Where's Waldo? Describing resilience linked land use behaviors of sheep via GPS collars

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Intensive vs. Extensive Agricultural Production

- Intensive Agriculture Has Clear Benefits
  - Consistent Environment
  - Proximity
  - Confined

- Precise, Accurate Data Capture

- Make Use of Challenging Environments
  - Extensive Agriculture Systems

Challenges Facing Extensively Managed Operations

- Scale
- Terrain
- Variable Climate
- Resource Distribution
- Disease
- Predation

How can we capture precise, accurate phenotypes on large, extensive operations?

GPS as a Precision Livestock Farming Tool

University of Idaho

What are we ultimately seeking to elucidate with PLF tools in extensive livestock production?
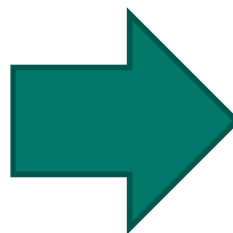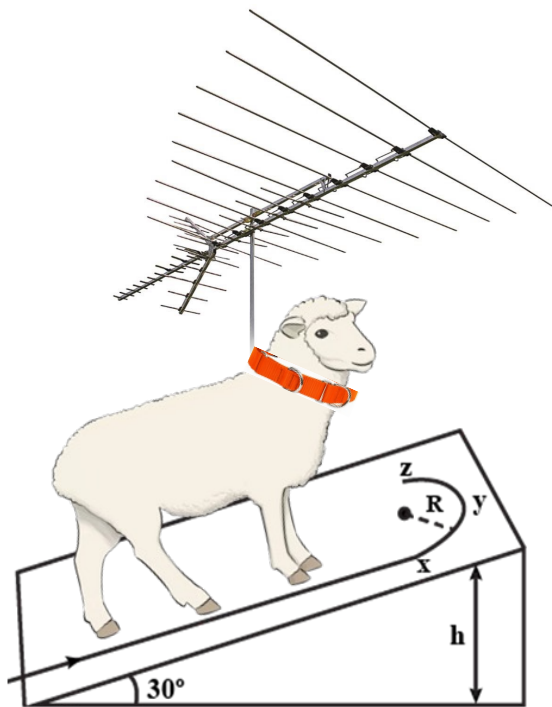
**Resilience,
Welfare
& Productivity**

Climatic Variability Necessitates Hardy Individuals

Resilience vs Robustness

Hedonic vs Eudaimonic Welfare

How do you intend to measure resilience and welfare with GPS coordinates?

GPS Metrics & Derived Phenotypes

Raw Data:

- Longitude, Latitude
- Date
- Time

Processed Data:

- Distance
- Altitude
- Slope
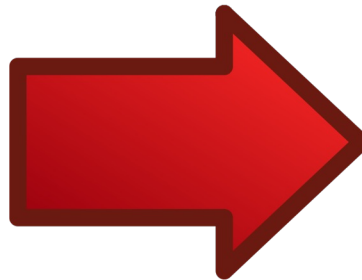
Land Usage Phenotypes:

- Distance traveled
  - Speed
- Dispersion
- Water usage
- Ewe-lamb proximity
  - Spatial social networks

Collared Sheep Summary

- 112 Collared sheep:
  - Merino
    - Ewes: 10; Lambs: 10; Pairs: 8
  - Merino X Rambouillet Composite
    - Ewes: 35; Lambs: 40; Pairs: 35
  - Unknown Merino/Rambouillet
    - Ewes: 10; Lambs: 7; Pairs: 7
- Average ewe age: 5 ± 2 years
- Average lamb age: 101 ± 1 days

Distance Traveled

- Missing Data

- Energy Expenditure
- Nutritional Density
- Health (lameness)
- Daily Individual Distance
  - 6938 ± 1856 m/day

- ρ = 0.22±0.05
- Day significant P-value = 2.72×10-4
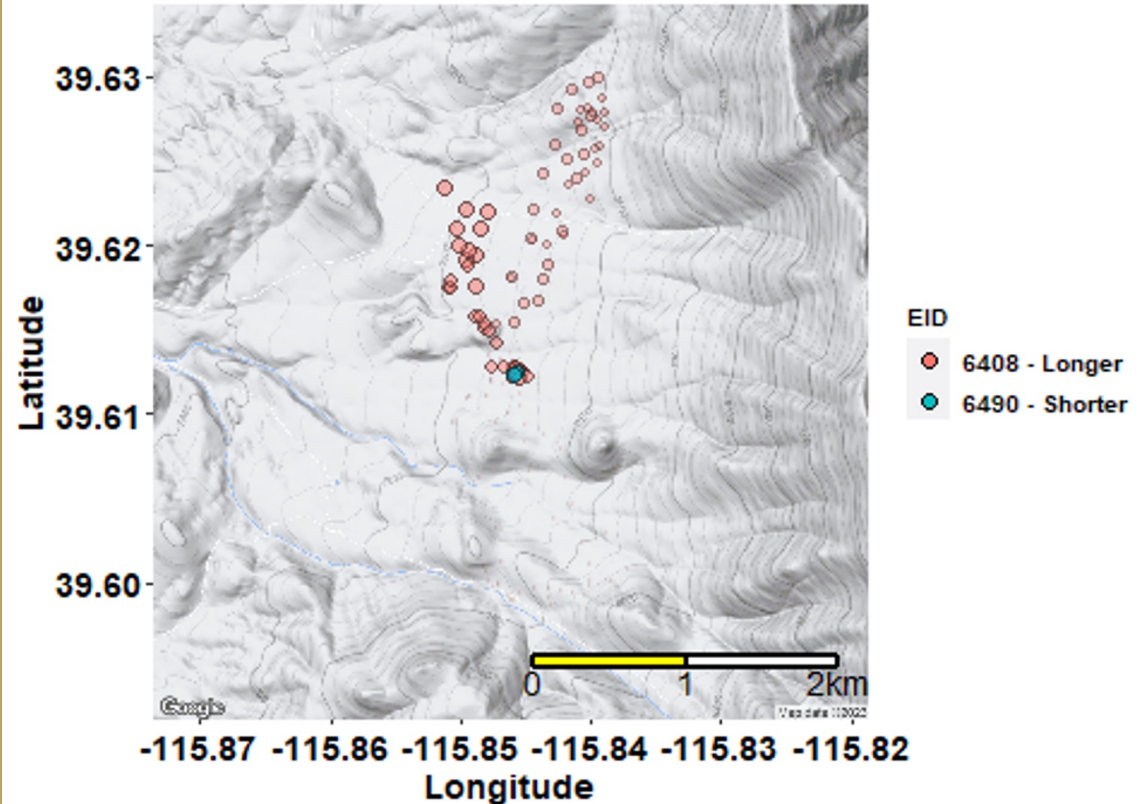
Longer = 8388 m/day | Shorter = 6883 m/day

Dispersion

- Z-Score Transformed
- Wanderers
  - Higher nutrition plane
  - Eudaimonic well being
- Flock Dwellers
  - May indicate heat stress
  - Energetic, physiological stress
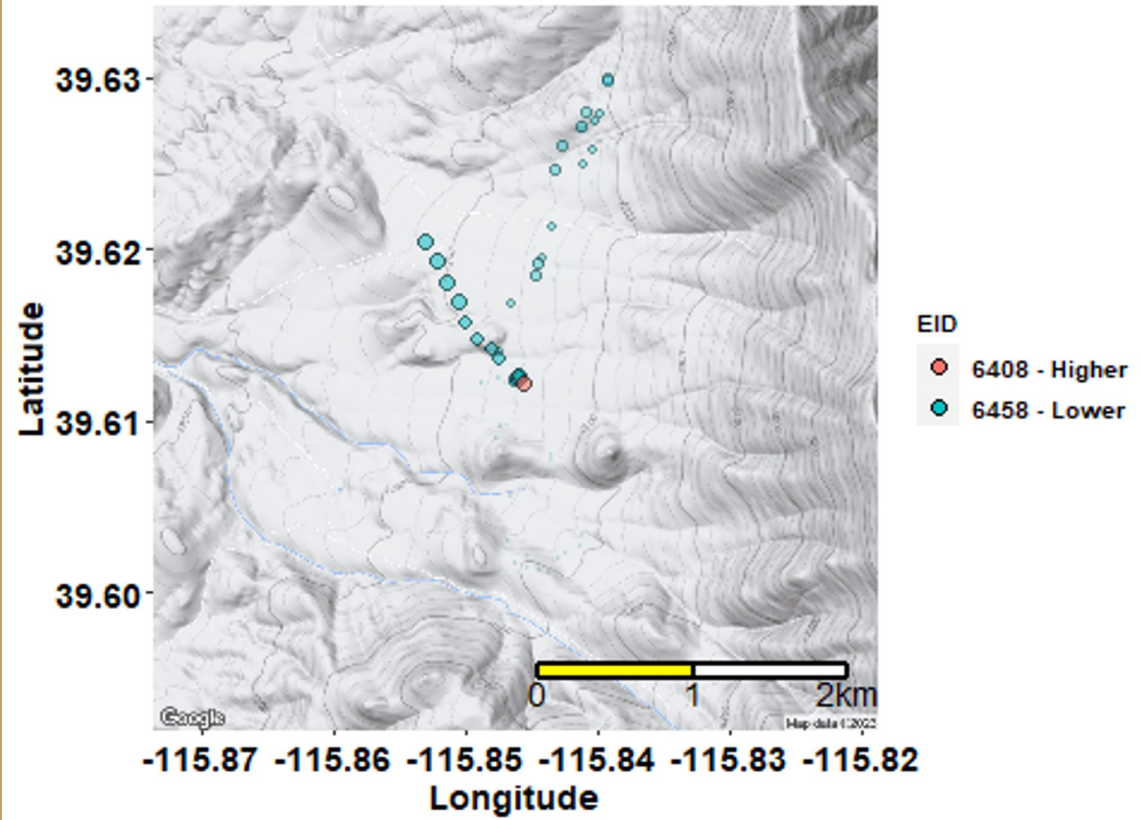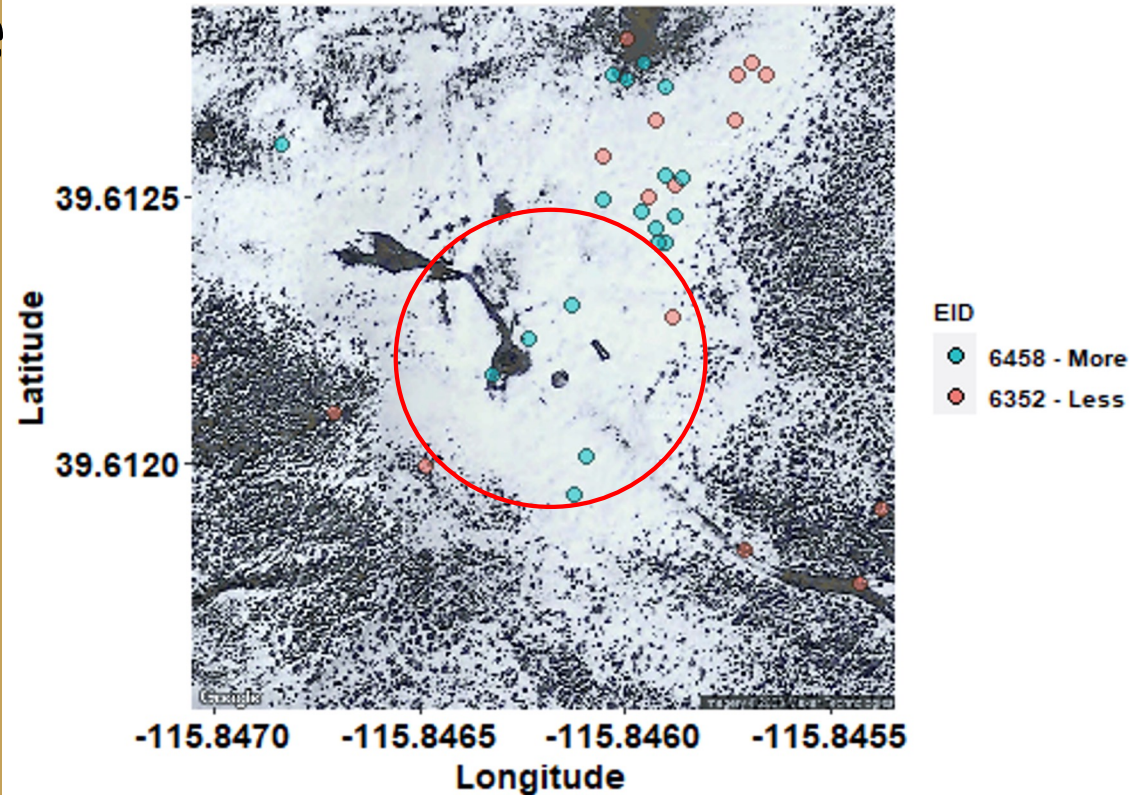- -0.01±0.15
- $\rho=0.10\pm0.03$

Elevation Z-Score Chosen for Demonstration

Higher = 0.389 Z-Score | Lower = -0.274 Z-Score

Water Usage

- Indicative of heat stress
- Level of hydration
- Quality of water
- Water availability
- Flock time near water
  - 10.7 ± 5.3%
- $\rho = 0.30 \pm 0.06$
- Day significant P-value = 1.06×10^{-3}

More = 16.1% | Less = 5.7%

Ewe & Lamb Paired Distance

- Coordinates taken within 5 minutes of each other within ewe-lamb pairs
  - 33 pairs of data within time frame
- 769 ± 670 paired records per ewe
  - 149.70 ± 7.98 s mean lag time
- Mean (blue) = 78.2 m
- Median (red) = 27.1 m
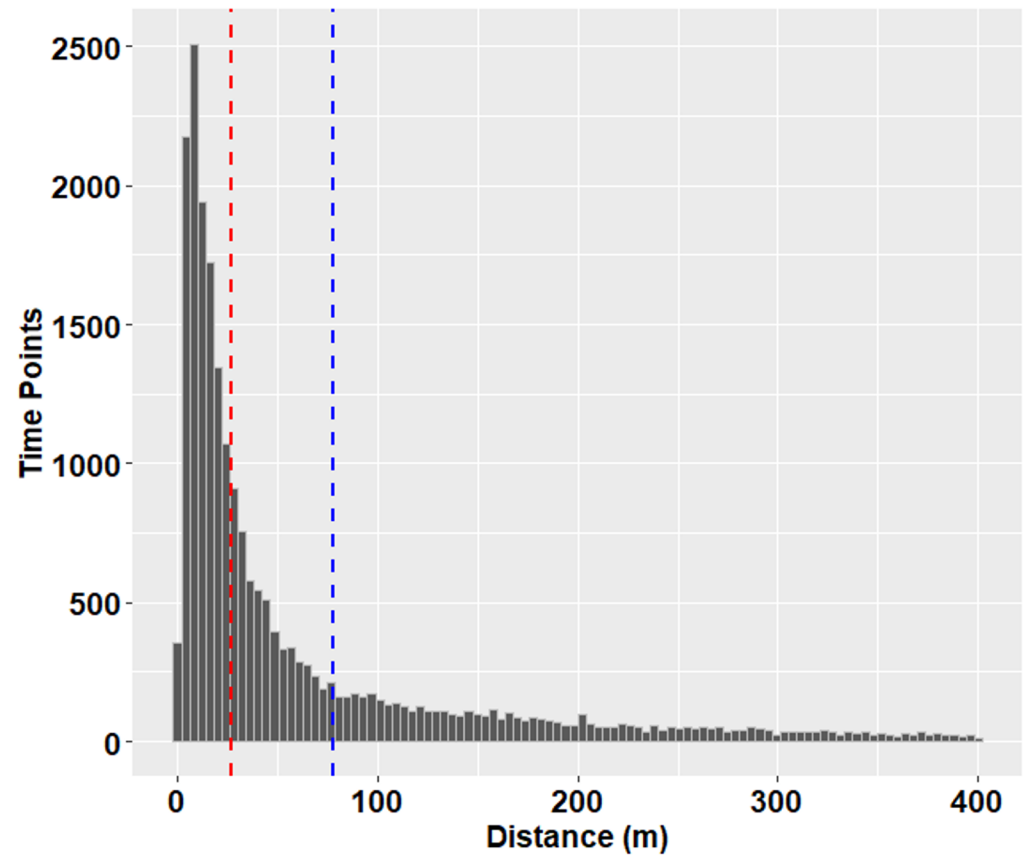
Ewe Lamb Pair Variation

- Mothering ability
- Learned behaviors
- Social connectivity

  Longer = 116.1 m
  Shorter = 70.8 m
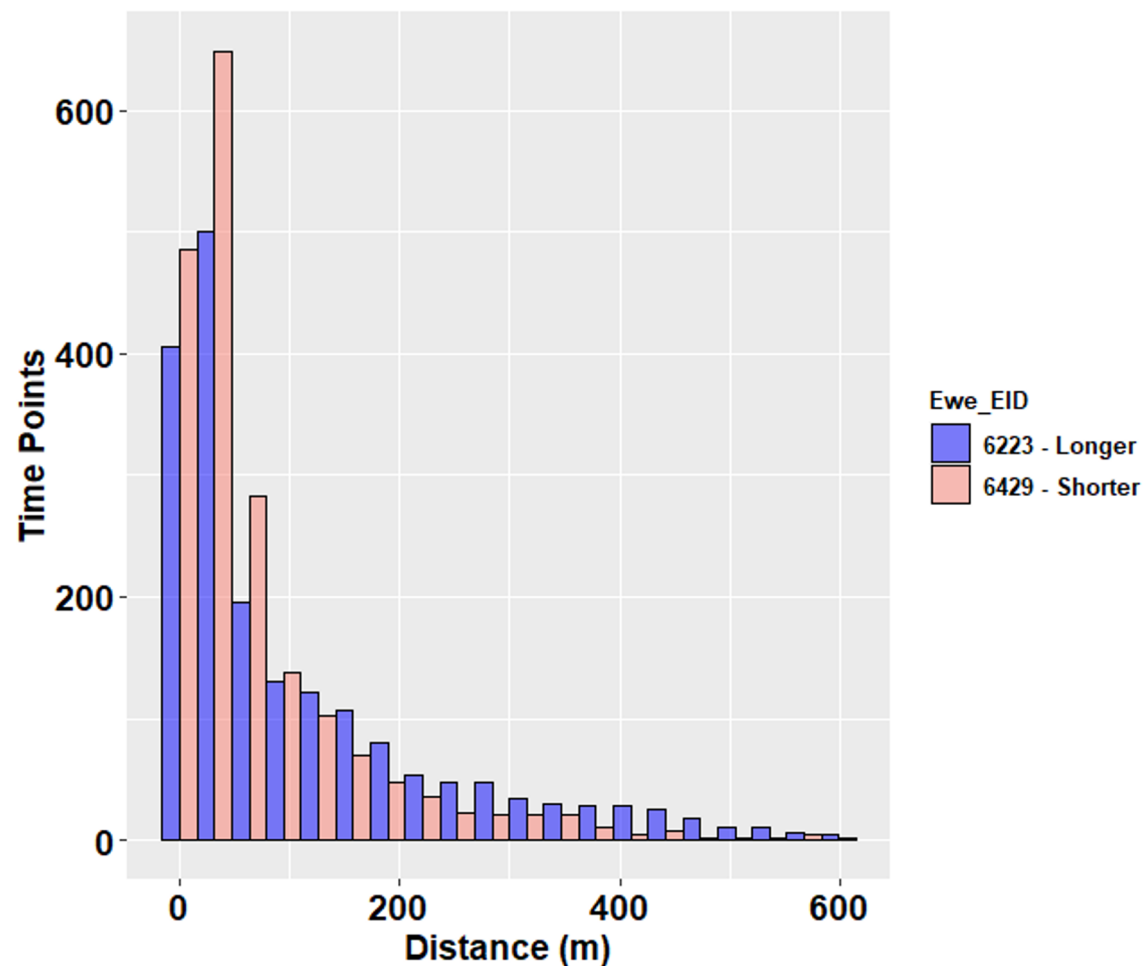
- $\rho=0.45\pm.08$

GPS Integration with Longitudinal Data Types

How do we acquire daily changes in productivity on extensive rangelands?

- Routine bodyweights via portable, walkover weigh (WoW) station

Portable WoW Station

- Baited with salt, molasses
- One way in, one way out
- Solar power allows for remote use
- Set up & take down ~ 15 minutes
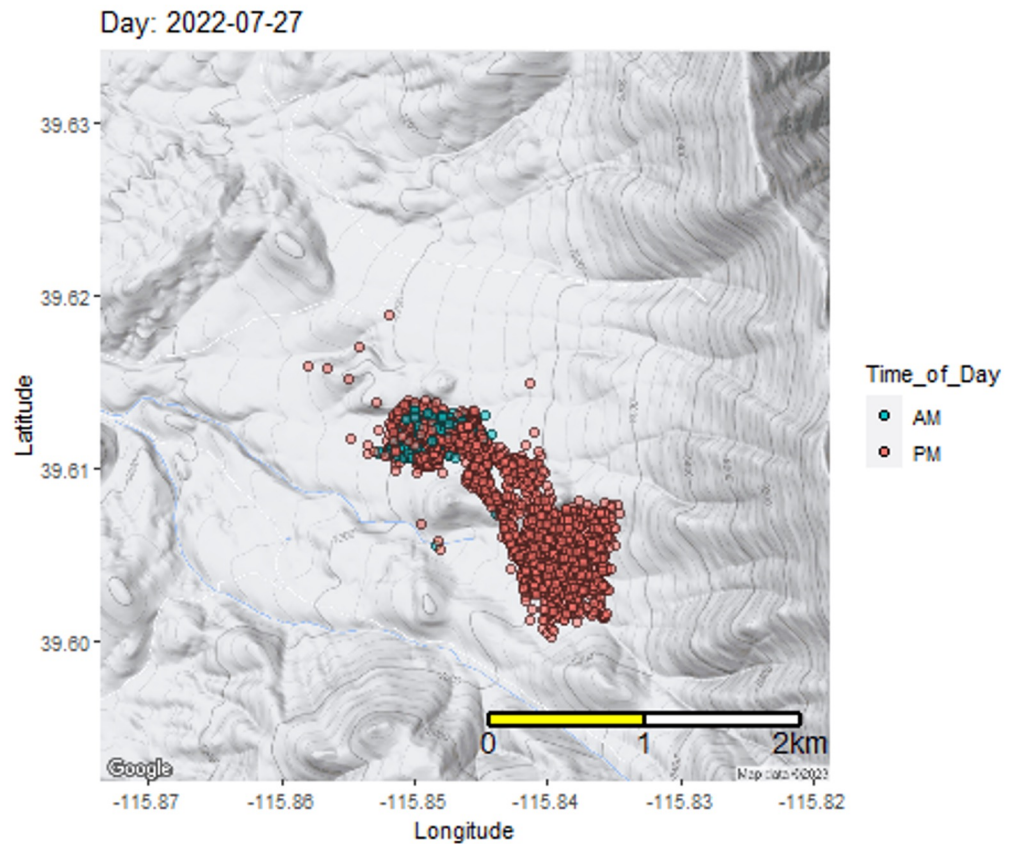- Transported in pickup bed

Precision Livestock Farming Data Integration

Integration:
- Climate data
- Remotely sensed vegetation
- Define relationship between behavioral traits and production
- Informs flock management decisions

Genetic Analysis:

- Estimate heritability
- GWAS

Achieving Sustainability Necessitates Systems Based Approaches

Selection of Best Adapted Individuals

Decreased Natural Resource Malinvestment

Maximizing Resilience

Increased Contribution of Phenotypic Data

Increased Global Production

Minimizing Environmental Consequences

Democratizing & Decentralizing Digital Divide

Increased Agricultural Systems Efficiency

Thank you!