AG2PI SEED GRANT PROPOSAL

Title of Proposal:

GPS collars as precision agriculture tools for managing extensive rangeland production systems

Lead PI (Name, Title, Affiliation(s), email)

Dr Andrew Hess

Assistant Professor of Agriculture

University of Nevada, Reno

ahess@unr.edu

Co-PI (Name, Title, Affiliation(s), email)

Mr. Scott Huber

Assistant Director & Research Coordinator – Nevada Agricultural Experiment Station

University of Nevada, Reno

shuber@unr.edu

Collaborator (Name, Title, Affiliation, email):

Ms. Tracy Shane

PhD student of Agriculture

University of Nevada, Reno

tshane@unr.edu

Dr Robert Washington-Allen

Associate Professor of Agriculture

University of Nevada, Reno

rwashingtonallen@unr.edu

Mr. Mike Cox

Big Game Biologist

Nevada Department of Wildlife

mcox@ndow.org

Grant Administrator:

Board of Regents, NSHE, obo University of Nevada, Reno
Sponsored Projects
1664 N. Virginia Street, 204 Ross Hall / Mail Stop 325
Reno, NV 89557-0325

Contact: Jennifer Bonk, Senior Research Administrator
Telephone: (775) 784-4040
Email: ospadmin@unr.edu

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1. Objectives/aims

When evaluating extensive production systems, impacts on the ecosystem and the ability to make a return on investment must be considered. Impacts on the ecosystem include the effects of grazing livestock on the forage crops available and the effects of co-mingling events on the health of native species (Fleischner, 1994). Animals in extensive production systems are faced with many environmental challenges which may impact their ability to perform and ensure return on investment (Holechek et al., 2020), including exposure to predators, which can injure or kill them. Rearing animals that do not realize their potential comes at a great environmental cost (consuming forage crops, expelling greenhouse gases, depositing waste into waterways) relative to their commercial benefit because they do not contribute to the profit of the enterprise.

GPS collars can provide a means to address the economic and environmental costs of an extensive sheep operation by providing real-time measures of animal behavior while grazing in a rangeland environment. A major challenge to implementing routine use of GPS collars has been the per unit cost, which has limited deployment on many individuals. However, recently developed GPS units using commercial off-the-shelf (COTS) parts have demonstrated that it is feasible to collect GPS data on individuals for ~$55 per unit (Karl and Sprinkle, 2019). Cost reduction will not only make it more feasible to capture GPS data on many individuals in a research setting, but, more importantly, it will also afford the ability to capture behavioral information on more high-value individuals within a production system.

We propose to use COTS GPS units as a precision agriculture management tool in the extensive sheep production system of Nevada to:

1) Make land-use management decisions to maintain a healthy ecosystem
2) Track animal behavior
3) Develop novel trait definitions for individual performance in a rangeland landscape

The requested funds will be used to purchase 180 COTS GPS collars, which will be fitted to 180 individuals (ideally ~90 ewes and their lambs, as well as the workers and dogs), to collect individual GPS coordinates over a one-month period. The land use data collected in this study can inform workers and ranch managers about how to maintain the health of both their flock and the rangeland landscape on which the animals are grazed. This project will be used as part of a wider research effort to explore methods that incorporate precision agriculture for management and genetic improvement in extensive rangeland sheep operations.

<u>GPS collars and land-use management decisions</u>

In a rangeland sheep operation, the ability of the worker to oversee and muster the flock to locations where feed is abundant is crucial to meet the nutritional requirements of the flock and mitigate the environmental impact of grazing to the ecosystem (e.g., identify areas that have been overgrazed and need a period to recover forage). Routinely collecting data on where the sheep are grazing more frequently will allow for better land-use management. This project will use GPS coordinates collected over time to generate easy-to-interpret figures (e.g., heatmaps) and metrics that show flock grazing patterns. Future efforts can integrate these data with drone-based forage

crop cover surveys to assess the nutritional potential of a region being grazed, as well as evaluate how that fits into the context of the management plan of the operation. This will maximize the nutritional potential of the operation while mitigating the environmental impact to the ecosystem.

Sheep grazed in a rangeland environment have the potential to co-mingle with resident wild sheep populations. These co-mingling events have the potential to be devastating to the wild populations if exposed to pathogens, e.g., *Mycoplasma ovipneumoniae,* that cause high rates of mortality in wild sheep populations, such as the bighorn sheep (*Ovis canadensis*) (Cassirer et al., 2018). The ability to track the movements of domestic sheep as they graze the rangeland has the potential to reduce co-mingling events and reduce the risk of transmitting pathogens that are devastating to native wildlife species. Therefore, this project will involve a collaborative effort between the University of Nevada, Reno, and the Nevada Department of Wildlife to gain an understanding of the grazing habits of the domestic operations and wildlife populations. We will then develop a domestic sheep grazing management plan that will mutually benefit both wild and domestic populations. This fits within the newly developed and executively ordained Nevada Wildlife Connectivity Plan (Nev. Exec. Order 2021-18), which aims to identify and conserve migratory corridors of wild ungulates and other key species in the state.

GPS collars and tracking animal behavior

A favorable maternal environment for a lamb to thrive is influenced both by the ability of the ewe to provide nutritional resources for her lamb as well as her ability to keep the lamb free of threats faced on the rangeland, both environmental and predatory. In the extreme case of poor mothering ability, the ewe fails to bond with the lamb and abandons it. These lambs are costly to an operation because the lamb is likely to die without intervention. Current common practice for assessing mothering ability use arena tests to measure behavior traits in the ewe (Cloete et al., 2020), which are cumbersome to collect and may not reflect ewe performance in a rangeland environment. Collecting GPS data on both the ewe and the lamb will allow assessment of mothering ability in a rangeland environment, e.g., by measuring the proximity of the lamb to its mother. Furthermore, by tracking the movements of the workers and the dogs, we will use the timestamped GPS coordinates to develop models to identify animal behavior (e.g., rapid movement through an area), indicative of a hazard in the region, e.g., the presence of a predator.

Developing novel trait definitions for individual performance in a rangeland landscape

Traits that adequately describe performance in a rangeland environment are needed to maximize the profitability of an extensive production system while reducing environmental impact. The data collected in this study will be used to define traits that could be used to select animals better suited to the rangeland environment. Although the numbers are scant for obtaining high-confidence heritability estimates of these traits, the longitudinal nature of this study will allow for repeatability estimates to be generated, which can serve as justification for further exploring these traits in a wider study. Examples of traits defined using these data include, but are not limited to:

1) Land-use behavior traits: identifying animals that prefer grazing particular landscapes can increase the efficiency of an extensive operation while reducing the environmental impact. Land-use behavior has previously been studied in beef cattle, and genomics-based studies

have shown that there is a heritable genetic component to land use behavior (Pierce et al., 2020). Therefore, an objective of the proposed study will be to collect preliminary data exploring the genetic basis of land-use behavior in sheep. This could be used to tailor sheep grazing behavior to the rangeland landscape of the sheep operation, which can have a positive impact on the environment if it is desirable to avoid certain landscapes (e.g., wildlife protection areas).

2) Mothering ability via ewe-lamb proximity data: this trait will reduce the environmental impact of an extensive sheep production system if a positive impact on lamb survival is realized, resulting in an increase in the profitability of the operation

2. Furthering the aims of the AG2PI

A major goal of AG2PI is to gain a better understanding of how genotypes perform in different environmental conditions. The standard sheep operation in the Western United States raises sheep under range conditions, making it a key representative production system for the sheep industry in the United States. Given that a critical assessment that will be made of all livestock operations moving forward will be how sustainably the animals are raised (i.e., their environmental impact), the health of the ecosystem needs to be evaluated when considering the success of an extensive operation. Digital agriculture tools offer a means to take an in-depth look into the operations of an extensive production system where it would previously have been too cumbersome, if even possible. To successfully integrate digital agricultural tools, this project will involve collaborative efforts from experts in livestock sciences, genetics, genomics, and data sciences. Sheep are reared in an uncontrolled environment with exposure to other wildlife species; therefore, cross-kingdom research is an integral part of our efforts to address the challenges of genome to phenome (G2P) research in extensive production systems.

Success of this project will be evaluated by successful data collection from COTS GPS collars in an extensive sheep production system and, from those data, development of open-source packages to generate novel phenotypes for management or selection purposes.

3. Expected outcomes & deliverables

A major priority activity of the AG2PI is to mitigate environmental impacts from crop and livestock production. The goal will be to provide an initial in-depth look at how GPS data can be used in an extensive sheep production system, which can be used to inform a more narrowly focused but larger effort to develop this as commonplace in the industry and understand opportunities to use these data for genetic improvement.

From this project, we will develop a publicly available package for utilizing GPS data for management practices. This will allow ranch managers to identify changes that need to be made in the operation to optimize animal performance and mitigate any threats that the flock will face. The Great Basin Research and Extension Center has the unique opportunity of having three bands (each of ~1000 ewes and their lambs) that are maintained for research purposes. This provides an opportunity to assess the utility of these tools to make decisions by comparing a band with these management tools to those without.

The data collected will also provide a first look into traits that can be defined for genetic selection to improve the profitability (e.g., through increased lamb performance/survival) as well as to reduce to environmental impact (e.g., through selecting for land-use behavior) of the operation. It is anticipated that this will be expanded into a wider effort for improvement of rangeland sheep operations in the Western United States, which will involve both genetic studies using pedigree as well as genomics studies to gain a better understanding of the genetic architecture of the traits.

4. Qualifications of the project team

Andrew Hess is an animal geneticist with experience using bioinformatics and statistical methods for big data analysis. He is interested in adapting novel technologies for high-throughput and cost-effective use for genetic improvement in the livestock industry. **Scott Huber** is the Field Research Coordinator for Nevada Agriculture Experiment Stations and plays a central role organizing and managing the research conducted at the experiment stations. **Tracy Shane** is interested in technology transfer of rangeland monitoring protocols and assistance to livestock producers. To this end, she has experience using COTS GPS systems for monitoring sheep behavior. **Robert Washington-Allen** has experience in applying passive and active ground to satellite-based remote sensing and geographic information system (GIS) technologies to problems in environmental monitoring to restore or maintain the sustainability of dryland landscapes. **Mike Cox** is a big game biologist at the Nevada Department of Wildlife. He is focused on tracking the bighorn sheep populations in the state and monitoring their health status.

5. Proposal timeline

Milestone	Activity	Completion
1: Testing	Purchase and testing of GPS units	2/28/22
2: Data Collection	Lambing (March), fitting of GPS collars and transfer of animals to rangeland (April) Data collected on sheep, worker, and dog activity for one month (May)	5/31/22
3: Data Analysis	Development of package for GPD data processing and visualization for flock management (June – August) Repeatability analysis and assessment of potential use of novel traits for genomic selection (August – October)	10/31/22
4: Reporting	Report on the findings of the study	11/30/22

6. Engaging AG2P scientific communities & underrepresented groups

The findings and future directions of this project and those of its kind will be further developed by hosting a virtual field day. The results from the project will be presented at conferences and published in scientific journals.

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Scope of work

Activity/Output	Dr Hess	Mr. Huber	Ms. Shane	Dr Washington-Allen	Mr. Cox
Testing	Units will be purchased by Dr Hess and he will work with Mr. Huber on testing the units	Will be responsible for testing the purchased units and ensuring functionality when implemented in the research flock	Will provide feedback about her previous experiences for implementing the collars in the research flock		
Data Collection	Dr Hess and Mr. Huber will fit collars to sheep and monitor data collection during the trial				
Data Analysis	Dr Hess will develop an R package designed to integrate GPS and survey data for flock management and process data into individual-level phenotypes		Dr Washington-Allen and Ms. Shane will assist with the development of the R package by providing feedback on methods to process and integrate GPS and field survey into the tools		Mr. Cox will assist with the development of the R package by providing feedback on methods to integrate bighorn sheep movement data into the tools
Reporting	All collaborators will be involved in final reporting efforts				