Potential of Accelerometers to Monitor Cattle Behavior and Welfare

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BE BOLD. Shape the Future.

Outline

- Prior Technologies
- Potential of Accelerometers
- Objective and Hypothesis
- Data
- Conclusions/Results
- Future Research

Livestock Monitoring

- Prior to Global Positioning System (GPS)
  - Researchers followed on foot or horseback

    (Herbel and Nelson, 1966; Roath and Krueger, 1982)
  - VibraCorders
    - Determine vertical movements of the head (Stobbs, 1970)
  - Very High Frequency (VHF) Tracking

GPS Livestock Monitoring

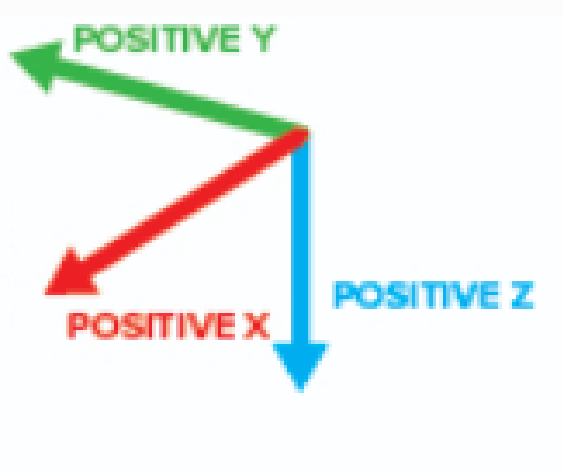
- GPS has been used to help understand animal distribution patterns and behavior. (Stephenson and Bailey, 2017)
- Due to the extensive nature of rangelands, behavior of individuals may not be observed.
- Position intervals lasting more than several minutes during tracking could lead to overlap in distances moved during activities such as walking, feeding, resting, etc. (Augustine and Derner, 2013)

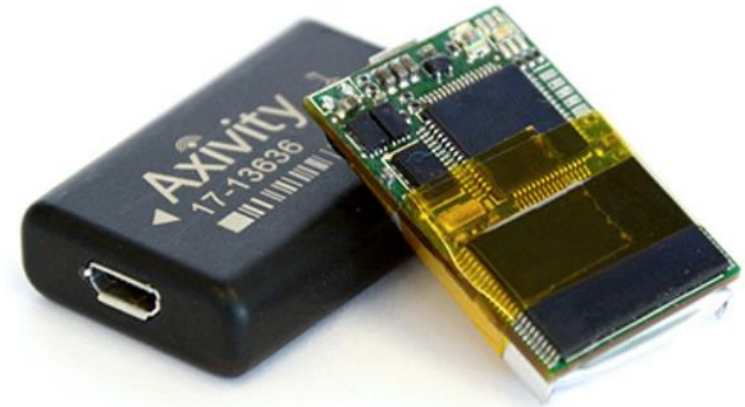
Potential of Accelerometers

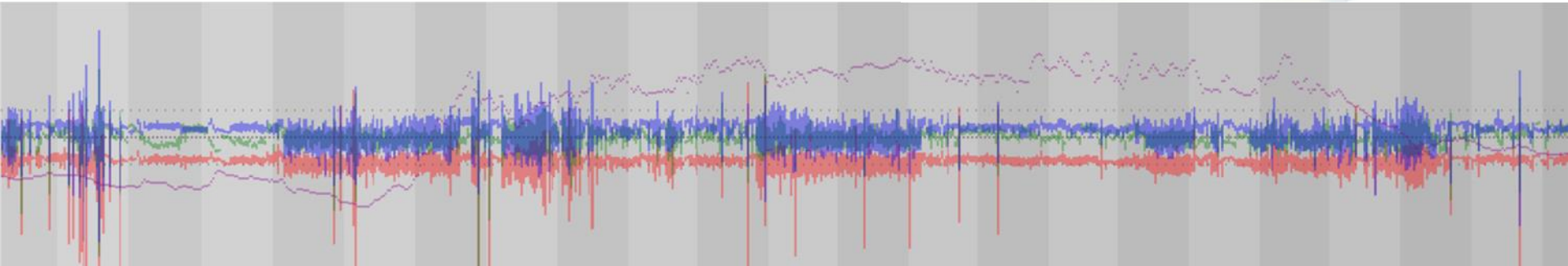
- Dairy Industry
  - Estrus and ovulation detection
  - Lameness
- Sheep Industry
  - Classification of Behaviors
  - Lameness
- Beef Industry
  - Classification of Behaviors
  - Drinking Behavior

Accelerometer Output

- Axivity AX-3 Output
  - X, Y, and Z Axis
- Convert Raw Data
  - Movement Intensity (MI)
    - $\sqrt{Xg^2 + Yg^2 + Zg^2}$
  - Signal Magnitude Area (SMA)
    - $|X| + |Y| + |Z|$

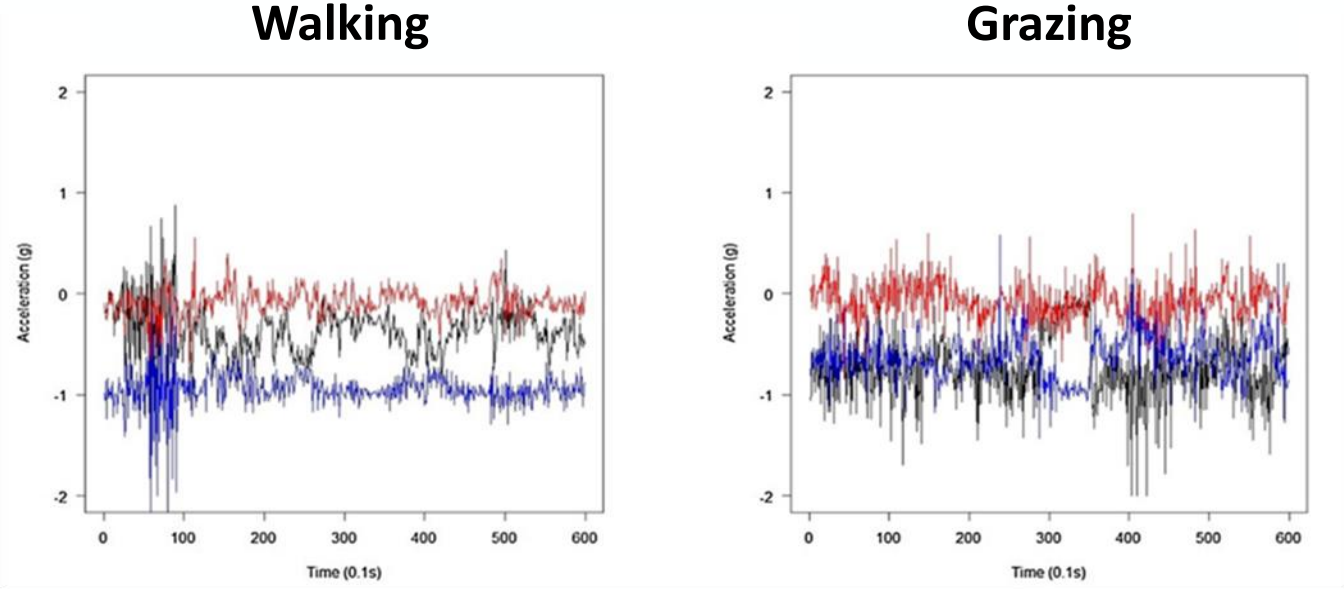






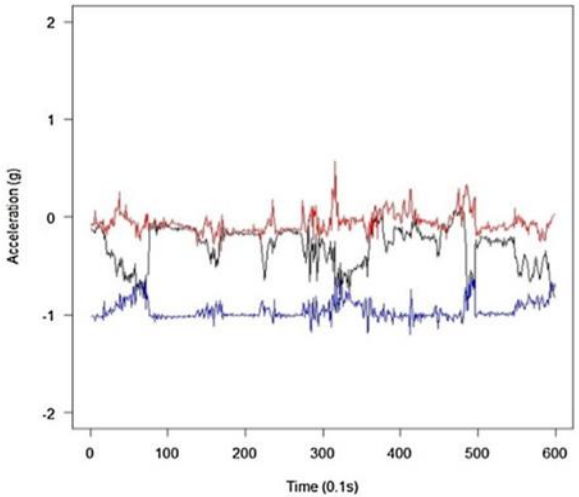
Alvarenga et al. (2016) Classified 5 Behaviors in Sheep

Walking

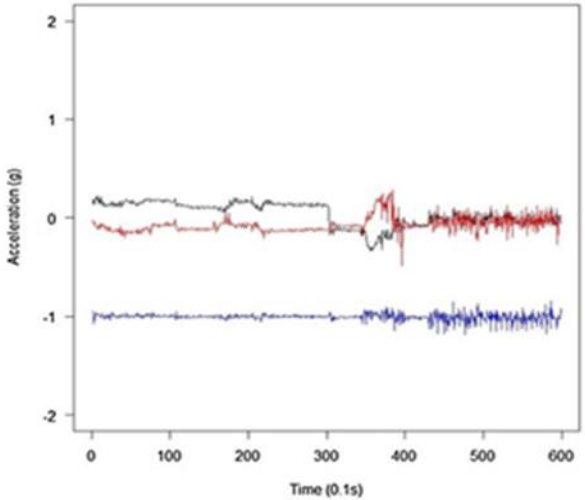


Grazing

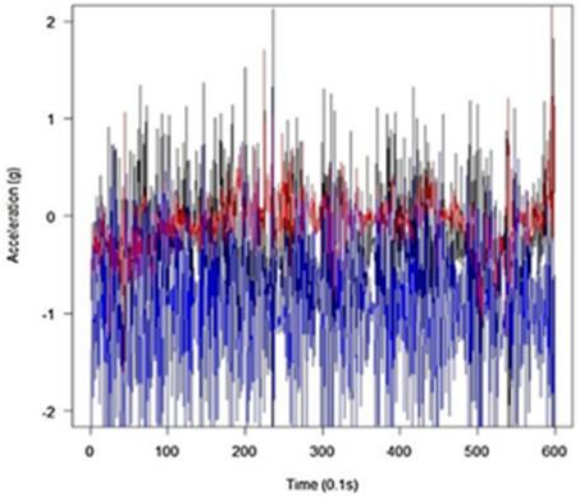
Standing



Laying

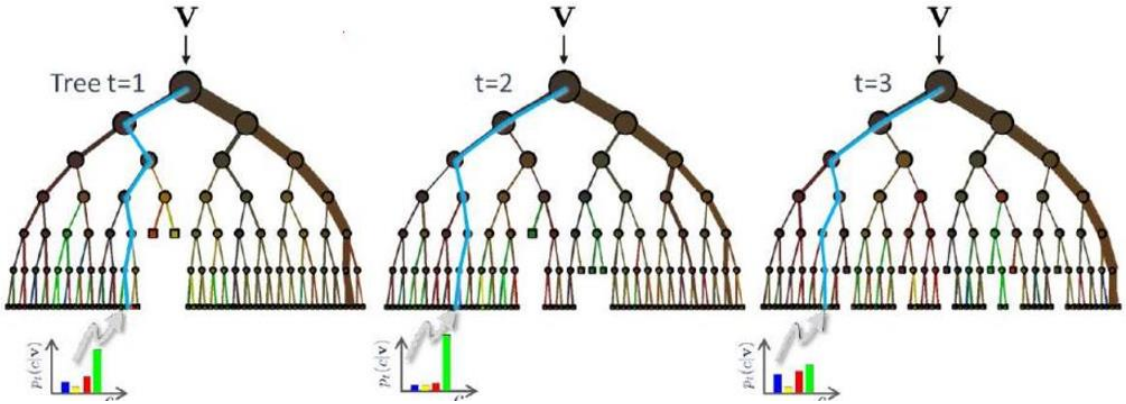


Running



Accelerometer Analysis

- Random Forest
  - Series of decision trees
  - High number of behavior observations needed
- Discriminate Analysis
  - Linear
  - Quadratic



Observations for Analysis

- Predicting lameness in sheep
  - 4419 observations @ 10 seconds (Barwick et al. 2018)
- Identify and classify sheep behavior
  - 4040 observations @ 3 seconds (Alvarenga et al. 2016)
- Drinking behavior in beef cattle
  - 4700 Observations @ 1 second (Williams et al. 2019)

Objectives

- Goal
  - Determine if an accelerometer can be used to detect changes in animal behavior due to a welfare issue before the issue is observed
- Objective
  - Determine if accelerometers and/or GPS tracking can detect when cattle are deprived of water
- Hypothesis
  - Accelerometers can detect increased movement due to anxiety from the restriction of water
  - GPS can be used to identify when cattle are not able to water in a normal manner

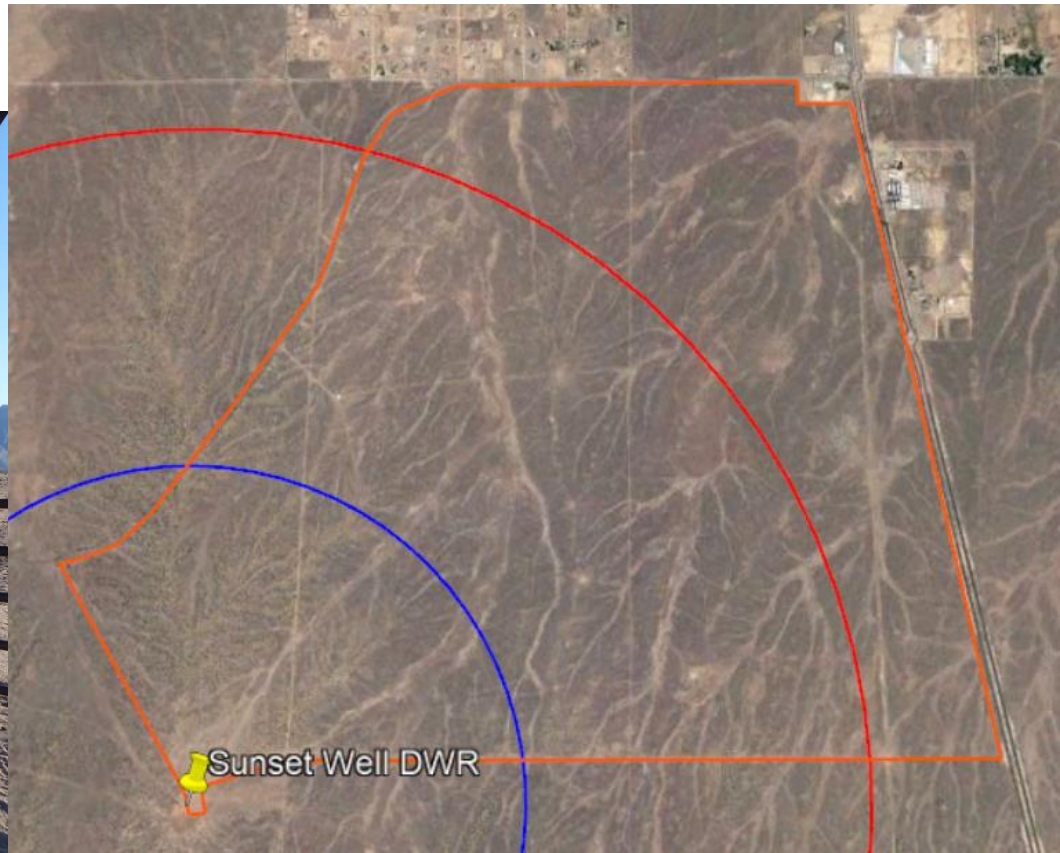
Study Site and Setup

- Deep Well Ranch
  - Prescott, Arizona
- 100 Corriente Cows
  - 10 IgotU-600 GPS
    - 2 minute intervals
  - 7 Axivity AX-3 accelerometer
    - 12 Hz data collection

- Protocol approved my NMSU IACUC

North Pasture

- One Water Source
- 4.2 km maximum distance to water
- 1600 ha



4 Cattle paired with GPS and Accelerometers

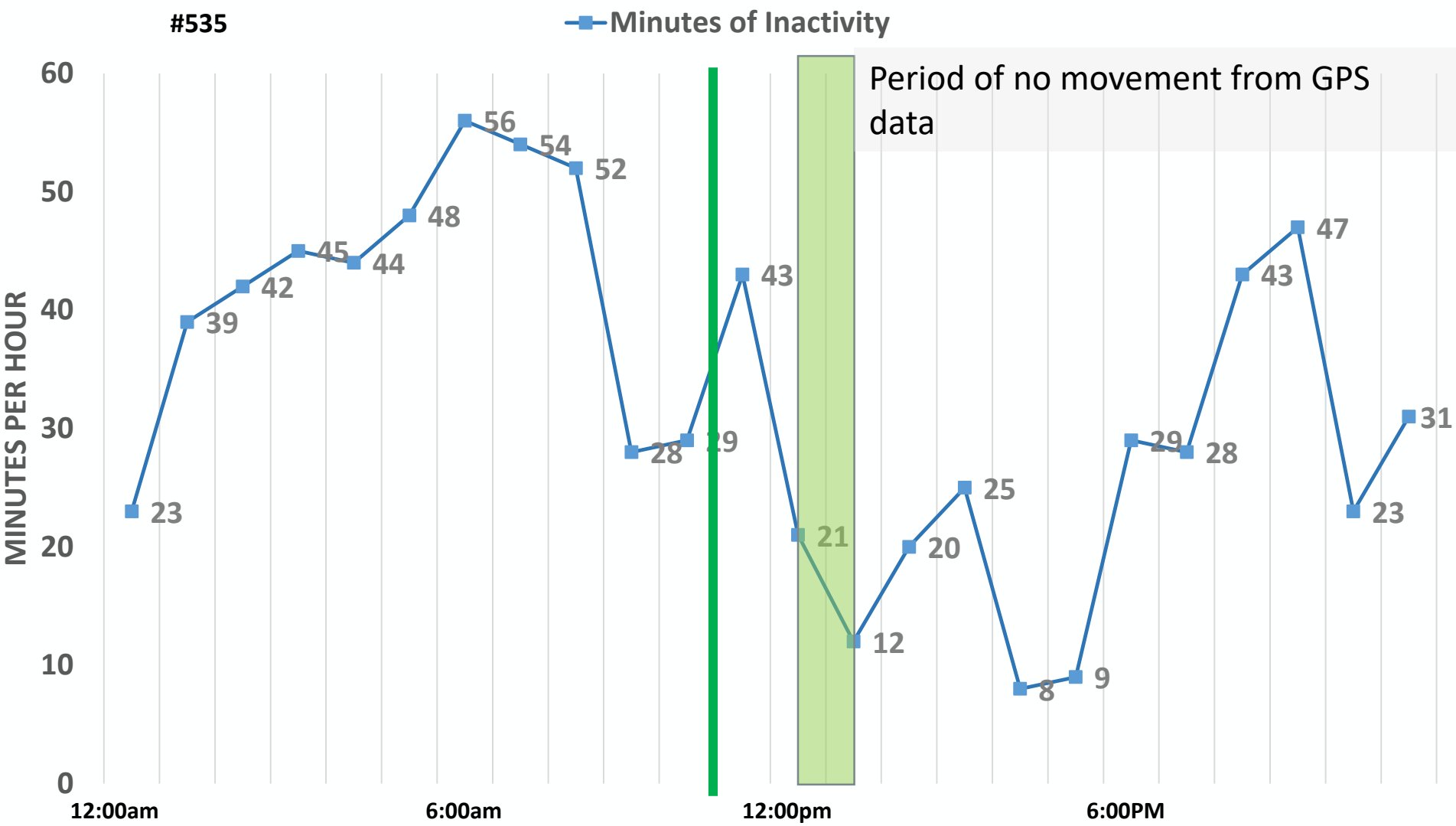
Water Restriction

- 4 hour bouts
  - 8am – 12pm
  - June 6th, 12th, and 18th

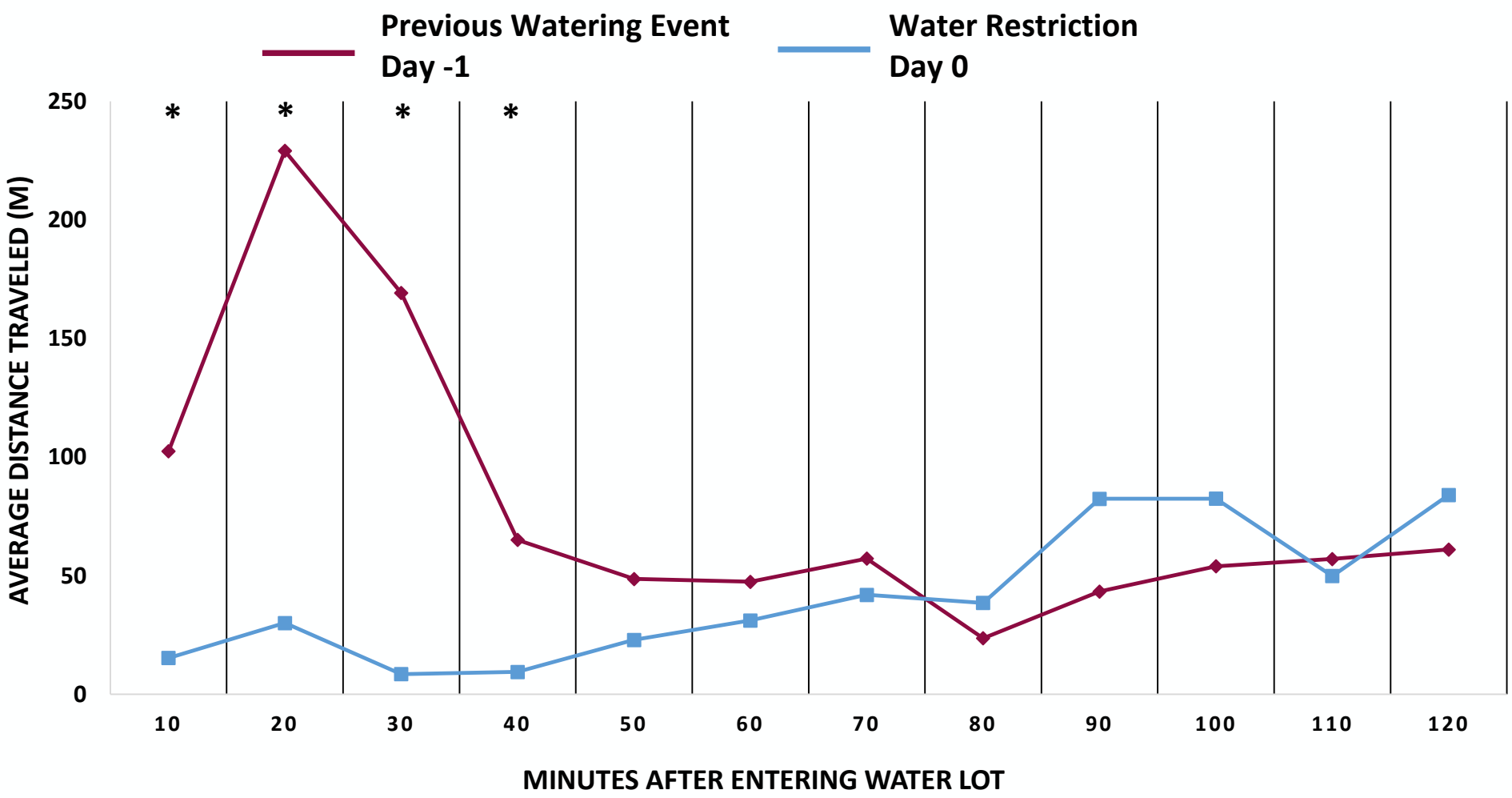
Accelerometer Data

- Aggregate data to 1 minute epochs
  - 720 accelerometer data points (60sec @ 12hz)
  - 100 behavior observations
- Random Forest
  - Variables
    - X Mean, Y Mean, Z Mean, MI, SMA, MI Standard Deviation, MI Variance
  - Misclassification rate
    - 47.4%

Applying Random Forest

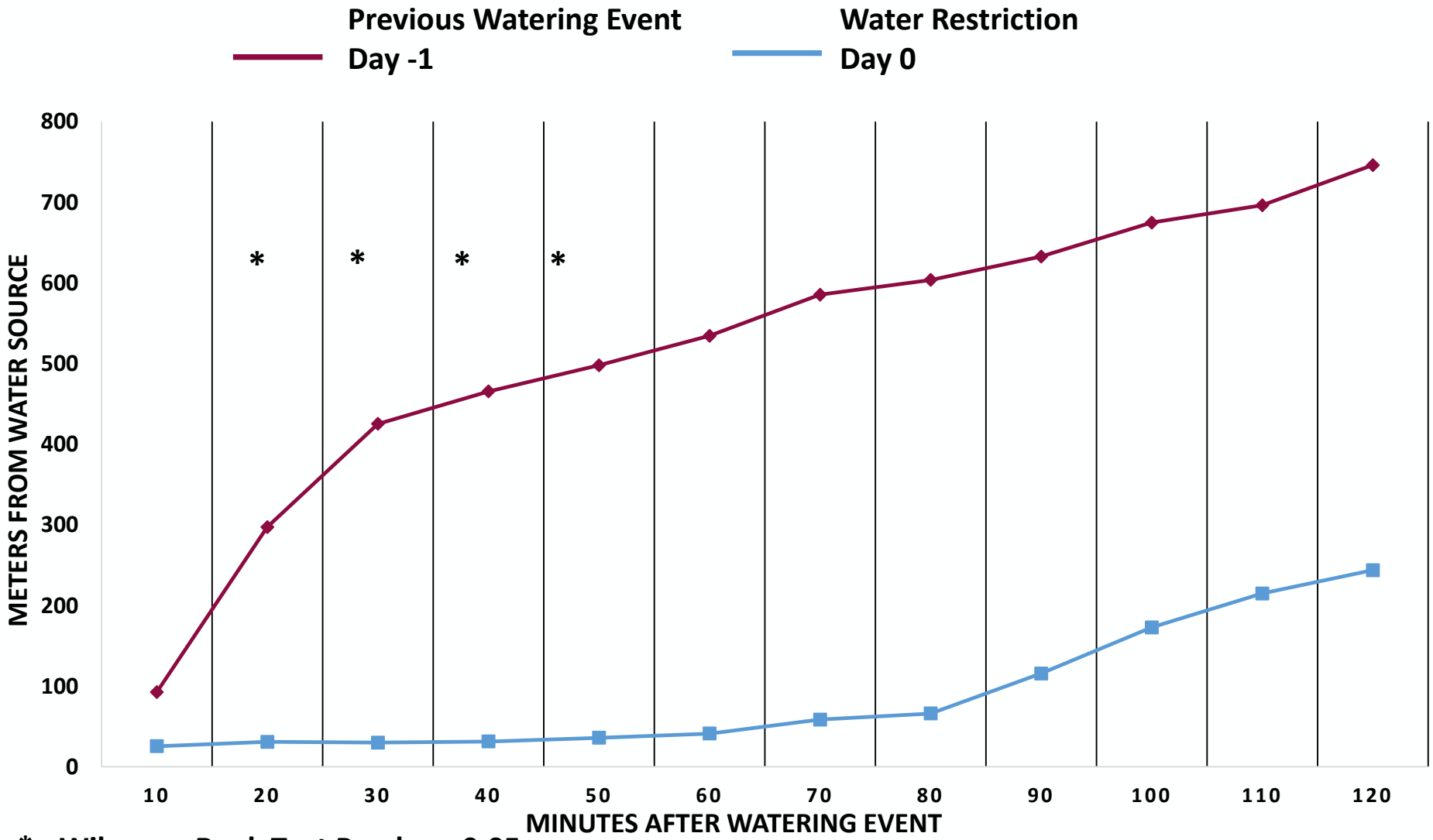


Distance Traveled After Watering Event (GPS)



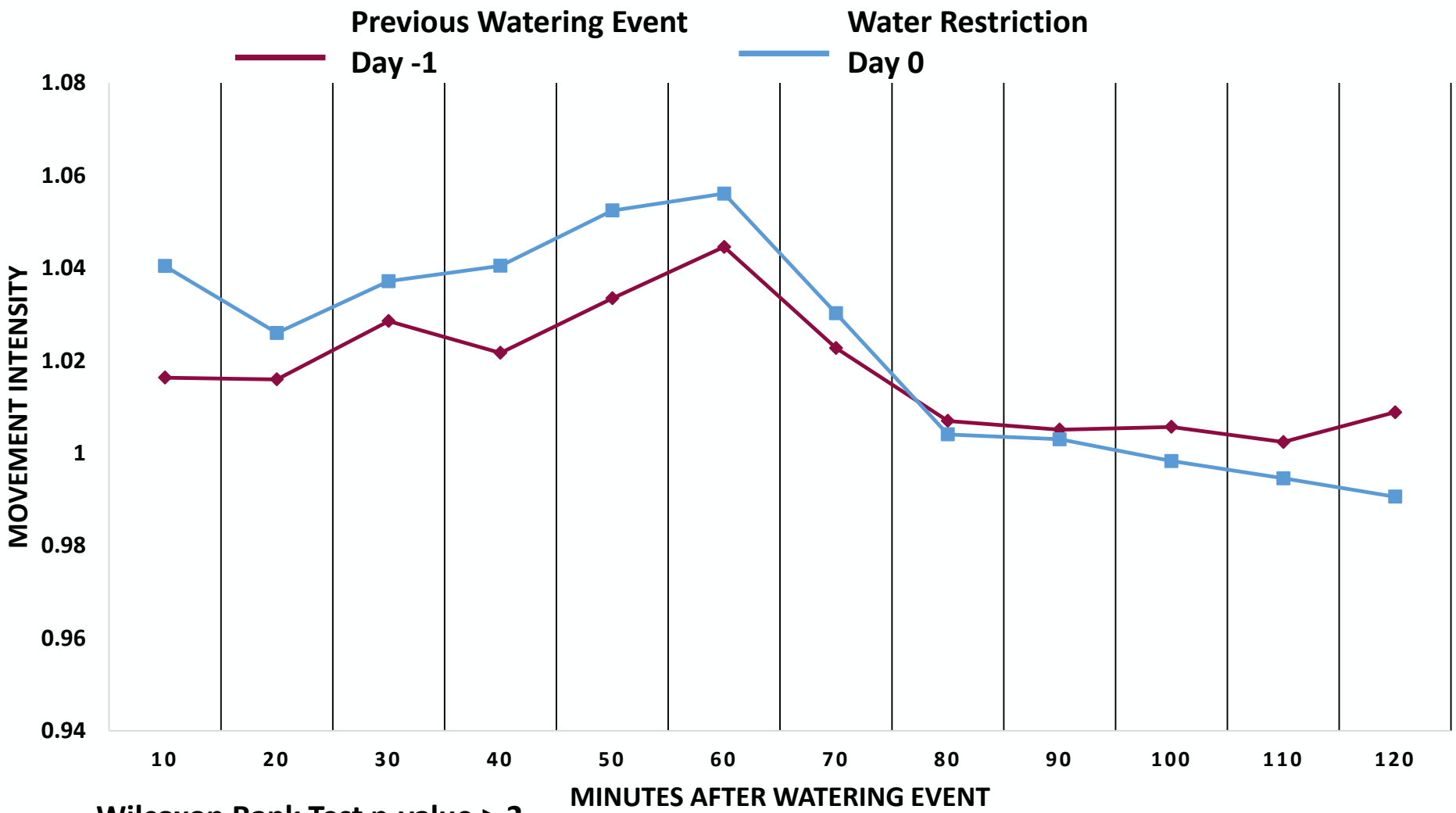
* - Wilcoxon Rank Test P-value< 0.05

Distance From Water (GPS)



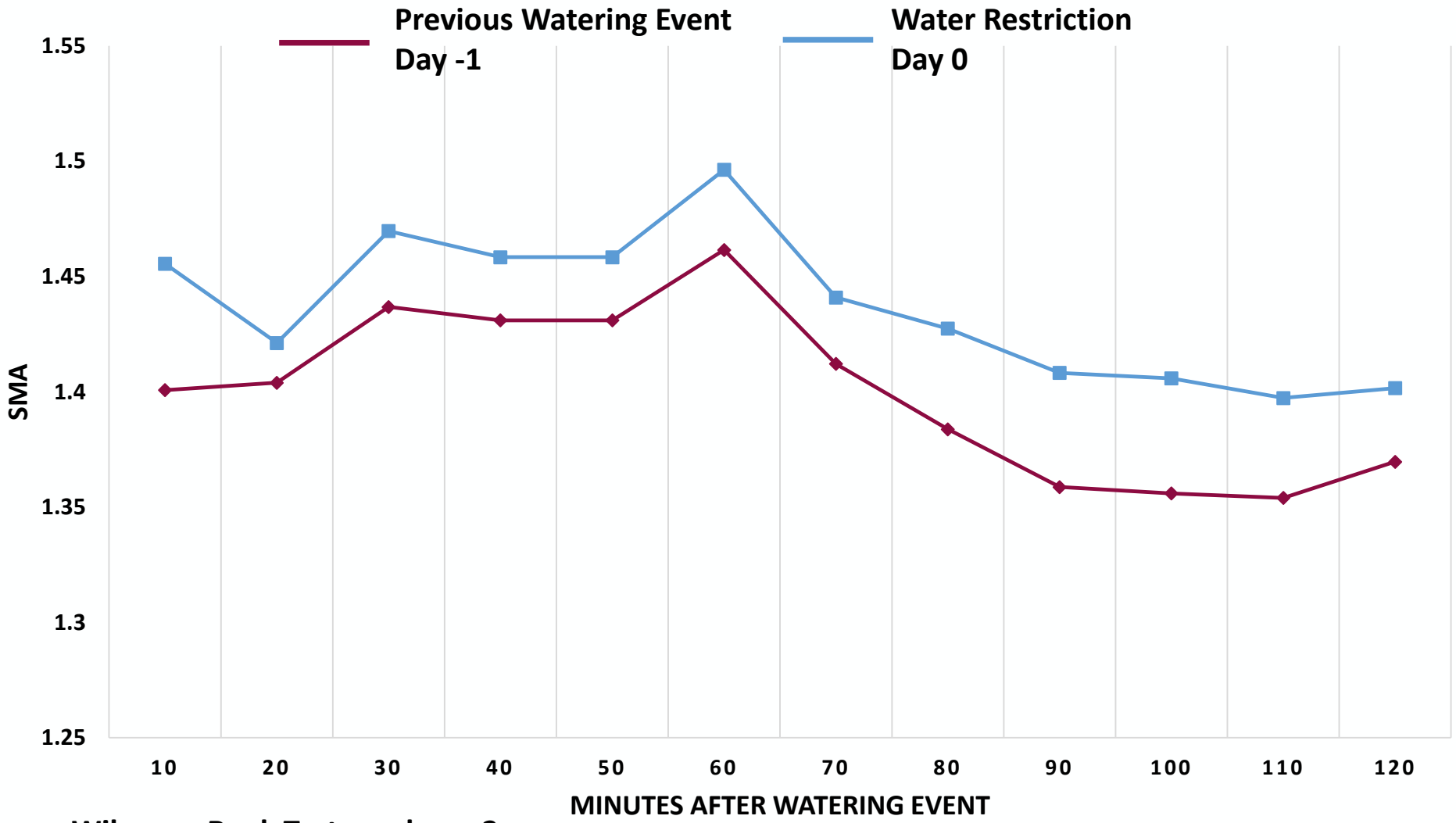
* - Wilcoxon Rank Test P-value< 0.05

Movement Intensity After Watering Event (Accelerometer)



Wilcoxon Rank Test p-value >.2

Signal Magnitude Area After Watering Event (Accelerometer)



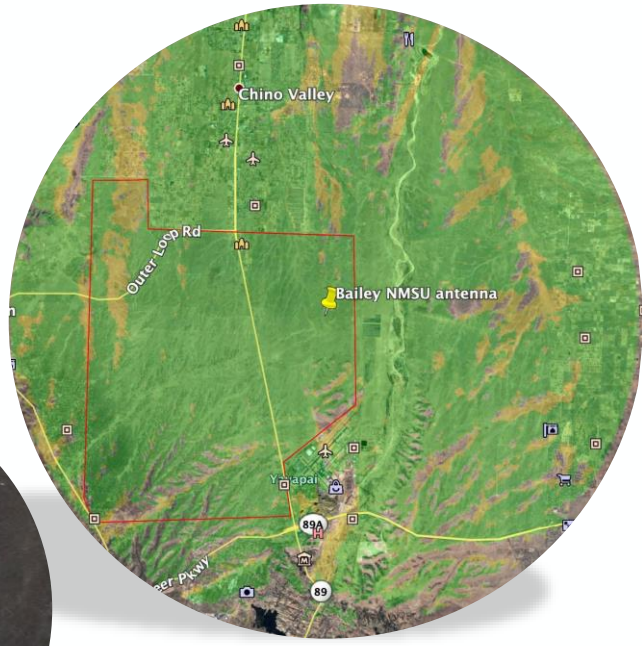
Wilcoxon Rank Test p-value <.2

Conclusion

- We did not detect anxiety and increased movement due to the restriction of water while using accelerometer alone
- We recognize the need for increased behavior observations to build a more reliable model for analysis
- We still believe that accelerometers have promise for detecting animal welfare issues in near real-time

Future

- mOOvement GPS Ear Tag
  - 1 fix per hour
  - 3m accuracy
  - 5 year lifespan
- HerdDogg-DoggTags
  - Near real-time data
  - Tag readers using cellular data
  - Based on 3-axis accelerometer



Acknowledgements

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  - Ron James
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Questions?