Aquatic and Riparian Effectiveness Monitoring Program

Interagency Monitoring Program – Northwest Forest Plan Area

2012 Annual Report

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January 2013

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Executive Summary

Steve Lanigan

The Aquatic and Riparian Effectiveness Monitoring Program (AREMP) is a "Service First" program consisting of USDA Forest Service (FS) and USDI Bureau of Land Management (BLM) employees working together to evaluate if the Northwest Forest Plan's (NWFP) Aquatic Conservation Strategy is maintaining and restoring watershed condition within the NWFP area. The NWFP provides management direction for 24 million acres of federal lands in western Washington and Oregon, and northern California. We are proud to share the following highlights of AREMP accomplishments during the 2012 fiscal year with you.

15-Year Evaluation of Watershed Condition

The 15-year assessment of watershed status and trend results was published in 2012. Key findings included:

- The majority of watersheds in the NWFP area had a positive change in condition trend score between 1994 to 2008.
    - Most of the larger positive changes were driven by both improvements in road (decommissioning) and vegetation (natural growth) scores.
- The greatest negative score changes were caused by the loss of large trees due to the Biscuit Fire and other fires along the eastern side of the Cascades.

Successful field season

We successfully sampled streams in 28 watersheds spread throughout the NWFP area.

- Collected stream data from 176 stream sites to measure physical and biological attributes used to assess watershed condition as part of our field sampling program.
- Continued our quality control program by resurveying 18 sites, to detect watershed condition trends.
- Continued to survey for aquatic invasive species as part of our stream condition surveys.

Support to Local Units

We assisted with several GIS analyses to provide tools for use by local FS/BLM specialists. We also provided an array of "value added" survey and monitoring services for BLM and FS units.

Cassie Whiteside

As one of several "value added efforts," we provided crews to help the BLM Roseburg District aquatic specialists map changes in substrate after they placed log jams in Little Wolf Creek.

Support to local units (which they funded) included:

- Surveyed streams and provided maps for stream restoration work.
- Conducted an aquatic organism passage study at replaced culvert sites.
- Deployed temperature sensors to establish an air and water temperature network.
- Measured stream shade to validate the RAPID shade assessment model.

Management review

We completed a Senior Management Group (SMG – this group is composed of directors from various federal agencies who provide direction to NWFP monitoring programs) review to determine if any changes were warranted in our stream survey program

- Several sample design changes for surveying stream reaches were considered, but the decision was made to stay with our current design.
- Per the SMG's direction, we are exploring how to use data collected by Oregon Department of Fish and Wildlife status and trend monitoring program for the Oregon coast area.
- Per the SMG's direction, we are analyzing our data to determine if stream survey data should be evaluated differently in high and low gradient streams.
- We compared watershed condition scores from the national FS watershed condition class assessment to AREMP scores and prepared a white paper discussing the differences between the two programs.

Sharing stream survey data with other agencies

We continued our participation in the Pacific Northwest Aquatic Monitoring Partnership (PNAMP) by participating in Lower Columbia River Endangered Species Act salmon recovery area workshops where state and federal agencies are proposing to use a master sample design to determine sampling sites, establish common protocols, and share data for habitat status and trend monitoring.

Emma Garner

This may take awhile... Stream surveyors measured the size of wood and counted the number of wood jams throughout each surveyed stream reach.

Introduction

Steve Lanigan

This report tells the story of our NWFP monitoring efforts and support to local units in fiscal year 2012 (October 2011 - September 2012). The NWFP, a management strategy applied to 24 million acres of federal land in the Pacific Northwest (fig. 1), was approved in 1994. The NWFP includes an Aquatic Conservation Strategy that requires the protection, restoration, and monitoring of aquatic ecosystems under the NWFP's jurisdiction (USDA-USDI 1994). AREMP was developed to fulfill the monitoring component of the strategy.

During 2012, AREMP staff worked toward or accomplished several key objectives. A complete discussion of each of these accomplishments is provided in subsequent sections. Updates are also provided for budget and personnel required to accomplish the tasks assigned to the monitoring program. The overall objectives of AREMP include:

- Assessing the condition of aquatic, riparian, and upslope ecosystems;
- Developing ecosystem management decision support models to refine indicator interpretation;
- Developing predictive models to improve the use of monitoring data;
- Providing information for adaptive management by analyzing trends in watershed condition and identifying elements that result in poor watershed condition; and
- Providing a framework for adaptive monitoring at the regional scale (Reeves et al. 2004).

Monitoring is conducted at the subwatershed scale (US Geologic Survey 6th-field hydrologic unit code [HUC]). These subwatersheds (hereafter referred to as "watersheds") are approximately 10,000 to 40,000 acres in size.

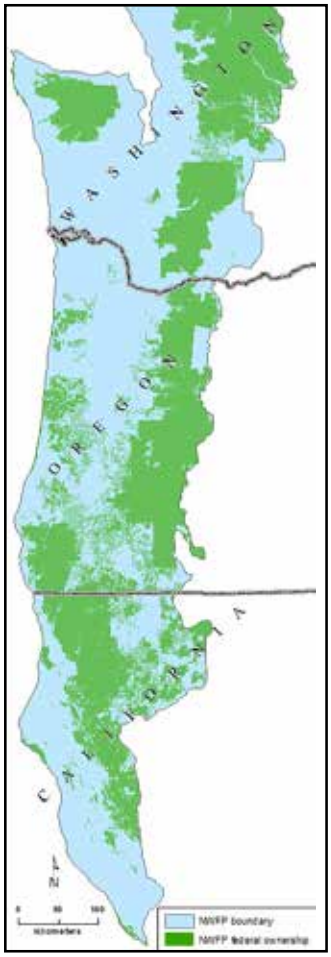

Figure 1. Northwest Forest Plan (NWFP) area and federal lands being evaluated for watershed condition.

Accomplishments

Steve Lanigan

15-Year Evaluation of Watershed Condition

The 15-year assessment of watershed condition status and trend was published as a General Technical Report in February 2012 (Lanigan et al. 2012). We evaluated the federal land portion of every 6th-field watershed with at least 25% federal (FS, BLM, and National Park Service) ownership along the total length of the stream - over 1370 watersheds! Status (fig. 2) and trend (fig. 3) maps were created for both aquatic provinces and for land allocations (e.g., matrix, late-successional old growth, Congressional reserves), based on the results of the decision-support models we developed with local specialists input. Watershed condition status and trend was also determined for key watersheds (where the emphasis is on restoration and protection).

The majority of watersheds had a positive change in condition scores (fig. 4), indicating that watershed condition improved. Of those with larger positive changes, most were driven by both improvements in road (decommissioning) and vegetation (natural growth) scores. The greatest negative score changes were caused by the Biscuit Fire and other fires along the eastern side of the Cascades due to the loss of large trees. Half of the fire-impacted watersheds were in Congressional reserves, 35 percent in late-successional reserves, and 15 percent in matrix (lands identified for timber production).

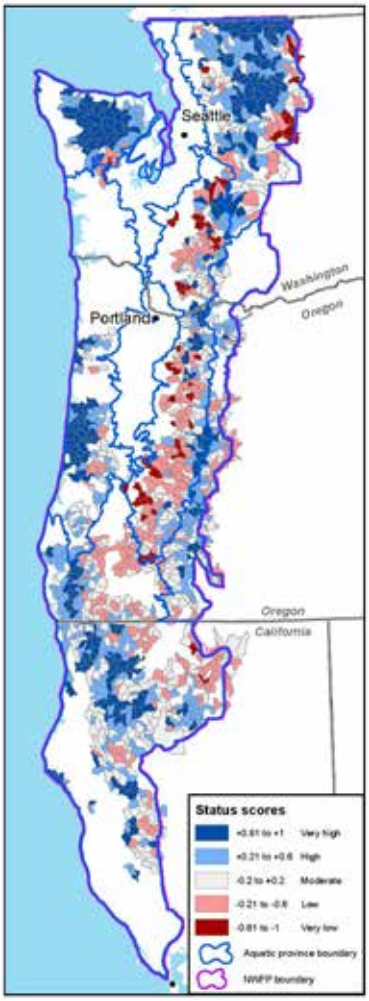

Figure 2. Watershed condition status scores in 2008, as determined from geographic information system and remote sensing data. NWFP – Northwest Forest Plan.

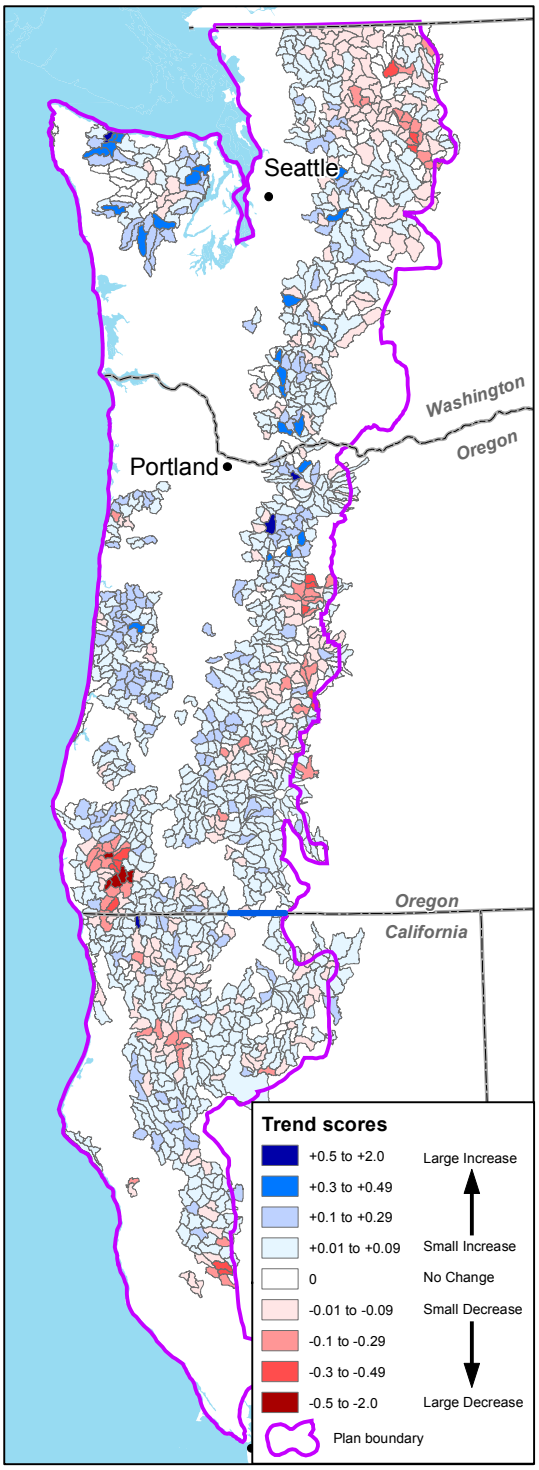

Figure 3. Watershed condition trend scores (change in status scores from 1994 to 2008) in the Northwest Forest Plan (NWFP) area, as determined from geographic information system data and remote sensing data.

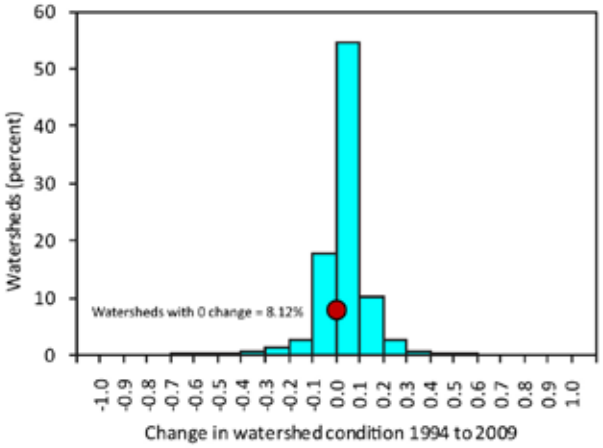

Figure 4. Distribution of changes in watershed condition scores between 1994 and 2008 (the red dot indicates watersheds with no change, 112 watersheds).

Stream Status and Trend Field Sampling

One hundred seventy six stream sites within 28 watersheds spread throughout the NWFP area were sampled during 2012 (fig. 5; app. A). These watersheds were sequentially sampled from the subset of the 250 watersheds originally selected for monitoring the NWFP. The 250 watersheds were selected at random using a generalized random tessellation sampling design, which guarantees a spatially balanced sample (Reeves et. al. 2004, Stevens and Olsen 2003, 2004). Eighteen sites were resurveyed as part of our quality control program.

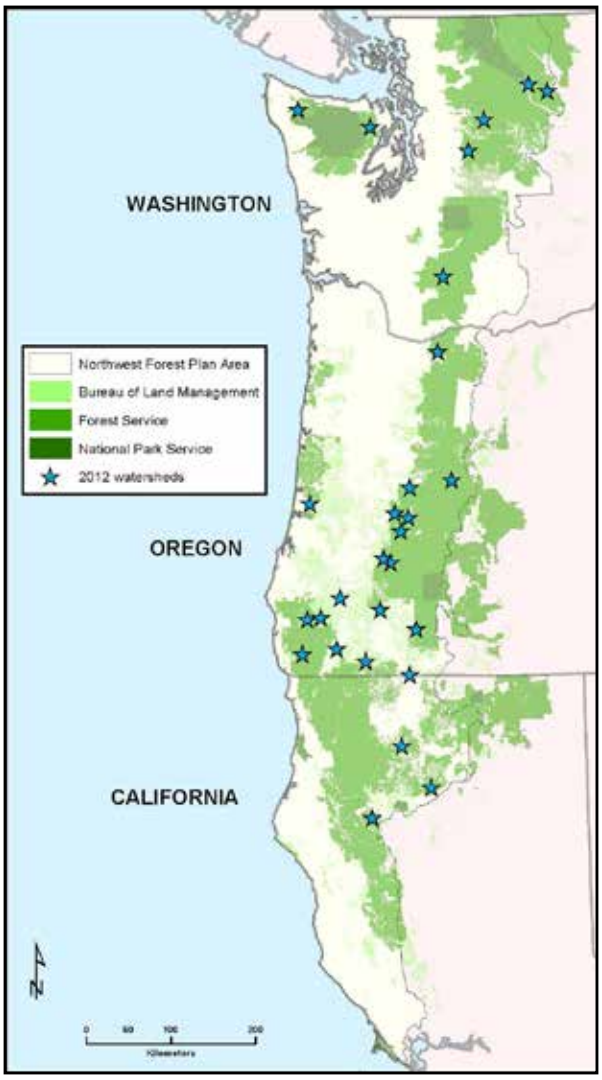

Figure 5. Map of the watersheds surveyed during the 2012 field season.

Protocol changes

There were four changes to the field sampling protocol this year:

1. We changed our large wood measurements.

    - We changed the minimum diameter criteria for large wood from 0.3 m to 0.15 m. This change was made for two main reasons: 1) local unit specialists were interested in looking at smaller wood (largely due to consultation and thinning questions) and 2) to be more consistent with other monitoring groups who are part of the Pacific Northwest Aquatic Monitoring Partnership integrated status and trend monitoring project.

    - We dropped wood location and submerged wood as attributes. In the past, these data were collected to be consistent with Oregon Department of Fish and Wildlife (ODFW) habitat surveys; however ODFW no longer measures these attributes.

2. We added the following aquatic invasive species to our list for 2012 per recommendation from the FS Region 6 Invasive Species Coordinator: bullfrog (*Rana cotesbeiana*), northern crayfish

Steve Lanigan

Stream survey crews used laser levels to map stream profiles.

(*Oronectes neglectus*, nutria (*Myocaster coypus*), variable-leaf milfoil (*M. heterophyllum*), yellow floating heart (*Nymphoides peltata*), giant salvina (*Salvinia molesta*), flowering rush (*Butomus umbellatus*), kudzu (*Pueraria lobata*), common reed (*Phragmites austalis*), curly-leaf pondweed (*Potomogeton crispus*), cultivated knotweed (*Polygonum polystachyum*), and salt cedar (*Tamarisk ramosissima*).

3. We started using Laser GIS software with a digital compass and laser to measure stream channel morphology rather than SurveyPro software. Laser GIS streamlined data collection because 1) it is more "user friendly" and it reduced training time and 2) back sighting was no longer necessary which saved time during the survey. However, this change does require an update to the calculation code and we will be working with a database specialist to make these changes.

Aquatic invasive species surveys

AREMP field crews participated in the sixth year of a regional survey effort to locate aquatic invasive species on federal lands (Raggon and Lanigan 2012). These surveys were funded by the FS Pacific Northwest Region (Region 6 - R6) Invasive Species Program and incorporated into our normal stream surveys. Protocols developed by Oregon State University Sea Grant College Program personnel were used to survey for 34 aquatic/terrestrial plants and animals identified as primary threats to northwest watersheds. Among the key species included were: New Zealand mudsnails (*Potamopyrgus antipodarum*), zebra mussels (*Dreissena polymorpha*), quagga mussels (*D. rostriformis bugensis*), yellow flag iris (*Iris pseudacorus*), kudzu (*Pueraria lobata*), fearl swine (*Sus scrofa*), nutria (*Myocaster coypus*), red swamp crayfish (*Procambarus clarkia*), ringed crayfish (*Orconectes neglectus*), rusty crayfish (*O. rusticus*) and northern crayfish (*O. virilis*).

Documentation and in-the-field training on species identification, data collection, and reporting were provided to AREMP field coordinators and field crews by personnel from the Oregon State University Sea Grant Program. The field protocols were the same as those used in 2008 - 2011.

In 2012, AREMP crew's recorded a total of 10 invasive detections. Nine of the 10 detections were of Himalayan [Armenian] blackberry (*Rubus armeniacus*). The other invasive aquatic species detected was the ringed crayfish (fig. 6) at the West Fork Trail Creek watershed (a tributary to the Rogue River upstream of Shady Cove). All 10 of the detections occurred in Oregon; none occurred in Washington or California.

Travis Hussey

Figure 6. This bad boy, the invasive ringed crayfish (*Orconectes neglectus*), was found in a tributary to the Rogue River upstream of Shady Cove, Oregon.

Quality assessment program

The monitoring program's Quality Assessment Program (QAP) includes several components. The data manager and GIS Analyst inspected data for errors (both correctable and non-correctable) and relayed mistakes back to the field crews to prevent further errors in data collection. Quality assessment information was also used to identify needed improvements in protocol training for the next field season.

During each field season, a subset of randomly selected watersheds are revisited (two stream sites in each watershed). Revisits generally occur within a few weeks of the initial site visit, and the survey is always performed by a crew (fig. 7) that differed from the previous visit. This allows us to compare the reliability of our measurements. Results from an extensive analysis of the QAP will be released in 2013. In short, the field attributes differ in the ability to detect status, trend, or both. Certain attributes such as dissolved oxygen were

Travis Neal

Figure 7. Crews resurveyed stream attributes to determine the reliability of their measurements.

not being measured consistently by different crews and were therefore dropped from the field surveys. Other attributes, such as gradient, are measured precisely so no change is recommended for this protocol. Appendix B presents an overview of the reliability of each attribute calculated as the linear relationship between the initial survey and the quality control survey.

We updated our ACCESS database in 2011 to an ArcGIS spatial database engine (SDE) to better integrate the spatial and tabular data collected by AREMP. Along with the update, we developed code for field data collection that will allow us to identify and correct errors in the field and easily import the data into our database. We are currently working with a database expert at Oregon State University and our decision support specialist to transfer, review, and update the calculation code from the old ACCESS database into our new SDE platform. This will reduce calculation errors, increase flexibility to update code as models are reevaluated, and create more efficient and transparent attribute calculations.

Stream condition trend analysis

In 2010, we began revisiting watersheds where streams were originally sampled in 2002. Currently, we have three years of repeated data that will eventually allow us to determine trend in stream condition. While most attributes were collected and uploaded into our SDE database by the end of a field season, some attributes such as water temperature and macroinvertebrate identification will take additional time to process and summarize. As we work to collate data and incorporate them into the SDE database, we are also reevaluating and updating the models we use to reflect the most accurate and current available science. We are also taking the results from our QAP analysis to reweight attributes based on the measurement reliability. For example, we are reducing the influence of amphibian presence since this is our most unreliable attribute.

Assisting Local Units

As FS, BLM, FS Pacific Northwest Research Station (PNW), and USDI Geological Services Forest Rangeland and Ecosystem Science Center (USGS FRESC) specialists have become aware of the high quality of AREMP crews and the products we produce, we have been funded at both the local and regional level to provide an array of "value-added" survey and monitoring services. Because we are a "Service First" organization, we were able to use both BLM and FS funds and have a very low (10%) overhead.

Value-added surveys were done with crews funded by the programs requesting our help. Value-added crews were also staffed independently from our core stream condition status and trend survey crews. Our support to local units usually consisted of conducting surveys/monitoring efforts when local units did not have the time needed to hire, train, and supervise crews for relatively short term survey or monitoring projects. The FS Region 6 Regional Office and BLM State Office also funded AREMP crews to collect data for regional projects. We also conducted several GIS analyses to assist local unit hydrologists and fish biologists. The following describe in more detail our support to local units. The agency/unit (s) that provided funds or in-kind support is shown in parentheses.

Surveying streams and providing maps for stream restoration work (Partner: Roseburg District BLM)

We continued to assist the Roseburg BLM District fisheries and hydrology staff with effectiveness monitoring, following a 2009 aquatic enhancement project, by mapping in-stream channel configuration so that geomorphic change could be assessed through time (fig. 8). Mapped habitat features included different types of substrate bar classifications (distinguished from unsorted bedload material), wood (both natural and placed), boulder weir structures, exposed bedrock sheets, and information about existing pools. In 2009, four sites in the Wolf Creek watershed (a tributary to the Umpqua River) totaling approximately 5000 feet were intensively mapped (on the order of 1 point per foot of stream length) in order to capture the existing channel and habitat features. These four sites were re-surveyed in the fall of 2012 to document changes in channel and habitat features and evaluate the effectiveness of the restoration project to recruit substrates conducive to spawning salmonids.

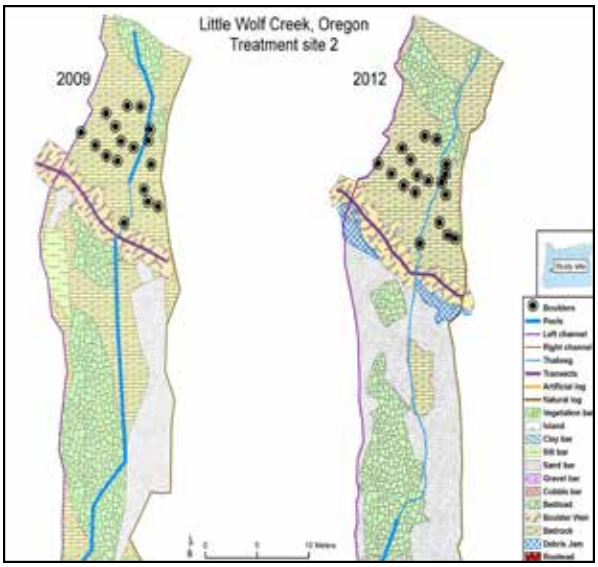

Figure 8. Detailed site maps we produced are being used by BLM district specialists to help plan and monitor stream channel restoration projects.

Aquatic organism passage study (Partners: FS-Region 6 Natural Resources and Engineering, BLM, USGS FRESC, and PNW)

We partnered with the FS Region 6, BLM Oregon State Office, PNW and USGS FRESC to conduct a 2012 pilot study to evaluate methods to monitor the effectiveness of aquatic organism passage (AOP) restoration (i.e., replaced culverts). Field work occurred on the Siuslaw National Forest. Two independent field efforts used separate methods to collect data about different biological responses to AOP crossings: individual movement and occupancy. The movement of individual fish implanted with passive integrated transponder (PIT) tags was monitored for five months at four AOP crossings. Each AOP crossing location was instrumented with stationary antennae that recorded data on fish movement through the crossing. Additional individual movement data was collected every two weeks using portable backpack antennae (fig. 9). The occupancy field effort completed 521 surveys associated with 103 culverts on the forest. Crews completed 79 mark-recapture surveys that will enable quantitative statements about the probability of capture to be made, and then as a result, the probability of occupancy and abundance of each species. Final data products and methods recommendations will be completed in 2013.

Jared Blake

Figure 9. AREMP employees electrofishing at an aquatic organism passage study site to determine fish movement.

Air and water temperature network (Partners: FS Region 6 and BLM Oregon State Office climate change programs)

In 2011 and 2012, we received funding from the FS R6 Regional Office and BLM Oregon State Office to monitor year-round instream and air temperatures (fig. 10) in watersheds throughout the NWFP Area in Oregon and Washington (Andersen 2012a). The purpose of this ongoing partnership is to provide baseline temperature data to climate scientists, aquatic ecologists, fish biologists, and hydrologists to help predict the sensitivity of streams to climate change, as well as, for use in our watershed condition model. Temperature sensor locations are also provided to the FS Rocky Mountain Research Station as part of an on-going project to map stream temperature sensor locations throughout the United States (http://www.fs.fed.us/rm/boise/AWAE/projects/stream_temperature.shtml).

Alanna Wong

Figure 10. Thermographs at each stream site were placed in the stream, directly next to the stream (this picture shows how they were located inside a solar shield), and at an upslope location.

Shade measurements (Partners: Siskyou National Forest and FS-R6 NR)

AREMP staff continued a partnership with FS hydrologists to expand the spatial extent of a "rapid shade model" developed for stream shade assessments. The model was originally developed for the Siskiyou National Forest, and then expanded to the entire NWFP area by Chris Park (Siskiyou NF hydrologist). The model uses gradient nearest neighbor (GNN) vegetation data (Ohmann and Gregory 2002) and 10 meter digital elevation models to determine current shade conditions (fig. 11) and site potential tree height to determine

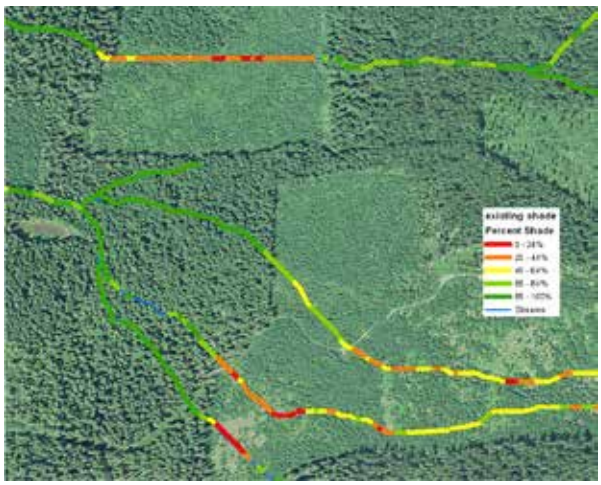

Figure 11. Existing shade results from the RAPID shade model. The model uses 10 meter digital elevation maps to create a steam layer and then estimates existing shade based on gradient nearest neighbor (GNN) vegetation data .

target shade conditions. It then compares current to potential shade to look for possible thinning and planting opportunities. AREMP survey crews collected stream shade measurements in over 144 watersheds during the past five years to validate the model. A subset of these data, from the Willamette National Forest, was used by our GIS Analyst to revise and increase the model efficiency. Our model validation is nearly complete and we hope to make the model available for use throughout the NWFP area in 2013.

Management review

The Senior Management Group, comprised of executives from federal agencies participating in the NWFP, requested a review of AREMP to determine if any changes were warranted in our stream survey program. The following describe the decisions made for each option (in bold) the SMG asked us to examine.

Evaluate different sampling designs

Change the sampling density of watersheds sampled in each aquatic province— Because stream condition results are reported by land management type, and not by aquatic province, it was decided that there was nothing to be gained by making this change.

Sample managed watersheds only—It would be possible to limit our stream surveys to only those watersheds with "management activities," e.g., harvest, fire rehabilitation, restoration activities. However, we determined that 73% of our surveyed watersheds do have management activities. Climate change specialist and researchers all strongly recommended continuing our current sampling of managed and unmanaged watersheds because otherwise we would lose our ability to compare managed to reference watersheds, and it would become impossible to determine if changes are due to climate change or other regional/global changes. No change was done.

Evaluate at smaller scales (land use allocations vs Forest Plan scale)—It was decided to maintain the current number of sampled watersheds so that inference could be made at both the NWFP area and land use allocations scales. If decreased funding necessitates having fewer crews, it was agreed that the number of sampled watersheds would decrease in order to maintain an eight year sampling cycle. It was acknowledged that a large decrease in sampled watersheds would likely result in being able to make inferences only at the NFWP area scale, and would reduce our overall precision to estimate watershed condition at the land use allocation scale.

Sample fewer sites within watersheds so that more watersheds could be sampled—An earlier review by Gaeuman et al., 2009) concluded that "given existing resources, probably little is to be gained in reallocating sampling effort to arrange an incremental increase in the number of watersheds surveyed. The simulations carried out in this study consistently show that such modifications yield only very modest increases in power that are unlikely to justify the additional costs that would in any case arise in visiting more watersheds." Therefore, no change was made.

Emphasize sampling low gradient reaches—Gradient constraints were added to several stream attributes in the decision support models used to assess stream condition for our 15-year status and trend report. Workshop participants told us they either did not think it was appropriate to use some attributes in high gradient streams or they were not sure what the evaluation criteria should be.

We asked ten monitoring experts and scientists from different state and federal agencies for their opinion on which attributes should be collected in high gradient streams. Their responses (fig. 12) varied from "continue surveying everything" to "survey only residual pool depth and amphibians." Given the lack

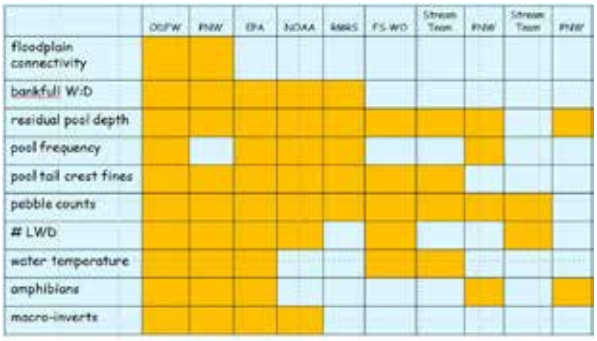

Figure 12. Responses we received from different state and federal agency monitoring experts when we asked the question, "which stream attributes should be sampled in high gradient streams?" Colored squares show which attributes the agency experts recommended. ODFW = Oregon Department of Fish and Wildlife, PWN = US Forest Service Pacific Northwest Research Station, EPA = Environmental Protection Agency, NOAA = National Oceanic and Atmospheric Administration, RMRS = US Forest Service Rocky Mountain Research Station, Stream Team = US Forest Service Stream Systems Technology Center, FS-WO = US Forest Service Washington Office.

of consensus, we are using a multivariate ordination technique using AREMP data to determine whether gradient constraints are appropriate.

Sharing stream survey data with other agencies

Several status and trend stream habitat monitoring programs exist within the Pacific Northwest. All differ, sometimes only slightly, in sample frames, the attributes measured, and the protocols used. Programs that use a probabilistic survey design (such as AREMP) that overlap in their sample frames have a unique opportunity to share data between programs. Several assumptions must be realized before data sharing can be implemented including individual metrics between organizations must be the same or built on a strong predictive relationship. A comprehensive synthesis of each groups sample design, frame, protocol, and individual metrics is currently being collated by the Pacific Northwest Aquatic Monitoring Partnership Integrated Status and Trend Monitoring Project. We are conducting a case study, to determine if ODFW and AREMP can share data within the coastal Oregon province (fig. 13). We expect results of this project to be completed in 2013.

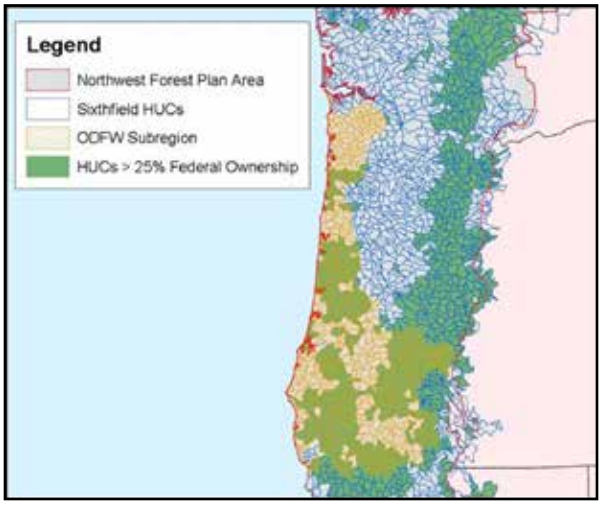

Figure 13. Map showing how the Oregon Department of Fish and Wildlife status and trend monitoring program overlaps with the Aquatic and Riparian Effectiveness Monitoring Program sampling domain (noted as HUCS > 25% Federal Ownership)

We are further adding to the regional effort to standardize macroinvertebrate taxonomy and evaluation through a cooperative agreement with Utah State University "Bug Lab." Here, our goal is to create a new macroinvertebrate bioassessment index that can be applied at both the regional and reach scales to make status determinations. A bioassessment index developed for use at multiple spatial scales would be highly valued by the various agencies that collect macroinvertebrates as bioindicators of stream condition. This tool would allow for each group to use standardized taxonomic information and a robust tool tailored to Pacific Northwest streams.

National Forest Service watershed assessment comparison

We compared the results of the National FS watershed condition class (WCC) assessment (Potyondy and Geier 2011) and AREMP (Lanigan and Gordon 2012) (fig. 14) and found that the

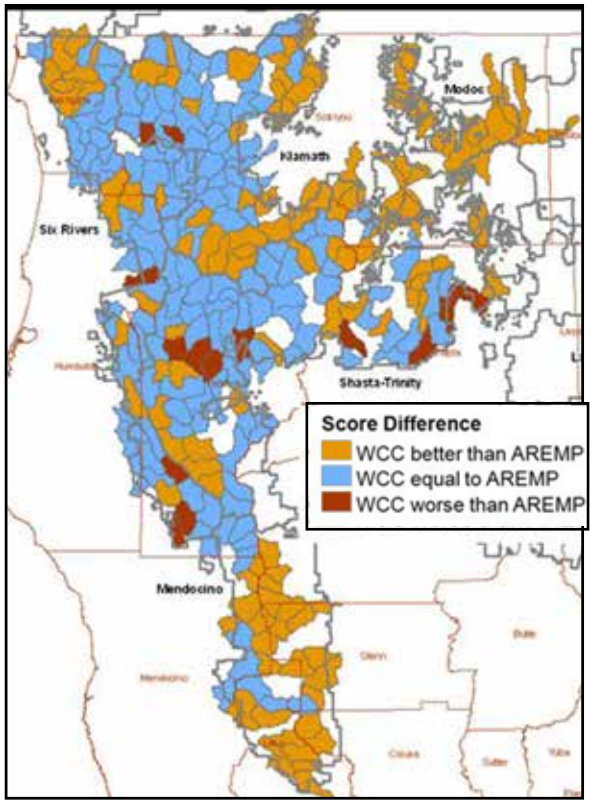

Figure 14. Comparison of NWFP area in Region 5 (northern California) national watershed condition classification and Aquatic and Riparian Effectiveness Monitoring Program upslope/riparian scores.

national WCC scores were most often the same (51%) or better (41%) than AREMP scores. The difference in scores resulted from the two efforts using different 6th-field watershed layers; the WCC used both quantitative and qualitative attribute data, while AREMP used only quantitative attribute data; and model structure were significantly different, especially with respect to how roads were evaluated and the lack of weighting in the WCC assessment. Discussions are underway to determine how AREMP can better support the national effort. We also suggested ways to improve the national WCC.

Program Updates

Employment

We employed nine year-round employees who were a combination of permanent and year-round "term" employees. Thirty four crew members were employed between May – October, they were a combination of seasonal employees, college students, and Student Conservation Association interns.

AREMP Summer employment information in 2013 is posted at http://www.reo.gov/monitoring/employment/index.shtml.

Student Conservation Association interns

Since 2004, a total of 49 Student Conservation Association (SCA) interns have gained valuable experience in the field of natural resources working with AREMP. In 2012, we hired four SCA interns as survey crew members and three SCA interns for our temperature monitoring crew to deploy stream and air temperature sensors in watersheds through out Oregon and Washington. We continued to collect high quality data and provided valuable work experience to the interns (Andersen 2012). Three of the GS-grade employees we hired in 2012 were formerly SCA interns: two were hired as a crew leaders and one was hired as a crew member. This was a very successful partnership and one we plan to continue in 2013.

Staffing update

We welcomed the arrival of the following:

Stephanie Miller as our lead fish biologist and analyst. Stephanie recently worked for the Oregon Department of Fish and Wildlife as a fisheries assistant project leader

Jason Brown as our staff technical assistant.

John Speece as field coordinator of the Aquatic Organism Passage study.

We sent our best wishes to the following that left for other positions:

- Chris Moyer, lead fish biologist, left for a promotion with the BLM as the "Service First" national program manager.
- Mark Isley, data base manager, left for a promotion with the National Park Service as the data base manager for the Chihuahuan Desert Network.
- Cindy Solis, time and attendance coordinator accepted a position with the US Fish and Wildlife Service in Alabama.

Annual watershed reports and data available on program website

Data summaries from 2002 to 2006 are available on our website: http://www.reo.gov/monitoring/data-maps/watershed-data-maps.shtml. We respond to all data requests and compile whatever custom data are needed and are working towards making all our data available in the enterprise data warehouse.

Data requests

In 2012, AREMP staff continued to provide data from our field surveys to local management units, Oregon Department of Fish and Wildlife, and other state and federal offices. The following data were requested and received in 2012:

- Amphibian, invertebrate data and stream temperature data for Salmon and Scott RD on the Klamath National Forest Stream temperature and survey summary data for Seattle public Utilities.
- Stream summary data for the Willamette National forest.
- Stream temperature data for Dan Isaak (RMRS) to support interagency stream temperature modeling effort across the Pacific Northwest area.
- Stream temperature data for the Shasta-Trinity National Forest Service.
- Invertebrate data for California for Joseph Furnish, FS Region 5 Aquatic Ecologist
- Stream survey summary information for Methow Valley Ranger District Okanogan National Forest.
- Other, non-specific data requests were directed to the AREMP data download website; http://www.reo.gov/monitoring/reports/watershed/aremp/aremp.htm

Literature Cited and Related Publications

Literature Cited

Andersen, H.V. 2012a. Aquatic and Riparian Effectiveness Monitoring Program. Stream and Air Temperature Monitoring Report. 2011 and 2012 Field Seasons. http://www.reo.gov/monitoring/reports/watershed/2012%20Thermograph%20report.pdf

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Acknowledgments

The Aquatic and Riparian Effectiveness Monitoring Program is an interagency effort funded by FS, BLM, National Oceanic and Atmospheric Administration National Marine Fisheries Service, and the US Environmental Protection Agency.

Pam Sterling of the BLM Oregon State Office (OSO) was critical in executing the Student Conservation Association agreement. Kelly Coleman, Lane Gaylord and Eileen Signor of the BLM OSO helped hire crews and process personnel actions. Sam Chan and Tania Siemens of the Oregon State University Oregon Sea Grant Extension and Robin Draheim of Portland State University provided training, support and guidance in the implementation of the invasive species monitoring protocol. Margie Witt, Beth Snyder, and Tom McKee all of the Siulsaw National Forest provided excellent support for both hand-held and vehicle radios; purchasing help and guidance; and fleet help and support, respectively. Forrest Kaye, Mobile GIS specialist of the BLM Oregon/ Washington State Office, was invaluable with his efforts to support and troubleshoot all problems with field data collection devices and software. Rich Ash of GeoMobile Innovations, Inc. provided advice and support implementing LaserGIS into our field data collection methods.

Jason Dunham, (USGS FRESC), Kim Clarkin (FS Pacific Southwest Research Station), Bruce Hansen (FS Pacific Northwest Research Station), Nate Chelgren (USGS FRESC), Jim Capurso (FS Region 6), and Brian Staab (FS Region 6) provided guidance and helped procure funds for the aquatic organism passage study (AOP). Brian Staab (FS R6), Marc Kramer (FS R6), Louisa Evers (BLM OSO), Jason Dunham (USGS FRESC), Zachary Holden (FS), and Eric Archer (FS) provided guidance, helped procure funding, and (or) provided technical assistance for deploying thermographs. Finally, Ray Davis the Late Successional and Old Growth Forest and Northern Spotted Owl Monitoring Lead for the Northwest Forest Plan provided amphibian capture and identification training for the field crews.

Sean Gordon assisted with all aspects of running our decision support models. Mark Isley handled data processing and database management. Jason Brown handled timesheets for the program during the field season. Steve Wilcox developed the field maps for the crews, and graphics for this report. John Speece contributed the write-up for the Aquatic organism passage study and handled AOP field crew coordination. Tom Knappenberger (FS) provided helpful report layout comments, Mike Hamel (BLM) resolved InDesign layout problems, and Becky Gravenmeier (PNW) provided editorial comments.

Summer field staff for assessing stream condition included Kim Beedle, Elina Lin, Travis Hussey, Nick Chambers, Jonathon Frech, Tracy Pennell, Emma Garner, Ray Lock, Melina Maltese, David Duckett, Rose Pazdral, Travis Neal, Amelia Yeager, Elijah Tome, Patrick Donworth, Stephanie Humphress, and Johanna Ruff. Our thermograph crew included Eric Lench, Alanna Wong, Curtis Roth, Ethan Rubenstein, Andrew Green, and Karen Villatoro. Our aquatic organism passage crew included Jared Blake, Ben Ramirez, Allen Gillette, Stefanie Olind, Seth Webster, Rebecca Ley, Kayla Johnston, Krista Blandin, Wes Burton, Colton Plumb, Sheia Van Hofwegen, Brittany Sahatjan, Ben Bamburg, Nathan Breece, and Loretta Ellenburg.

We thank the following people for helping to retrieve thermographs in California: Jon Grunbaum – Klamath National Forest, Eric Wiseman – Shasta Trinity National Forest and Adam Dresser – Six Rivers National Forest.

Cover photo by Steve Lanigan

Eli Tome

Appendix A - Watersheds Surveyed in 2012

Watersheds surveyed in 2012 with the number of sites surveyed in each watershed. Creek Codes with a (^) represent resurveyed watersheds that were initially surveyed in 2003 or 2004.

Note: Sites where quality assessment/quality control (QA/QC) were also conducted are denoted by (*). QA/QC sites are where a second independent crew returned to sample the same reach to determine variability in our measurements. Two sites were resurveyed in each QAQC watershed.

State	Province	Local Unit	6th Field HUC	6th Field HUC Name	Creek Code	County	Number of Sites
CA	KLAMATH/SISKIYOU	SHASTA-TRINITY NF	180102111102	LITTLE FRENCH CREEK	CAFRN	TRINITY	6
CA	KLAMATH/SISKIYOU	SHASTA-TRINITY NF	180102110102	LITTLE TRINITY RIVER	CATRN^	TRINITY	8*
CA	KLAMATH/SISKIYOU	SHASTA-TRINITY NF	180102120302	NORTH FORK HAYFORK CR	CANFH	TRINITY	7
CA	HIGH CASCADES	SHASTA-TRINITY NF	180002031103	LOWER SQUAW CREEK	CASQW	SHASTA	8*
OR	FRANCISCAN	SISKIYOU NF	171003120106	BOULDER CREEK	ORBDR^	CURRY	5
OR	FRANCISCAN	SISKIYOU NF	171003100601	SHASTA COSTA CK	ORSHA^	CURRY	8*
OR	HIGH CASCADES	MEDFORD BLM	180102060502	SCOTCH CREEK	ORFAL^	JACKSON/SISKIYOU	5
OR	HIGH CASCADES	ROGUE RIVER NF	171003070402	CLARKS FORK CK/FOURBIT CK	ORFOR^	JACKSON	7
OR	KLAMATH/SISKIYOU	MEDFORD BLM	171003090203	APPLEGATE R/STAR GULCH	ORSTR^	JACKSON	11
OR	KLAMATH/SISKIYOU	MEDFORD BLM	171003110502	MIDDLE DEER CREEK	ORDER	JOSEPHINE	6
OR	KLAMATH/SISKIYOU	MEDFORD BLM	171003100403	ROGUE RIVER/BIG WINDY CK	ORWND^	JOSEPHINE	6
OR	KLAMATH/SISKIYOU	ROSEBURG BLM	171003020901	MIDDLE CREEK	ORMDL^	DOUGLAS	6
OR	OREGON COAST RANGE	SIUSLAW NF	171003030706	LOWER NF SMITH RIVER	ORLNS	DOUGLAS	6
OR	WESTERN CASCADES	MEDFORD BLM	171003070602	WEST FORK TRAIL CREEK	ORWFT^	JACKSON	6
OR	WESTERN CASCADES	MT. HOOD NF	170800010504	CEDAR CREEK	ORCDR^	CLACKAMAS	6
OR	WESTERN CASCADES	UMPQUA NF	171003011104	EMILE CREEK	OREML^	DOUGLAS	6
OR	WESTERN CASCADES	UMPQUA NF	170900020101	LAYNG CREEK	ORLNG^	LANE	8*
OR	WESTERN CASCADES	UMPQUA NF	171003011101	LITTLE RIVER HEADWATERS	ORLRV^	DOUGLAS	9*
OR	WESTERN CASCADES	UMPQUA NF	171003010801	STEAMBOAT HEADWATERS	ORSTM^	LANE	9*
OR	WESTERN CASCADES	WILLAMETTE NF	170900010902	FALL CREEK / HEHE CREEK	ORHHE^	LANE	9*
OR	WESTERN CASCADES	WILLAMETTE NF	170900010504	MF WILLAMETTE R / LARISON CK	ORLAR^	LANE	6
OR	WESTERN CASCADES	WILLAMETTE NF	170900040201	UPPER SEPARATION CREEK	ORSEP^	LANE	6
WA	NORTH CASCADES	MT. BAKER-SNOQUALMIE NF	171100100303	TAYLOR RIVER	WATLR	KING	5
WA	NORTH CASCADES	MT. BAKER-SNOQUALMIE NF	171100090201	UPPER NF SKYKOMISH R	WASKY^	SNOHOMISH	8*
WA	NORTH CASCADES	WENATCHEE NF	170200090203	FISH CREEK	WAFSH^	CHELAN	4
WA	OLYMPIC PENINSULA	OLYMPIC NF	171001010501	NF CALAWAH RIVER	WANFC	CLALLUM	8
WA	OLYMPIC PENINSULA	OLYMPIC NF	171100180601	UPPER BIG QUILCENE RIVER	WAQUL^	JEFFERSON	6
WA	WESTERN CASCADES	GIFFORD PINCHOT NF	170800020203	ELK CREEK	WAELK^	SKAMANIA	9*

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Appendix B- Quality Assessment Program

Overview of the reliability of each stream survey attribute calculated as the linear relationship between the initial survey and the quality assessment/quality control (QA/QC) site surveys. QA/QC sites are where a second independent crew returned to sample the same stream site to determine variability in our measurements. Transformations were used to meet assumptions of normality and homoschedasticity of residuals (* = square root transformed; ** = log transformation). A R^2 of 1 represents a perfect linear relationship between the initial and quality control survey. P-values less than 0.05 are significant relationships between the two surveys. CV, the coefficient of variation, is the relative standard deviation of the variable (the inverse of the signal to noise ratio).

ATTRIBUTE	DF	F Value	Pr > F	R^2	CV
GRADIENT*	1,128	11380.2	<.0001	0.9890	4.65
STREAM_LENGTH**	1,133	886.8	<.0001	0.8704	12.25
AVERAGE_BFWIDTH**	1,133	680.0	<.0001	0.8395	9.30
AREMP_WOOD_PIECES*	1,133	685.2	<.0001	0.8385	17.63
TOTAL_WOOD_PIECES**	1,106	658.1	<.0001	0.8329	10.25
SMALL_WOOD_PIECES**	1,133	652.6	<.0001	0.8318	14.01
AREMP_WOOD_FREQUENCY*	1,133	572.1	<.0001	0.8125	17.35
SMALL_WOOD_FREQUENCY**	1,133	511.3	<.0001	0.7948	-13.92
DSM_WOOD_PIECES**	1,106	354.9	<.0001	0.7717	34.38
AREMP_NON_DSM_WOOD_FREQUENCY**	1,133	444.5	<.0001	0.7710	-12.82
ODFW_KEY_WOOD_PIECES**	1,133	380.7	<.0001	0.7425	30.30
DSM_WOOD_FREQUENCY**	1,106	264.1	<.0001	0.7155	-16.85
ODFW_KEY_WOOD_FREQUENCY**	1,133	287.4	<.0001	0.6853	-17.85
INTOLERANT_RICHNESS	1,960	194.8	<.0001	0.6722	18.28
POOL_FREQUENCY*	1,122	217.9	<.0001	0.6430	0.23
MEDIUM_WOOD_FREQUENCY**	1,133	236.9	<.0001	0.6422	-16.99
NUMBER_POOLS**	1,122	196.4	<.0001	0.6188	18.13
COND **	1,950	147.8	<.0001	0.6112	12.62
RESIDUAL_DEPTH*	1,121	184.9	<.0001	0.6065	1.58
D50 _bedrock removed*	1,127	129.01	<.0001	0.5059	29.34
AVERAGE_BFDEPTH**	1,133	119	<.0001	0.4779	-66.59
INVERTEBRATE_SCORE	1,960	81.32	<.0001	0.4612	302.10
AVERAGE_BF_WD	1,133	106.14	<.0001	0.4495	9.40
LARGE_WOOD_PIECES**	1,133	105.98	<.0001	0.4453	395.82
EPT_RICHNESS	1,960	74.21	<.0001	0.4386	13.42
REACH_LENGTH_SINUOSITY**	1,111	73.45	<.0001	0.4004	195.75
CLINGER_RICHNESS	1,960	62.51	<.0001	0.3969	17.98
PERCENT_FINES**	1,990	40.62	<.0001	0.2931	171.10
DO	1,930	34	<.0001	0.2698	10.60
AMPHIBIAN SCORE**	1,400	0.8	0.376	0.0201	-49.27
DSM_TERRESTRIAL_AMPHIBIANS	1,130	0.14	0.7116	0.0118	38.04
TERRESTRIAL_AMPHIBIAN_SI	1,130	0.04	0.8409	0.0035	44.73

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