Oregon Stream Protection Coalition

Association of Northwest Steelheaders

Audubon Society of Portland

Cascadia Wildlands

Center for Biological Diversity

Coast Range Association,

Defenders of Wildlife

Hells Canyon Preservation Council

Institute for Fisheries Resources

KS Wild

McKenzie Flyfishers

Native Fish Society

Northwest Environmental Advocates

Northwest Guides and Anglers

Northwest Sportfishing Industry Association

Oregon Wild

Pacific Coast Federation of Fishermen's Associations

Pacific Rivers Council

Rogue Riverkeeper

Sierra Club

Trout Unlimited,

Umpqua Watersheds

The Wetlands Conservancy

Wild Earth Guardians

Wild Salmon Center

BEFORE THE OREGON BOARD OF FORSTRY
Wednesday, November 2, 2016
Ashland, Oregon
Statement of Mary Scurlock
Coordinator, Oregon Stream Protection Coalition
Regarding Agenda Item 7 and Staff Recommendation to begin implementing the Updated Monitoring Strategy

On behalf of the Oregon Stream Protection Coalition (OSPC), I thank you for considering my input on implementation your updated monitoring strategy. Staff work to pull together input from various stakeholders has resulted in an updated list of important compliance and effectiveness questions, but Board direction and ongoing oversight will be critical to ensuring that monitoring resources are deployed in was that best serve the public interest.

My comments support two requests:

1. We urge the Board to direct monitoring staff to begin work in support a riparian rule change to meet the water quality standards for stream temperature in the Siskiyou -- whether or not this project is linked to a rule change in Eastern Oregon. We believe that there is adequate support for a resource degradation finding for failure to meet the PCW based on a full examination of existing literature and research. We provide a memorandum that helps lay a template for what kinds of existing data should be considered before designing further field monitoring projects.

Specifically, we request that the Board bring the Work Plan item related to Riparian Policy in the Siskiyou and the Eastside off of "hold" and direct that the monitoring staff produce a report to the Board that answers the following questions:

What available information indicates that:
a) the findings of the RipStream study with regard to stream warming are/ are not reasonably applicable to the small and medium Salmon and Steelhead streams of the Siskiyou? Of the Eastside?
b) the relationship between shade and stream warming on Small and Medium streams of the Siskiyou is/is not different than the relationships established in ODF's predictive modeling for western Oregon? Of the Eastside?

2. We further urge the Board to consider the need to provide the public with some kind of tangible monitoring and adaptive management response to the full range of forest practices issues identified by EPA and NOAA in their 2015 disapproval of Oregon's coastal nonpoint pollution control measures. This means developing a plan for addressing the adequacy of current rules to protect water quality on non-SSBT fish streams, non-fish streams, minimizing

3. forest-practices related alteration of landslide regimes, and addressing problem impacts from older roads on private forests.

I. Lack of Information not a Reason for Inaction in the Siskiyou

The attached memorandum by aquatic ecologists Frissell and Nawa (11 pp) strongly supports our contention that an entirely new "RipStream" study is not necessary to support a rule change to meet the Protecting Coldwater Criterion in the Siskiyou. Frissell and Nawa find that: 1) "there is adequate information at hand for the Board to find that the current riparian rules do not meet the statewide limitation on stream warming set by the Protecting Coldwater Criterion (PCW) and to determine what stream protection would be adequate in the Siskiyou region."

We summarize the key findings of the memo as follows;

- Even though none of the Ripstream field data were collected in the Siskiyou, because available Siskiyou-specific data are consistent with these data, existing information provides a rational basis to presume the PCW is not being met on numerous small and medium salmon, steelhead and bull trout (SSBT) streams throughout western Oregon -- with the possible exception of some higher-elevation streams in the Cascades.

- Available information does not indicate the relationship between shade and stream warming on Small and Medium streams in the Siskiyou is different than the relationships established in ODF's predictive modeling for western Oregon.

- Available data suggest ecological differences between the Siskiyou and other regions of western Oregon have relatively little effect on stream temperature and riparian shade relations. If differences do exist, there is no reason to believe they would modify the basic causal relation between forest shade reduction and warming of streams, and they do not undermine the clear relevance of the RipStream findings to Southwest Oregon.

- The only possible exceptions to the above conclusions are Siskiyou streams draining watersheds with certain geologies and soils where forests are too sparse to support commercial forestry, most of which are in federal ownership.

- Geologic and hydrologic conditions in the Siskiyou do not appear to cause Siskiyou streams to be inherently warmer under natural conditions, but to the extent they affect shade-temperature relations, regional ecological differences *possibly increase*, rather than decrease the sensitivity of Siskiyou streams to shade loss.

- The fact that in 1994 the Board chose to set a 10ft² per acre lower minimum conifer basal area when it set standards for riparian logging in the Siskiyou does not logically relate to the Board's decision to exclude the Siskiyou from the new rule. Until specific information is available to substantiate an hypothesized departure of stream temperature conditions and causal relationships for the region, it is irrational and unjustified to exclude Siskiyou streams from the protections afforded those in other western Oregon regions.

This information qualifies some of the statements made in previous ODF staff reports. For example,: 1) "systematic review of literature that contained primary measurements of stream temperature, riparian shade, or a proxy of the latter" completed in January 2013, found "no relevant studies in the Siskiyou region." (Agenda Item 5, 4.27.16 Board materials); 2) "[w]ith the Board's November [2015] decision not to extend the riparian rule results to the Siskiyou region, the department does not have temperature monitoring evidence related to forest practices in that region." We hope the Board agrees that the lack of ODF monitoring sites in the Siskiyou in the RipStream study does not mean that those data are therefore not relevant and could not have been reasonably extrapolated to support a rule change or that there is not other information –including but not limited to that cited by Frissell and Nawa -- that supports such extrapolation.

We urge the Board not to defer action to address riparian protection needs in the Siskiyoiu. recognizing that this region is part of the Coastal Zone and inaction here relates directly to the current coastal nonpoint plan disapproval by NOAA and EPA.

II. How do the CZARA Findings figure in to the Board's implementation of the monitoring strategy?

Given the 2015 and repeated earlier NOAA and EPA findings related to the insufficiencies of Oregon's forest-practices rules to meet coastal water pollution control expecatations, OSPC constituents do not have a clear picture of what the Department's response is to those findings other than the coldwater protection rulemaking which deals only with a small subset of the issues. We request that the Board consider the adequacy of riparian protection on non SSBT small and medium fish streams and nonfish streams to be of priority concern to Oregonians, as well as the adequacy of forest practices rules to prevent increased risk to aquatic resources from management on sites at high risk of mass wasting and from older roads. These issues should be explicitly addressed in developing the Board's monitoring Work Plan.

Sincerely,

Mary Scurlock, Coordinator

Protecting Coldwater for Salmon and Steelhead

on Private Timberland Streams of Oregon's Siskiyou Region:

A Synoptic Scientific Look at Stream Warming, Shade, and Logging

Prepared for the Oregon Stream Protection Coalition by

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31 October 2016

INTRODUCTION

The Oregon Board of Forestry proposes to exclude the Siskiyou Georegion from a proposed new coldwater protection rule, citing inadequate monitoring information. This memo examines this proposition, and argues that a finding to exclude the Siskiyou region is, by scientific criteria, without merit. To the contrary, there is adequate information at hand for the Board to find that the current riparian rules do not meet the statewide limitation on stream warming set by the Protecting Coldwater Criterion (PCW) and to determine what stream protection would be adequate in the Siskiyou region.

Principal Findings:

- Salmon and steelhead are widely distributed in the Siskiyou Georegion, and a variety of large, medium and small stream provide critical habitat for them, including listed Coho salmon. Many of the most important habitats for extant populations are associated with forest lands, and private forestry under current practice is recognized as an important contributor to habitat impairment.

- The RipStream study provides a rational basis to find the PCW is not being met on small and medium salmon, steelhead and bull trout (SSBT) streams throughout western Oregon (with the possible exception of some higher-elevation streams in the Cascades), even though none of the field data specific to this study were collected in the Siskiyou.

- Evidence in the literature and available relevant studies does not indicate the relationship between shade and stream warming on Small and Medium streams (per ODF size classification) in the Siskiyou is different than the relationship established in ODF's predictive modeling for western Oregon.

- Available data suggest ecological differences between the Siskiyou and other regions of western Oregon have relatively little effect on stream temperature and riparian shade relations. Any differences that do exist certainly do not modify the basic causal relation between forest shade reduction and warming of stream thermal maxima, and they do not undermine the clear relevance of the RipStream findings to SW Oregon.

- Possible exceptions to the above conclusions are Siskiyou streams draining watersheds rich in ultramafic rock types and the soils derived from them. However, forests in these streams are so sparse that for the most part they do not support commercial forestry, and most of these lands are in federal ownership as a result. Moreover, across most areas of ultramafic geologic influence, riparian vegetation is larger and denser than upland vegetation, and this together with an abundance of perched shallow aquifers contribute to moderating stream temperatures.

- To the extent that geologic and hydrologic conditions contribute to differences between Siskiyou Georegion streams and those in other western Oregon regions, these conditions do not appear to inherently cause Siskiyou streams to be warmer under natural conditions; to the extent they affect shade-temperature relations, regional ecological differences likely *increase*, rather than decrease the sensitivity of Siskiyou streams to shade loss.

- The fact that in 1994 the Board chose to set a $10ft^2$ per acre lower minimum conifer basal area when it set standards for riparian logging in the Siskiyou does not logically relate to the Board's decision to exclude the Siskiyou from the new rule. It simply indicates that conifer basal area is known to be less dense in some riparian forests of this region than those in wetter regions. However, even where conifer density is low, shade is nevertheless provided by hardwood species (some of which are also commercially logged). Furthermore, even where they are reduced in density, conifer trees commonly have higher crown height and therefore may contribute a greater proportion of shade to streams, as well as providing important large wood and wildlife habitat functions. These factors all taken together argue that oversimplified and unsubstantiated assumptions about shade and riparian forest conditions and relations should not be the basis of excluding Siskiyou riparian forests from improved protective rules based on regionally applicable "Ripstream" science. Until specific information is available to substantiate an hypothesized departure of stream temperature conditions and causal relationships for the region, it is irrational and unjustified to exclude Siskiyou streams from the protections afforded those in other western Oregon regions.

- In summary, available monitoring and research evidence documents that degradation of freshwater resources maintained by stream shade in the Siskyou Georegion is likely if improved riparian forest protections proposed for elsewhere in western Oregon are not adopted and implemented there.

DETAILED COMMENTS

In this report we focus on streams considered by ODF to fit in the Small and Medium size categories. By ODF criteria (ODF 1994), Small streams have an average annual flow of 2 cfs or less. Medium streams have an average annual flow greater than 2 cfs but less than 10 cfs. Large streams have an average annual flow of 10 cfs or greater. Any stream with a drainage area less than 200 acres is considered small. Average drainage area equivalents that typically produce discharge within this ranges were derived ODF based on mean annual precipitation. Generally, we assigned streams to size categories on an approximate basis using drainage area criteria, and in some cases based on familiarity with the channels and flows of the streams in question.

QUESTION 1: ARE RIPARIAN FORESTS IN THE SISKIYOU GEOREGION FUNDAMENTALLY DIFFERENT?

ODF Stream and Riparian Forest Monitoring Data

An ODF monitoring study (Dent 2001) assembled monitoring data from field surveys on riparian forest conditions and logging effects at 40 streams in ODF's Small, Medium and Large size categories statewide, and the data set included two streams in the Siskiyou Georegion. While the Siskiyou area data are sparse, they offer an opportunity for a provisional look at whether obvious differences exist in riparian areas of the Siskiyou Region and those in other regions, including the Coast Range, Interior, South Coast, and Cascades regions where ODF's currently proposed shade rules are set to apply. (Post-harvest riparian conditions were highly variable because streamside logging prescriptions were not controlled in this 2001 study, so are not considered here.)

Dent (2001) at p.37 (Table 6) reported measured values of **percent cover** for surveyed reaches of two Siskiyou Region streams and 22 other streams from western Oregon georegions. Dent reported cover prior to harvesting as the best measured index of natural shade in the surveyed streams. Cover was 80 percent for the Large size class Siskiyou stream (Glade Creek, stream width 16.7 feet); by comparison the range for all 8 streams in the Large category drawn from the four western Oregon georegions was 76 to 94 percent cover, with a median of 78 percent.

The Small class Siskiyou stream in the sample (Jamison Creek, stream width 4 feet) had a pre-harvest cover of 91 percent. The range for all 9 Small streams in the study sample in western Oregon was 83 to 97 percent with a median of 91 percent. So these Siskiyou region streams fall very near the western Oregon median and mean for streams of the same size class. Though sparse, the data offer no evidence that riparian forest canopy cover conditions are different in the Siskiyou region than in other western Oregon regions, and suggest the opposite.

Pre-harvest **Conifer and hardwood basal area** was reported by Dent (2001) in Table B-1 (p. 66). Reported conifer basal area of the Siskiyou Region Large stream (Glade Cr.) Riparian Management Area (RMA) was 248 square feet per 1000 linear feet of stream. The range for all 11 western Oregon sites was 0 to 927 ft^2/1000ft, with a median of 97. Hardwood basal area in the RMA of the Large Siskiyou stream was reported as 13 ft^2/1000ft, compared to a western Oregon range of 13 to 502 ft^2/1000ft. At this Siskiyou site, then, a larger proportion of existing

cover (and therefore likely canopy shade) was comprised of conifers and a smaller portion of hardwoods than at the Large stream sites surveyed elsewhere in western Oregon. However, the Small stream category is of more direct interest for purposes of the present report. For the Small Siskiyou stream (Jamison Cr.), reported conifer basal area within the RMA was 97 ft^2/1000ft, compared to a range of 0 to 180 ft^2/1000ft and a median of 115 ft^2/1000ft across 14 streams throughout western Oregon (Blue Mountains streams in the study were excluded from these calculations). Reported hardwood basal area in this Siskiyou Small stream RMA was 70 ft^2/1000ft, compared to a range of 22-184 ft^2/1000ft and a median of 70. Furthermore, the cumulative average basal area of conifers and hardwoods in relation to distance from the stream channel (Dent. Fig. 4, pp. 20-21) for the Small Siskiyou stream was very similar to the same curves for aggregated Small Coastal Streams from western Oregon.

These data do not suggest that the basal area of conifers and hardwoods at the Siskiyou Small stream site was in any way anomalous relative to the other surveyed western Oregon Small stream sites; rather, they suggest the opposite. Additionally, the reported basal areas for the two Siskiyou sites fall squarely within the range of conifer basal areas Dent (2001) compiled from literature sources for western Oregon Coast Range streams (Fig. 3,p.19 and Appendix A). These facts suggest there is no discernible forest ecological basis for assuming from the results of ODF's riparian shade and stream temperature studies should not be extended to the Siskiyou Georegion.

That finding corresponds with the senior author's own extensive field observations of riparian forests and stream channels in the Siskiyou Georegion and the other western Oregon regions. While the proportions of tree and shrub species, growth rates, and microclimates vary, as does the stem density of certain commercially valued species like Douglas-fir, overall canopy shade conditions for Small and Medium sized streams do not vary in a systematic way that corresponds with the georegion delineation. Similar near-complete crown closure in the absence or near-absence of disturbance across western Oregon likely results from the simple fact the forest vegetation develops to maximize utilization of available light wherever sufficient moisture and nutrients are available to support this, and sufficient moisture and nutrients are generally available in riparian areas throughout western Oregon. The Siskiyou region, at least outside of areas of ultramafic bedrock and in the absence of grazing, urbanization, or channelization, is capable of supporting a sufficient density of larger trees in riparian areas that tree crowns can span and overlap across the full width of most Medium-sized streams.

QUESTION 2: ARE SMALL STREAMS IN THE SISKIYOU GEOREGION WARMER THAN STREAMS IN OTHER AREAS OF WESTERN OREGON?

1) Regional patterns of Stream Temperature

This question could be quantitatively addressed by statistical comparison of temperature records among streams with at least several years of daily maximum temperature records. Numerous records exist, have been compiled by federal researchers, and are available for query in the data base at the NorWest stream temperature web page at http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST.html. A comprehensive quantitative comparison of this kind, while feasible, is beyond the scope of this memorandum.

However, a visual test of the question can be made by inspection of the regional "Thermalscape" map produced by the NorWest project and available online at http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/images/ThermalscapeWesternUS_StreamTemperatures082016.jpg. This map presents the results of a spatial statistical network model that predicts stream temperature based on a small set of physical characteristics and the best fit to existing field data on stream temperature for thousands of sites in the NorWest data base. The mapped output is comprehensive for the Pacific Coastal, Great Bain, and Rocky Mountain areas, including all of western Oregon. For the purposes of this memo we have excerpted the Western Oregon area map and roughly outlined the boundaries of ODF's Siskiyou Georegion (Figure 1). An inspection of this figure reveals no evidence that stream temperatures trend warmer in the Siskyou Georegion than in the surrounding Oregon coastal and interior Willamette and Umpqua areas. Although smaller and mid-order streams in the Cascades region at higher elevations do appear cooler on average then their counterparts elsewhere in western Oregon, that pattern is well-known and is associated with geohydrologic differences, with additional influence of elevation and snowmelt runoff, and the extensive watershed areas managed under Northwest Forest Plan and federal Wilderness policies.

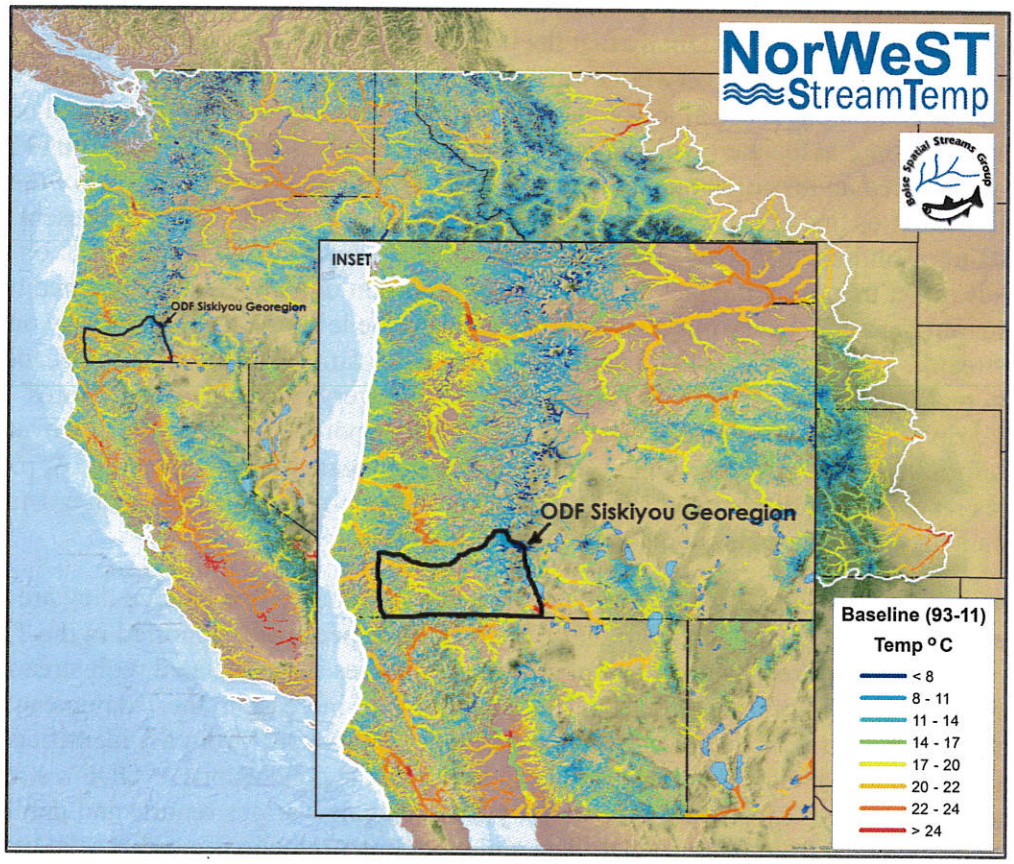

Figure 1. "Thermalscape Map "of stream temperatures synthesized from a spatially explicit model calibrated to an extensive set of temperature site data across the Pacific Northwest. Graphic modified to depict approximate area of the ODF Siskiyou Georegion from http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/images/ThermalscapeWesternUS_StreamTemperatures082016.jpg.

2) Riparian Canopy, Stream Shade and Stream Temperature Relations

Clean Water Act 303d listings of stream segments impaired by elevated temperature is widespread in the Rogue Basin (ODEQ 2008). Temperature impairment listings are especially prevalent in three stream categories: 1) along larger rivers and large streams in all land ownership and use categories, 2) medium size and small streams draining agricultural and urban lands, and 3) small and medium-sized streams draining private industrial forest lands. TMDL Reports (Siskyou National Forest and ODEQ 1999, ODEQ 2002, 2003, 2007) identify forestry effects, particularly those reducing stream shade by riparian logging and near-stream roads, as a major contributor to thermal loading. These reports also project through spatially explicit, calibrated models of thermal loading under different flow and land management scenarios, how much streams have likely warmed as a consequence of past forestry activity, and conversely how much they could be expected to cool with restrictions on near-stream logging that would be necessary to allow regrowth of mature riparian forest conditions.

As an index of the magnitude of temperature change associated largely with forestry activities, in Table 1 we have excerpted relevant data from small and medium-sized streams Oregon Department of Environmental Quality (ODEQ) Total Maximum Daily Load (TMDL) studies where we could establish provisionally that the predominant land use is private land forestry. Excepting some streams where very large canopy cover reductions are likely associates with agricultural or exurban land use at lower elevations, these data suggest that recent and past forestry activities are associated with canopy cover and shade losses range from around 2 to 45 percent, with a median loss of about 15%. We note that these shade losses may be conservative relative to the losses that occur within the first few years after logging, as they represent the current stand conditions that span a range of years of recovery since last logging; but on the other hand this is offset in part by the fact that many sites represent older harvests conducted before present stream protection rules that require some shade to be left in place, particularly on fish-bearing streams. What is clear is that post-logging recovery times likely stretch to decades especially on Medium and larger streams, because full recovery of shade often requires substantial riparian forest tree height. The various TMDL reports cited here offer recovery time estimates for 303d listed streams. One example is the Applegate TMDL Appendix A, p.45 which lists recovery to full potential shade as ranging from 6 to 87 years, based on existing vegetation height and a growth model calibrated to site class.

Maximum temperature data (Table 1) are very sparse in this source (we believe they are likely available in model documentation from DEQ, but were not specifically reported in the TMDL reports), but a couple of reported values suggest canopy losses are associated with stream temperature increases of at least 1 to 4°F. This magnitude of increase in the 7-day mean daily maximum temperature is on the order of magnitude one could expect from the identified magnitude of canopy shade reduction, roughly in line with the conclusions of ODF's stream shade and temperature ("Ripstream") research by Groom et al. (various reports and published papers). The evidence from these TMDL data and modeling projections appear to fall well in line with Ripstream results and predictions from sites in other western Oregon streams, offering no evidence that Siskiyou Region streams operate differently with regard to the thermal effects of shade and shade loss.

Table 1. Siskiyou Georegion existing and potential canopy cover estimates for selected streams as documented in ODEQ TMDL reports (1999, 2002, 2003, 2007). Stream size class is approximate; streams reported here were selected as those known to flow largely through private forest land, though other land uses and intermingled blocks of federal ownership also occur. Measured maximum temperature and projected maximum temperature under full potential canopy cover and shade are also reported here.

		Approx.	Average Canopy Cover			Maximum Temperature (°F)		
Stream Name	Basin	Size Class	Current	Potential	Difference	Current	Potential	Difference
Walker Cr	L. Rogue/Bear	M	41%	86%	-45%			
Griffin Cr	L. Rogue/Bear	M	47%	85%	-38%	71.4	70	+1.4
Coleman Cr	L. Rogue/Bear	M	67%	89%	-21%			
Neil Cr	L. Rogue/Bear.	M	71%	88%	-17%	68	64	+4
Emigrant Cr	L. Rogue/Bear	M	54%	85%	-31%			
Bear Cr	L. Sucker	M	88%	96%	-8%			
Little Grayback Cr	L. Sucker	M	86%	96%	-10%			
N Fk Munger Cr	Applegate	S	76%	92%	-16%			
Goodwin Cr	Applegate	S	89%	96%	-7%			
Lone Cr	Applegate	M	89%	96%	-7%			
Tree Branch Cr	Applegate	S	88%	94%	-6%			
Right Hand Fk.	Applegate	M	87%	92%	-5%			
Bear Wallow Cr	Applegate	M	80%	95%	-15%			
Clapboard Cr.	Applegate	M	91%	93%	-2%			
Sugarloaf Cr	Applegate	S	89%	95%	-6%			
Rock Cr.	Applegate	M	87%	92%	-5%			
Rt Hand Rock Cr	Applegate	M	89%	97%	-8%			
Glade Fk	Applegate	M	94%	97%	-3%			
Benson Gulch	Applegate	S	64%	94%	-30%			
Lightning Gulch	Applegate	M	82%	92%	-11%			
1918 Gulch	Applegate	S	62%	90%	-28%			
1917 Gulch	Applegate	S	63%	89%	-26%			
Ladybug Gulch	Applegate	M	70%	92%	-22%			
Alexander Gulch	Applegate	S	75%	92%	-17%			
Deadman Gulch	Applegate	S	94%	97%	-3%			
Pete's Camp Cr	Applegate	S	91%	94%	-3%			
Rock Gulch	Applegate	S	86%	96%	-10%			

The Siskiyou National Forest and ODEQ Sucker Creek TMDL (1999) quantitatively related canopy cover and effective shade to observed water temperature in Sucker Creek and Tributaries (Figure 2). These data demonstrate a statistically significant inverse relationship equivalent to roughly a 4°F stream temperature increase for every 10% loss in riparian cover or effective shade. This relationship is approximately of the same magnitude as reported for other western Oregon streams in Oregon Department of Forestry's "Ripstream" Riparian Shade and Stream Temperature (Groom et al., various articles and reports).

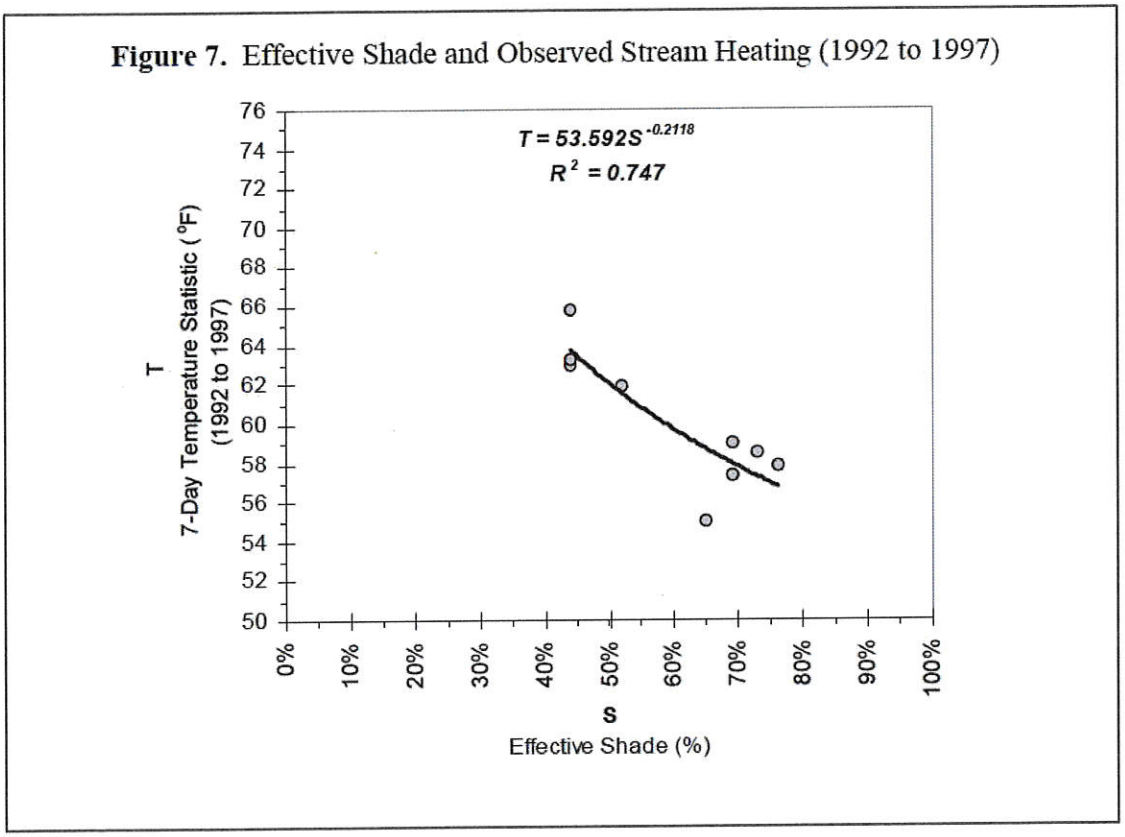

Fig. 2. Excerpt from Appendix G of the Sucker Creek TMDL Report (Siskiyou National Forest and ODEQ 1999, p. G-18) displays the relationship between field-measured 7-day maximum stream temperature and percent effective canopy shade across 10 stream reaches in the Sucker Creek Watershed. This data set spans small, medium and large streams across federal and private ownerships

QUESTION 3: IS CLIMATE IN THE SISKIYOU GEOREGION DIFFERENT?

1) Effects of Climate on Stream Temperature

Climate undoubtedly differs on average in the Siskiyou region in comparison to climate of other western Oregon regions. However, the somewhat warmer, drier prevailing condition does not conform to a discrete departure or boundary. Numerous watersheds and streams exist in the Coastal and Interior regions that have local climate and other ecological characteristics of Siskiyou region streams. Likewise, many streams within the Siskiyou region have local ecological conditions more characteristic of wetter, cooler watersheds in the surrounding western Oregon regions. However, it is important to recognize that natural riparian forest vegetation strongly buffers the local microclimates that influence stream temperature. Microclimate buffering is one of the less-well-studied aspects of riparian forest function, but one of its effects is that streams with naturally developed riparian forests are substantially protected from direct exposure to the climate stressors that prevail at larger scales (Olson et al. 2007).

The most important considerations are the aspects of climate that contribute to water temperature conditions in streams. Poole and Berman (2001) reviewed the principal environmental vectors contributing to structuring the thermal profile and warming and cooling of streams. While air temperature does exert some influence, groundwater temperature and distribution, solar insolation and the mediation of solar insulation via shade, and stream flow volume are by far the strongest determinants of stream temperature. Of these factors, the one most strongly, directly, and extensively affected by human management, whether positively or negatively, is stream shade provided by vegetation. The consequences of removal or restoration of forest shade easily overwhelm the effects of all other factors, when considered across the landscape of a large river basin. Therefore protection of forests in streamside areas is critical in virtually any region outside of the high arctic and the driest deserts—most certainly including the Siskiyou Georegion.

2) Climate Change and Stream Shade

Climate change is likely to warm groundwater by a few degrees. As a result, at their point of origin, headwater streams will warm. At the latitude of the Siskiyou, stream source temperatures will remain within the thermal range preferred by salmonid fishes, but because streams will be warmer at emergence, they will be vulnerable to being more easily and rapidly warmed to levels exceeding salmonid preference and tolerances as they flow downstream. This means shade will be even more important in the future than it is today to maintain suitable stream temperatures for salmonids and other coldwater-dependent species.

Climate change is also likely to increase peak flows and reduce stream low flows across the Pacific Northwest (in fact several published papers have documented the onset of steadily declining low flows over the past 15-20 years). Reduced low flows will increase the vulnerability of all streams to heating from sunshine, further increasing the importance of forest shade to maintain suitable temperatures.

Climate change may increase the prevalence and possibly the severity of wildfire in the Siskiyou and other regions, but the consequences of this for riparian forests and streams are not well

understood. Stream temperatures may increase when riparian canopy shade decreases after fire, but increased groundwater discharge and low flow volume post-fire can sometimes largely offset shade effects. However, we do know that as a general rule, where and when fire reduces riparian forest cover over extensive areas, the importance of forest cover wherever it remains and the shade it offers only increases.

Climate change is a global phenomenon not easily managed or reversed by any single policy measure. That means policies that allow humans to adapt to or mitigate the effects of climate change will be vital. Restoring and maintaining maximum potential levels of shade in streamside forests and areas of shallow, near-surface groundwater is the principal management action that humans can invoke to mitigate the likely effects of climate change identified above. Excluding the Siskiyou region from improved streamside forest protection rules unquestionably renders streams in the region more vulnerable to the adverse effects of stream heating associated with climate change.

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