**AGRICULTURAL RESEARCH FOUNDATION**
**FINAL REPORT**
**FUNDING CYCLE 2019 – 2021**

**TITLE:** Creating a Software Package to Launch Cattle Behavior Research

**RESEARCH LEADER:** Sergio Arispe, Oregon State University Extension Service—Malheur County, Department of Animal & Rangeland Sciences

**COOPERATORS:**
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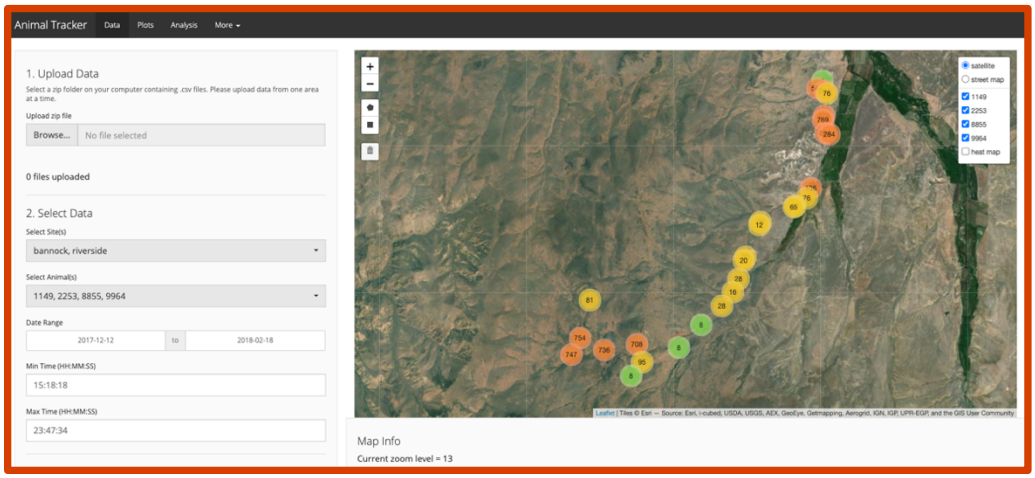


## EXECUTIVE SUMMARY

The Agricultural Research Foundation (ARF) project, *Creating a Software Package to Launch Cattle Behavior Research*, is complete after a two-year funding cycle. The research leader worked with cooperators to produce an *R* package, "*animaltracker*," published within the Comprehensive *R* Archive Network (CRAN). The *R* package is currently accessible to global users within the R community. Our research team created *animaltracker* to use a Shiny package, which is a web-based dynamic interface for cleaning, augmenting, and visualizing the GPS data. It can be accessed using Chrome, Safari, and Firefox to clean, process, and visualize data, which agreed 99.958% with peer reviewed, conventional methods. The research leader and collaborators purchased 10 GPS cow collars and collected 167,901 data points, across multiple seasons, to refine the *animaltracker* so it would be a user-friendly, functional app to launch cattle behavior research. To date, the *animaltracker* package is published in version 0.2.0. The ARF Funding equipped our team with capacity to hire two students for programming. Furthermore, it contributed to two international presentations and one undergraduate poster, through the Society for Range Management. The development of a functional *animaltracker* package allowed the research leader to secure an additional $18,500 in funding—$8,500 from the

Oregon Beef Council and $10,000 cash from a Malheur County cow-calf producer. Two publications are in the works to ensure the work is disseminated within the scientific community.

**OBJECTIVES**

Our goal is to develop an *R package* to process, analyze, and visualize GPS data to launch a research program for cattle behavior and rangeland restoration.

**PROCEDURES**

Ten new Mobile Action i-gotU GPS collars were purchased and configured to collect waypoints at a 10-minute interval. Working with the project cow-calf cooperator, the GPS collars were deployed on 10 beef cows placed on rangelands for at least two months in Malheur County, OR. After two months, the cow-calf operator and lead researcher removed the GPS collars and processed the data using @TripPC, proprietary software supplied by the manufacturer, and export data into separate files (Approximately 9,000 rows of data, recorded at 10-minute increments) in a standardized comma-separated (*.csv) file format. The data files each contained 16 fields for each measurement in time, including an identifier, date and time, geolocation (latitude, longitude, and altitude), indicators of movement (speed, course, distance), and diagnostics of satellite connectivity. Manual labeling of files added metadata, that included pasture, and an identifier for the animal. A procedure to clean the data files, initially conducted manually in spreadsheets, has been translated to an automated *R* script, providing for computation of rate of travel, geographic distances, and removal of erroneous data (e.g., geolocation outside the study area, computed speeds in excess of cow capabilities).

The ARF funding equipped our team with materials and capacity to create the *R* package, *animaltracker*, within CRAN. The product includes a Shiny package, which uses a web-based dynamic interface for cleaning, augmenting, and visualizing the GPS data. Visualizations included OpenStreetMap, allowing for user interaction to select a subset of cows and a date range of interest, with map tools to inspect individual points, select geographic areas of interest, and basic statistical summaries (e.g., elevation plots, indicators of data quality). The package was developed and deployed through a public GitHub repository, which provided broad access and high-quality debugging and issue tracking. Additional features developed within the package, include customizable statistical analyses, improved user interaction, and tools for visualizing scientifically relevant geographic data layers (e.g., slope gradients, terrain, water features). A standalone R package, which is the standard format for reusable R code is accessible to the more than 2 million global R users alongside the 10,000+ existing packages in a central repository (CRAN). Development of the package included extensive testing and debugging, implementation of procedures for error handling as potential users uploaded their own data, cross-validation with existing data sets, and thorough documentation. Datasets were compared to the same files processed by Dr. Knight who used Excel and ArcGIS.

**SIGNIFICANT ACCOMPLISHMENTS**

As a scientific software development project, *animaltracker* has been successful. The repository, available publicly at https://github.com/mathedjoe/animaltracker, includes about 617,000 lines of code, including *R* functions addressing all of the proposed objectives, and

separate interactive *R* Shiny applications for (1) processing and visualizing GPS data and (2) validating data processed by the package against externally processed data. After several months of review and efforts to ensure compliance with standards for inclusion in the central repository for R packages, the package was officially published in CRAN on March 25, 2020. The stable URL for the package is: https://cran.r-project.org/web/packages/animaltracker/index.html

The *animaltracker* package continues to undergo updates based on feedback from global users. Since publishing the package in CRAN, it has been downloaded 5,463 times according to statistics from R Studio's CRAN mirror—01/26/2021. Users have submitted 67 issues through the github repository, of which all but 12 have been resolved. The codebase includes a development branch with experimental features, and thorough documentation of all functions, external dependencies, and applications.

The user interface of the primary data processing application includes features for importing raw data in multiple formats (including a new format for Columbus GPS units), data cleaning and augmentation, and downloading via comma-separated text files. Data Visualization and dynamic data selection via Open Street maps improves usability (see Figure 1), and a separate Analysis tab of the application allows for investigation of sampling rates of GPS units, spatial distributions of individual animals, and side-by-side comparisons of elevation and speed measurements.

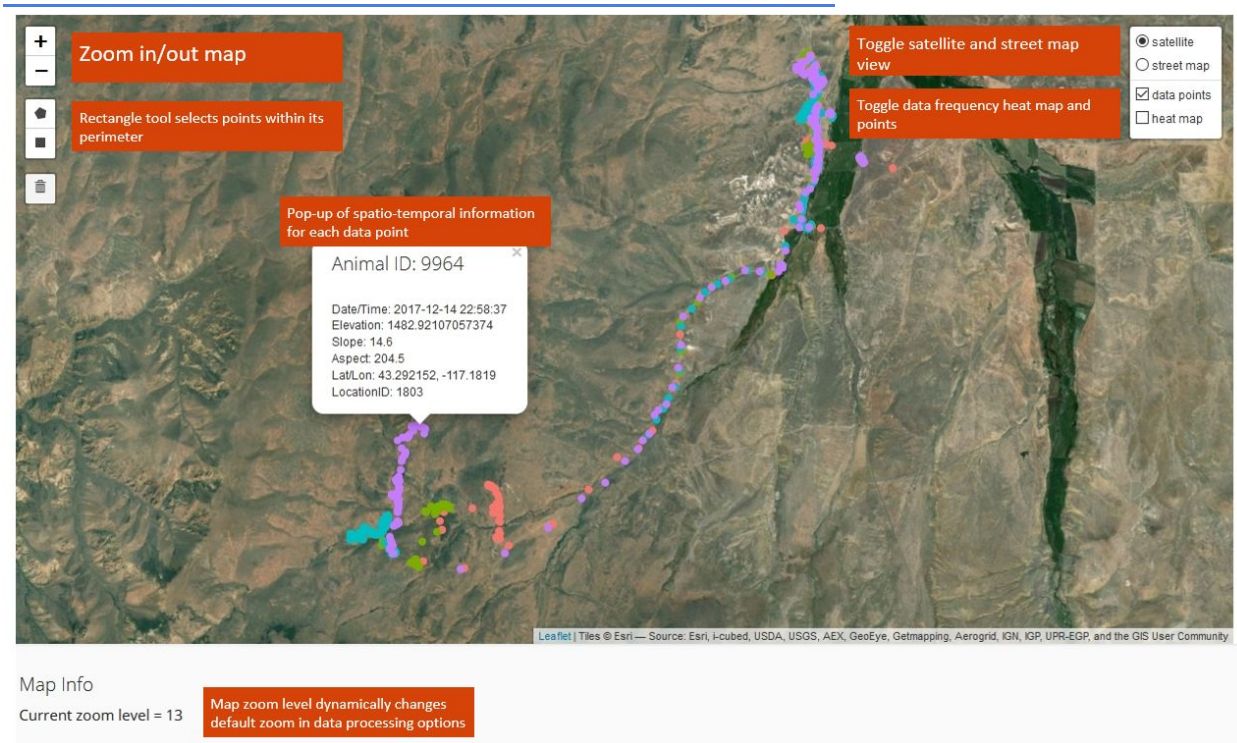


*Figure 1. Annotated Screenshot of animaltracker's Data Selection Interface*

In order to assess the validity of the automated data processing functions of *animaltracker*, Dr. Champion collaborated with Dr. Arispe and Dr. Colt Knight to cross-validate

data flagged by the applications implementation of anomaly detection procedures developed by Dr. Knight's prior research against the corresponding data from Dr. Knight's spreadsheet-based implementation of the anomaly detection. The results of the data validation analysis, which included eight data sets with a total of 167,901 spatial measurements, are provided as an addendum to this report. The main finding was, "The cleaning methods agree in 99.958% of cases, except for 6 cases (0.004%) kept by *animaltracker* but discarded by manual processing and 64 cases (0.038%) kept by manual processing but discarded by *animaltracker*." (p. 2)

**BENEFITS & IMPACT**

To date, ARF funding produced several accomplishments related to extension, scholarship, and funding. Specifically, funding allowed our team to:

- Purchase 10 GPS cow collars to refine the *animaltracker*
- Hire one computer science and one engineering student to write code, validate the App (Figure 2), and publish the package in the CRAN repository.

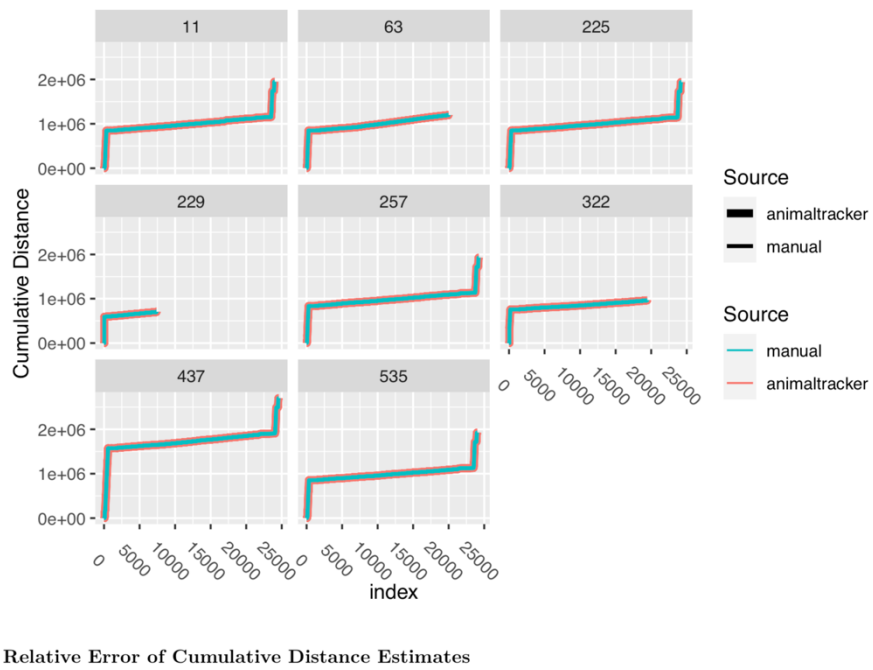


Figure 2: Animal Data Validation using data from 6 GPS cow collars. The blue lines are data cleaned by the conventional, long-hand method. The red line is candidate data processed by the *animaltracker* package.

- Obtain a second dataset with 60,000 datapoints to further refine the validation process
- 1 Invitation to speak at an international conference highlighting data processing using the *animaltracker* package—26 participants
- 1 presentation at an international conference highlighting producer acceptance of the low-cost GPS cow collar technology—26 participants
- 1 undergraduate student post at an international conference highlighting animal behavior between spring and winter seasons—"Characterizing Cattle Behavior in the Rugged Rangeland of SE Oregon Using Low-Cost GPS Collars"—Figure 3
- 3 abstracts within the proceedings of the Society for Range Management
- 5,463 *animaltracker* package downloads on CRAN between 3/25/2020 through 01/26/2021

- Used to clean and visualize data from Kazakstan
- Served as an Oregon State University Computer Science Capstone Project for three undergraduate students

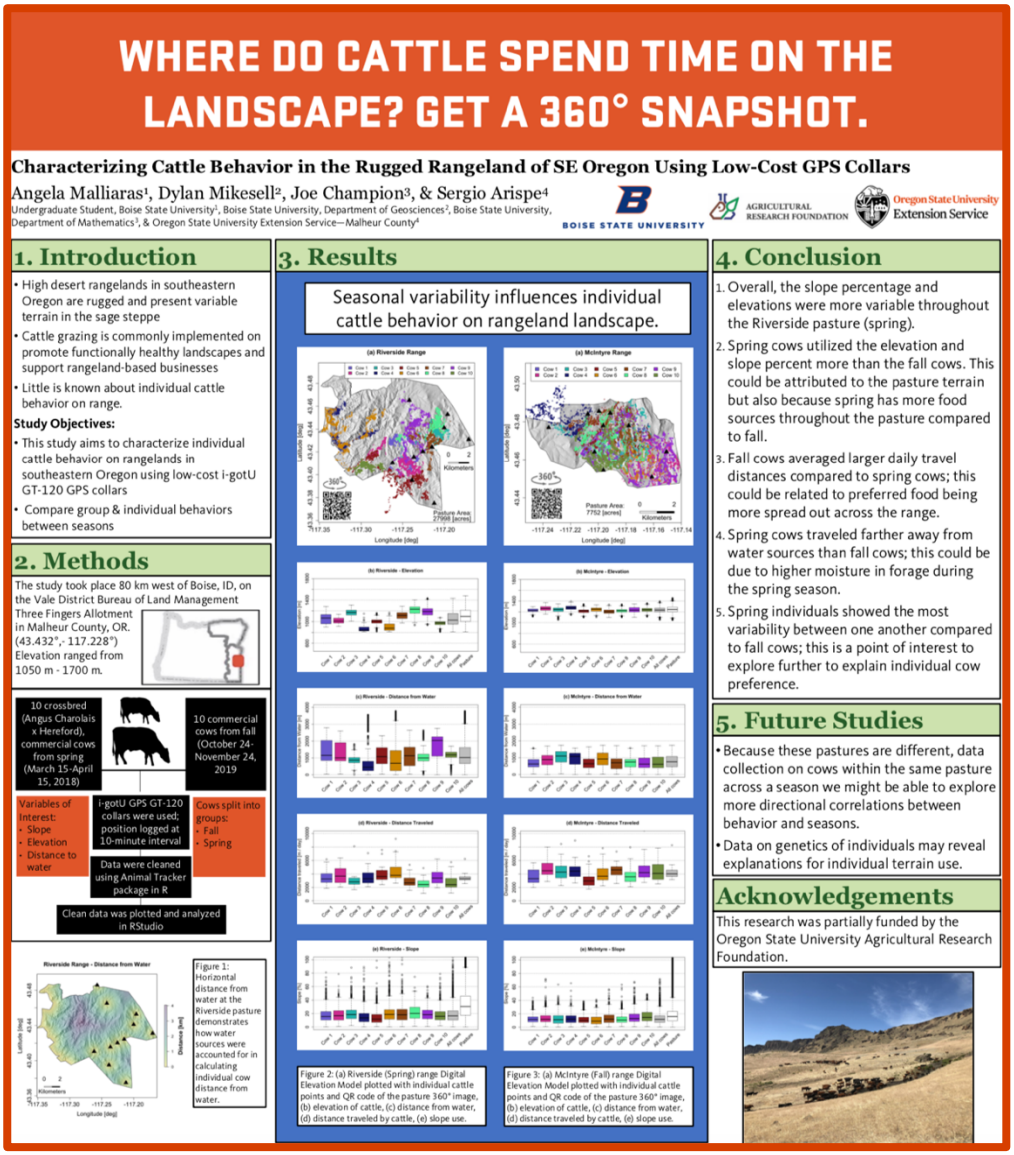


Figure 3: Undergraduate research poster resulting from ARF-funded research to launch cattle behavior research in SE Oregon.

**ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM:**

Software development is critical to launch a broader cattle behavior research program. The *animaltracker* package provided the opportunity for an additional $8,500 from the *Oregon Beef Council*, as well as an additional $10,000 cash from a local cow-calf operator. The funding will go toward monitoring cattle behavior to identify cattle disturbance remotely.

**FUTURE FUNDING POSSIBILITIES:**

All collaborators are grateful for the opportunity to conduct this research, and deeply appreciate the support of the ARF, without which the software could not have been developed with such high quality. Multiple researchers at Boise State and beyond have expressed interest in ongoing collaboration, and all collaborators are optimistic about ongoing development of the

software for scientists, wildlife and land management officials, and industry applications. Once the *animaltracker* is finalized and recognized in the literature—later this year—our team will search for funding opportunities from USDA-NIFA, NSF, and industry. Finally, our research team submitted another ARF proposal to integrate accelerometer data, which would measure behavior, that could integrate into *animaltracker* to reveal more comprehensive behavioral information.