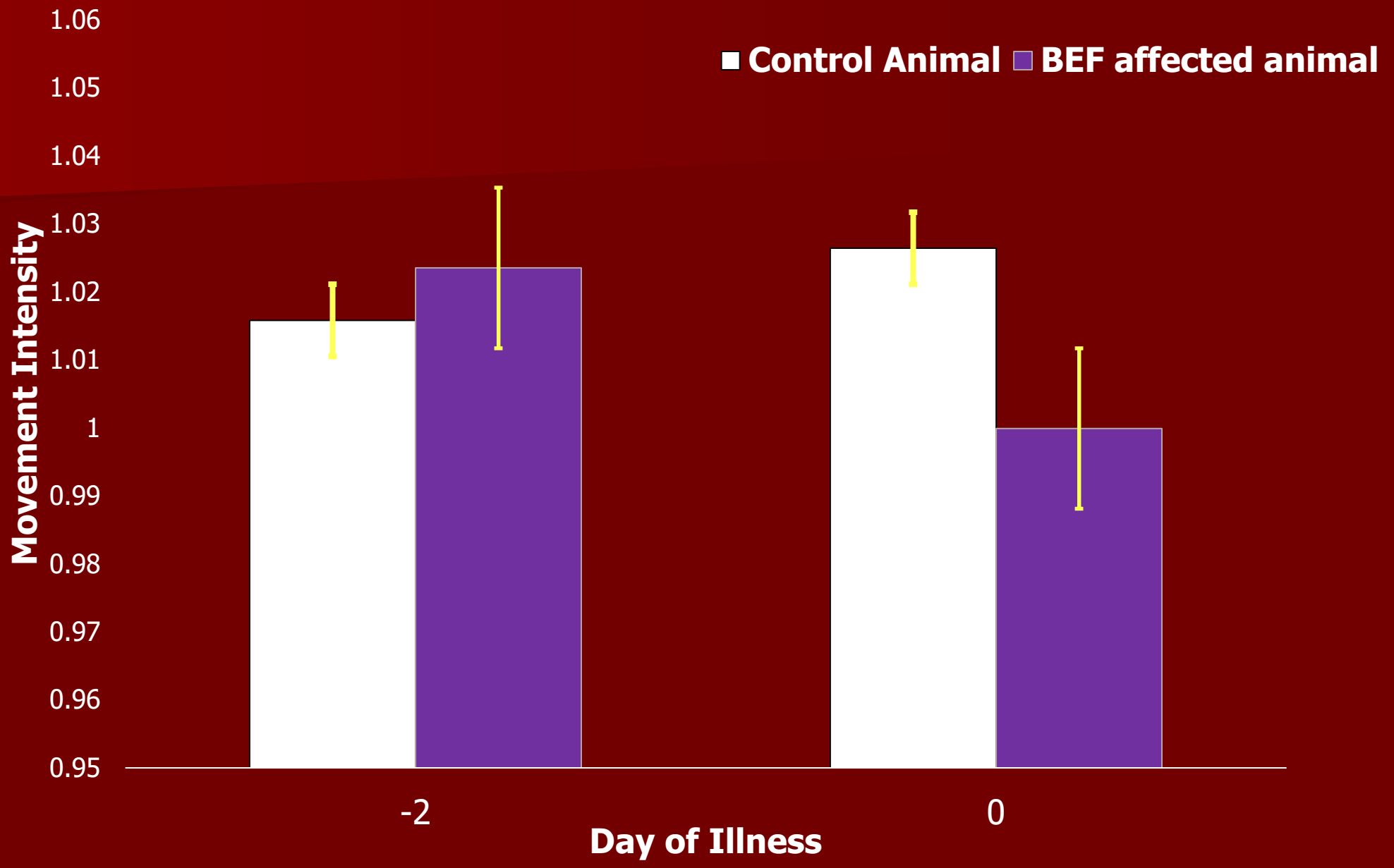




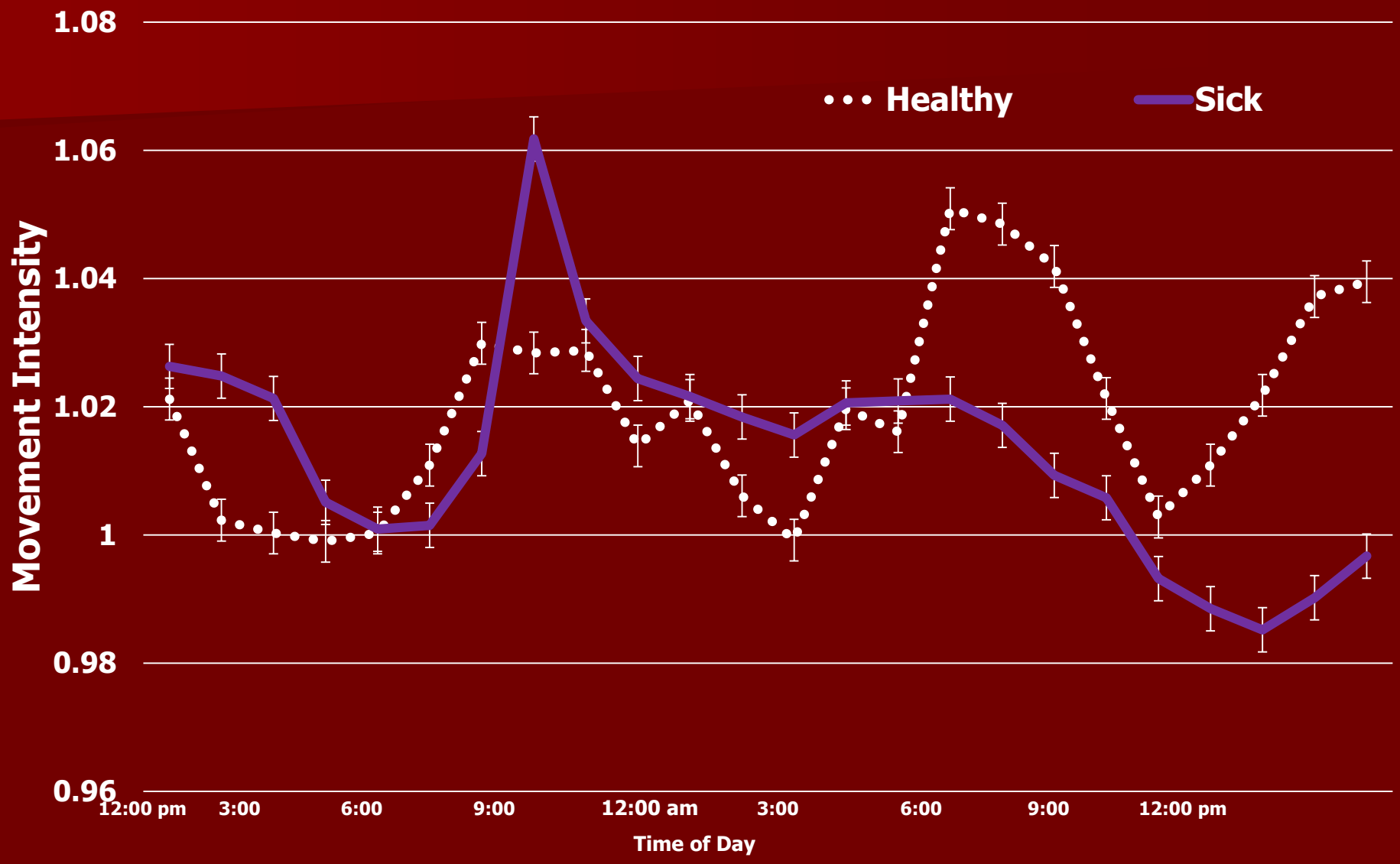
Potential for Precision Livestock Management to Improve Welfare: Examples

3-Day Sickness

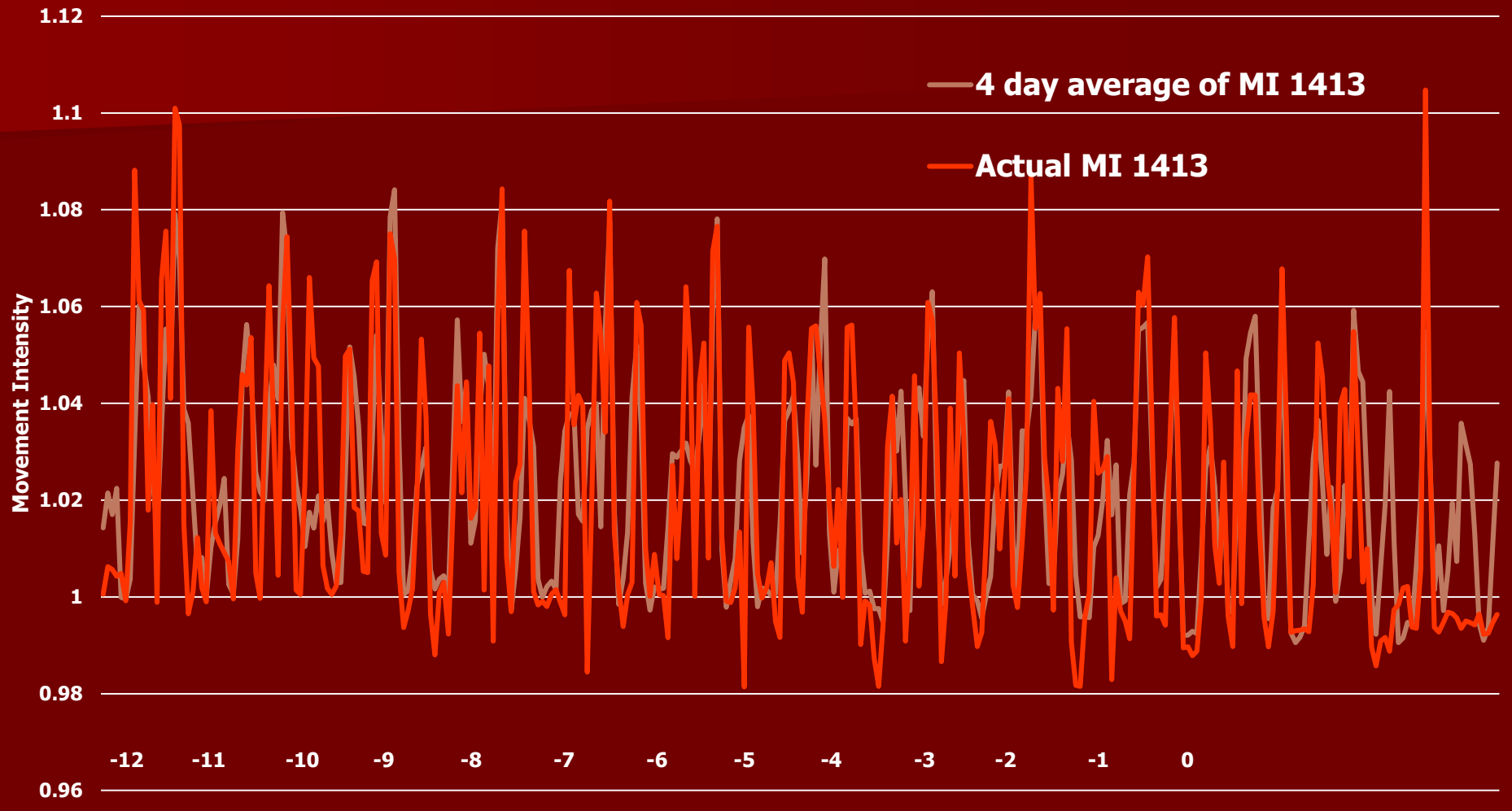
- Viral disease of cattle and buffalo
- Mosquitos and other biting insects are vectors
- Sudden onset of high fever
- Shiver, stiff and may be lame
- Stop eating and drinking
- Depressed
- Illness lasts for only a few days


Control Animal
BEF affected animal
Movement Intensity
1.06
1.05
1.04
1.03
1.02
1.01
1
0.99
0.98
0.97
0.96
0.95
-2
0
Day of Illness

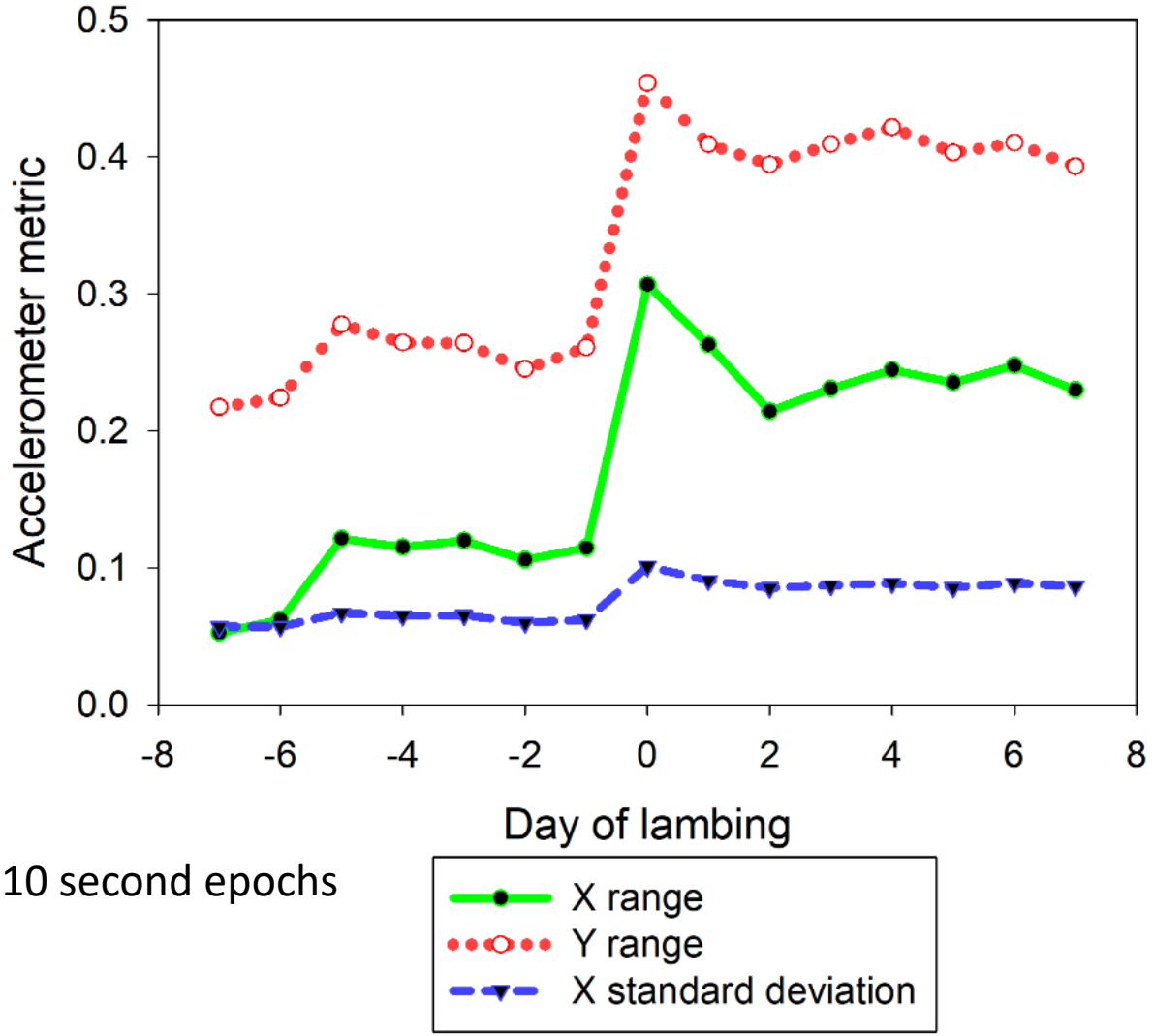
Diurnal activity pattern of heifers the day prior to the diagnosis of BEF for affected and control animals



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



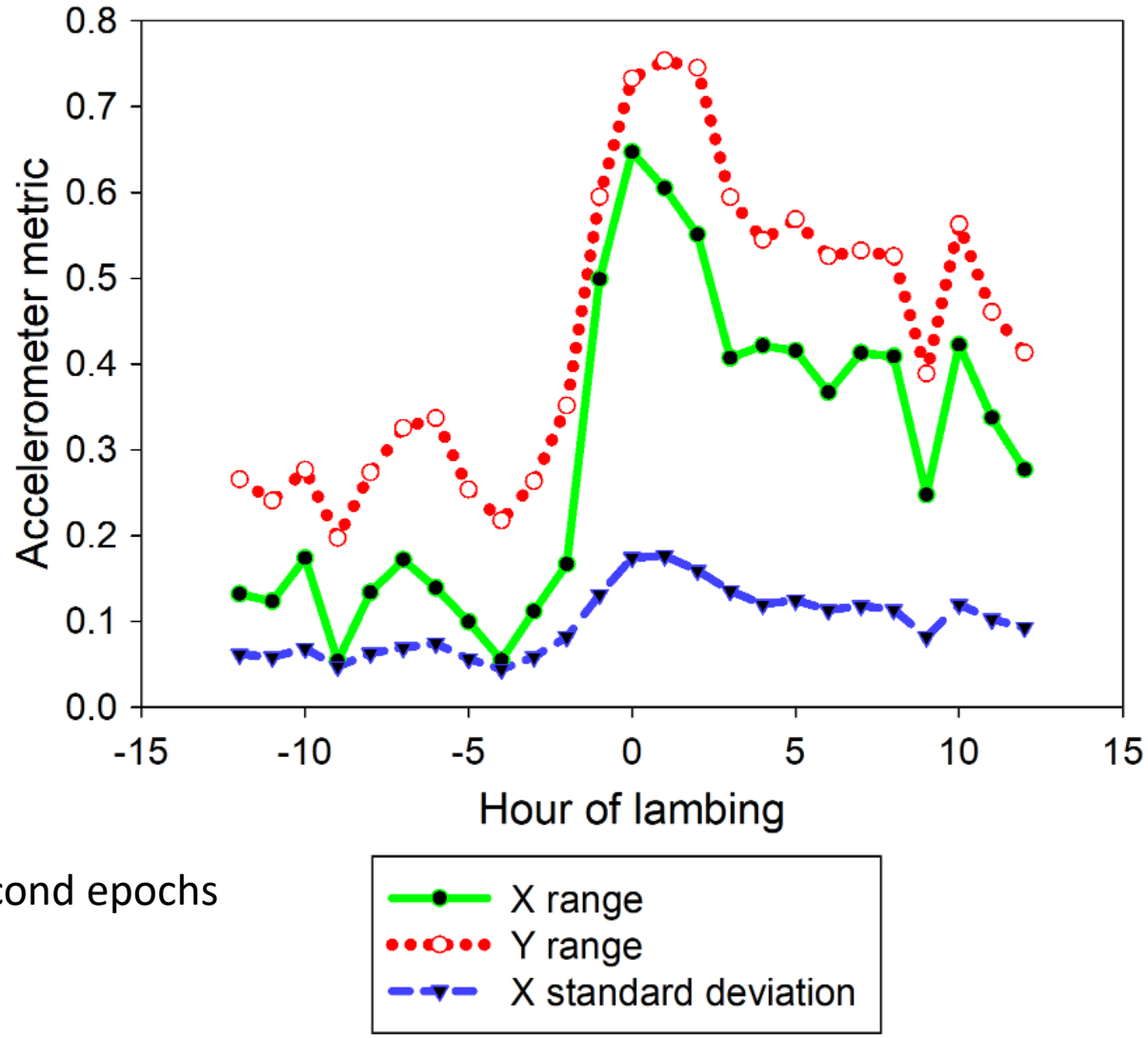
Detection of Lambing
NMSU Pen Study



10 second epochs

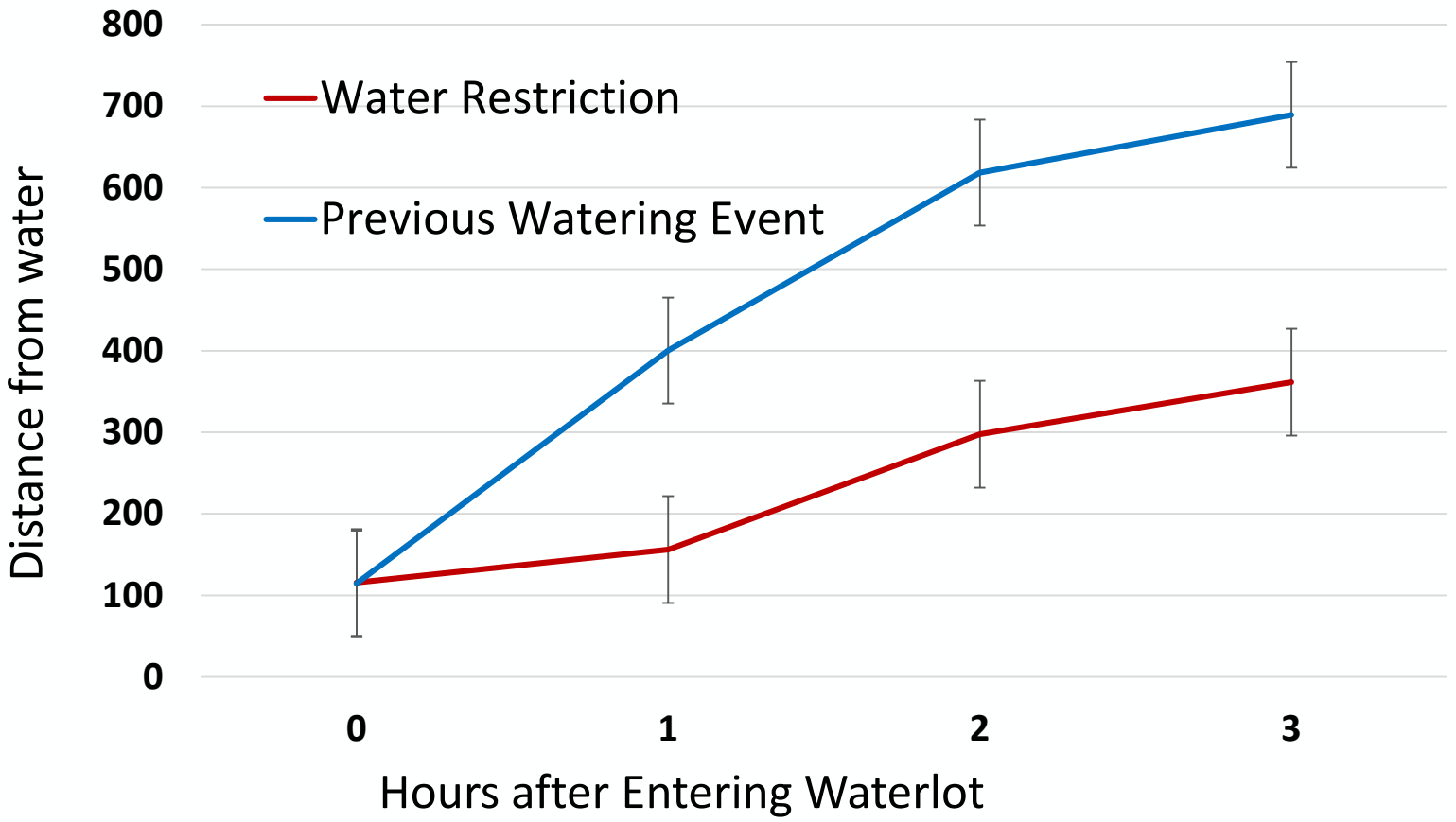
Clear indications of lambing from metrics derived directly from accelerometer,

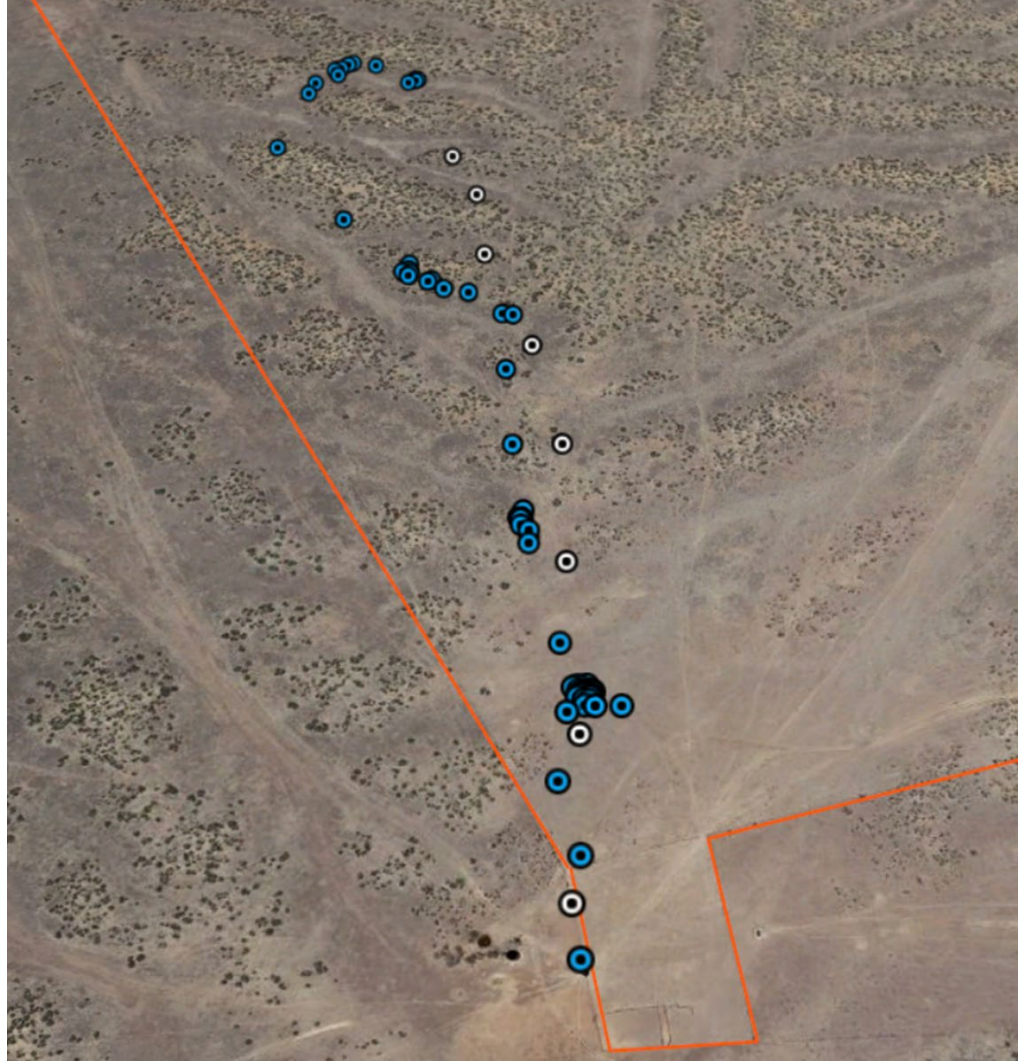
but not from predicted behaviors using “random forests” machine learning



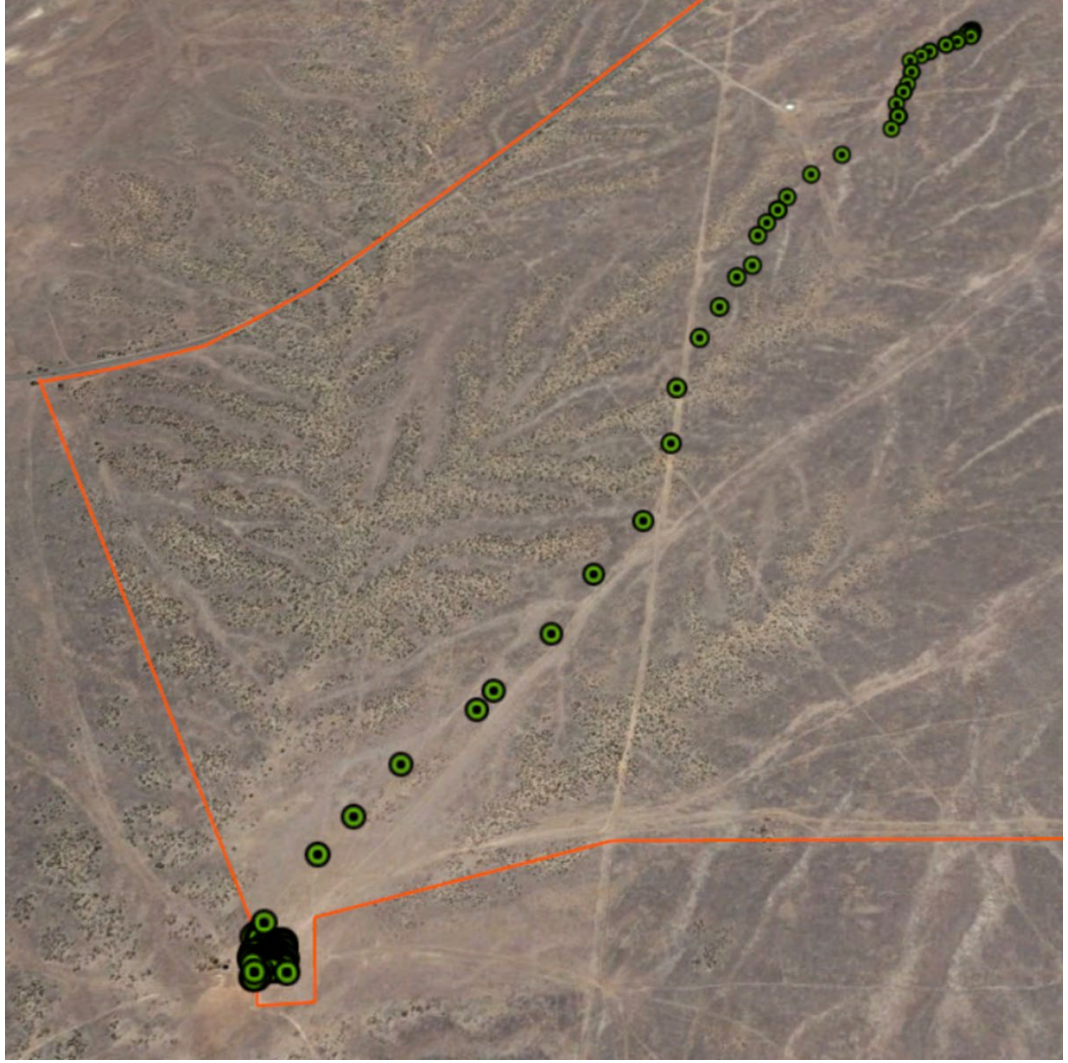
10 second epochs

Real time GPS tracking can detect simulated water failure





Typical watering event

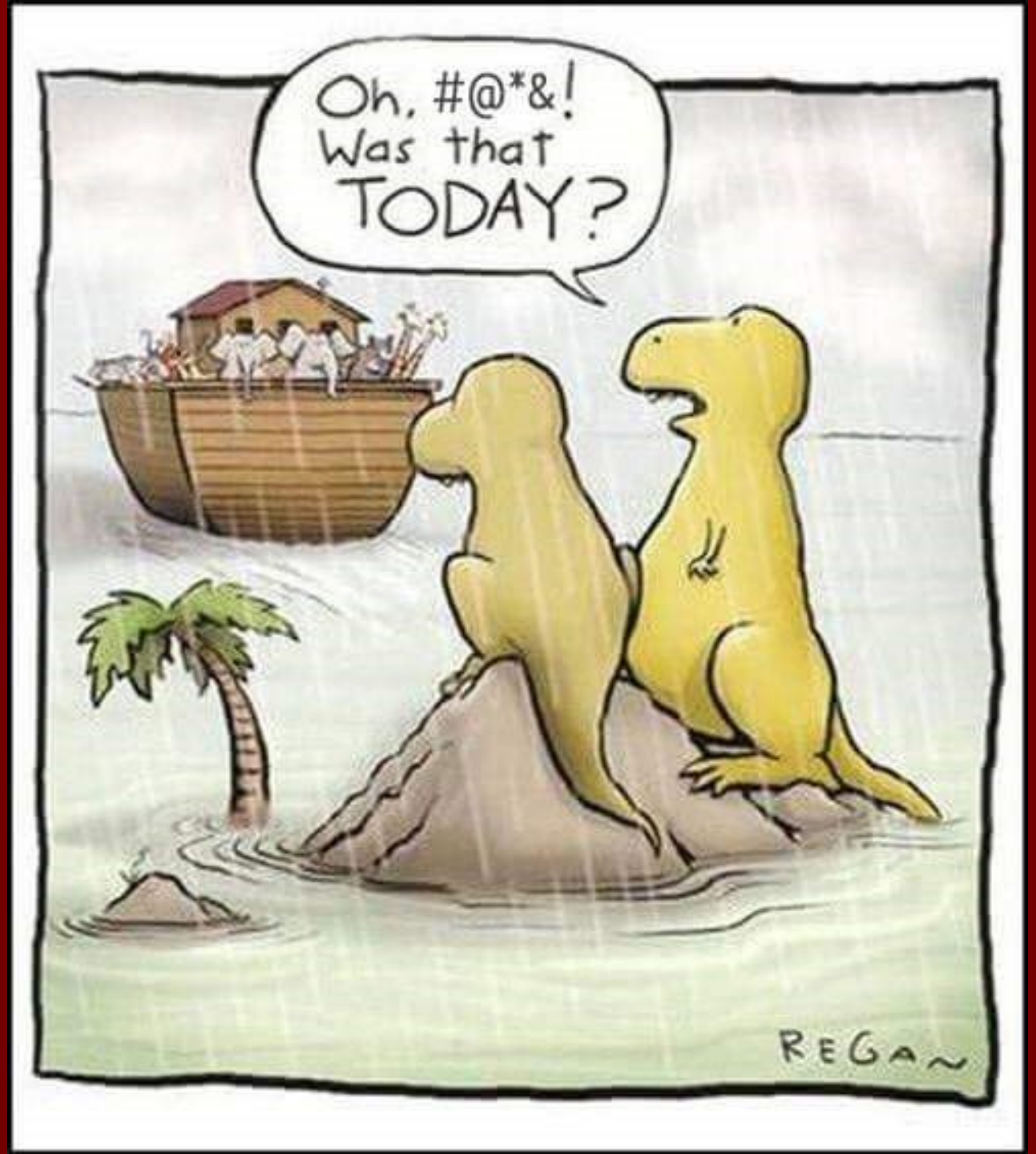


Simulated water failure

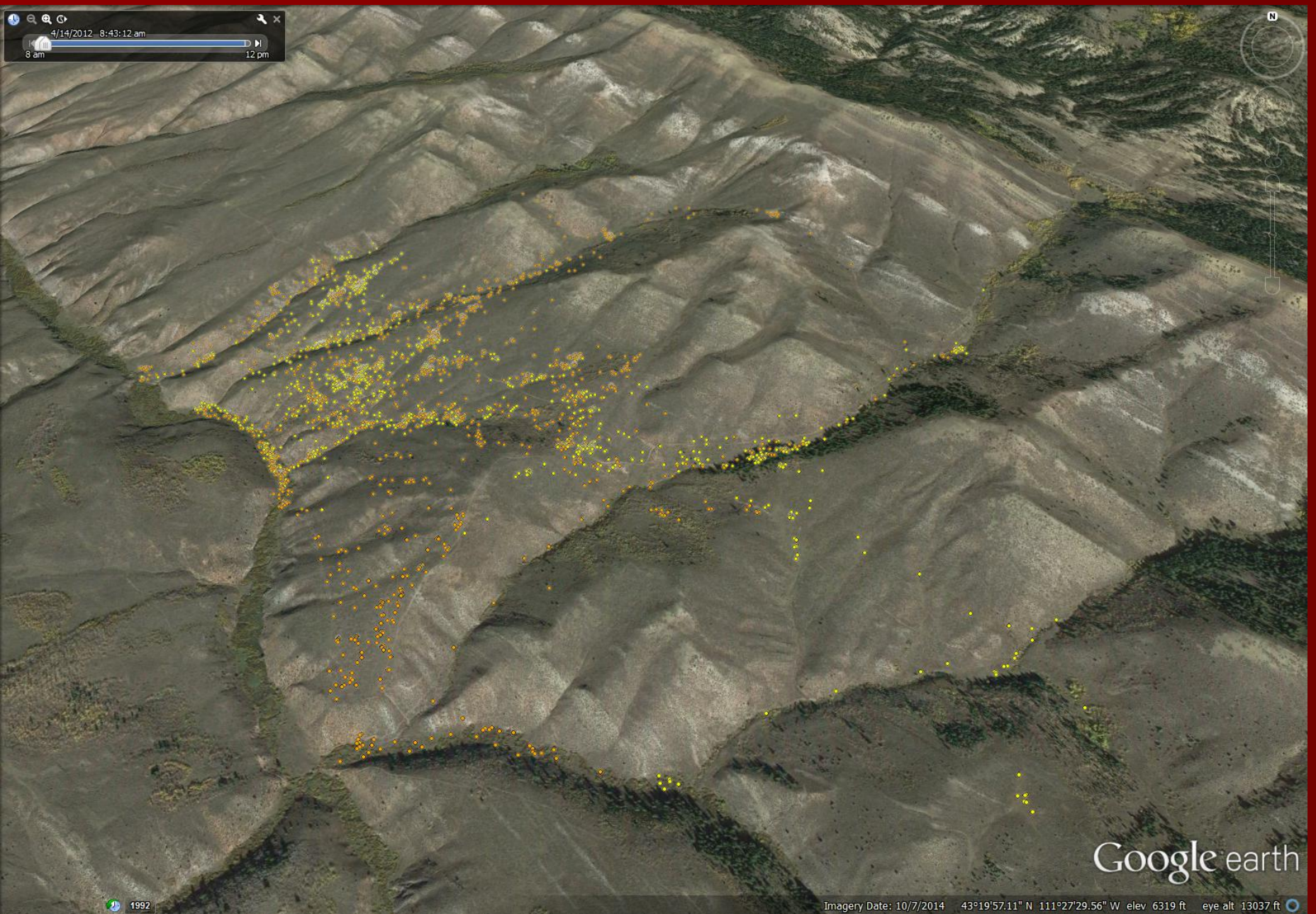
Sustainability of Livestock Grazing

Grazing levels are critical and time sensitive, especially for riparian areas

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



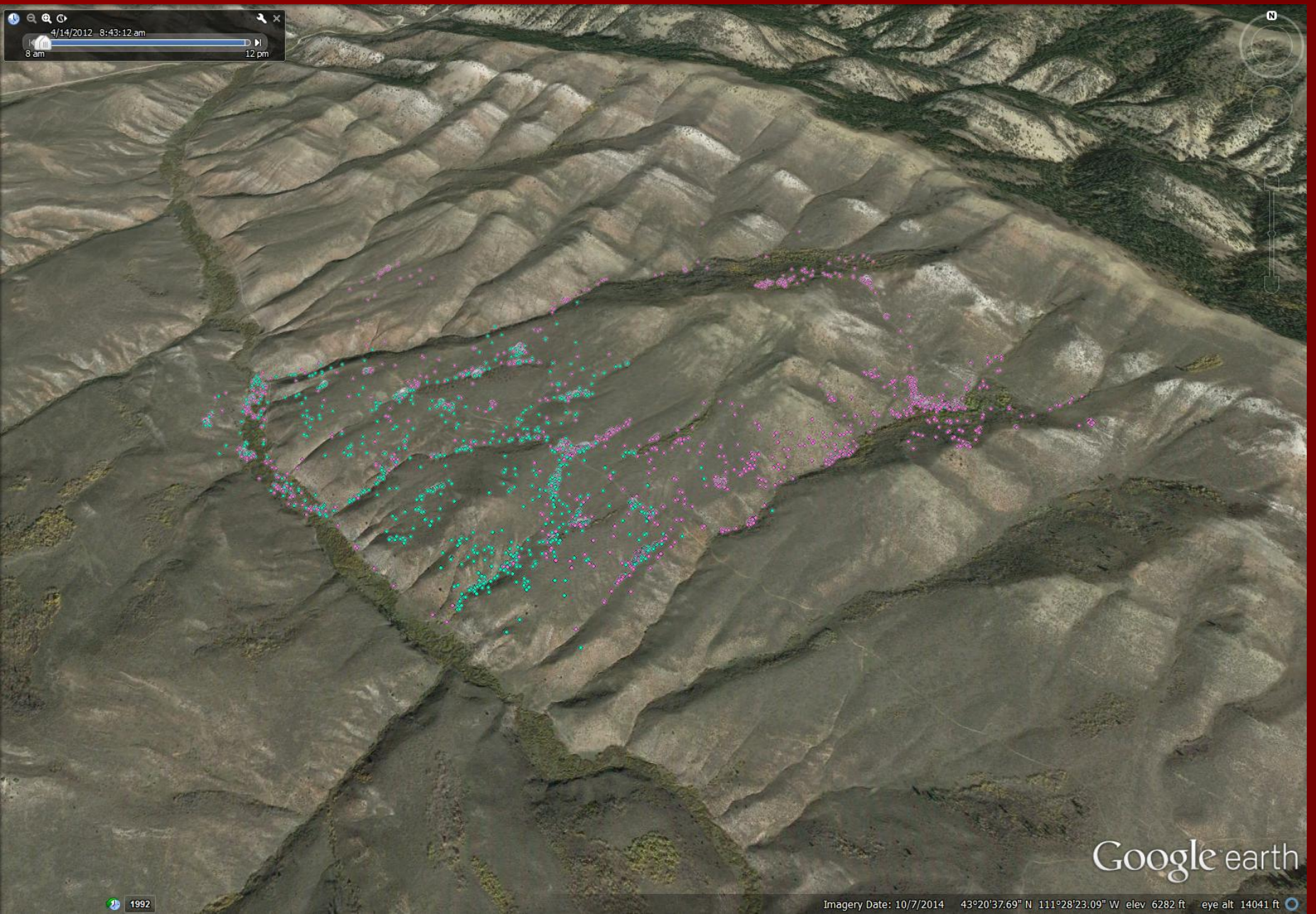
Efficacy of management practices could be monitored



Traditional herding
-1 time / week

- Early Season
- Late Season

Efficacy of management practices could be monitored

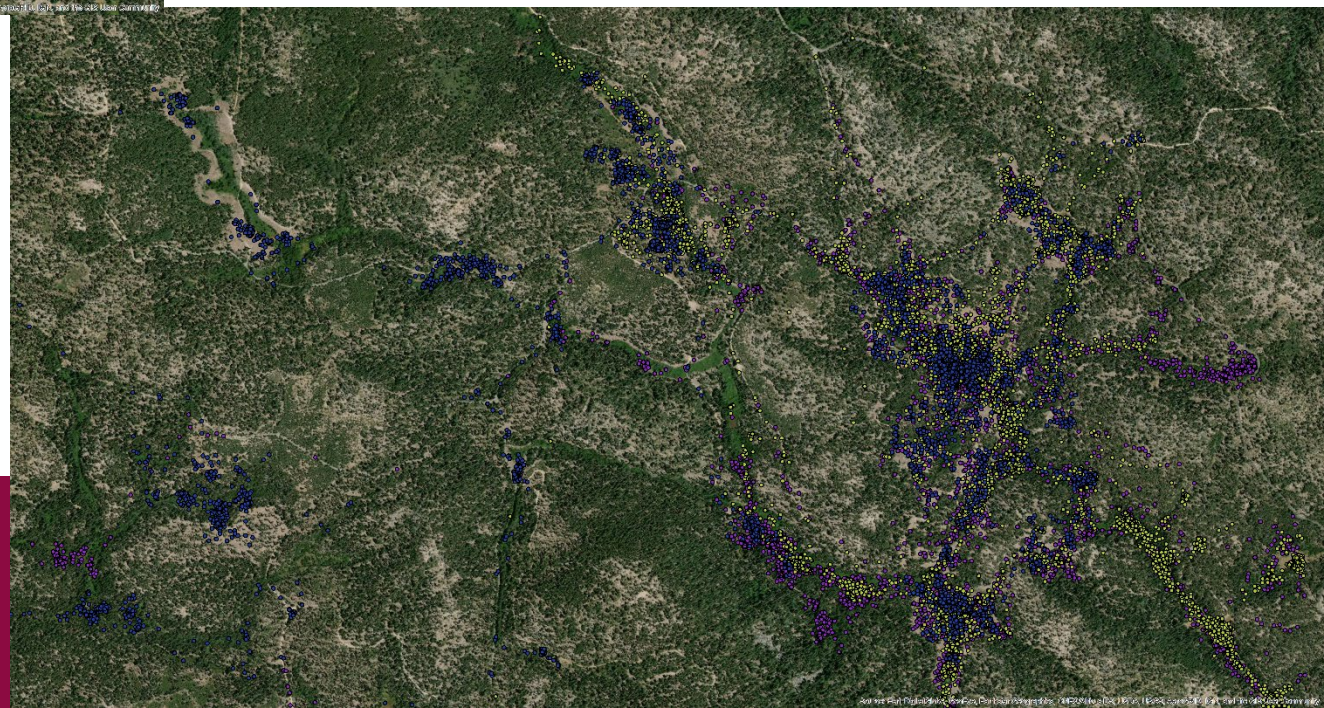


Low-Stress
Stockmanship Herding
5 times / week
plus Supplement

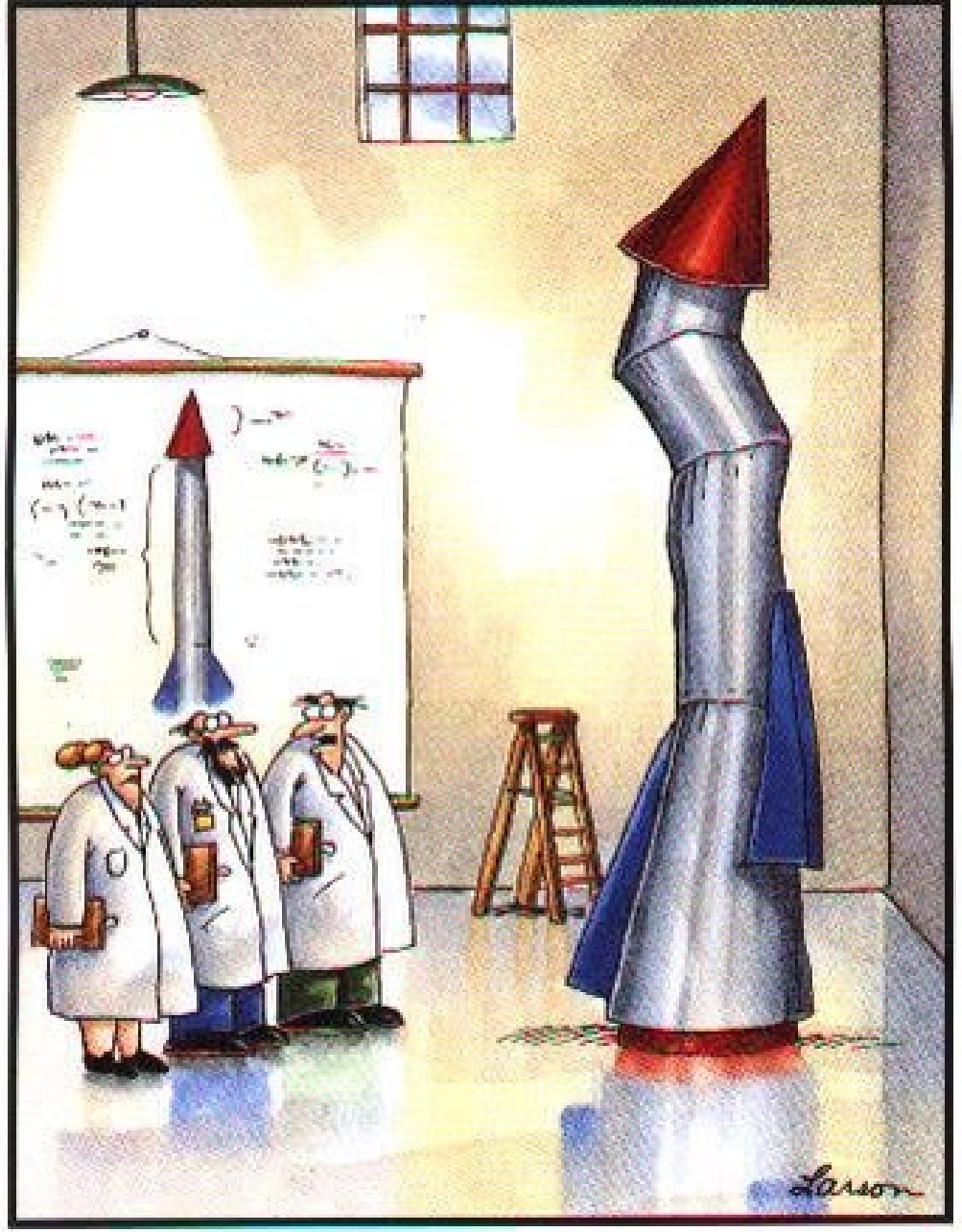
Early Season
Late Season

With imagery and real time tracking, we should be able to predict distribution patterns and monitor use in areas of concerns

Managers could then proactively move cows or implement some practice (e.g., herding) to reduce cattle use

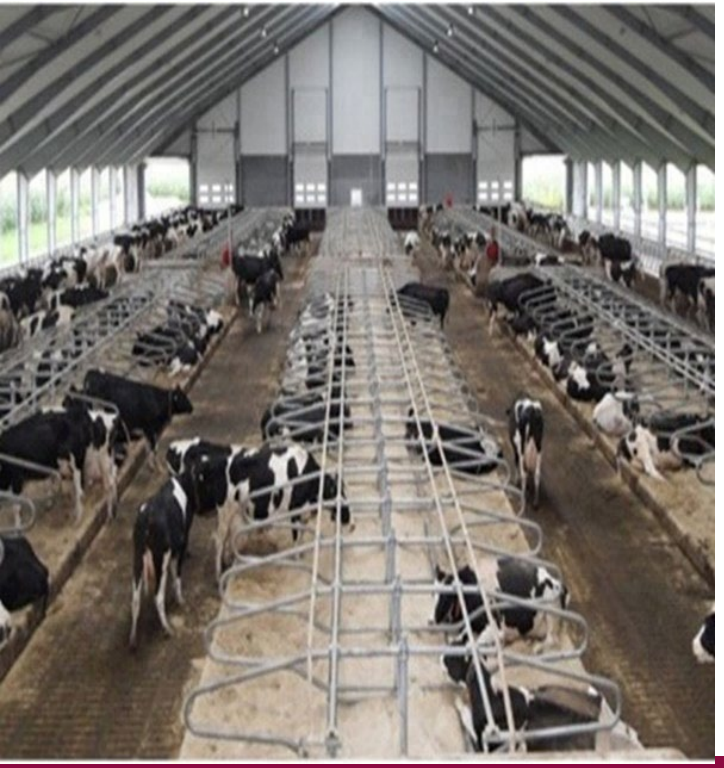


Monitoring Grazing Patterns in Real Time Will Require More Research



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

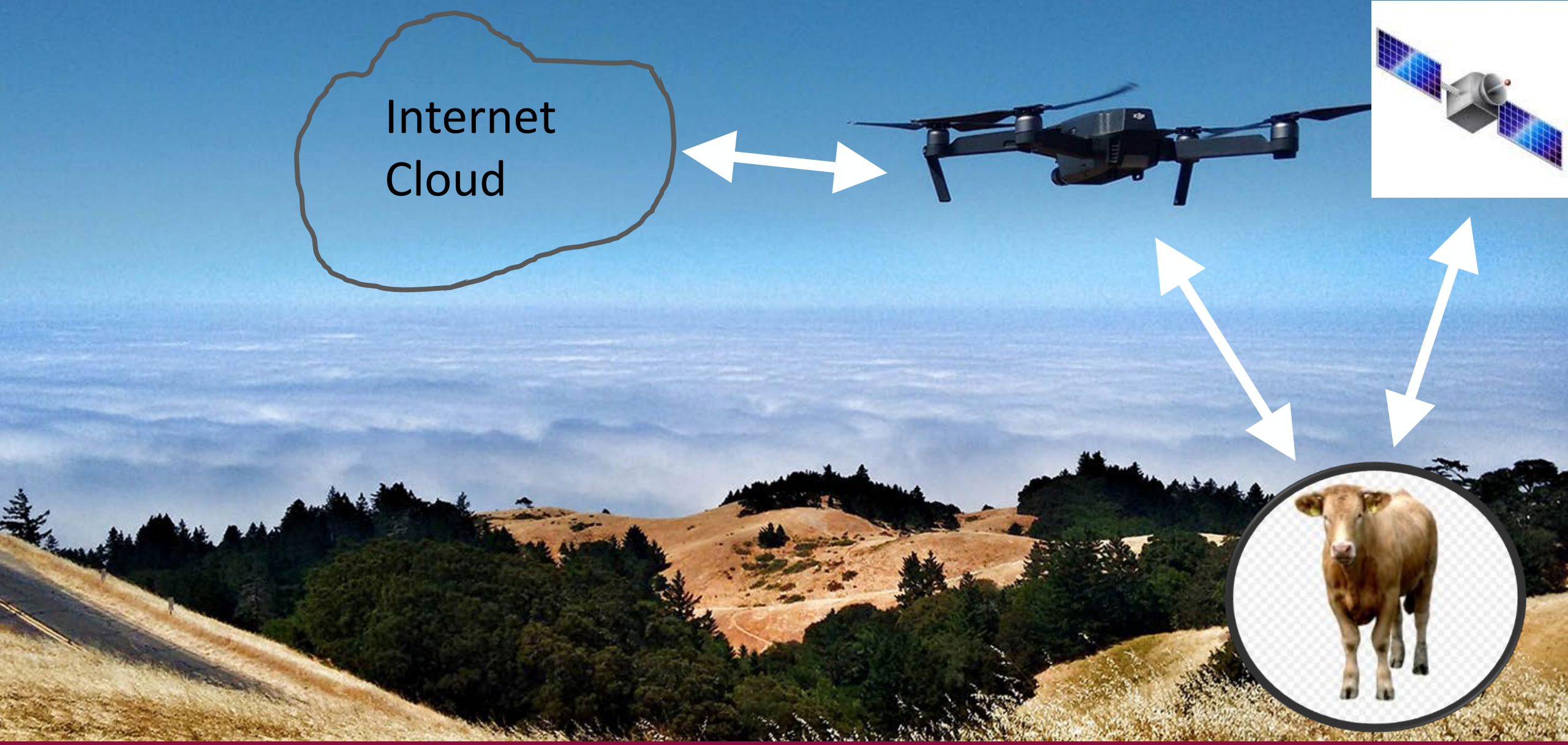
Challenges of Real Time Tracking and Monitoring on Rangelands



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

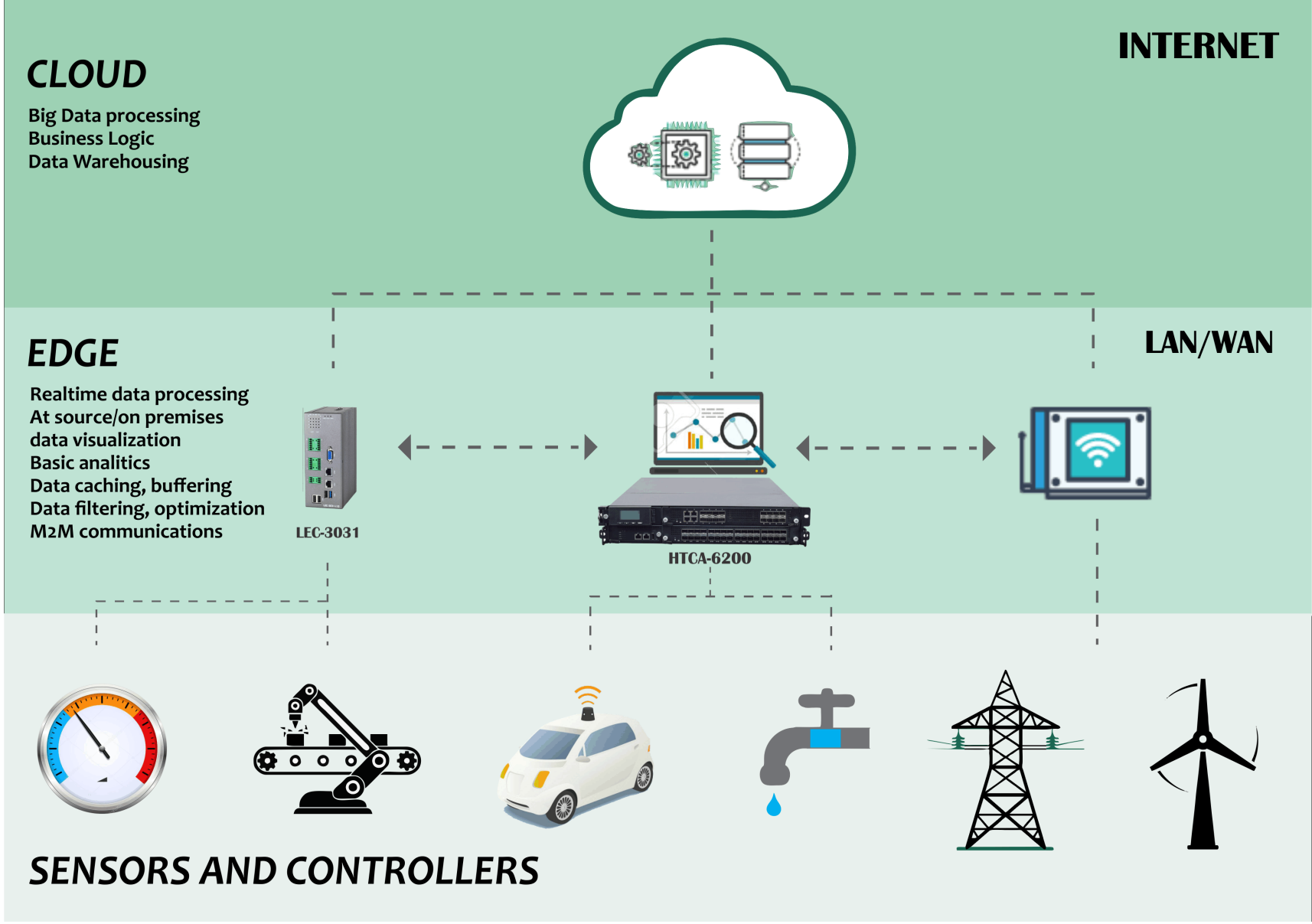
To identify differences in cattle grazing patterns:

Place barcodes on cows and record locations using drones or planes


Internet
Cloud

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



Livestock Guardian Dogs
- Dan Macon, UC Davis

Continue testing "real-time" monitoring of cattle and sheep

Deep Well Ranch
Harold James
Family Trust

Test bed of new technologies

Dr Hernandez Gifford

- Detection of lambing
- Ram behavior

Questions?