Aquatic and Riparian Effectiveness Monitoring Program
Stream and Air Temperature Monitoring Report
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Introduction

The Aquatic and Riparian Effectiveness Monitoring Program (AREMP) began a partnership in 2011 with the US Forest Service (USFS) Pacific Northwest Regional Office, Bureau of Land Management (BLM) Oregon State Office (OSO), and US Geologic Survey (USGS) Forest Rangeland and Ecosystem Science Center to monitor year-round instream and air temperatures in watersheds throughout the Northwest Forest Plan Area in Oregon and Washington. The purpose of this ongoing partnership is to provide baseline year round air and stream temperature data to climate scientists, aquatic ecologists, fish biologists, and hydrologists to help determine the sensitivity of stream temperature to climate change. AREMP receives more requests for temperature data than for any other data collected.

AREMP temperature data is shared with the USFS Rocky Mountain Research Station (RMRS) as part of the NorWeST regional stream temperature project (Isaak et al 2011). The NorWeST project gathers existing full year stream temperature data from federal government, state, tribal and private sources from across the Northwest to develop spatially explicit stream network models for climate change scenarios. Outputs from these models are available on the NorWeST website for use by biologists, hydrologists, and researchers to better understand thermal impacts on aquatic species and to help prioritize conservation efforts (http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html).

Methods

AREMP field crews consisting of BLM employees and Student Conservation Association (SCA) interns have calibrated, deployed and downloaded instream and air temperature sensors for the last three field seasons (2011-2013). Crews placed sensors instream, directly next to the stream (stream-side), and at an upslope location 300 ft to 700 ft (91 m to 214 m) in elevation above the stream-side sensor. Solar radiation shields were used for instream (fig.1) and air temperature monitoring stations (fig. 2) to minimize the impact of direct sunlight on temperature data.

Figure 1— Stream temperature sensors were housed in PVC pipes to prevent direct solar radiation. (Photo by Alanna Wong.)

Figure 2—Student Conservation Association Intern Julie O'Neil downloads data from an air temperature sensor housed in a thermal shield. (Photo by Steve Lanigan).

Based on 2012 field season results, we learned that the method used to secure instream sensors did not work in some stream types for year-round deployment. Approximately 30% of the 2012 instream temperature sensors checked were lost during the winter due to high flows, tampered with or vandalized, or just simply not relocated because different technicians deployed the devices. To minimize loss and examine additional sensor deployment techniques we partnered with Dan Isaak from the RMRS for a small-scale experiment during the 2013 field season. In areas where sensors were lost due to flow, we tested an additional sensor type and sensor deployment methods. Two different sensor attachment methods were tested; using epoxy to attach sensors to boulders and zip ties to attach sensors to large wood in the stream channel. In streams where the epoxy method was employed, we used both Onset HOBO sensors along with Onset Tidbit sensors. The Tidbit sensor solar shields and epoxy for this experiment were provided by Dan Isaak.

We attached 26 temperature sensors to boulders using epoxy (fig. 3). In eight watersheds, two instream sensors were deployed; one sensor was secured with epoxy and an additional sensor using cable. We were unable to fully test each method simultaneously at each site since both large boulders or large wood are needed. In 2014, we will assess these experimental thermograph deployments. We will determine whether epoxy or cable is a better attachment method for securing temperature sensors in certain stream types.

Figure 3—Student Conservation Association Intern Julie O'Neil uses epoxy to attach a temperature sensor inside a PVC solar shield to a boulder to assess the effectiveness of sensor deployment methods. (Photos by Steve Lanigan).

Results

Temperature sensors were deployed in the Northwest Forest Plan area on USFS, BLM, and National Park Service Lands in Oregon and Washington (fig. 4). AREMP is currently monitoring a network of 144 instream sensors and 231 air sensors (table 1). In 2013, crews visited 102 watersheds to download or deploy temperature data from instream sensors (table 2). Crews also replaced sensors lost over the winter. Of the current AREMP instream temperature sensors, 63% have logged temperatures for one year or longer (table 3). Four of these sensors were lost during one winter, so here data are not continuous. A smaller percentage of sensors checked in 2013 (8%) have logged temperatures for two years or more.

Crews also downloaded and deployed stream side and upslope air temperature sensors in the 102 watersheds that were visited during the 2013field season. Air temperature sensors had lower loss rates; 6% for stream-side thermographs and 7% for upslope air sensors. Of these sensors, more than half (54%) have been logging temperatures for one year or longer. These low loss rates were likely an artifact of re-employing the same seasonal employees from the prior field season who deployed the air sensors. We anticipate this number will increase during the 2014 field season if new seasonal employees are hired.

Table 1—Number of watersheds instrumented with instream water temperature, and stream-side and upslope air temperature sensors by state as of November 2013

	Instream (water)	Stream-side (air)	Upslope (air)
Oregon	101	77	76
Washington	43	39	39
Total	144	116	115

Table 2—Total number of watersheds visited to deploy and download instream water temperature sensors, and stream-side and upslope air temperature sensors by year. Variation in number of watersheds visited per year was due to crew size

	Instream (water)			Stream-side (air)			Upslope (air)		
	2011	2012	2013	2011	2012	2013	2011	2012	2013
Deployed	80	44	26	24	73	18	24	66	17
Downloaded	0	77	49	0	21	72	0	24	74
Replaced	0	33	27	0	5	6	0	0	7
Total	80	123	102	24	97	96	24	90	98

Table 3—Number of months sensors have logged temperatures since initial deployment

Months of data	Instream (water)	Stream-side (air)	Upslope (air)
0-6	31	26	24
6-12	23	26	32
12-24	78	56	54
24+	12	7	5

Lessons Learned

More accurate GPS locations for sensors would help increase relocation rates. We currently use recreational grade GPS units with an accuracy of 100 ft. (30m) whereas survey grade units have an accuracy of 3 ft. (1m).This is a significant difference in accuracy when attempting to locate a small temperature sensors in a stream. Further, we have found it difficult to enter these data into the regional FS Natural Resource Manager (NRM) temperature database due to the inaccuracy of GPS coordinates. GPS points do not always accurately reflect the USGS National Hydrology Dataset (NHD) GIS layers used by NRM which creates ambiguity in temperature sensor locations. For example, if the GPS point falls between a tributary and the mainstem of a river, we would not have enough information to identify the correct location. The problem of relocating air temperature sensors is even more difficult since they are not associated with a stream. Upslope air temperature sensors are placed at a location approximately 300 ft from the instream sensor. They are

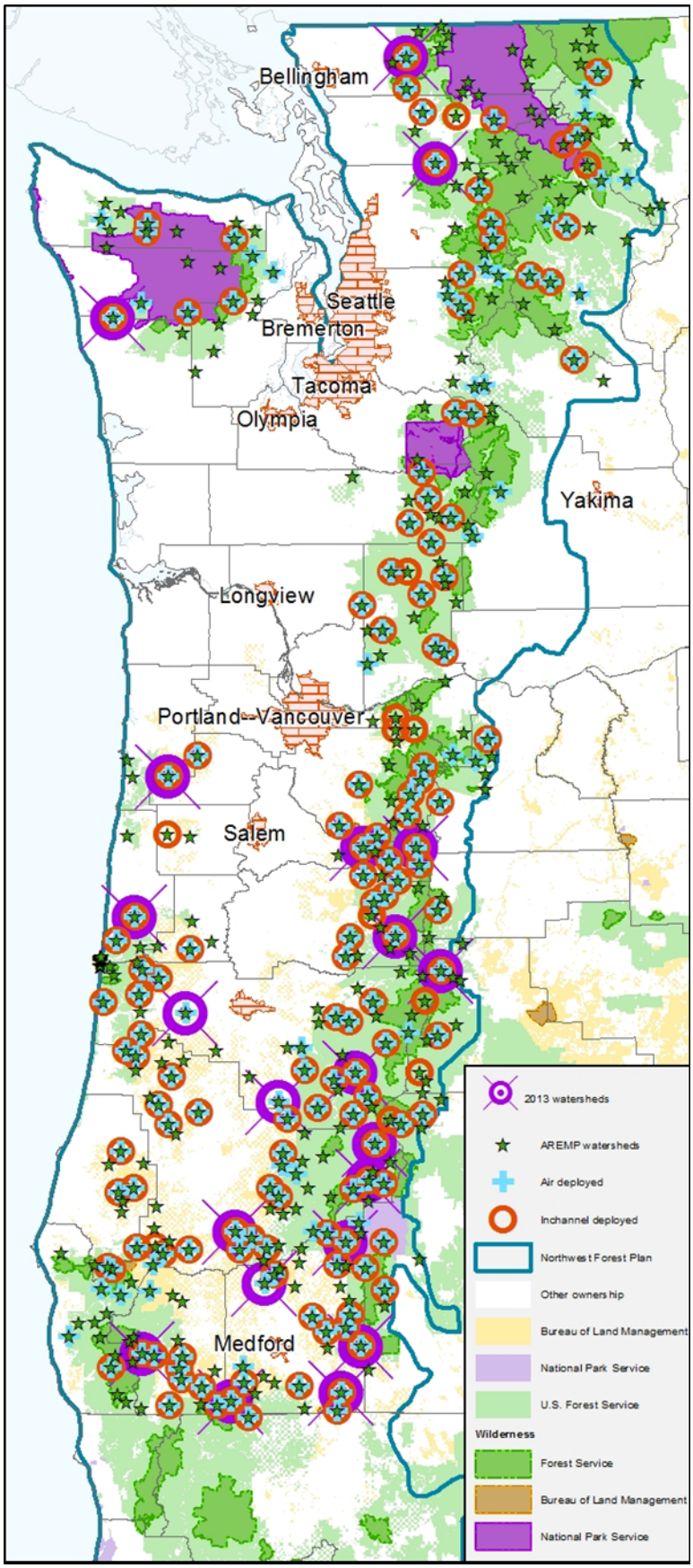

Figure 4*—Location of instream and air sensors placed by Aquatic and Riparian Effectiveness Monitoring Program (AREMP) crews in the Northwest Forest Plan area of Oregon and Washington. The purple bull's eye represent watersheds surveyed for stream condition by AREMP in 2013. The green star represents all of the 192 AREMP watersheds being surveyed to determine stream condition status and trend in Oregon and Washington. The blue plus designates AREMP watersheds with a stream-side and upslope air sensor. The red circle depicts AREMP watersheds with an instream sensor. Current as of November 6, 2013. (Map courtesy of Steve Wilcox.)*

placed as to not encourage vandalism but still retain the ability for different crew members to locate the unit at a later date. The majority of the loss we incur from upslope sensors is the inability of later crews to relocate the unit. We strongly suggest additional funding of $6,000 to upgrade to the survey grade GPS units (two units at $3,000 each).

Figure 5—Temperature sensors can be difficult to relocate without consistent staffing and accurate GPS locations, particularly when checked once a year or at longer intervals. This air sensor was covered by moss that fell from a tree, but was more easily relocated because the technician that initially deployed it also downloaded the data. (Photo by Alanna Wong).

After three seasons of temperature sensor deployments, it is clear there is a strong need for continuity in staffing for the thermograph crew. Sensors are difficult to relocate due to their small size and a need for very accurate GPS locations (fig 5). Since our current staff consists of seasonal employees, we were lucky to have seasonals on AREMP field crews for multiple field seasons. One way to mitigate this is to hire a year-round term (GS-6) field coordinator to oversee this project. The field coordinator would be responsible for winter planning and summer field work. Benefits of hiring a year-round field coordinator include:

- Staff continuity to relocate sensors since the same individual will deploy and download sensors.
- The field coordinator will work towards the ultimate goal of having local hydrologists and/or fish biologists permanently take over the long term maintenance of sensors located on their units and upload data to the regional NRM temperature database by:
  - ◊ Making more consistent contact with local Forest Service and Bureau of Land Management districts to share data and determine the feasibility of having local units maintain sensors.
  - ◊ Development of a database with contact information for hydrologists and biologists who could be contacted yearly to deploy, download and/or retrieve thermographs on their local units.
  - ◊ Work with local units to ensure all temperature data is downloaded into a regional database.
  - ◊ The advantages of local units downloading sensors are that sensors would be checked more frequently, consistency in staffing to find the sensors which are deployed for multiple years, and sensors are in place and would not have to be purchased by local units.
- More time for logistics and planning in the off season to maximize time spent during the field season for downloading sensors rather than spending extra time in the office calibrating sensors and planning for trips.
- Improve consistency of data collection.
- More time for QAQC of data as it is collected rather than waiting until the end of the field season and having individuals who did not collect the data collate it for reporting purposes.

- A person to upload data to the NRM stream temperature monitoring database.
- AREMP personnel are currently streamlining this process by assigning a single point in each watershed for sensor locations. Once this is accomplished, it will be easier to upload data to the regional database. including development of mobile GIS application that can connect data deployments directly into corporate databases
- Help develop and improve data collection applications for field computers which will help prevent data entry errors by incorporating error checking as the data is collected in the field. The mobile application currently in development (Service First Mobile GIS Oregon Washington) can be used by local units for data collection.

Future Considerations

There are 48 remaining AREMP watersheds that need to be instrumented with temperature sensors. Two of those watersheds were inaccessible due to road construction. Fifteen of those watersheds reside in wilderness areas which require permits to install sensors. After discussions with FS Regional Office and BLM Climate Change Lead, it was decided not to instrument these wilderness watersheds with sensors due to the lengthy process associated with obtaining permits and the additional time required to backpack into these watersheds. Instrumenting the remaining 31 watersheds is a priority for the 2014 field season.

Literature Cited

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