Modeling Livestock Movement to Manage Landscapes

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Stephanie Larson presented work done as part of her PHD at Oregon State University on modeling livestock movement to manage landscapes. The research conducted has been referred to as “Cows in Space” and is a multi-state (California, Oregon, and Montana), USDA funded research project. The research was conducted at the Sierra Field Station in Marysville, California where vegetation data was collected over a two-year period from 2001-2003 in paired treatment areas. Two herds of twenty cows equipped with global positioning collars were programmed to take a position fix every five minutes. One pair of two pastures was grazed 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 was collected utilizing a Trimble GPS unit.

Previous research and literature has examined the movement of a variety of animals and developed models to predict these movements. This knowledge has begun being utilized for vegetation management. This research examined homogenous versus heterogeneous environments and how livestock foraging decisions vary over spatial and temporal scales. These decisions result in their specific patterns of movement across the landscape over time. Spatial behavior can be characterized by quantities such as patch size, distance between patches, and turning rates for example. Small scales of space and time successfully predict intake rates; the goal of this research is to broaden these scales to cover vast landscapes over longer periods of time.

The goal is to develop a relationship between spatial and temporal scales and when livestock begin grazing, the frequency with which they graze, the distribution of grazing, and the amount of time allocated to grazing. The spatial scale pertains to where livestock go, why they go, and what they do there. The spatial scales range from the individual bite area, to the feeding station, to the somewhat heterogeneous patch, to the feeding site, to the camp, and finally the animals’ home range. The temporal scale is also an important component of the model as foraging strategies vary through time. Daily grazing patterns are the response of livestock to environmental and internal factors. These factors include climate, geomorphologic, distance to water, vegetation, physiologic state, and animal behavior (not just livestock but also predator and manager behavior too).

The goal of the research is to develop a user-friendly model to effectively manage landscapes. Existing models can be utilized to compare the new model with and determine its effectiveness. In the end researchers hope to develop methods to apply the model to different landscapes and successfully combine ecological theory to management objectives.

The objectives of the research are to quantify and describe livestock movement, create a practical conceptual model of what guides livestock movements, develop and apply predictive models to manage livestock distribution, and to address emerging natural resource issues with a better understanding of animal movement.

Several methods were utilized to model movement including: hidden Markov models, random walks, fractal analysis, and state-space models. The Markov chain, named after Andrei Markov, is a discrete-time stochastic process. The process states that "the past is irrelevant for predicting the future given knowledge of the present" in other words things happen randomly. However, unknown or hidden parameters can be determined and utilized to predict movement. The correlated random walk method determines animal movement by three parameters; the number of steps, step size, and the distribution of random turning angles. Researchers hope to utilize these characteristics to predict vegetation utilization. The fractal analysis adds layers to the model, creating a fractal dimension that demonstrates the pattern of interaction between animal movement and landscape heterogeneity, allowing researchers to determine how vegetation affects movement. The fractal analysis also measures the sinuosity or tortuousity of animal movement versus the spatial scale, demonstrating how far animals move, and how much they turn based on vegetation and internal and external factors. Researchers examined variations in tortuousity of small path segments along the path of movement, and the correlation between tortuousities of adjacent path segments. State-space models allow researchers to build and fit empirically based movement models to data, allowing for the comparison of theoretical models to empirical data.

A meta analysis framework will be utilized to combine individual animal trajectory models into one population model; there by gaining population insights from individuals and aiding in the prediction of how the herd will act. This framework also will help to reduce "noise" or error resulting from differences between the GPS readings and actual animal movement. The meta analysis will allow theoretical models to be connected to data thereby connecting ecological range theories to actual animal movements.

Stephanie quoted Dr. Fred Provenza; "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)."

Future research will aim to predict animal movement in familiar and unfamiliar areas, help design fencing and location of attractants by combining GIS and simulations of animal movements, and promote the utilization of previously unused or under grazed areas by utilizing operant conditioning, taste aversions, attractants, and cultural learning. In sum, researchers hope to utilize the information obtained from this study to predict where animals are going to go and to use this information to better utilize landscapes and maintain rangeland health.