2013 LTER Training Workshop Final Report
Remote Data Acquisition Sensor Training Workshop

Dates: June 16-22, 2013
Location: UNM Sevilleta Field Station

Proposers: Renee F. Brown and Donald O. Natvig,
Department of Biology, University of New Mexico

Summary:
This training workshop focused on several topics involved with the remote acquisition of environmental data typical of LTER sites. Areas covered included basic electronics, photovoltaic power systems, Wi-Fi networking and telemetry systems, sensor theory, and Campbell Scientific datalogger wiring and programming. We employed a combination of field demonstrations, lectures, hands-on activities, and discussions to illustrate these concepts. Participants included a diverse group of graduate students, technicians, post-doctoral associates, and faculty members in need of hands-on experience in these areas.

Goals:
The main objectives of this training workshop were to provide participants with a comprehensive and affordable introduction to the major aspects of field-based data acquisition with an emphasis on hands-on learning. No other formal training of this nature is currently available to scientists working in environmental fields. As a result, scientists are often faced with a steep learning curve when first faced with the installation and management of sensors and associated instrumentation. Our goal was to present theory and practice as well as to provide a forum for participants to share alternative approaches, successes, and failures.

Immediate Outcomes:
We had a total of 23 applications and 18 participants. While we accepted all applications as they arrived, 5 applicants were unable to attend due to either lack of funding as a result of government sequestration, finding another job, fieldwork conflict, inability to come up with registration fee, or inability to obtain a visa. As a result, we trained 11 field technicians, 2 graduate students, 1 postdoctoral associate, 1 early career faculty member, and 3 other research professionals. Of these, 9 participants represented 7 LTER sites (JRN, HFR&HBR, MCM, NWT, SEV, SGS), while the remaining participants represented a variety of institutions, including 3 from the US Forest Service. Participant names and affiliations are listed with the group photo at the end of this report.

All participants were required to fund their travel to the Sevilleta Field Station. Additionally, each participant was charged a $500 registration fee in order to defray the

costs of running the workshop, which included catering, equipment costs, and vehicle use for airport shuttles and field trips.

As shown in the agenda presented below, we provided five days of intense training and discussion. While we did not perform a post-workshop survey, we received numerous unsolicited comments from participants that were universally positive. Most of these comments were verbal, but we have listed a couple of the written comments we received post-workshop:

Thank you both so much for all the time and effort you put into bringing this workshop together! I learned an incredible amount of information in the last week. I am confident now that I know enough about RDA to figure out what we didn't learn as it becomes necessary or relevant to my work. The two of you did a phenomenal job this week.

Just wanted to say thanks for organizing and presenting the wireless workshop this past week. I felt everything was well planned and organized. I found most all the sessions to be quite useful, even those which reviewed skills I had already used extensively in the past. You covered a lot of material in one week - nice job.

Longer-term Outcomes:
We have set up a mailing list (rda2013@sevilleta.unm.edu) to facilitate and promote further discussion among participants and instructors on the topics we covered in the training workshop.

The success of this and other sensor-oriented LTER training workshops over the past three years have indicated the need for further resources on these topics. This led to the organization of the SensorNIS Working Group at the 2012 LTER All Scientists Meeting; a collaborative effort initiated by several LTER affiliated personnel, including Renee Brown, for the purposes of developing resources to aide the environmental sensor user community. The SensorNIS team has been actively developing an online Sensor Best Practices resource guide and wiki that will include topics related to all aspects of using environmental sensors, from field deployments to data management. The team regularly meets via WebEx conference calls and occasionally in person 1-4x per month. The Sensor Best Practices online resource guide and wiki is expected to go live by December 2013.

Budget:
Based on the outcome of the 2012 RDA workshop, we originally requested $29,810 to fund travel expenses, meals, and lodging for all participants and instructors in addition to Sevilleta Field Station facility and vehicle use fees. This funding would have also provided additional equipment needed for hands-on exercises.

Instead, we were awarded only $5090, the bulk of which went to funding lodging at the Sevilleta Field Station for the 18 participants and 2 instructors ($4,400.00). The remainder of the funds went towards Sevilleta Field Station facility fees ($630).

Additional Support:
Funds received through registration fees covered the purchase of Wi-Fi radios, antennas, and other miscellaneous equipment, shuttle transportation to and from the Albuquerque International Sunport, and use of field trip vehicles.

The Sevilleta Field Station provided staff logistical support for meals, snacks, and laboratory setup. Moreover, an award from the Field Station and Marine Laboratories program at NSF allowed us to purchase new computers and furniture for a training classroom in which most of the workshop activities took place. These upgrades sped up computer exercises, improved transitions across workshop sections, helped with workshop preparation logistics and increased participant comfort.

The Sevilleta LTER loaned additional sensors and other miscellaneous equipment for use during training exercises.

The equipment purchased for this and last year's workshop by LNO and Sevilleta Field Station funds is stored in the SERF Electronics Laboratory at the Sevilleta Field Station in anticipation of offering similar training workshops on a regular basis.

Agenda:

Sunday, June 16, 2013

12:00 – 6:00 PM	Arrivals
6:30 – 7:30 PM	**Opening Remarks, Introductions, & Overview Presentation** (*SERF, Room 203*)
7:30 –	BBQ & Social Mixer (*Patio*)

Monday, June 17, 2013

7:30 – 8:00 AM	Breakfast (*Patio*)
8:00 – 6:00 PM	**Field Trip I** (*Depart from Main Parking Lot*)**:**
8:45 – 9:45 AM	- Meteorological Station: Deep Well - Nighttime Warming Experiment

10:15 – 11:00 AM - Extreme Drought in Grasslands Experiment: Blue Grama
- Los Piños Mountains Wireless Backhaul

11:30 – 1:00 PM - Piñon-Juniper Rainfall Manipulation Experiment
Guest speaker: Rob Pangle, Postdoctoral Associate
- Boxed Lunches

1:45 – 2:15 PM - New Mexico Upland Flux Network: Piñon-Juniper Control
Guest speaker: Skyler Hackley, Field Technician

3:45 – 4:15 PM - Middle Rio Grande Flux Network: Bosque del Apache
Guest speaker: Jim Thibault, Field Technician

4:45 – 5:30 PM - Socorro, NM Grocery Supply Run

6:30 – Dinner (*Patio*)

Tuesday, June 18, 2013

7:45 – 8:30 AM Breakfast (*Patio*)

8:30 – 12:00 PM **Basic Electronics** (*SERF, Room 206*)**:**
- Low voltage DC systems
- Introductory circuit theory
- Ohm's Law & Watt's Law
- Multimeter skills for checking and troubleshooting circuits
- *Hands-on exercise: using a multimeter to measure voltage, current, resistance, and continuity*

12:00 – 1:00 PM Lunch (*Patio*)

1:00 – 6:00 PM **Photovoltaic Systems** (*SERF, Room 206*)**:**
- Components of photovoltaic systems: solar panels, charge controllers, batteries, wiring, inverters, fuses, & grounding
- Solar panel mounting: construction options & tilt angles
- Sizing photovoltaic systems
- *Hands-on exercise: using MS Excel to calculate power budgets and size photovoltaic systems*

6:30 – Dinner (*Patio*)

Wednesday, June 19, 2013

7:45 – 8:30 AM Breakfast (*Patio*)

8:30 – 12:00 PM **Wi-Fi Telemetry Systems** (*SERF, Room 206*)**:**

- Antenna fundamentals: gain, frequency, directionality, polarization, cabling, line-of-sight (LOS), and Fresnel zones
- Tools for designing physical telemetry network infrastructure: LOS calculators, topographic maps, GPS devices, and ground truthing
- *Hands-on exercise: using online tools to calculate LOS*
- Wi-Fi radio fundamentals: 802.11 protocols, access points (AP), clients, bandwidth, frequency, channels, interference, security, and advanced features
- Lightning protection and grounding

12:00 – 1:00 PM Lunch (*Patio*)

1:00 – 6:00 PM **Wi-Fi Telemetry Systems** (*SERF, Room 206*)**:**

- Fundamentals of Internet Protocol (IP) networking: IP address, gateway, subnet mask, domain name server (DNS), public vs. private networks, network address translation (NAT), static vs. dynamic (DHCP) addressing, and routing
- Ethernet cabling: types, tools for making and testing
- *Hands-on exercise: making Ethernet cables*
- *Hands-on exercise: configuring AP and client Wi-Fi radios to create classroom network*
- *Hands-on exercise: testing and troubleshooting Wi-Fi networks using ping and speed tests*

6:30 – Dinner (*Patio*)

Thursday, June 20, 2013

7:45 – 8:30 AM Breakfast (*Patio*)

8:30 – 11:50 AM **Dataloggers, Sensors, and Software** (*SERF, Room 206*)**:**

- Introduction to the Campbell Scientific CR1000 datalogger
- Sensors: types, measurement, Campbell vs. non-Campbell, specifications, extending, field installation, and labeling
- Other data acquisition equipment: multiplexers, wiring, conduit, enclosures, hardware, and tools
- Wiring planners and documentation
- *Hands-on exercise: using MS Excel to develop a wiring plan*

12:00 – 1:00 PM Lunch (*Patio*)

1:00 – 6:00 PM **Datalogger Programming** (*SERF, Room 206*)**:**

- Introduction to LoggerNet 4.1
- Components of a typical datalogger program: variable declarations, data tables, subroutines, main program
- Programming fundamentals: data types, conditional statements, repetition using for loops
- Style and readability: comments, indentation, and spacing
- *Hands-on exercise: using LoggerNet to setup and connect to a CR1000 datalogger*
- *Hands-on exercise: programming for control*
- *Hands-on exercise: write a program to measure and collect data from temperature and soil moisture sensors*

6:30 – Group Photo & Dinner (*Patio*)

Friday, June 21, 2013

7:30 – 8:00 AM Breakfast (*Patio*)

8:00 – 10:15 AM **Field Trip II** (*Depart from Main Parking Lot*)**:**

8:45 – 9:45 AM
- Monsoon Rainfall Manipulation Experiment
- Extreme Drought in Grasslands Experiment: Black Grama

10:30 – 12:00 PM **Data Acquisition and Management** (*SERF, Room 206*)**:**
- Overview of Sevilleta LTER data acquisition system
- Overview of SensorNIS initiative

12:00 – 1:00 PM Lunch (*Patio*)

1:00 – 4:00 PM **Data Acquisition and Management** (*SERF, Room 206*)**:**
- Using serial-to-ethernet converters to provide real-time data access: configuration, Campbell vs. non-Campbell
- *Hands-on exercise: configuring Campbell NL200 serial-to-ethernet converters and connecting all classroom CR1000s to classroom Wi-Fi network we set up on Wednesday*
- Software tools for data management and visualization

4:00 – 5:00 PM **Group Discussion & Final Remarks** (*SERF, Room 203*)

5:30 – 8:00 PM Dinner at Socorro Springs Brewing Company in Socorro, NM

Saturday, June 22, 2013

5:30 – 8:30 AM Departures

2013 RDA Sensor Training Workshop Participants (from left): Brian Godbois (Harvard Forest LTER & Hubbard Brook LTER), Manuel Minwary (UC Natural Reserve System), Hillary Buchanan (Niwot Ridge LTER), Branko Zdravkovic (University of Saskatchewan Global Institute for Water Security), Anne Axel (Marshall University), John Anderson (Jornada Basin LTER), Melissa Johnston (Shortgrass Steppe LTER), Robert Pangle (Sevilleta LTER), Renee Brown (Instructor, Sevilleta LTER), Carrie Dorrance (USDA USFS Marcell Experimental Forest), Colin Duffy (Shale Hills CZO), Nathan Schoepp (UC San Diego), Elle Plato (UW Madison), Christopher Cassidy (USDA USFS Northern Research Station), Kyle Cronin (McMurdo Dry Valleys LTER), Robert Evans (USDA USFS Bartlett Experimental Forest & Howland Research Forest), Michelle Mattocks (Jornada Basin LTER), Ben Specter (Sevilleta LTER), Roxanne Chepsongol (Jornada Basin LTER), Don Natvig (Instructor, Sevilleta LTER)