NPLCC FINAL PROGRESS REPORT INSTRUCTIONS

1. ADMINISTRATIVE INFORMATION:

Project title: Developing a comprehensive interagency stream temperature database and high-resolution NorWeST climate scenarios for the North Pacific LCC

Agreement number: 13IA11221634169

Project manager: Dan Isaak (disaak@fs.fed.us; 208.373.4385), U.S. Forest Service

Reporting date: 11/27/2015 for period 7/15/2013 to 11/27/2015

2. PUBLIC SUMMARY:

The aquatics community within the U.S. portion of the NPLCC has collected significant amounts of stream temperature data through their collective monitoring efforts in previous decades. The NorWeST project has amassed copies of those data from state, federal, tribal, municipal, and county resource agencies into a comprehensive interagency stream temperature database and developed accurate (R^2 = 91%; RMSE = 1.0˚C), high-resolution (1 kilometer) climate scenarios. Historic and future climate scenarios are available for all streams within the NPLCC south of the Canadian border and are mapped to the 1:100,000-scale National Hydrography Dataset. The scenarios and temperature databases are available in user-friendly digital formats from the NorWeST website (www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html) and can also be viewed dynamically online through LCMap (https://www.sciencebase.gov/gisviewer/NorWeST/). Daily summaries (min/max/mean) of the stream temperature data are available through the website if permission was given for their distribution. All data are attributed to the original source agency in accompanying metadata files. By providing open access to stream temperature information in user-friendly formats, the NorWeST project is facilitating interagency coordination of monitoring activities, better conservation planning, and new research on temperature dynamics and thermal ecology. Moreover, because NorWeST information was developed from data collected by those in the local landscapes by the aquatics community, it is being rapidly adopted into local decision making and conservation practices. The NorWeST website currently receives 12,000 visits/year and 100s of data products are downloaded annually.

3. PURPOSE AND OBJECTIVES:

The primary objective of this project is an accurate assessment and description of historical and future stream temperatures so that planning efforts can be undertaken more efficiently and with greater confidence across the NPLCC. Specific tasks include: 1) developing a comprehensive, interagency stream temperature database, 2) developing a stream temperature model that incorporates important climate drivers, riparian conditions, and geomorphic factors; 3) using the model to predict historic and future patterns in stream temperatures for all fish-bearing streams; and 4) translating stream temperatures to thermal habitat maps for assessing species distributions and climate relationships across the NPLCC.

4. METHODS, ORGANIZATION AND APPROACH:

This project encompassed approximately 131,000 km of fish-bearing streams and rivers across Washington and Oregon west of the Cascades, and northwestern California within the NPLCC area. Database technicians were hired and, with assistance from professional support staff at the Boise Aquatic Sciences Lab, organized temperature data into a relational Oracle database so that it can be efficiently queried and summarized for modeling. Spatial statistical stream network models developed by project collaborators were used to model patterns in stream temperature data and develop accurate, high-resolution climate scenario maps (more information at the SSN/STARS website: http://www.fs.fed.us/rm/boise/AWAE/projects/SpatialStreamNetworks.shtml). Previous applications to stream temperature databases suggest the spatial models provide unbiased parameter estimates and good predictive accuracy; typically accounting for ~90% of the variability in stream temperatures with average prediction errors < 1.0 ˚C. Calibration of the stream temperature model to data within river basins and derivation of model outputs (see Deliverables) follows procedures developed earlier and extensively documented at the NorWeST website (http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html).

5. PROJECT RESULTS:

As of late 2015, stream temperature data for 17,438 summers of monitoring effort from 6,142 unique sites had been aggregated, organized into a database, and used to develop 30 high-resolution stream temperature scenarios for 131,000 stream and river kilometers in the southern extent of the NPLCC. Figure 1 shows typical model performance with the temperature dataset compiled for the Oregon Coast area. Figure 2 shows a historical stream temperature scenario map for this area that was interpolated using the model. Similar results are available for the Washington Coast and northwestern California.

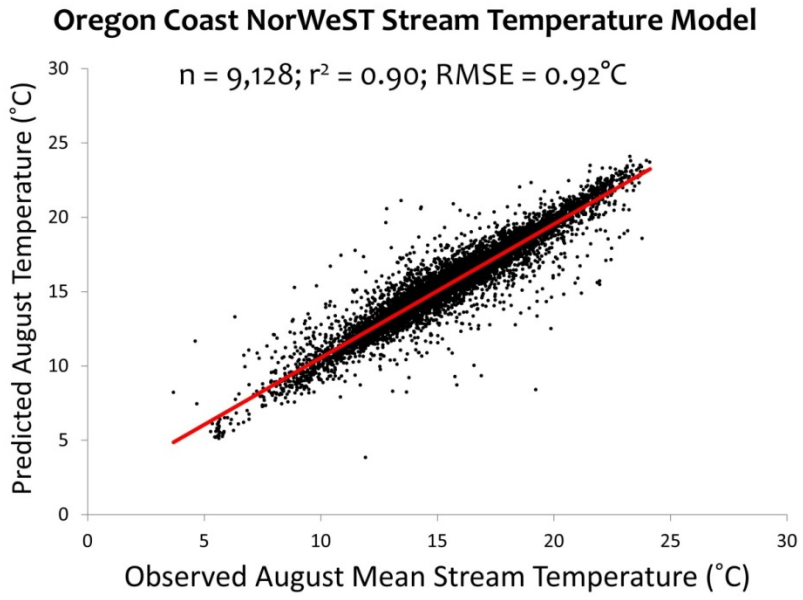


Figure 1. Graph showing temperature predictions from the NorWeST model fit to an interagency database compiled for the Oregon Coast.

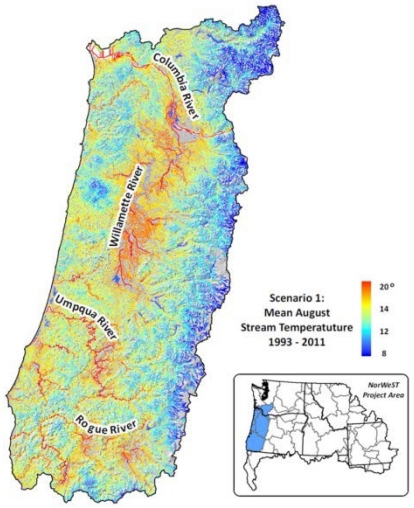


Figure 2. Stream temperature map interpolated from the NorWeST model to represent a historical scenario across the Oregon Coast.

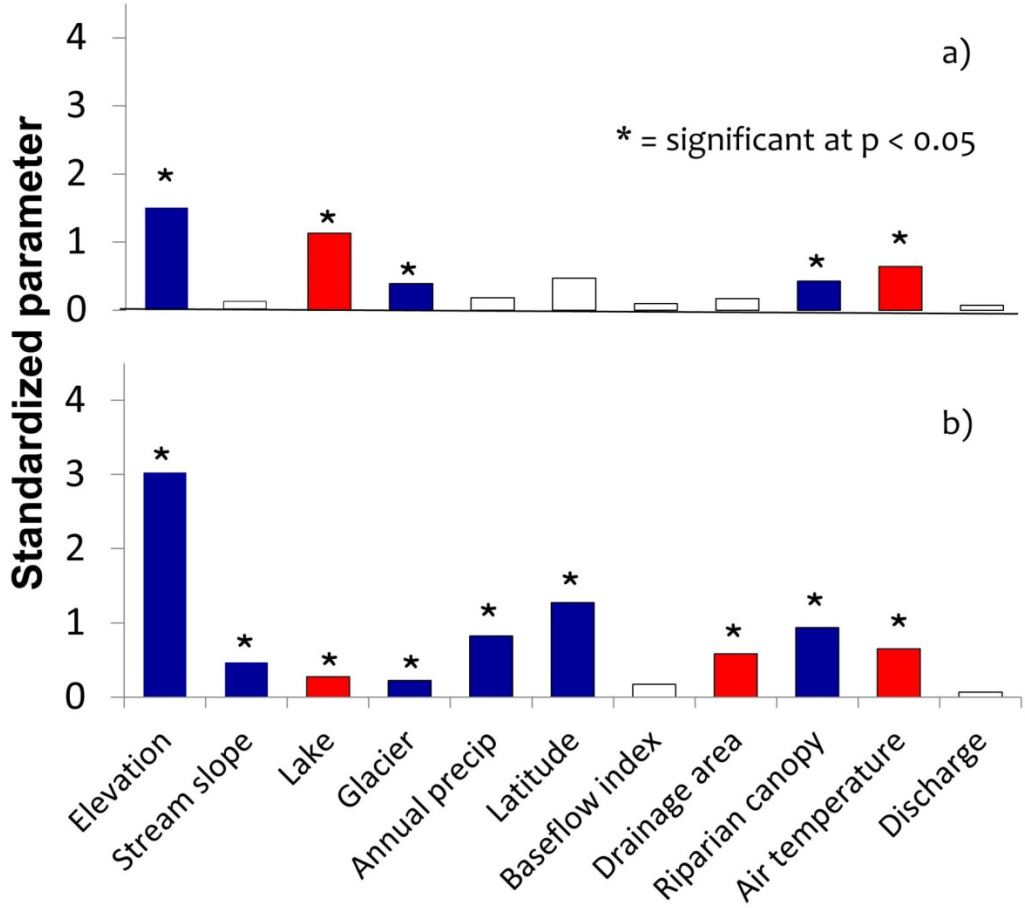


Figure 3. Relative importance of predictor variables in the NorWeST stream temperature model fit to different locations within the NPLCC area.

6. FINDINGS AND CONCLUSIONS:

Considerable variation exists along the coast in terms of the amount of stream temperature data that have been collected. The density of data is lowest in southwestern Washington but high throughout Oregon, California, and northwestern Washington. The relative importance of the predictor variables in the temperature model also differed among areas. All predictor variables had significant effects in the Oregon Coast area except for the baseflow index and interannual variation in discharge (Figure 3). Fewer than half the predictor variables were significant in the Washington Coast area and northwestern California.

7. LESSONS LEARNED AND RECOMMENDATIONS:

There were two primary lessons learned from the project. First, there has been a tremendous amount of redundant monitoring effort among agencies prior to the NorWeST project. Moreover, most stream temperature monitoring has occurred only during the summer months and data for other parts of the year or long-term data are relatively rare. Second, it is possible to accurately model and predict streams temperatures using new spatial-statistical network models with dense datasets to provide useful information for all agencies. Going through the process of developing a comprehensive interagency database and stream temperature scenarios has raised awareness regarding those issues and more efficient monitoring and communication among agencies now occurs routinely through the use of the open-access data products at the NorWeST website.

8. MANAGEMENT APPLICATIONS AND PRODUCTS:

A full list of the managers and decision makers that have been engaged on this project is beyond the scope of this project. More than 100 agencies have contributed data to the project, and are using NorWeST information and data projects to better accomplish their respective missions. Generally speaking, NorWeST information is used for climate vulnerability assessments, to improve and refine temperature monitoring networks, in revisions to landuse plans, for strategic assessments of conservation investments, and new research on the thermal ecology of many species. Study results have been communicated broadly throughout the aquatics community using traditional means (e.g., talks and research papers) and wide variety of digital and social networking technologies (e.g., email chat, GIS, websites, webtools, blogs). Examples of those are provided below. Our main metric of success on the NorWeST project is measured in the size of the user-community that regularly visits the website. Since the launch of the website 3+ years ago, >30,000 visits have occurred and the number of visits continues to increase each year. During those visits, 100s of temperature data products have been downloaded and are now commonly viewed and used as standard tools and information sets in discussions about stream temperature.

9. PUBLICATIONS AND OUTREACH:

Results of the NorWeST project and specifics pertinent to the NPLCC area are communicated through a variety of webinars, workshops, scientific meetings, and peer-reviewed manuscripts (some recent examples are listed below). Most importantly, the project website distributes stream temperature information in many user-friendly digital formats (e.g., ArcGIS shapefiles and .pdf files) and these are frequently downloaded for use by managers and decision makers.

Posters

Isaak, D., D. Nagel, M. Groce, S. Wenger, E. Peterson, J. Ver Hoef, C. Luce, S. Hostetler, J. Dunham, J. Kershner, B. Roper, D. Nagel, D. Horan, G. Chandler, S. Parkes, S. Wollrab, C. Breshears, N. Bernklau, S. Chandler. 2014. A thermal map for all Oregon streams. Pacific Northwest Climate Science Conference. Seattle, WA, September 10-11. (POSTER)

Isaak, D., D. Nagel, M. Groce, S. Wenger, E. Peterson, J. Ver Hoef, C. Luce, S. Hostetler, J. Dunham, J. Kershner, B. Roper, D. Nagel, D. Horan, G. Chandler, S. Parkes, S. Wollrab, C. Breshears, N. Bernklau, S. Chandler. 2015. A thermal map for all Washington streams. (POSTER)

Recent presentations

Isaak, D., S. Wenger, E. Peterson, J. Ver Hoef, C. Luce, S. Hostetler, J. Dunham, J. Kershner, B. Roper, D. Nagel, D. Horan, G. Chandler, S. Parkes, S. Wollrab. 2015. Development and application of NorWeST stream temperature climate scenarios for the Pacific Northwest. North Pacific Landscape Conservation Cooperative webinar, January 27.

Isaak, D, S. Wenger, E. Peterson, J. V. Hoef, C. Luce, D. Nagel, S. Hostetler, J. Dunham, J. Kershner, B. Roper, D. Horan, G. Chandler, S. Parkes, and S. Wollrab. 2015. NorWeST stream temperature model: Data structure, covariates, and applications. EPA Region 10 webinar. February 11.

Isaak, D., S. Wenger, E. Peterson, J. V. Hoef, C. Luce, D. Nagel, S. Hostetler, J. Dunham, J. Kershner, B. Roper, D. Horan, G. Chandler, S. Parkes, and S. Wollrab. 2015. Development and application of NorWeST temperature scenarios for northwestern California. Klamath Falls, OR, November 4.

Isaak, D., S. Wenger, E. Peterson, J. V. Hoef, C. Luce, D. Nagel, S. Hostetler, J. Dunham, J. Kershner, B. Roper, D. Horan, G. Chandler, S. Parkes, and S. Wollrab. 2015. Developing a comprehensive interagency NorWeST stream temperature database and climate scenarios for California. Surface Water Ambient Monitoring Program (SWAMP). California State Water Board roundtable meeting. Sacramento, CA, November 5.

Websites:

LCMap temperature tool: https://www.sciencebase.gov/gisviewer/NorWeST/

NorWeST website: http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/Publications.shtml

Peer-reviewed manuscripts and reports that have used NorWeST data (several others will be published in 2016).

Al-Chokhachy, R., S.J. Wenger, D.J. Isaak, and J.L. Kershner. 2013. Characterizing the thermal suitability of instream salmonids: a cautionary example from the Rocky Mountains. *North American Journal of Fisheries Sciences* x:xxx-xxx

Al-Chokhachy. In Press. Long-term monitoring data reveal brown trout displacement of bull trout across western Montana. Canadian Journal of Fisheries and Aquatic Science

Dauwalter, Daniel C., Kurt A. Fesenmyer, and Robin Bjork. 2015. Using Aerial Imagery to Characterize Redband Trout Habitat in a Remote Desert Landscape. Transactions of the American Fisheries Society 144:1322-1339.

Isaak, D.J., M.K. Young, D. Nagel, and D. Horan. 2014. Cold water as a climate shield to preserve native trout through the 21st Century. Pages 110 - 116 *in* R. F. Carline and C. LoSapio, editors. Wild Trout XI: Looking Back and Moving Forward. Wild Trout Symposium, Bozeman, Montana. 392 pages.

Isaak, D.J., M.K. Young, D. Nagel, D. Horan, and M. Groce. 2015. The coldwater climate shield: Delineating refugia to preserve salmonid fishes through the 21st Century. Global Change Biology 21:2540-2553.

Isaak, D.J., K. Ramsey, J. Chatel, D. Konnoff, R. Gecy, and D. Horan. 2016. Climate change, fish, and aquatic habitat in the Blue Mountains. Pages x-x in Halofsky, J.E.; Peterson, D.L., eds. 2016. Climate change vulnerability and adaptation in the Blue Mountains. Gen. Tech. Rep. PNW-GTR-xxx. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

Isaak, D.J., M.K. Young, C.H. Luce, S.W. Hostetler, S.J. Wenger, Erin E. Peterson, Jay Ver Hoef, Matt Groce, Dona L. Horan, David Nagel. In Review. Slow climate velocities of mountain streams portend their role as refugia for cold-water biodiversity. Proceedings of the National Academy of Sciences

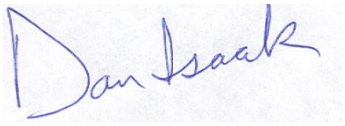
Wenger, S., D.J. Isaak, and M.K. Young. In Review. Realized thermal niches of stream organisms derived from massive biological and water temperature datasets. Ecosphere

Westley P., A. Dittman, E. Ward, and T. Quinn. 2015. Signals of climate, conspecific density, and watershed features in patterns of homing and dispersal by Pacific salmon. Ecology 96:2823–2833.

Williams J.E., Isaak D.J., Imhof J., Hendrickson D.A. and McMillan J.R. 2015. Cold-water fishes and climate change in North America, Reference Module in Earth Systems and Environmental Sciences, Elsevier. doi:10.1016/B978-0-12-409548-9.09505-1.

Young, M.K., D.J.Isaak, D. Nagel, D. Horan, and M. Groce. In Press. Climate vulnerability of native salmonids in the Northern Rockies. U.S. Forest Service, Region 1. Northern Rockies Adaptation Partnership. Pages x-x in D. Peterson, editor. U.S. Forest Service, Pacific Northwest Research Station, GTR-PNW-x, Portland?.

11. Signature: The Agreement Project Manager should sign and date the final report to certify their submittal of the report.



Signed: 11/27/2015