Modeling livestock movement to manage landscapes

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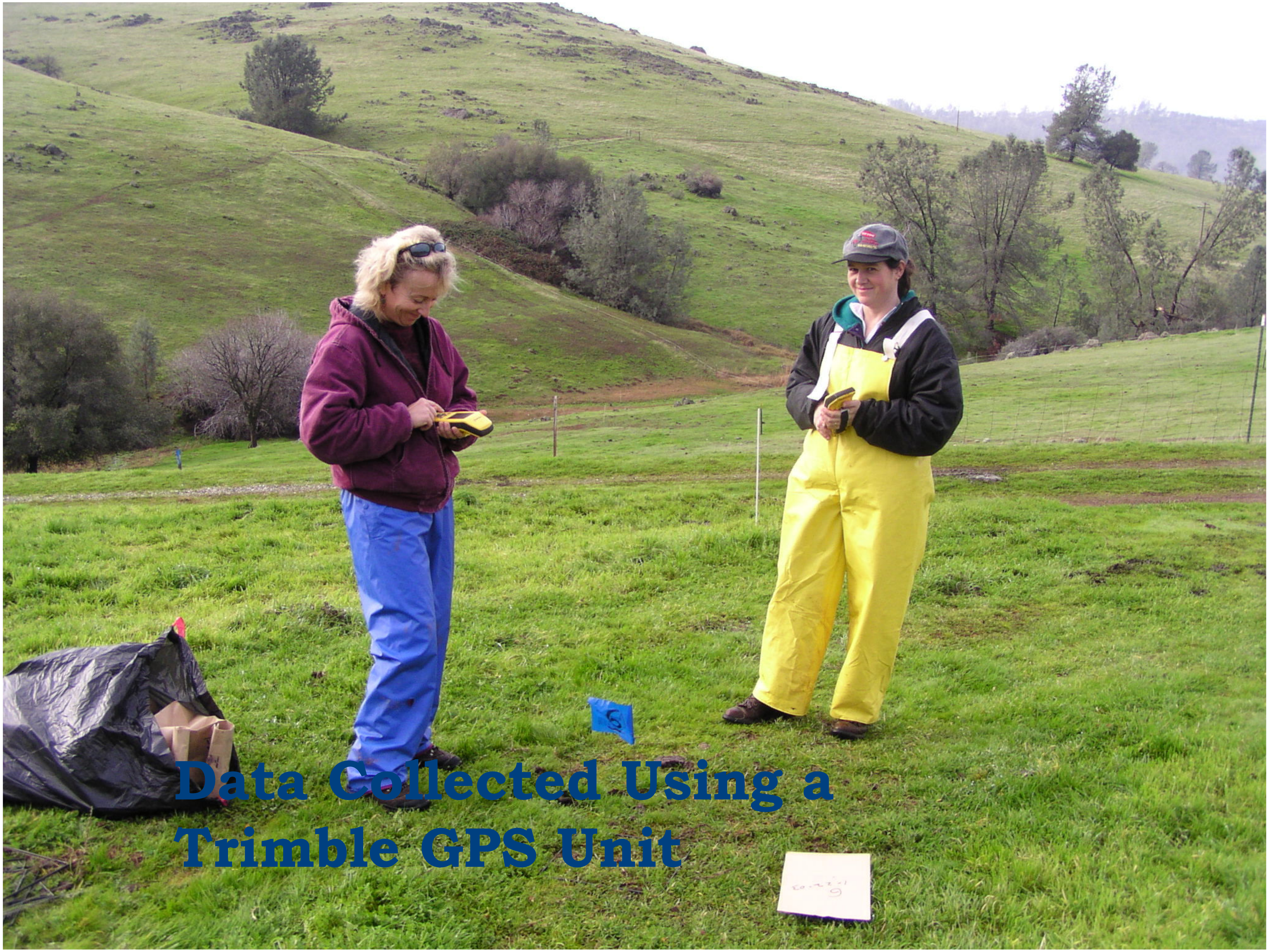
Research Conducted – “Cows in Space”

- Multi state USDA funded research project – California, Oregon & Montana
- Research conducted at the Sierra Field Station, Marysville, California
- Collected vegetation data over a two year period in the paired treatment areas, 2001-2003

Research Conducted

- Two herds of 20 cows, equipped with global positioning collars, programmed to take a position fix every 5 minutes
- Grazed one pair of 2 pastures one week and the other pair the following week during January, March, April-May and August.
- One pair of pastures was open woodland, the other pair was cleared, devoid of trees, except in the riparian corridor.


Data Collected Using a
Trimble GPS Unit

Previous Research & Literature

- Examined the movement of animals
- Developed models to predict movements
- Began to use this knowledge for vegetation management

Homogeneous vs. Heterogeneous Environments

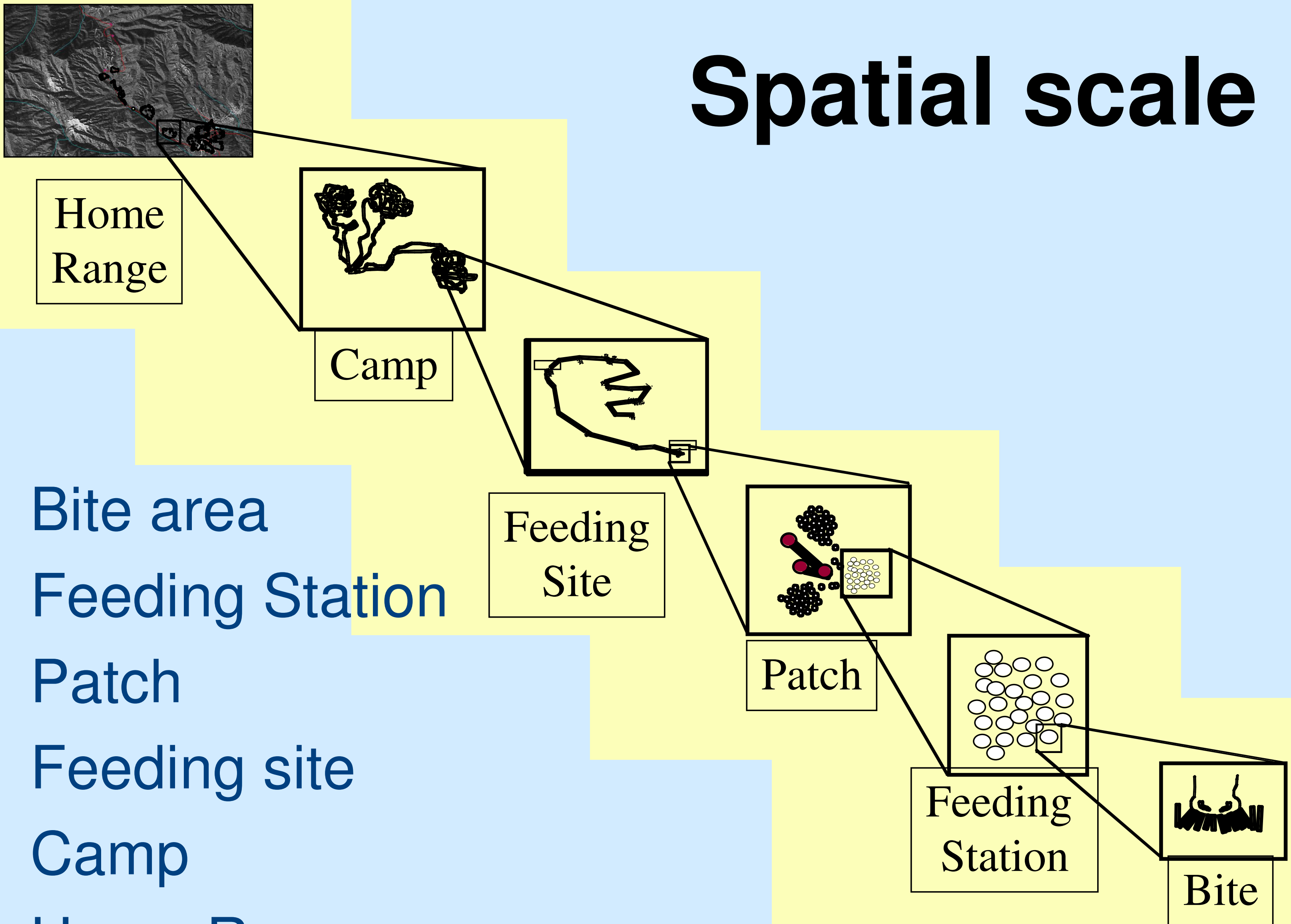
- Livestock foraging decisions vary over spatial and temporal scales
- These decisions result in their specific patterns of movement in the landscape over time
- Spatial behavior can be characterized by quantities such as patch size, distance between patches, turning rates, etc.
- Small scales of space and time, successfully predict intake rates

Gross et al. 1995

Spatial-Temporal Scales

- When to begin grazing
- Frequency of grazing
- Distribution of grazing
- Allocation of grazing time

Spatial scale



- Bite area
- Feeding Station
- Patch
- Feeding site
- Camp
- Home Range

Bailey et al. 1996

Temporal Scale

- Foraging strategies vary through time
- Daily grazing patterns are a response to livestock responding to environmental and internal factors

Gregorini et al. 2006

Environmental & Internal Factors

- Climate
- Geomorphologic
- Water
- Vegetation
- Physiologic state
- Animal Behavior

Research Goal:

- Develop a “user friendly” model to manage landscapes

- Use existing models to compare

- Develop methods to apply models to different landscapes

- Combine ecological theory to management objectives

Research Objectives

- Quantify and describe livestock movement
- Create a practical conceptual model of what guides livestock movements
- Develop and apply predictive models to manage livestock distribution
- Address emerging natural resource issues with better understanding of animal movement

Methods to model movement

- Hidden Markov models
- Random walks
- Fractal analysis
- State-space models

Markov Chain

- Named after Andrei Markov, is a discrete-time stochastic process
- The process states, “the past is irrelevant for predicating the future given knowledge of the present.”
- Unknown (hidden) parameters need to be determined to predict movement

Correlated Random Walk

- Determining animal movement by three parameters:
  - » Number of steps
  - » Step size
  - » Distribution of random turning angles

John Byers 2001

Fractal Analysis

- Fractal Dimension – the pattern of the interaction between animal movement and landscape heterogeneity
- Measuring the sinuosity or tortuosity of movement

Peter Turchin 1999

Sinuosity/Tortuousity

- Measuring animal movement by path tortuousity (measured with fractal dimension) versus spatial scale
- Variations in tortuousity of small path segments along movement path
- Correlation between tortuousities of adjacent path segments

Vilis Nams 2005

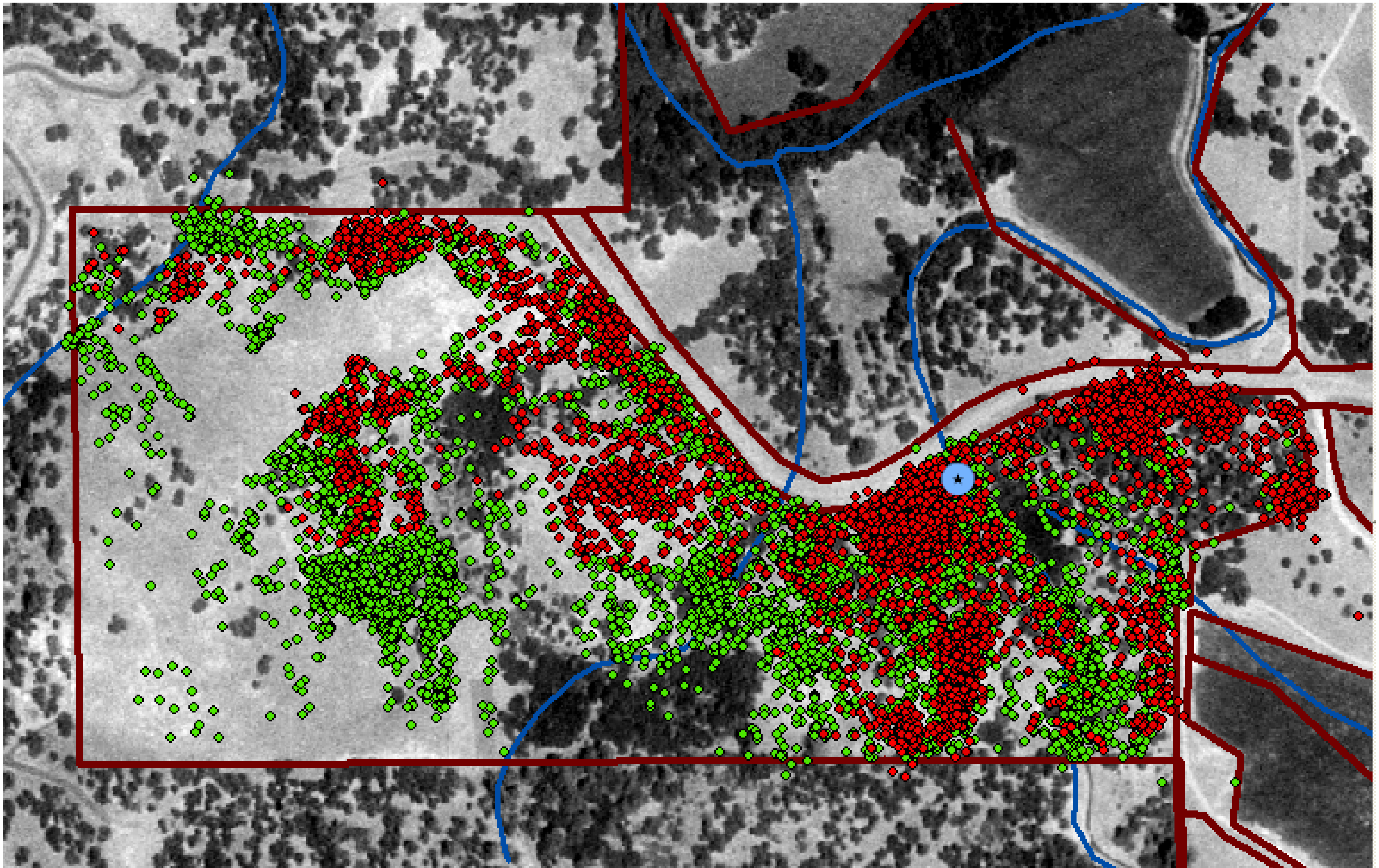
State-Space models

- Allows researchers to build and fit empirically based movement models to data
- Allows for comparing theoretical models to empirical data

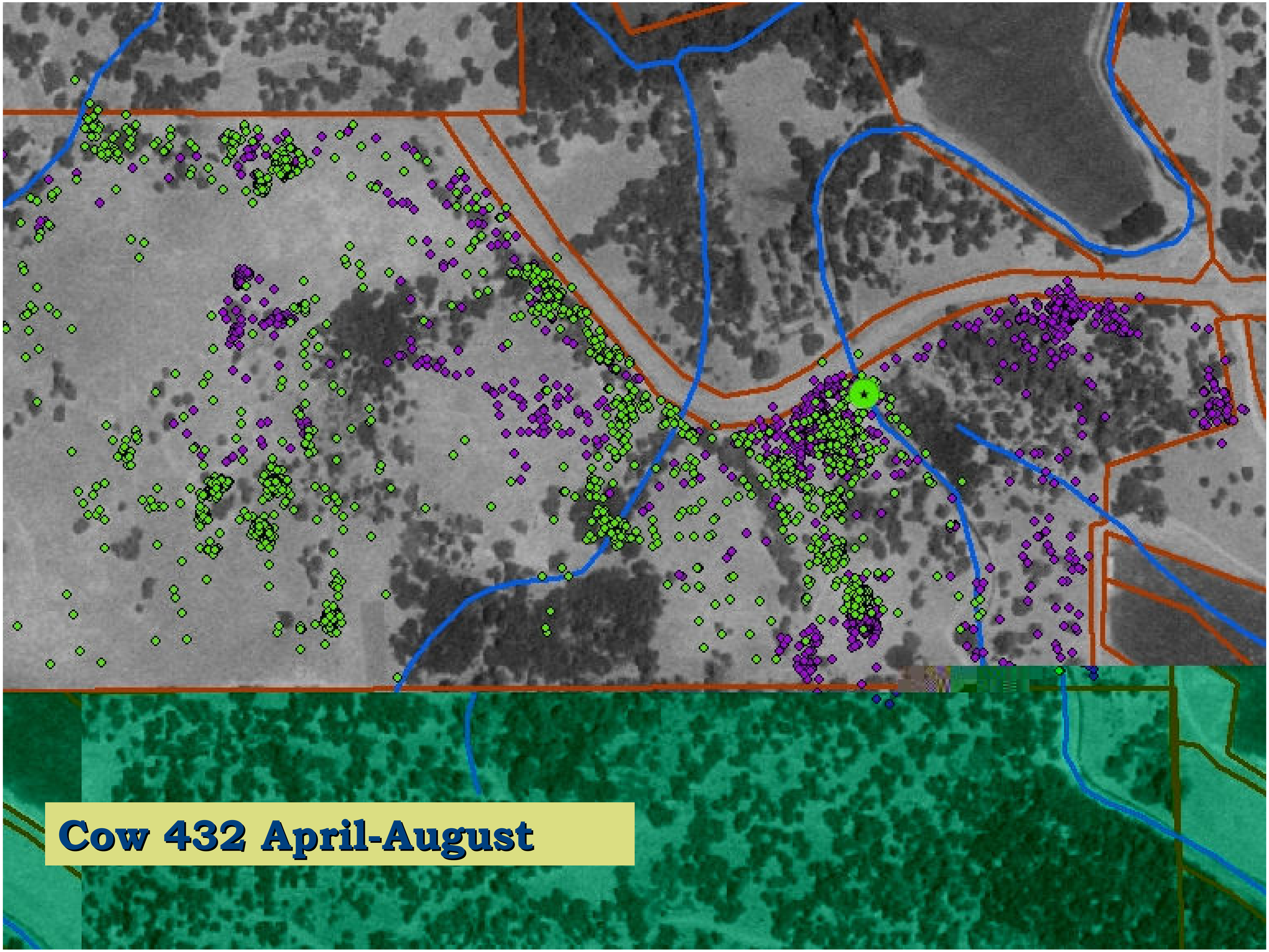
Jonsen et al. 2003

Meta Analysis Framework

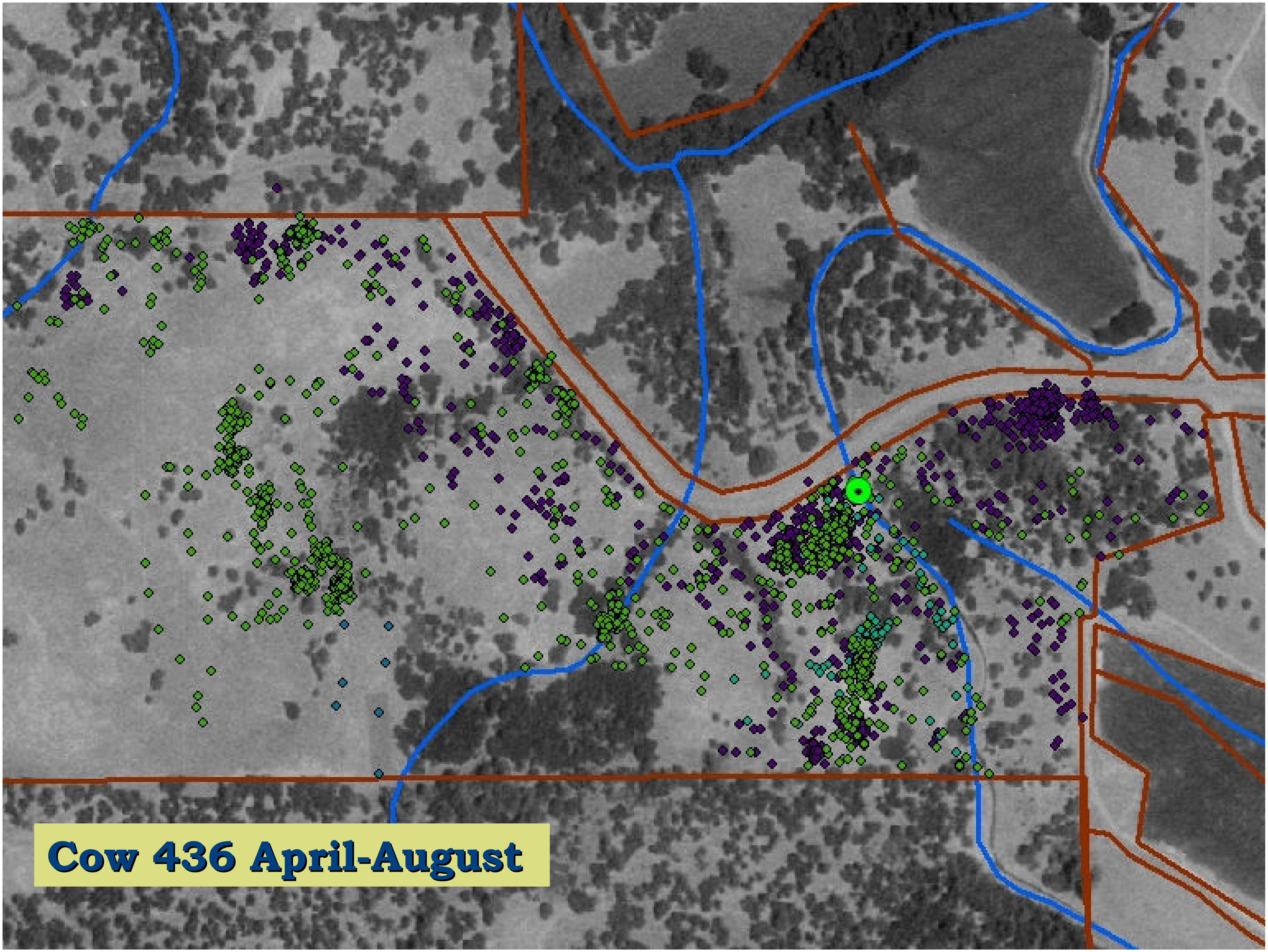
- Combining individual animal trajectory models into one population model
- Gaining population insights from individuals
- Reducing “noise”
- Connecting theoretical models to data
- Use modern techniques to predict movement



April = Green **August = Red**



Cow 432 April-August


Cow 436 April-August

- “There are interesting analogies between agricultural systems and the three pillars of physics – Newtonian Mechanics, Quantum Theory and Relativity Theory – in that some facets of agriculture are predictable (Newtonian), whereas others are relative (Relativity) and considerably less predictable (Quantum).”

Dr. Fred Provenza

Future Research

- Predicting animal movement in familiar and unfamiliar areas
- Design fencing and location of attractants by combining GIS and simulations of animal movements
- Promote utilization of previously or under-grazed areas by using operant conditioning, taste aversions, attractants, and cultural learning