



# The David Little Livestock Range Management Endowment

AT THE UNIVERSITY OF IDAHO

## **2018 Project Progress Report:**

### ***Development and testing of a new low-cost GPS collar system for livestock using commercial off-the-shelf parts***

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### **PRELIMINARY RESULTS for 2018:**

**BACKGROUND:** Many of today's pressing rangeland research and management questions hinge on being able to know or infer the distribution and movement of livestock. Global Positioning System (GPS) collars provide a means for gathering detailed information on livestock movements within pastures – information that could provide ranchers with knowledge and options for managing grazing to meet economic and ecological objectives.

Many studies have demonstrated the value of GPS location data for understanding grazing behavior, describing livestock use of rangelands, and quantifying livestock/wildlife interactions. However, in a quick survey of recent studies using GPS collars on cattle in rangelands, the average number of collars implemented was less than 10 per study area, and studies were often conducted on very small herds or in small study areas. To adequately describe the distribution and movement patterns of real-world-size herds of grazing animals that can be dispersed through a landscape, a much higher density of GPS collars would be needed. The limiting factor in doing this, though, is cost. While commercial collars are still prohibitively expensive, even homemade collars still cost around \$150 a piece. Even at this reduced cost, the cost of outfitting a large number of livestock with collars would be prohibitive; thus new, inexpensive GPS collars need to be developed.

Dramatic drops in cost of electronic components and the rise of modular micro-processors and sensors have created an opportunity to significantly boost the amount of location data gathered from livestock herds through low-cost, custom GPS collars.

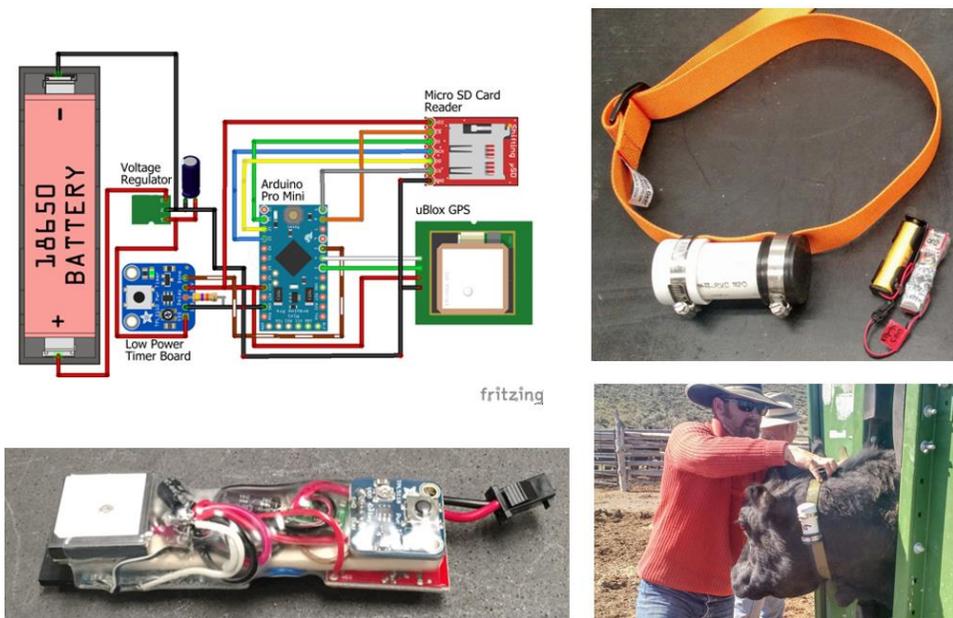
**HYPOTHESIS or OBJECTIVES:** The overarching hypothesis for this proposed work was that accurate and reliable GPS collars could be built at low cost from commercial off-the-shelf (COTS) parts and used to describe the distribution and movement of livestock grazing within an area. The main objectives of this proposed work were to build prototypes of inexpensive GPS collars, deploy them on cattle in one of the Idaho Sage Grouse and Spring Grazing project study areas in 2018, and test them against a set of existing GPS collars (provided by Dr. Jim Sprinkle). The GPS collar data collected through this work will be used initially to test three objectives:

1. Build low-cost GPS collars built from COTS parts and test their performance against a set of existing GPS collars in a field trial;
2. Compare field measures of grazing utilization collected as part of the Grouse and Grazing project (use-pattern mapping, percent grazed plants, ocular utilization estimates, and height/weight utilization estimates) to the distribution and intensity (i.e., density and duration) of livestock in the study area as measured by the GPS collars;
3. Compare livestock distribution and density over time within the study area to sage-grouse nest locations and nest success.

This progress report details the accomplishment of Objective 1. Objectives 2 and 3 are ongoing.

**PROCEDURES:** Detailed parts lists and assembly instructions for the COTS GPS devices, device firmware, description of the GPS data format, and collar construction are available at [https://github.com/jkarl/COTS\\_GPS\\_Collars](https://github.com/jkarl/COTS_GPS_Collars).

**GPS Location Tracker Construction:** The core of our COTS GPS collars is an inexpensive and readily available Arduino microcontroller (Figure 1, center of top-left panel). The Arduino handles the initiation and polling of the GPS unit and writing of the location information to a data card. To maximize battery life and control timing of GPS readings, we used a low-power timer board. The timer board passes current from the battery to the Arduino until the Arduino signals that it has completed recording GPS information. At that point, the timer board cuts off power to the Arduino and enters a sleep cycle. The duration of the sleep cycle was set to 5-minutes. The COTS GPS collars were powered by a single-cell 3.7v lithium polymer battery. Given measurements of power consumption from prototype units, we estimated that a 3,500 mAh battery would last approximately 30 days.



**Collar Construction:** The collar assembly for the COTS GPS units was made from 38mm (1.5") nylon webbing belts (1.37m [54"] long) with aluminum "ladderloc"-style buckles and 102mm (4") of 38mm (1.5") diameter polyvinyl chloride (PVC) tubing (Table 1). A fixed PVC cap was glued to one end of the tubing, and a removable neoprene rubber cap was fit over the other end. The PVC housing was secured to the nylon belt using 63.5mm (2.5") hose clamps (Figure 1).

**GPS Collar Testing:** Twenty-five COTS GPS collars were assembled and each run for 24 hours to verify proper functioning. To evaluate accuracy and precision, we placed a COTS GPS collar at a location with known coordinates and measured the displacement between the COTS GPS collar locations and the known

Figure 1. GPS Collars made from commercial off-the-shelf (COTS) parts (left, top and bottom). GPS collars were contained in PVC housing secured to a 1.5" width nylon belt (top right). Twenty-five COTS collars and 24 existing collars were deployed on a herd of 100 cows for 6 weeks in a southern Idaho study area (bottom right).

point. To test the durability and field performance of the GPS collars, we deployed the 25 COTS GPS collars along with 24 existing GPS collars from Dr. Jim Sprinkle in a study area southwest of Malta, Idaho, USA. Both collar types were set to record at 5-minute intervals. From a herd of 100 cows with calves, 49 cows were selected at random and fitted with either a COTS or Knight GPS collar. Cattle were released into a 65-ha (141-ac) holding pasture for 5 days before being turned out to a larger pasture for approximately 6 weeks.

**ACCOMPLISHMENTS or RESULTS:** Total cost including per COTS GPS collar was \$54.78. This included \$3.45 per collar in parts shipping charges (6.3% of total cost). Cost savings could have been realized by sourcing components from different suppliers or prioritizing free shipping. However, due to project timing constraints (6 weeks between when funding became available and when collars needed to be installed on cattle for the field trial), quick availability was prioritized over shipping cost. Actual costs will fluctuate over time with supplier costs and parts availability. Subsequent redesign of the collars (see below) should drop the per-unit cost down below \$45 each. Accuracy of the COTS GPS collars was equivalent to the existing collars. At 1-second intervals, average displacement from the test location for the COTS collars was ~4m. At 5-minute intervals, average displacement was ~20m.

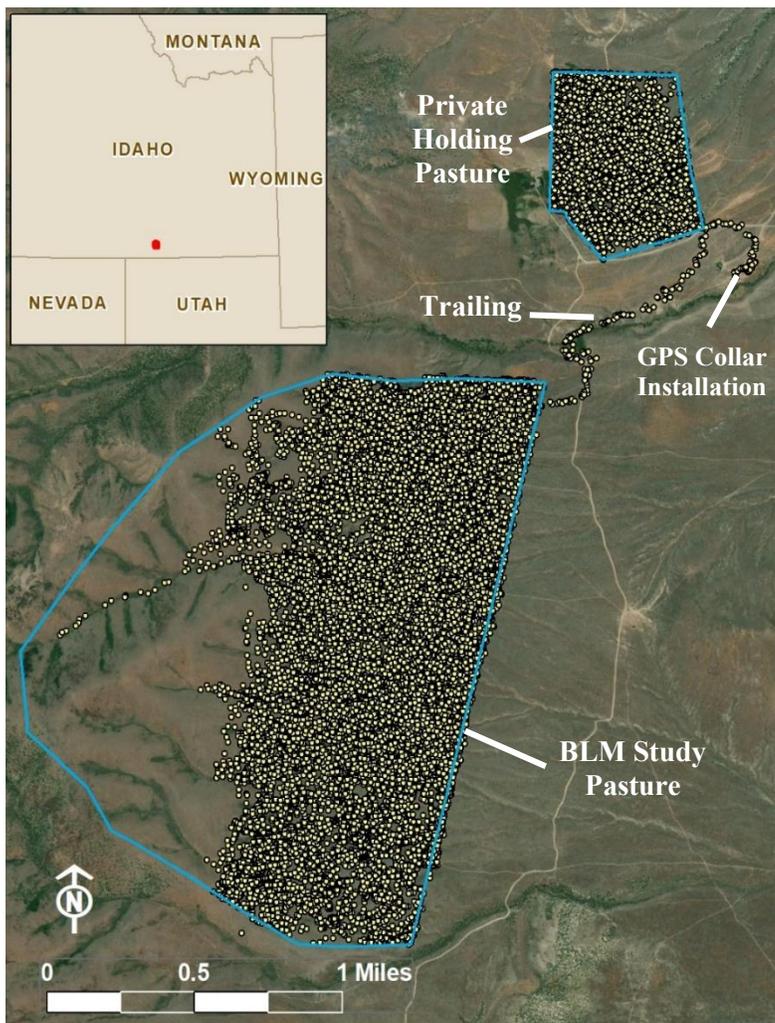


Figure 2. Livestock locations from the trial of COTS GPS collars and existing GPS collars. Study site was one of the grazing pastures for the UI Sage Grouse and Spring Grazing Study.

None of the COTS GPS collars were lost during the study, but two of the existing GPS collars were lost. At the conclusion of the study, no evidence of excessive rubbing or chafing of the COTS collars on the cows was observed. Through the trial study, a total of ~ 87,000 livestock locations were recorded (Figure 2). Notable observations from these GPS locations were: 1) livestock use was well distributed in the study area, and 2) movement patterns of individual animals did not show strong evidence of clustering or herding within the study area.

Longevity of the COTS GPS collars was mixed. During the holding pasture test, 1 of the COTS collars experienced failure of the GPS device and recorded no data. While all the remaining collars lasted through the holding pasture trial, no collars operated the full 30-day design requirement. Average lifespan of the COTS GPS device was 18 days. Several factors contributed to this shortened lifespan. In several devices, inconsistent grounding caused by faulty soldering or wiring caused inconsistent performance. In five devices, packaging of the GPS device in the collar led to an exposed reset button becoming depressed when the collar was jostled (e.g., when the cows walked). This had the effect of interrupting GPS fixes, causing loss of data and shortening the interval between GPS readings causing the battery to deplete faster.

While not perfect, we considered the outcomes of this first trial to be a limited success. Using information from the trial, we were able to redesign the COTS GPS collars to minimize or eliminate many of the problems encountered during the first year. One significant change for 2019 is the use of a custom-printed circuit board to reduce wire/solder connections that were a point of weakness (Figure 3). In the redesign we were also able to eliminate the timer board and several other components and shift the power management to the microcontroller. This simplifies the system, reduces cost, and allows for more sophisticated GPS management. For 2019, we plan to deploy GPS collars at four new study sites (50 collars at each site; 200 collars total). Production of GPS units for 2019 has begun.

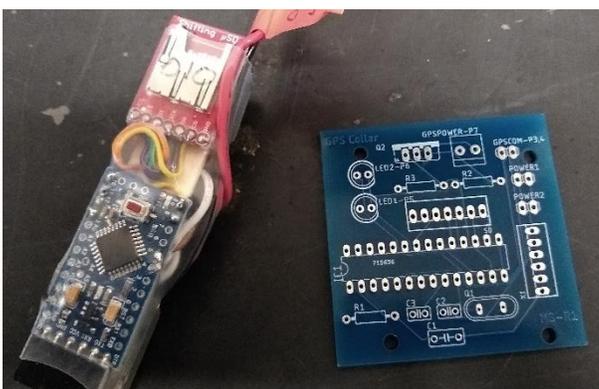


Figure 3. Custom circuit board for redesigned GPS collars (right) compared to 2018 COTS GPS Collar (left). Custom circuit board will remove most of the wire connections and exposed reset button that were a point of weakness in the original design.

**PUBLICATIONS or OUTPUTS:** The results of this study have been described in a manuscript in preparation to submit to *Rangeland Ecology & Management* (Karl, J.W. and J.E. Sprinkle. *In prep.* A livestock GPS collar from commercial off-the-shelf parts: technical note. *Rangeland Ecology & Management*). Additionally, the GPS collar design and preliminary results were key to receiving a NRCS Conservation Innovation Grant for \$661,000 for using livestock GPS collars to tie field measures of utilization to satellite models of seasonal biomass change. This new NRCS funding will assist in addressing Objectives 2 and 3 of this project. The NRCS-CIG grant, in particular the livestock GPS collars, were featured in a UI Press release and appeared in several regional newspapers and radio shows.