Written Public Comments for Proposed
Protection Rules for Salmon, Steelhead and Bull Trout Streams
in the Siskiyou Geographical Region
Submitted prior to 5PM on September 28, 2020

From:	WAGENBLAST Greg * ODF
To:	PUBLICCOMMENT PRIVATEFORESTS * ODF
Cc:	WAGENBLAST Greg * ODF; BARNARD Josh W * ODF
Subject:	FW: Public comments for SSBT hearing
Date:	Monday, September 21, 2020 9:41:30 AM
Attachments:	RRK and WSC Comments SSBT Rule 9.18.20.pdf

From: Stacey Detwiler <stacey@rogueriverkeeper.org>
Sent: Friday, September 18, 2020 12:45 PM
To: WAGENBLAST Greg * ODF <Greg.WAGENBLAST@oregon.gov>
Cc: OLIVOS-ROOD Hilary * ODF <Hilary.Olivos-rood@oregon.gov>; VANDYK Bob <bvandyk@wildsalmoncenter.org>
Subject: Public comments for SSBT hearing

Hi Greg,

Please see the attached public comments for the SSBT rulemaking comment period.

Thanks,

Stacey

--
Stacey Detwiler
Conservation Director
Rogue Riverkeeper
stacey@rogueriverkeeper.org | (541) 488-9831
Pronouns: she, her, hers
https://rogueriverkeeper.org

Greg Wagenblast
Oregon Department of Forestry
2600 State Street, Building D
Salem, OR 97310

September 18, 2020

Re: Public Comment on Proposed Rulemaking to Apply Salmon, Steelhead, and Bull Trout ("SSBT") Stream Buffer Standards to Siskiyou Georegion

Dear Mr. Wagenblast:

Thank you for the opportunity to provide public comment on the proposed rulemaking to apply the Salmon, Steelhead, and Bull Trout ("SSBT") stream buffer standards to the Siskiyou Georegion. Rogue Riverkeeper is a non-profit organization based in Jackson County within the Siskiyou Region that works to protect and restore clean water, native fish, and healthy communities in the Rogue River Basin. The Wild Salmon Center is a non-profit organization that works to strengthen local stewardship and ensure long term salmon conservation.

Following the Board of Forestry's November 2015 decision to exclude the Siskiyou region from the new SSBT stream buffer rule, Rogue Riverkeeper and the Wild Salmon Center have consistently advocated for the Board to review and update the existing stream buffer standards for the region. Leaving small and medium streams that support salmon and steelhead in the Siskiyou region with significantly less protections than the rest of western Oregon is a serious concern given the compelling evidence that current rules are inadequate to prevent logging that warms water temperatures in violation of the Protecting Coldwater Criterion ("PCW"), a fundamental component of the state's water quality standard for stream temperature.[1]

On behalf of our members and supporters, we support the proposed rulemaking to apply the SSBT stream buffer standards adopted in 2017 for western Oregon to the Siskiyou region. This represents a modest improvement and a first step to bring stream buffer standards in the Siskiyou up to the same level as the rest of western Oregon. However, we would like to emphasis the following points:

1. **Neither the Board of Forestry nor the Oregon Legislature made any associated findings that the current stream buffer standards for the Siskiyou are sufficient to meet water quality standards, any TMDL, or to be used as the basis for an approval HCP.**

[1] Groom et al. 2011. *Response of Western Oregon (USA) stream temperature to contemporary forest management*, Forest Ecology and Management, 262: 1618-1629.

First, we want to be clear that, although this rule change is an improvement to current protections that apply in the Siskiyou, neither the Board nor the legislature has made any associated findings that the current stream buffer standards for the Siskiyou are sufficient to meet water quality standards for temperature. Further, no findings were made regarding the sufficiency of current standards to meet any other water quality standards, for any TMDL, or as the basis for an approvable Habitat Conservation Plan under the Endangered Species Act. The proposed rulemaking to apply the SSBT standards to the Siskiyou is a direct result of Senate Bill 1602, and does not reflect any decision or finding regarding whether or not the current standards are sufficient to protect water quality under the Clean Water Act.

2. **The science is clear that only 120-foot buffers will achieve compliance with the PCW to the maximum extent.**

Second, we want to reiterate that the science is clear that only 120-foot buffers will achieve compliance with the Protecting Cold Water (PCW) criterion to the maximum extent, or nearly 100% of the time. Even the final "Siskiyou Streamside Protections Review" released in the September 9th Board packet reiterates this point. A 100-foot buffer is expected to meet the PCW 80-85% of the time. A 90-foot buffer is expected to meet the PCW 50% of the time. The SSBT buffer standards require 60-foot and 80-foot buffers respectively on small and medium streams. As a result, the SSBT standard creates a high degree of risk that the PCW will not be met.

Additionally, we would emphasize that there are six temperature TMDLs within the Siskiyou region and five of those have a Human Use Allowance of 0 degrees Celsius. The Rogue Basin TMDL has an HUA of 0.04 degrees Celsius.

We incorporate by reference all of our previous comments and those submitted by the Oregon Stream Protection Coalition regarding the RipStream study and the resulting development of the 2017 stream buffer standard.

3. **Conclusions**

In conclusion, we support the proposed rulemaking to apply the SSBT stream buffer standards adopted in 2017 for western Oregon to the Siskiyou region. We also want to emphasis that no findings regarding the sufficiency of existing stream buffer standards in the Siskiyou were made as part of this process. Further, the science is clear that only 120-foot stream buffers will be likely to achieve maximum compliance with the PCW. The 2017 SSBT stream buffer standards create a high degree of risk that the PCW will not be met. As a result, we expect that riparian protections on small and medium SSBT streams will be on the table for future policy development as part of the statewide Habitat Conservation Plan discussions.

Thank you for the opportunity to provide public comments.

Sincerely

Stacey Detwiler
Conservation Director
Rogue Riverkeeper

Bob Van Dyk
Policy Director for Oregon and California
Wild Salmon Center

From:	Brown, Dan
To:	PUBLICCOMMENT PRIVATEFORESTS * ODF
Cc:	ABRAHAM Kyle * ODF; FRUEH Terry * ODF; WIGAL Jennifer; FOSTER.eugene.p@deq.state.or.us; SEEDS Joshua; Barber, Anthony
Subject:	EPA Comments on Proposed Siskiyou Georegion salmon, steelhead, and bull trout stream protection rules
Date:	Thursday, September 24, 2020 9:54:50 AM
Attachments:	image003.jpg 9-24-2020 EPA Comments to ODF re proposed SSBT Expansion to Siskiyou.pdf 2-22-2017-EPA Comments on ODF SSBT Proposed Riparian Rule Changes.pdf 1-30-2015 NOAA-EPA OR CZARA decision.pdf

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Mr. Greg Wagenblast

We thank the Oregon Department of Forestry for the opportunity to provide comments on the Proposed Siskiyou Georegion salmon, steelhead, and bull trout stream protection rules.

Attached are EPA's comments along with the two documents reference in the comment letter. Please feel free to contact me with any questions or concerns you may have.

Sincerely,
Dan Brown

Dan Brown,
Natural Resource Advisor - Forest Sector
U.S. EPA, Region 10: Oregon Operations Office,
805 SW Broadway, Suite 500
Portland, Oregon 97205
(503)326-6832

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
OREGON OPERATIONS OFFICE
805 Southwest Broadway, Suite 500
Portland, Oregon 97205

September 24, 2020

Mr. Greg Wagenblast
Oregon Department of Forestry
2600 State Street Bldg. D
Salem, OR 97310
(sent via email to privateforests.publiccomment@oregon.gov)

RE: Proposed Siskiyou Georegion salmon, steelhead, and bull trout stream protection rules

Dear Mr. Wagenblast;

We thank the Oregon Department of Forestry for the opportunity to provide comments on the proposed Siskiyou Georegion salmon, steelhead, and bull trout (SSBT) stream protection rule. We understand ODF is proposing the rulemaking in accordance with Senate Bill 1602, passed in the June 2020 special session of the Oregon Legislature.

We applaud Oregon's legislators for recognizing the need for stream protections in the Siskiyou and we're grateful for ODF's expediency in proposing to extend current SSBT protection into the Siskiyou. While the proposed rule meets the intent of SB 1602, EPA is suggesting ODF consider wider riparian buffers to protect water quality in the Siskiyou Georegion.

The attached February 22, 2017 letter from EPA to ODF transmitting comments on the originally proposed SSBT rules provides the rational for wider riparian buffers. Specifically, EPA found the SSBT riparian buffers to be less protective than what scientific data and modeling concluded was necessary to attain water quality standards and protect beneficial uses. We believe the more protective options outlined in our 2017 comments should be considered for adoption.

We also note that SB 1602, Section 1 requires the Governor to facilitate mediation sessions between the representatives of the forest industry and environmental interests that signed the Memorandum of Understanding announced by the Governor on February 10, 2020. According to SB 1602, the purpose of the mediation sessions is to develop an approach to evaluate and jointly recommend substantive and procedural changes to Oregon Forest Practices Act laws and regulations to advance the attainment of federal regulatory assurances for aquatic and riparian-dependent species.

While the mediation process is independent of the currently proposed rulemaking, it may offer an additional opportunity to address options for improving the SSBT rules. In addition to EPA's 2017 SSBT comments, the attached January 30, 2015 EPA and NOAA disapproval of Oregon's Coastal Nonpoint Pollution Control Program identified the needed protections for all small and medium fish-bearing and non-fish-bearing streams in Oregon. Together these two attachments should prove useful in identifying gaps for the mediation process to address.

Again, we thank you for the opportunity to provide comments and look forward to the results of this rulemaking and the recommendations from the mediation process. If you have any question or concerns please contact Dan Brown of my staff at 503-326-6832, or brown.dan@epa.gov.

Sincerely,

ANTHONY BARBER

Digitally signed by ANTHONY BARBER
Date: 2020.09.22 10:46:26 -07'00'

Anthony L. Barber, PE
Regional Forestry Executive Lead
Director, Oregon Operations Office

Attachments

cc: Kyle Abrahms, ODF
Jennifer Wigal, ODEQ

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 10
805 Southwest Broadway, Suite 500
Portland, OR 97205

OREGON OPERATIONS OFFICE

February 22, 2017

Private Forest SSBT Rulemaking
Oregon Department of Forestry
Attn: Stream Rules
2600 State Street
Salem, Oregon 97310

Subject: EPA Region 10 Comments on Oregon Board of Forestry's proposed riparian rule changes

The U.S. Environmental Protection Agency has reviewed the Oregon Department of Forestry's proposed action to expand water protection rules to include small and medium salmon, steelhead, and/or bull trout streams. Our review focuses on the extent to which the proposed rule revisions support Oregon's existing water quality standards and provide protection for the State's established beneficial uses. The EPA has the responsibility for implementing the Clean Water Act nationally, in partnership with states and tribes. Our review also considers the proposed revisions within the context of the January 2015 findings of the EPA and the National Oceanic and Atmospheric Administration on Oregon's Coastal Nonpoint Program under Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990.[1]

The EPA recognizes and appreciates the time and effort the ODF staff and management have put into this proposed rule. We especially appreciate ODF's work on the "Private Forests Riparian Function and Stream Temperature Study," or "RipStream," and the associated Bayesian modeling effort, which allowed for a statistically defensible examination of how changes in basal area would affect shade and alter stream temperatures. These are robust analytical products that can be used to make sound decisions regarding riparian rule revision to ensure the protection of water quality standards and the support of beneficial uses.

Our review finds that the proposed rule revisions are not wholly consistent with what RipStream and ODF modeling recognized as necessary to protect cold water. We are concerned that the proposed rule will not result in water quality standards attainment and protection of beneficial uses. We are also concerned that the proposed rule is geographically limited. The rule would apply only to SSBT streams; it would not apply in the Siskiyou Region; and it would not provide needed protections for non-fish-bearing streams and some fish-bearing streams that feed into SSBT streams.

The EPA is further concerned that the proposed action is not an acceptable management measure for the purposes of addressing the riparian deficiencies in Oregon's Coastal Nonpoint Pollution Control Program as identified by the NOAA and the EPA. On January 30, 2015, the NOAA and the EPA

[1] https://coast.noaa.gov/czm/pollutioncontrol/media/Oregon%20CZARA%20Decision%20SIGNED%201302015.pdf

disapproved Oregon's CNPCP. This decision was based in part on an identified need to establish programs to protect small and medium fish-bearing streams and non-fish-bearing streams from increases in stream temperatures. Our concern in this regard is threefold:

(1) As noted above, we do not believe the proposed rule will be adequately protective of cold water;
(2) The proposed rule applies only to SSBT streams, to the exclusion of other small and medium fish-bearing streams and non-fish-bearing streams that were called out under the CZARA determination; and
(3) The rule does not apply to the Siskiyou region, which is within the coastal zone boundary for the purposes of the CZARA.

The EPA's detailed comments on key elements of the proposed revisions are enclosed with six additional attachments. Our comments are consistent with those of EPA representatives who provided testimony at the Oregon Board of Forestry meetings on April 22, 2015, June 3, 2015, July 23, 2015, and November 5, 2015. Please feel free to contact me at (503) 326-6890 if you have any questions about our comments, or you may call Alan Henning of EPA's Watershed Unit at (541) 687-7360.

Sincerely,

Anthony L. Barber, PE
Regional Forestry Executive Lead
Director, Oregon Operations Office

Enclosures

EPA Region 10 Detailed Comments on the
Oregon Department of Forestry's
Proposed Riparian Rule Changes to Protect SSBT Streams

629-642-0105(1) The purpose for the vegetation retention prescriptions in this section is to ensure that, to the maximum extent practicable, forest operations will not impair the achievement and maintenance of the protecting cold water criterion described in OAR 340-041-0028(11).

The EPA recognizes that in the crafting and application of rules, practicability must be taken into consideration. In the case of the current rule, however, it is not clear how the determination was made that the proposed rule represents "maximum practicability" with regard to ensuring that forest operations will not impair the achievement and maintenance of the Protecting Cold Water Criterion (PCW). The results of RipStream and ODF modeling clearly demonstrate that buffers should be at least 90 feet wide in order to achieve this objective. (See Attachments 1-3.) Given the existing evidence, we do not see a compelling case made in the rule or in the supporting materials that the adoption of a buffer that is less than 90 feet wide will adequately protect cold water, nor do we see sufficient justification for the conclusion that a 90-foot-wide buffer is not practicable.

629-642-0105(2) The vegetation retention requirements for Type SSBT Streams apply to the following Geographic Regions as described in OAR 629-635-0220: Coast Range, South Coast, Interior and Western Cascades

ODF's proposed rule revisions will not apply to the Siskiyou Region. The Oregon portion of the Siskiyou Region includes over one million acres of private forest land (i.e., 1,151,680 acres). Our analysis showed that there are 986 miles of SSBT streams located along these private forest lands of which 408 miles are small and medium sized SSBT streams. Six hundred and seventy- two (672) miles of streams have been included on the State' 303(d) list for temperature impairment along privately managed forested lands in the Oregon portion of the Siskiyou Region.

The EPA does not concur with the ODF determination that there is inadequate monitoring information or scientific study to justify regulation in the Siskiyou region. The extent of temperature-impaired streams in the Siskiyou Region indicates that the application of existing Oregon Forest Practice Act (FPA) riparian rules has not resulted in the achievement of water quality standards or the support of beneficial uses in this Region. The 2011 Rogue Basin Water Quality Status and Action Plan lists temperature as a parameter of concern throughout the basin, and a sampling of TMDL shade targets for the Rogue River and its tributaries reflect shade deficits ranging from 9% to 41%.[2] Furthermore, the results presented in the RipStream study can rationally be extrapolated to the Siskiyou Region. Although there may be some variation in system dynamics, we do not find evidence in the literature to suggest that the relationship between shade and stream warming is different in the Siskiyou when compared to the

[2] See Table 8 of the 2011 Rogue Basin Water Quality Status and Action Plan - http://www.deq.state.or.us/wq/watershed/Docs/RoguePlan.pdf

study sites included in the RipStream study. We believe there is both an urgency and a demonstrated need for additional stream protection in the Siskiyou Region.

Furthermore, the Siskiyou Region is included within the State of Oregon's Coastal Nonpoint Pollution Control Program (CNPCP) developed under the CZARA. As noted in our cover letter, the EPA and the NOAA disapproved Oregon's CNPCP in January of 2015 due in part to an identified need to establish programs to protect small and medium fish-bearing streams and non-fish-bearing streams from increases in stream temperatures. Oregon's CNPCP can be approved only upon the adoption of additional management measures for riparian protection throughout the zone covered by the CNPCP, including the Siskiyou region.

We strongly encourage the Board to include the Siskiyou Region in the current rule revision. Delay in addressing riparian buffers in this region would result in a prolonged timeframe for protecting critical cold water streams and for arriving at a CNPCP that can be approved under the CZARA.

629-642-0105(3) General Vegetation Retention Prescriptions for Type SSBT Streams – Operators shall apply the vegetation retention requirements as described in this rule to the riparian management area of the following streams:

(a) Type SSBT streams.

(b) The main stem of any Type F stream upstream of the mapped end of SSBT use to the higher of:

(A) The upstream boundary of the harvest unit containing SSBT, or

(B) The upstream boundary of any adjacent upstream harvest unit commenced within a year of completing harvest of the unit containing SSBT.

The EPA is concerned that the linear distance above an SSBT stream, where the proposed vegetation requirements for non-SSBT streams would apply, is not based on demonstrated thermal impacts, but is dependent on the geographical location of the upstream end of the SSBT stream within the proposed harvest unit. As presented, the proposed rules provide no consistency in the distance up-stream of the end of a SSBT stream where larger buffers will be required. Consequently, we have no assurance that SSBT streams will be protected from temperature increases from inadequately buffered non-SSBT streams flowing into them. In testimony to the BOF on July 23, 2015, the EPA offered that ODF's own staff provided strong evidence that buffer protections are needed 1000 feet above an SSBT stream to prevent temperature increases to the SSBT stream while the ODF analysis clearly shows that a "minimum of a 1,600 foot upstream extent is needed to ensure that water temperatures entering into SSBT streams do not, on average, violate the PCW rule". (Attachment 3). *629-642-0105(10) Type SSBT Prescription 1 – Expanding existing no-cut buffers on small SSBTs from 50' to 60' and on medium SSBTs from 70' to 80'.*

ODF's proposed *Prescription 1* adds 10 feet of buffer to the currently required 50-foot buffer on small SSBT streams and 10 feet of buffer to the currently required 70-foot buffer on medium SSBT streams. Although the additional buffering will help reduce temperature increases that occur when the existing Oregon Forest Practice Act (FPA) riparian rules are applied, results from the RipStream study estimate that a 60' no-cut buffer on small SSBT streams and an 80' no-cut buffer on medium SSBT streams would result in an average temperature increase of 0.4° C (ranging from 0.2° to 0.7°) and 0.9° C (ranging from 0.6° to 1.1°) respectively. (See Attachments 1 and 2.) These estimated increases exceed Oregon's Protecting Cold Water Criterion (PCW) of no temperature increase of 0.3°C or greater. There is strong

evidence from the RipStream analysis that shows a minimum of 90' intact harvest riparian buffer is needed to ensure that both medium and small streams do not violate PCW. Other research on this subject in the Northwest completed over the last decade also supports this finding. (See Attachment 3, Figures 1a. and 1b.)

629-642-0105(11) Type SSBT Prescription 2: Variable Retention Buffers

ODF's proposed *Prescription 2* establishes riparian management areas (RMAs) of 60 feet for small SSBT streams and 80 feet for medium SSBTs. The proposed 60-foot RMA for the small SSBT streams is divided into three zones: a 20-foot no-cut zone that begins from the high water mark of the stream; zone 2 - the area from 20 feet to 40 feet from the high water mark of the stream; and zone 3 - the area from 40 feet to 60 feet of the high water mark of the stream. The basal area targets for zone 2 and 3, based on 500-foot stream segments, is 10 sq. ft. The total basal area target for the RMA for a small SSBT stream is 37 sq. ft. The proposed 80-foot RMA for medium SSBTs is also divided into three zones: a 20 foot no-cut zone that begins from the high water mark of the stream; zone 2 - the area from 20 feet to 50 feet from the high water mark of the stream; and zone 3 - the area from 50 feet to 80 feet of the high water mark of the stream. The basal area target for zone 2 and 3, based on 500-foot stream segments, is 18 sq. ft. The total basal area target for the RMA for a medium SSBT stream is 69 sq. ft. The proposed rule also requires that the unlogged trees outside of the no-cut zone be evenly distributed throughout zones 2 and 3 in both types of RMAs. More specifically, the proposed rule requires that 25 percent of the required basal area target and 50 percent of the required live conifers be located in zones 2 and 3 of each type of RMA.

This proposal is an improvement over the existing FPA rules because it establishes greater basal area targets, and it requires a more even distribution of the unlogged trees within zones 2 and 3 of the RMAs for both the small and medium SSBT streams. However, any harvesting within the proposed 60-foot and 80-foot RMAs will result in additional heat loading to all small and medium SSBT streams. Utilizing the ODF's Ripstream Bayesian models, EPA calculated that the proposed variable retention buffers associated with *Prescription 2* will increase water temperatures by 1.2° C in small streams and 0.6° C in medium streams (See Attachment 1). As previously stated in our comments on *Prescription 1*, the RipStream model indicated that at least a 90' no-cut buffer on both small and medium SSBTs is needed to prevent temperature increases that violate the established PCW standard. Any harvesting within the proposed RMAs will further increase temperature loading, negatively impact water quality, and decrease the ability of these streams to meet PCW.

629-642-0105(12) Type SSBT Prescription 3 – 40' North-side Buffers

ODF's proposed *Prescription 3* applies to all SSBT streams where the stream valley direction is between 60 and 120 degrees east and 240 and 300 degrees west. On stream reaches of 200' or greater that meet this orientation requirement, *Prescription 3* allows for a 40' buffer on the north side of the stream. The south-sided buffer would continue as prescribed in proposed *Prescription 1 or 2.*

A reduction in the size of the North-side buffers from 60 feet to 40 feet on small SSBT streams and from 80 feet to 40 feet on medium SSBT streams will add to temperature increases already projected from the application of *Prescriptions 1 and 2.* (See the EPA's comments on *Prescriptions 1 and 2.*) In our July 23, 2015 testimony to the BOF, the EPA stated that south-side buffers will not provide protection

against temperature increases resulting from harvest in north-side buffers. We also commented that shade modeling shows that shade loss resulting from additional north-side buffer harvest could result in a violation of the PCW standard, even without the effects of shade loss associated with south-side harvest (see Attachment 3.) Beyond this, we do not find support in the scientific literature for applying a reduced buffer on the north side of streams and the limited Heat Source modeling presented by ODF staff (see ODF Rule Analysis presented at July 23, 2015 BOF meeting) does not provide an adequate scientific foundation for this proposed rule modification. We strongly recommend that Prescription 3 be removed from the proposed rule language.

629-642-0110 Relief for General Vegetation Retention Prescriptions for Type SSBT streams

"629-642-0110 Relief for General Vegetation Retention Prescriptions for Type SSBT streams" provides that a landowner can seek relief from having to implement buffer requirements identified in proposed Prescriptions 1 and 2 if the forested stream area encumbered by the SSBT classification is 8 percent or more of the landowner's parcel. If granted relief, the landowner would have the choice to apply: 1) proposed *Prescription 1* using a reduced RMA of 50' and 70' for small and medium SSBTs respectively; or 2) proposed *Prescription 2* using a reduced RMA of 50' and 70' for small and medium SSBTs respectively with reduced basal area targets and live conifer tree requirements.

This proposal will result in affected segments violating the PCW standard. As provided in the EPA's comments on proposed prescriptions 1 and 2, the RipStream study shows that a 90-foot no-cut buffer is needed on both small and medium streams to ensure PCW is achieved. Utilizing ODF's Bayesian model, EPA determined that the proposed *Relief Prescription 1* (i.e., reducing the no cut buffer width to 50' and 70') will result in a 1.2° C and 0.7 °C stream temperature increase, respectively (see Attachment 2). Additional thinning allowed with *Relief Prescription 2* will result in even greater stream temperature increases than expected with *Relief Prescription 1*.

We also note that ODF analysis (presented at the BOF meeting on July 20, 2016) shows that the proposed rule would have an extremely limited impact on the majority of landowners (i.e. 90% of landowners would experience an additional encumbrance of less than 1%, and 99% of landowners would experience an additional encumbrance of 4% or less). Given the implications for water quality and the limited number of landowners affected, we recommend removing the language proposing 8% as a threshold for encumbrance.

Greater protections for all small and medium fish- and non-fish-bearing streams.

As noted in our comment on section *629-642-0105(2)*, the EPA and the NOAA disapproved Oregon's CNPCP in January of 2015 due in part to an identified need to establish programs, including rules, to protect small and medium fish-bearing streams and non-fish-bearing streams from increases in stream temperatures. The scientific basis for this determination is presented on pages 4 through 7 of the agencies' decision document. (See footnote 1.) ODF's proposed riparian rules provides increased protections only for small and medium SSBT streams and, where applicable, portions of non-SSBT fish-bearing streams. The EPA estimated that SSBT streams only comprise 11% of the stream miles within lands managed under FPA rules in Western Oregon, which corresponds to 73,987 stream miles not designated as SSBT streams. The EPA also estimated that SSBT streams only comprise 26% of the type F and perennial streams in Western Oregon, which corresponds to 25,611 miles of streams not

designated as SSBT streams. (See Attachment 5.) In testimony to the BOF on June 3, 2015, the EPA expressed the need to establish rule revisions that provided greater riparian protections for all medium and small streams and non-fish-bearing streams, in additional to SSBT streams. Non-fish-bearing streams are often headwaters that provide critical cold water and wood for meeting water quality standards and supporting beneficial uses. Currently, over 7732 miles of Western Oregon rivers and streams have been or are currently listed for temperature. (See Attachment 6). The EPA believes a substantial number of studies show the need for greater riparian protections. The current proposed rule change, which does not include adequate rule revisions for both SSBT streams and other fish and non-fish bearing streams, will not, by itself, enable water quality standards to be achieved or beneficial uses to be protected.

Attachment 1 – Shade loss and temperature increases resulting from the Implementation of Option A and Option B of the proposed Oregon Forest Practices Rule for SSBT streams in sections of Western Oregon. (P. Leinenbach Memo to A. Henning, January 27, 2016, 11 pages).

Attachment 2 – Estimating the stream temperature response associated with *Relief Prescription 1* for small and medium streams in Western Oregon. (P. Leinenbach Memo to A. Henning, February 17, 2017, 1 page).

Attachment 3 – Leinenbach, P. 2015. Testimony of Peter Leinenbach, Aquatic and Landscape Ecologist, Environmental Protection Agency, Region 10, Before the Oregon Board of Forestry, July 23, 2015.

Attachment 4 – The EPA's analysis of South-sided Buffers. (P. Leinenbach Memo to A. Henning, July 13, 2015, 3 pages.)

Attachment 5 – Comparison of stream miles associated with designated SSBT streams. (p. Leinenbach Memo to A. Henning, April 10, 2015, 4 pages).

Attachment 6 – Henning, A, 2015. Testimony of Alan Henning, Environmental Protection Specialist, Environmental Protection Agency, Region 10, Before the Oregon Board of Forestry, June 3, 2015.

NOAA/EPA FINDING THAT OREGON HAS NOT SUBMITTED A FULLY APPROVABLE COASTAL NONPOINT PROGRAM

FOREWORD

This document contains the bases for the finding by the National Oceanic and Atmospheric Administration (NOAA) and the United States (U.S.) Environmental Protection Agency (EPA) (collectively, the federal agencies) that the State of Oregon (State) has not submitted a fully approvable Coastal Nonpoint Pollution Control Program (Coastal Nonpoint Program) as required by section 6217(a) of the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA), 16 U.S.C. 1455b. NOAA and EPA arrive at this decision because they find that the State has not adopted additional management measures applicable to forestry that are necessary to achieve and maintain applicable water quality standards under Clean Water Act section 303 and to protect designated uses. NOAA and EPA first identified and notified the State of the need to implement the additional measures in 1998.

On January 13, 1998, the federal agencies approved the Oregon Coastal Nonpoint Program subject to specific conditions (see *Oregon Conditional Approval Findings*). Since then, NOAA and EPA have been working with the State to address the conditions. The State has made incremental modifications to its program and has since met most of those conditions.

On December 20, 2013, the federal agencies provided notice of their intent to find that the State has not fully satisfied the conditions related to new development, onsite sewage disposal systems (OSDS), and additional management measures for forestry (see *Oregon Coastal Nonpoint Program NOAA/EPA Proposed Finding*). The federal agencies invited public comment on the proposed findings, as well as on the extent to which those findings support a finding that the State has not submitted an approvable program under CZARA. Based on comments and concerns the federal agencies received about agriculture nonpoint source management in the State, the federal agencies also invited public comment on the adequacy of the State's programs and policies for meeting the CZARA 6217(g) agriculture management measures and conditions placed on Oregon's Coastal Nonpoint Program. Because the December 20, 2013, notice of intent did not propose a specific decision on whether Oregon had satisfied the CZARA 6217(g) agriculture management measures and the public did not have an opportunity to comment on a specific proposed decision and rationale for that decision, the adequacy of Oregon's agriculture programs is not a basis for the findings that Oregon has not submitted an approvable coastal nonpoint program. (For a summary of the comments received and the federal agencies' response to them, see *NOAA and EPA Response to Comments Regarding the Agencies' Proposed Disapproval Finding that Oregon has Not Submitted a Fully Approvable Coastal Nonpoint Program*.)

In response to NOAA and EPA's proposed findings, Oregon provided an additional submission in support of its coastal nonpoint program on March 20, 2014 (see *Oregon's Response to Proposed Disapproval Findings*).[1]

NOAA and EPA have carefully reviewed the public comments received and the State's March 2014 submission and have made a finding that Oregon has not submitted a fully approvable coastal nonpoint program. This decision is made because the State did not address the additional management measures for forestry condition. Based on information the State provided in March, the federal agencies believe that Oregon has now satisfied the conditions for new development and OSDS, so those conditions are no longer a basis for the finding that Oregon has not submitted an a fully approvable coastal nonpoint program.

For further understanding of terms in this document and the basis of this decision, the reader is referred to the following documents:

- *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* (EPA January 1993);
- *Coastal Nonpoint Pollution Control Program: Program Development and Approval Guidance* (NOAA and EPA January 1993);
- *Flexibility for State Coastal Nonpoint Programs* (NOAA and EPA March 1995);
- *Final Administrative Changes to the Coastal Nonpoint Pollution Control Program Guidance for Section 6217 of the Coastal Zone Act Reauthorization Amendments of 1990* (CZARA) (NOAA and EPA October 1998);
- *Policy Clarification on Overlap of 6217 Coastal Nonpoint Programs with Phase I and II Stormwater Regulations* (NOAA and EPA December 2002); and
- *Enforceable Policies and Mechanisms for State Coastal Nonpoint Source Programs* (NOAA and EPA January 2001).

Electronic copies of the documents cited above as well as any other references cited in this document and the Federal Register notice announcing this action will be available at the following website: http://coast.noaa.gov/czm/pollutioncontrol.

SCOPE OF DECISION

This document explains NOAA and EPA's finding regarding the additional management measures for forestry condition. This finding forms the basis for the federal agencies' decision that the State has not submitted a fully approvable program.[2] The document also notes that the new development and OSDS management measures are no longer a basis for this decision. In addition, the document acknowledges the comments received regarding the adequacy of Oregon's agriculture programs and policies for meeting the 6217(g) agriculture management

[1] In a Settlement Agreement entered in 2010 to resolve a lawsuit brought by a nonprofit organization, Northwest Environmental Advocates v. Locke, et al., Case No. CV09-0017-PK (D. Ore), NOAA and EPA agreed to make a final decision on whether to approve or disapprove Oregon's Coastal Nonpoint Program by May 15, 2014, later extended to January 30, 2015.

[2] CZARA provides for NOAA and EPA to withhold a portion of CZMA Section 306 and CWA Section 319 grant funds when a disapproval decision is made. NOAA and EPA may withhold funding as early as July 1, 2015.

measures and conditions placed on Oregon's Coastal Nonpoint Program. However, at this time, the agencies have not made a decision on the adequacy of the agricultural measures.

NOAA and EPA's findings in this document are based on information the State has submitted in support of each condition, the federal agencies' knowledge of coastal nonpoint source pollution management in Oregon, and the public comments received. Oregon may–and is encouraged to–continue to work on and improve its program to satisfy all coastal nonpoint program requirements. Should the State submit subsequent information upon which NOAA and EPA determine that the State has submitted a fully approvable program, the federal agencies will provide another opportunity for public comment. At that time, the public will be asked to provide comment on whether the State has satisfied all conditions placed on its program in 1998 and met all CZARA requirements.

FINDING OF NOT HAVING SUBMITTED A FULLY APPROVABLE PROGRAM

NOAA and EPA have determined that the State of Oregon has not submitted a fully approvable program pursuant to Section 6217(a) of CZARA.

I. UNMET CONDITION

A. ADDITIONAL MANAGEMENT MEASURES– FORESTRY

PURPOSE OF MANAGEMENT MEASURE: The purpose of this management measure is to identify additional management measures necessary to achieve and maintain applicable water quality standards and protect designated uses for land uses where the 6217(g) management measures are already being implemented under existing nonpoint source programs but water quality is still impaired due to identified nonpoint sources.

CONDITION FROM JANUARY 1998 FINDINGS: Within two years, Oregon will identify and begin applying additional management measures where water quality impairments and degradation of beneficial uses attributable to forestry exist despite implementation of the 6217(g) measures (1998 Findings, section X).

FINDING: Oregon has not satisfied this condition. By not adopting and implementing additional management measures applicable to forestry and forested lands that are necessary to achieve and maintain water quality standards and to protect designated uses, Oregon has not submitted a fully approvable program under CZARA.

RATIONALE: Oregon proposed to address the additional management measures for forestry condition through a combination of regulatory and voluntary programs. Those measures include best management practices or other control measures by rule established by the Board of Forestry (Board). In addition, the Environmental Quality Commission (EQC), the rulemaking body for the Oregon Department of Environmental Quality (ODEQ), can petition the Board if it

believes the Forest Practices Act (FPA) rules are not adequate for achieving water quality standards. While Oregon has made some progress towards meeting this condition, the State has not identified or applied additional management measures that fully address the program weaknesses the federal agencies noted in the January 13, 1998, Findings for Oregon's Coastal Nonpoint Program. Specifically, the State has not implemented or revised management measures, backed by enforceable authorities, to (1) protect riparian areas for medium-sized and small fish-bearing (type "F") streams and non-fish-bearing (type "N") streams; (2) address the impacts of forest roads, particularly on so-called "legacy" roads; (3) protect high-risk landslide areas; and (4) ensure adequate stream buffers for the application of herbicides, particularly on non-fish-bearing streams.

Protection of Riparian Areas: Oregon relies on both regulatory and voluntary measures to provide riparian protections for medium-sized and small fish-bearing streams (type "F" streams) and non-fish-bearing streams (type "N" streams). Generally, under the State's current FPA rules, no tree harvesting is allowed on private lands within 20 feet of fish-bearing streams, or medium-sized and large non-fish-bearing streams. Also, all snags and downed wood that do not represent a safety or fire hazard must be retained within riparian management areas around small and medium-sized fish-bearing streams (from the stream edge out to 50 and 70 feet, respectively). In addition, the FPA rules establish conifer basal area and density targets for some riparian management areas. For example, along medium-sized fish-bearing streams, there is a requirement to leave 30 trees (at least 8 inches diameter at breast height [DBH]) per 1,000 feet. Oregon has no vegetation retention requirements for small non-fish-bearing streams in the Coast Range and Western Cascades.

In addition to regulatory requirements, the forestry industry in the State of Oregon has adopted voluntary measures to protect riparian areas for high aquatic potential streams (i.e., streams with low gradients and wide valleys where large woody debris recruitment is most likely to be effective at enhancing salmon habitat). These voluntary measures include large wood placement, retaining additional basal area within stream buffers, large tree retention, and treating large and medium-sized non-fish-bearing streams the same as fish-bearing streams for buffer retentions.[3]

Based on the results of a number of studies including those summarized below, NOAA and EPA previously determined and continue to find that additional management measures (beyond those in FPA rules and the voluntary program) for forestry riparian protection around medium-sized and small fish-bearing streams and non-fish-bearing streams are necessary to attain and maintain water quality standards and to protect designated uses. Therefore, Oregon must still adopt and implement management measures applicable to the forestry land use and forested areas in order to protect small and medium-sized fish-bearing streams and non-fish-bearing streams from water quality impairments attributable to forestry practices in riparian areas.

[3] According to Oregon's March 2014 coastal nonpoint program submittal, information on voluntary efforts was reported to the Oregon Watershed Restoration Inventory. http://coastalmanagement.noaa.gov/nonpoint/oregonDocket/StateofOregonCZARAsubmittal3-20-14.pdf.

A significant body of science, including 1) the Oregon Department of Forestry (ODF) Riparian and Stream Temperature Effectiveness Monitoring Project (RipStream)[4]; 2) *A Statewide Evaluation of Forest Practices Act Effectiveness in Protecting Water Quality* (i.e., the *Sufficiency Analysis*)[5]; and 3) the Governor's Independent Multidisciplinary Science Team (IMST) Report on the adequacy of the Oregon forest practices in recovering salmon and trout[6], indicates that riparian protection around small and medium-sized fish-bearing streams and non-fish-bearing streams in Oregon is not sufficient to achieve and maintain water quality and protect designated uses. The 2011 RipStream reports found that FPA riparian protections on private forest lands did not ensure achievement of the Protection of Cold Water (PCW) criterion under the Oregon water quality standard for temperature.[7,8] The PCW criterion prohibits human activities (e.g., timber harvest) from increasing stream temperatures by more than 0.3ºC at locations critical to salmon, steelhead, or bull trout. The RipStream analysis demonstrated that the chance of a site managed using FPA rules exceeding the PCW criterion between a pre-harvest year and a postharvest year was 40 percent.[9,10]

The RipStream study also demonstrated that stream temperature fluctuations increased, in part, with a reduction in shade, and that shade was best predicted by riparian basal area and tree height. The findings suggest that riparian protection measures that maintain higher shade (such as measures implemented on State forest land) are more likely to maintain stream temperatures similar to control conditions.[11]

The 2002 Sufficiency Analysis found that the Oregon FPA's prescribed riparian buffer widths for small and medium-sized fish-bearing streams may be inadequate to prevent temperature impacts. That analysis concluded that 1) FPA standards for some medium-sized and small Type F streams in western Oregon may result in short-term temperature increases at the site level; and 2) FPA standards for some small Type N streams may result in short-term temperature increases at the site level that may be transferred downstream (this may impact water temperature and cold-water refugia) to fish-bearing streams.[12] In water bodies colder than the numeric criteria, temperature increases of 0.3°C measured for all sources combined at the point of maximum

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[4] Three peer-reviewed articles present the results of the RipStream analysis:

Dent, L., D. Vick, K. Abraham, S. Shoenholtz, and S. Johnson. 2008. Summer temperature patterns in headwater streams of the Oregon Coast Range. *Journal of the American Water Resources Association* 44:803–813.

Groom, J.D., L. Dent, and L.J. Madsen. 2011a. Stream temperature change detection for state and private forests in the Oregon Coast Range. *Water Resources Research* 47 W01501. doi:10.1029/2009WR009061.

Groom, J.D., L. Dent, and L.J. Madsen. 2011b. Response of western Oregon stream temperatures to contemporary forest management. *Forest Ecology and Management*. doi:10.1016/j.foreco.2011.07.012.

[5] Oregon Department of Forestry and Oregon Department of Environmental Quality. 2002. *Sufficiency Analysis: A Statewide Evaluation of Forest Practices Act Effectiveness in Protecting Water Quality*. Oregon Department of Forestry and Oregon Department of Environmental Quality.

[6] Independent Multidisciplinary Science Team. 1999. *Recovery of Wild Salmonids in Western Oregon Forests: Oregon Forest Practices Act Rules and the Measures in the Oregon Plan for Salmon and Watersheds*. Technical Report 1999-1 to the Oregon Plan for Salmon and Watersheds, Governor's Natural Resources Office, Salem, OR.

[7] Groom et al., 2011a.

[8] Daugherty, P., and J.D. Groom. 2011. *Update on Private Forests Riparian Function and Stream Temperature (RipStream) Project*. Staff Report; November 3, 2011.

[9] Ibid. 2.

[10] Groom et al., 2011a.

[11] Ibid.2. 3.

[12] Oregon Department of Forestry and Oregon Department of Environmental Quality, 2002, pp. 44-45.

impact where salmon, steelhead, or bull trout are present is a violation of the State's PCW criterion.

As early as 1999, the IMST study found that the FPA rule requirements related to riparian buffers and large woody debris needed to be improved. Based on its scientific analysis, the IMST team concluded, "…the current site-specific approach of regulation and voluntary action is not sufficient to accomplish the recovery of wild salmonids."[13] The IMST team made the following recommendations: 1) Because nongame fish and other aquatic organisms play a role in a functioning stream system, and the distribution of salmonids will change over time, non-fish-bearing streams should be treated no differently than fish-bearing streams when determining the buffer width protections;[14] 2) there should be an increase in the basal area and requirements for riparian management areas for both small and medium-sized streams, regardless of the presence of fish; and 3) there should be an increase in the number of trees within the riparian management area for both fish- and non-fish-bearing small and medium-sized streams.[15]

In 2013, the EPA, together with the U.S. Geological Survey (USGS) and the Bureau of Land Management, reevaluated and summarized pertinent scientific theory and empirical studies to address the effects of riparian management strategies on stream function, with a focus on temperature.[16] With regard to no-cut buffers adjacent to clearcut harvest units, the paper noted that substantial adverse effects from reduced available shade have been observed with no-cut buffers ranging from 20 to 30 meters,[17] and that minimal adverse effects on stream shading and temperature have been observed in studies that examined no-cut buffer widths of 46 meters.[18] For no-cut buffer widths of 46–69 meters, the effects of tree removal on shade and temperature were either not detected or were minimal.[19] The paper also documented that, with no-cut buffer widths of less than 20 meters, pronounced reductions in shade and increases in temperature occurred, as compared to wider buffers. The most dramatic effects were observed at the narrowest buffer widths (less than or equal to 10 meters).[20] As already noted, existing FPA standards for small and medium-sized fish-bearing streams require only 20-foot (or approximately 7-meter) no-cut buffers within a riparian management zone of approximately 17–23 meters. No vegetation retention is required on small non-fish-bearing streams in the Coast Range and Western Cascades.

Oregon also has been investing in three paired watershed studies that are designed to analyze the effects of timber harvesting on a watershed and reach scale.[21] Several commenters have cited the paired watershed study as evidence that the current FPA practices for riparian protection are effective at achieving and maintaining water quality standards and protecting designated uses. Unpublished preliminary data from the Hinkle Creek study indicate that changes in stream

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[13] Independent Multidisciplinary Science Team, 1999, 2.
[14] Ibid. 21 and 43.
[15] Ibid. 44-45.
[16] Leinenbach, P., G. McFadden, and C. Torgersen. 2013. *Effects of Riparian Management Strategies on Stream Temperature*. Prepared for the Interagency Coordinating Subgroup (ICS), 22 pp.
[17] Brosofske et al., 1997; Kiffney et al., 2003; Groom et al., 2011b as cited in Leinenbach et al. 2013.
[18] Science Team Review, 2008; Groom et al., 2011a as cited in Leinenbach et al. 2013.
[19] Anderson et al., 2007; Science Team Review, 2008; Groom et al., 2011a; Groom et al., 2011b as cited in Leinenbach et al. 2013.
[20] Jackson et al., 2001; Curry et al., 2002; Kiffney et al., 2003; Gomi et al., 2006; Anderson et al., 2007 as cited in Leinenbach et al. 2013.
[21] Watershed Research Cooperative. Accessed 2014. Watershed Studies. Available online at: http://watershedsresearch.org/watershed-studies/.

temperature after timber harvest along non-fish-bearing streams were variable. In addition, there was no measureable downstream effect on temperatures.[22] The variation in stream temperature and overall net observed temperature decrease, however, could be attributable to increased slash debris along the stream after harvest, as well as a likely increase in stream flow post-harvest that could reduce any increase in temperatures and contribute to lower mean stream temperatures.[23] Because a variety of factors confound the draft conclusions from the Hinkle Creek study, NOAA and EPA do not rely on that analysis. In its evaluation of the study results, DEQ concluded that temperature data from the Hinkle Creek and Alsea River studies show that for fish-bearing streams, temperature increases downstream from the harvest sites were very similar to the increases found in the RipStream study.[24] The 2011 RipStream reports found that FPA riparian protections on private forest lands did not ensure achievement of the PCW criterion under the Oregon water quality standard for temperature.[25,26]

NOAA and EPA acknowledge that Oregon is working to address some of the inadequate riparian protection measures in the FPA. The Board has the authority to regulate forest practices through administrative rule making and require changes to the FPA rules to protect small and medium-sized fish-bearing streams. Recognizing the need to better protect small and medium Type F streams, the Board directed ODF to undertake a rule analysis process that could lead to revised riparian protection rules. At its September 2014 meeting, the Board voted unanimously in favor of continuing to analyze what changes might be needed in the Oregon Forest Practice Rules to provide greater buffer protection for medium-sized and small fish-bearing streams on private forest lands. NOAA and EPA encourage the State to move forward with this rule-making process expeditiously.

The Board and ODF have not proposed increased protection for riparian areas around small non-fish-bearing streams. As previously discussed in the IMST study, non-fish-bearing streams should be treated no differently than fish-bearing streams when determining the appropriate buffer width required to protect designated uses.[27] Oregon should revise and implement additional management measures for riparian areas adjacent to small non-fish-bearing streams necessary to achieve and maintain water quality standards and protect designated uses. These measures may be regulatory or voluntary, however voluntary measures must be monitored for effectiveness and backed up by enforcement authorities should voluntary measures not be implemented or effective.

Impact of Forestry Roads: In the 1998 approval conditions, NOAA and EPA identified specific concerns with Oregon's FPA rules concerning road density and maintenance, particularly with respect to so-called "legacy" roads. The federal agencies noted that "legacy" roads—roads

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[22] Watersheds Research Cooperative. 2008. *Hinkle Creek Paired Watershed Study*. Available online at: http://oregonforests.org/sites/default/files/publications/pdf/WRC_Hinkle.pdf.
[23] Kibler, K.M. 2007. *The Influence of Contemporary Forest Harvesting on Summer Stream Temperatures in Headwater Streams of Hinkle Creek, Oregon*. Master's thesis, Oregon State University.
[24] Seeds, J., R. Mitchie, D. Jepsen, and G. Foster. 2014. *Responses to Questions/Concerns Raised by Oregon Forestry Industries Council Regarding the Protecting Cold Water Criterion of Oregon's Temperature Water Quality Standard*. Oregon Department of Environmental Quality and Oregon Department of Fish and Wildlife Memo. June 19, 2004.
[25] Groom et al., 2011a.
[26] Daugherty and Groom, 2011.
[27] Independent Multidisciplinary Science Team, 1999.

constructed and used prior to adoption of the FPA in 1971 and not used or maintained since—were not required to be treated and stabilized before closure. In some locations, that practice has resulted in significantly altered surface drainage, diversion of water from natural channels, and serious erosion or landslides, conditions that threaten to impair coastal waters and protect designated uses.

Legacy roads threaten water quality standards and designated uses due to their location and construction. Historic settlement patterns and relative ease-of-construction led early developers to preferentially locate roads in valley bottoms near streams. Those roads often paralleled low gradient streams (historically the most productive coho habitat) and crossed many tributaries.[28] Prior to modern best management practices, mid-slope roads would often be connected to the valley bottom roads to access harvest units.[29] The poorly designed forest roads increase sediment supplied to streams by altering hillslope hydrology, surface runoff, and sediment flux.[30] They represent a chronic source of low-level sediment over time.[31] The ecological consequences of sediment continuously supplied from roads may be equally or even more detrimental over time than periodic sediment pulses.[32] Furthermore, legacy roads sometimes serve as initiation points for landslides many years, or even decades, after construction.[33] For example, one study found that forestry roads in Oregon built before 1984 have higher landslide rates than those built later.[34]

Oregon's IMST found that:

> "'Old roads and railroad grades' on forestlands, sometimes called legacy roads, are not covered by the OFPA rules unless they are reactivated for a current forestry operation or purposes. IMST believes the lack of a mechanism to address the risks presented by such roads is a serious impediment to achieving the goals of the Oregon Plan. A process that will result in the stabilization of such roads is needed, with highest priority attention to roads in core areas, but with attention to such roads and railroad grades at all locations on forestlands over time."[35]

In 1996, the National Marine Fisheries Service (NMFS) provided a scientific analysis of the draft Coastal Salmon Restoration Initiative (CSRI) report—which later evolved into the Oregon Plan

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[28] Nicholas J., B. McIntosh, and E. Bowles. 2005. *Oregon Coastal Coho Assessment. Part 1: Synthesis of the Coastal Coho ESU Assessment.* Oregon Watershed Enhancement Board and Oregon Department of Fish and Wildlife, Salem, OR.

[29] Wemple, B.C., F.J. Swanson, and J.A. Jones. 2001. Forest roads and geomorphic process interactions, Cascade range, Oregon. *Earth Surface Processes and Landforms* 26:191-204.

[30] Reid, L. M., and T. Dunne. 1984. Sediment production from forest road surfaces. *Water Resources Research* 20(11):1753-1761; Luce, C.H., and T.A. Black. 1999. Sediment production from forest roads in western Oregon. *Water Resources Research* 35(8):2561-2570; Wemple, B.C., and J.A. Jones. 2003. Runoff production on forest roads in a steep, mountain catchment. *Water Resources Research* 39, doi:10.1029/2002WR001744; Skaugset, A., and M.M. Allen. 1998. *Forestry Road Sedimentation Drainage Monitoring Project for Private and State Lands in Western Oregon*. Prepared for the Oregon Department of Forestry by the Forestry Engineering Department, Oregon State University; Robison, E.G., K. Mills, J. Paul, L. Dent, and A Skaugset. 1999. *Storm Impacts and Landslides of 1996: Final Report*. Forest Practices Technical Report, Vol. 4. Oregon Department of Forestry, Corvallis.

[31] MacDonald, L.H., and D.B.R. Coe. 2008. Road sediment production and delivery: processes and management. *Proceedings of the First World Landslide Forum, International Programme on Landslides and International Strategy for Disaster Reduction.* United Nations University, Tokyo, Japan. pp. 381–384.

[32] Detenbeck, N.E., P.W. Devore, G.J. Niemi, and A. Lima. 1992. Recovery of temperate stream fish communities from disturbance: a review of case studies and synthesis of theory. *Environ. Manage*. 16:33-53.

[33] Oregon Department of Forestry and Oregon Department of Environmental Quality, 2002.

[34] Ibid. p. 33, Sessions, 1987.

[35] Independent Multidisciplinary Science Team, 1999, pp. 47.

for Salmon and Watersheds. NMFS indicated that the forest practice rules have no well-defined process to identify problems with older logging roads and railroad grades constructed prior to 1994.[36]

In addition to water quality impacts, sedimentation and erosion from forestry roads have adverse impacts on salmon. Salmonid spawning is one of Oregon's designated uses. Logging roads are a source of fine sediments that enter spawning gravel and can lower the success of spawning and recruitment for coho salmon.[37] NMFS's scientific analysis for their Endangered Species Act (ESA) section 7 listing for Oregon coast coho salmon also continues to recognize forestry roads, including legacy roads, as a source of sediment and a threat to Oregon coastal coho salmon. NMFS explained that "existing and legacy [forestry] roads can contribute to continued stream degradation over time through restriction of debris flows, sedimentation, restriction of fish passage, and loss of riparian function."[38]

Since 1998, the Board has made several improvements to general road maintenance measures to improve water quality. Changes made in 2002 and 2003 included (1) establishment of a *Avoiding Roads in Critical Locations* Policy to avoid building roads in critical locations (e.g., high-hazards landslide areas, steep slopes, or within 50 feet of water bodies); (2) creation of additional rules to address wet-weather hauling (OAR 629-625-0700); and (3) revision of an existing road drainage rule to reduce sediment delivery (OAR 629-625-0330). Those improvements should reduce sedimentation on roadways in forested areas in order to achieve water quality standards and to protect designated uses. The new drainage requirements, however, become operative only when new road construction or reconstruction of existing roads occurs. The rule changes and new policies do not address legacy roads (i.e., roads that do not meet current State requirements with respect to siting, construction, maintenance, and road drainage) or impairments associated with a large portion of the existing road network where construction or reconstruction is not proposed.

Oregon proposed to address those legacy road issues and gaps in its FPA rules through voluntary efforts, including restoration and monitoring activities carried out through the voluntary Oregon Plan. For example, in its March 2014 submittal in response to NOAA and EPA's proposed determination, the State described ODF's voluntary Road Hazard and Identification and Risk Reduction Project through which private and State forestland owners survey their road networks to identify roads that pose risks to salmonid habitat and prioritize roads for remediation. While Oregon reports that thousands of road miles have been inspected and repaired across the State since the inception of the program in 1997, Oregon does not have a monitoring or tracking program that can report on the significance of these efforts relative to the universe of the road network, nor report on whether these projects addressed active forest roads and roads retired according to current FPA practices, and which projects addressed problems associated with older, legacy roads. As noted in the Oregon Coastal Coho Assessment,[39] old roads make up the

[36] NOAA National Marine Fisheries Service. 1996. *Analysis of the Oregon Department of Forestry's (ODF) Most Recent Submission for the State of Oregon's Coastal Salmon Restoration Initiative*. September 10, 1996 memo from Rowan Baker to Steve Morris and Elizabeth Garr.
[37] Cederholm, C.J., L.M. Reid, and E.O. Salo. 1980. *Cumulative Effects of Logging Road Sediment on Salmonid Populations in the Clearwater River, Jefferson County, Washington*. Contribution No. 543. College of Fisheries, University of Washington, Seattle, WA.
[38] NOAA National Marine Fisheries Service. 2012. *Scientific Conclusions of the Status Review for Oregon Coast Coho Salmon (Oncorhynchus kisutch)*. NOAA Technical Memorandum NMFS-NWFSC-118, June 2012. Pg. 78.
[39] Nicholas et al., 2005.

majority of forest roads and the road inventory data on private land is often not made available. As a result, it is not possible to determine the extent to which voluntary efforts have addressed the sedimentation problems and landslide risk posed by the legacy road network.

The federal agencies are also concerned about the long-term implementation of the voluntary program. As noted in the State's March 2014 submission, "voluntary reporting of OPSW [Oregon Plan for Salmon and Watersheds] voluntary measures has diminished in the past years, however it is reasonable to assume that voluntary measure implementation has not." The State does not provide the basis for this statement. Without methods for tracking and evaluating the effectiveness of those voluntary programs, the federal agencies cannot approve the voluntary approach for addressing the forestry management measures as they pertain to old or legacy roads.

Oregon also noted that it has entered into a cooperative agreement with the U.S. Forest Service to update the State's geographic information system (GIS) data layer for forest roads. The data layer will help the State conduct a rapid road survey to evaluate and prioritize road risks to soil and water resources. Oregon noted it hoped to begin the survey in 2014. NOAA and EPA encourage the State to move forward with the road survey. However, the federal agencies are not aware if the GIS data layer and the survey will include (or even identify) legacy roads or whether the State will use the data to direct future management actions.

In addition, the State also discussed it was undertaking a third-party audit in 2014 to assess compliance with the FPA rules governing forest road construction and maintenance among other issues. While NOAA and EPA encourage the State to continue to conduct that and other audits to assess compliance with FPA rules, as noted earlier, legacy roads are not subject to FPA rules. Since the audit will assess compliance with the FPA rules, NOAA and EPA conclude that issues resulting from legacy roads as well as issues resulting from general road maintenance where construction or reconstruction is not occurring will not be addressed in this audit since the FPA rules do not apply in these situations.

In summary, NOAA and EPA recognize that legacy roads are being addressed through voluntary measures and that they have been the target of significant landowner investment. As noted in the Oregon Coastal Coho Assessment,[40] however, old roads make up the majority of forest roads, and road inventory data on private land is not widely available. As a result, NOAA and EPA cannot determine, and the State has not made information-based representations specifying, the extent to which voluntary efforts have addressed the sedimentation problems and landslide risk posed by the legacy road network.

In addition, as the federal agencies' *1998 Final Administration Changes Memo* states, in order for states to rely on voluntary programs to meet coastal nonpoint program requirements, a state must, among other things (1) describe the voluntary program, including the methods for tracking and evaluating those programs the State will use to encourage implementation of the management measures; and (2) provide a legal opinion from its Attorney General asserting the

[40] Ibid.

State has adequate backup enforcement authority for the voluntary measures and commit to exercising the backup authority when necessary. While the State has provided the federal agencies with a legal opinion detailing the suitability of its backup authorities, it has not demonstrated (either in writing or through past practice) a commitment to exercise its backup authority to require implementation of the additional management measures for forestry roads, as needed, nor identified a prior instance when it may have exercised that authority.

Additionally, the State has not described specifically how voluntary efforts have and will continue to address legacy road issues within the coastal nonpoint management area or how it will continue to monitor and track the implementation of those measures to address forestry road issues, including legacy roads.

The suite of voluntary programs Oregon has described could satisfy the forestry roads element of this management measure. However, as discussed above, additional information is needed at this time. The federal agencies encourage the State to provide a commitment to use its backup authority to ensure implementation of forestry road additional management measures. The agencies also encourage the State to move forward with establishing a road survey or inventory program that considers both active, inactive, and legacy roads, including a mechanism for tracking and monitoring implementation of voluntary measures to carry out identified priority forest road improvements. To support an approvable coastal nonpoint program, the inventory could establish, among other things, a timeline for addressing priority road issues, including retiring or restoring forest roads that impair water quality, and a reporting and tracking component to assess progress for remediating identified forest road problems. Establishing a roads inventory with appropriate reporting metrics would provide valuable information on State and private landowner accomplishments to improve and repair roads and identify where further efforts are needed. Such an approach could help verify whether the combination of current rules and the Oregon Plan's voluntary measures are effective in managing forest roads to protect streams within a reasonable timeframe.

Protection of Landslide-Prone Areas: In the 1998 findings, the federal agencies identified areas where existing practices under the FPA and FPA rules should be strengthened to achieve and maintain water quality standards and protect designated uses; among them was the need to provide better protection of areas at high risk for landslides.

Oregon proposed to address the landslide element of the additional management measures for forestry condition through a mix of regulatory and voluntary approaches. Since January 13, 1998, Oregon has amended the Oregon FPA rules to require the identification of landslide hazard areas in timber harvesting plans and road construction and placed certain restrictions on harvest and road activities within the designated high-risk areas for public safety (OAR 629-623-0000 through 629-623-0800). Under these amendments, however, shallow, rapidly moving landslide hazards directly related to forest practices are addressed only as they relate to risks for loss of life and property, not for potential adverse impacts on water quality or designated uses. Timber harvest and the construction of forest roads, when alternatives are not available, continue without controls on high-risk landslide hazard areas as long as such harvest and road construction are not deemed a public safety risk.

In addition to the regulatory programs, Oregon stated that it employs a voluntary measure under the Oregon Plan that gives landowners credit for leaving standing live trees along landslide-prone areas as a source of large wood. The large wood, which may eventually be deposited into fish-bearing stream channels, contributes to stream complexity, a key limiting factor for coastal coho salmon recovery. While this is a good management practice, the measure is not designed to protect high-risk erosion areas but rather to ensure large wood is available to provide additional stream complexity when a landslide occurs. NOAA and EPA do not consider this voluntary action a sufficient management measure to reduce high-risk landslides that adversely affect water quality standards or designated uses.

Also, Oregon's voluntary program is incomplete. To rely on voluntary approaches to meet CZARA requirements, a state not only needs to describe the voluntary approach but also needs to describe how it will monitor and track implementation of that approach, provide a legal opinion asserting the state has adequate backup authority to ensure implementation of the management measure, and provide a commitment to use that backup authority, when needed.

As noted in the January 13, 1998, findings, logging on unstable steep terrain can increase landslide rates, which contributes to water quality impairments. A number of studies continue to show significant increases in landslide rates after clearcuts compared to unmanaged forests in the Pacific Northwest. For example, one study found that in three out of four areas studied in very steep terrain, landslide densities and erosion volumes were greater in stands that were clearcut during the previous nine years.[41] The study observed that landslide rates on Mettman Ridge, within the Oregon Coast Range, increased three to nine times the background rate after clearcut harvest. Another study performed a regional analysis from the Mettman Ridge study and found that forest clearing dramatically accelerates shallow landslides in steep terrain typical of the Pacific Northwest.[42] In another study in southwestern Washington, landslide densities in recently harvested sites were roughly two to three times the landslide densities in old stands when exposed to rainfall intensities greater than the 100-year event.[43] That research found that very few landslides occurred when rainfall was less than or equal to a 100-year rainfall event.

Other research has examined the role of root cohesion on landslide susceptibility in forested landscapes. "Root cohesion" is a measure of the lateral reinforcing strength the root system provides. The higher the root cohesion, the better the root system can stabilize the soil, reducing the risk of landslides.[44] One study noted that median lateral root cohesion is less for industrial forests with significant understory and deciduous vegetation (6.8–23.2 kiloPascal (kPa), a unit of pressure) compared to natural forests dominated by conifers (25.6–94.3 kPa). Additionally, in

[41] Robison et al., 1999.
[42] Montgomery, D. R., K. M. Schmidt, H. M. Greenberg, and W. E. Dietrich. 2000. Forest clearing and regional landsliding. *Geology* 28: 311-314.
[43] Turner, T.R., S.D. Duke, B.R. Fransen, M.L. Reiter, A.J. Kroll, J.W. Ward, J.L. Bach, T.E. Justice, and R.E. Bilby. 2010. Landslide densities associated with rainfall, stand age, and topography on forested landscapes, southwestern Washington, USA. *Forest Ecology and Management* 259:2233–2247.
[44] Schmidt, K.M., J.J. Roering, J.D. Stock, W.E. Dietrich, D.R. Montgomery, and T. Schaub. 2001. The variability of root cohesion as an influence on shallow landslide susceptibility in the Oregon Coast Range. *Canada Geotech. J* 38; 997-1024.

clearcut areas, the researchers found that lateral root cohesion is uniformly less than or equal to 10 kPa, making those areas much more susceptible to landslides.

Sakals and Sidle modeled the effect of different harvest methodologies on root cohesion over time.[45] They found that, of the methodologies examined (i.e., clearcutting, single-tree selection cutting, and strip cutting), clearcuts produced the greatest decline in root cohesion. Further, they found that root cohesion may continue to decline for 30 years postharvest. That decline is attributed to the decay of the root systems of the harvested trees and the fact that young root systems have smaller root volumes and less radial rooting extent. They concluded that clearcuts on hazardous slopes could increase the number of landslides as well as the probability of larger landslides. They also stated that a management approach requiring the retention of conifers on high-risk slopes would increase root cohesion and reduce the risk of landslides.

The peer-reviewed science demonstrates that timber harvesting in landslide-prone areas degrades water quality and impairs designated uses in Pacific Northwest streams by delivering excessive sediment load that can block fish passage and smother or scour spawning grounds. Whittaker and McShane explained:

> "In the Pacific Northwest, … [l]andslides alter aquatic habitats by elevating sediment delivery, creating log jams, and causing debris flows that scour streams and stream valleys down to bedrock (Rood 1984; Cederholm and Reid 1987; Hogan et. al. 1998). The short-term and long-term impacts of higher rates of landslides on fish include habitat loss, reduced access to spawning and rearing sites, loss of food resources, and direct mortality (Cederholm and Lestelle 1974; Cederholm and Salo 1979; Reeves et. al. 1995). The restoration of geomorphic processes to natural disturbance regimes is crucial to the recovery of endangered salmonids (*Oncorhynchus* spp.) and other aquatic species in the Pacific Northwest as these species evolved under conditions with much lower sediment delivery and landslide frequency (Reeves et. al. 1995; Montgomery 2004)."[46]

In 2013, the Cooperative Monitoring Evaluation and Research committee (CMER) of the Washington State Department of Natural Resources published a study that explored landslide response to a large 2007 storm in southwestern Washington.[47] Within the 91-square-mile study area, a total of 1,147 landslides were found within harvest units that delivered sediment load to public resources (mostly streams). The majority (82 percent) occurred on hillslopes and the rest initiated from roads. In examining the landslides, the study found that unstable hillslopes logged with no buffer had a significantly higher (65 percent) landslide density than did mature stands. Unstable slopes logged with no buffer also delivered 347 percent more sediment than slopes with unlogged mature stands. The authors conclude that buffers on unstable slopes likely reduce landslide density and sediment volume. That conclusion has important implications for water

[45] Sakals, M.E., and R.C. Sidle. 2004. A spatial and temporal model of root cohesion in forest soils. *Canadian Journal of Forest Research* 34(4): 950-958.
[46] Whittaker, K.A., and D. McShane. 2012. Comparison of slope instability screening tools following a large storm event and application to forest management policy. *Geomorphology* 145-146:115-122.
[47] Stewart, G., J. Dieu, J. Phillips, M. O'Connor, and C. Veldhuisen. 2013. *The Mass Wasting Effectiveness Monitoring Project: An examination of the landslide response to the December 2007 storm in Southwestern Washington.* Cooperative Monitoring, Evaluation and Research Report CMER 08- 802; Washington Department of Natural Resources, Olympia, WA.

quality and designated beneficial uses. Sediments delivered from landslides clog and damage fish gills, suffocate fish eggs, smother aquatic insect larvae, and fill in spaces in streambed gravel where fish lay eggs. Sediment can also carry other pollutants into water bodies, creating issues for domestic water supply and public water providers.[48]

Given the evidence that clear-cutting increases the rate of landslides and that landslides adversely affect water quality and designated beneficial uses, adoption and implementation of additional management measures applicable to forestry in landslide-prone areas is necessary to achieve and maintain water quality standards and protect designated uses. To develop the required additional management measures, the State could pursue several actions that would collectively address this issue, such as some of the following:

- Adopt harvest and road construction restrictions that apply to all high-risk landslide-prone areas with moderate-to-high potential to impact water quality and designated uses.

- Develop a scientifically rigorous process for identifying high-risk areas and unstable slopes based on field review by trained staff. The process could include the use of slope instability screening tools to identify high-risk landslide areas that take into account site-specific factors such as slope, geology and geography, and planned land management activities (e.g., roads development).

- Develop more robust voluntary programs to encourage and incentivize the use of forestry best management practices to protect high-risk landslide areas that have the potential to impact water quality and designated uses, such as employing no-harvest restrictions around high-risk areas and ensuring that roads are designed, constructed, and maintained in a manner that minimizes the risk of triggering slope failures. Widely available maps of high-risk landslide areas could improve water quality by informing foresters during harvest planning.

- Institute a monitoring program to track compliance with the FPA rules and voluntary guidance for high-risk landslide-prone areas and the effectiveness of the practices in reducing slope failures.

- Establish an ongoing monitoring program that assesses the underlying causes and water quality impacts of landslides shortly after they occur and generates specific recommendations for future management. Integrate into the Total Maximum Daily Load (TMDL) development process procedures to identify high-risk landslide-prone areas and specific best management practices to protect those areas. For example, in the Mid-Coast Basin, ODEQ is currently developing a sediment TMDL to address water quality limited

[48] Whittaker and McShane, 2012; Cederholm et al., 1980; Jensen, D.W., E.A. Steel, A.H. Fullerton, and G.R. Pess. 2009. Impact of fine sediment on egg-to-fry survival of pacific salmon: A meta-analysis of published studies. *Reviews in Fisheries Science* 17(3):348-359; EPA. 2003. *Developing Water Quality Criteria for Suspended and Bedded Sediments (SABS): Potential Approaches (Draft)*. U.S. Environmental Protection Agency; Bauer, S.B., and S.C. Ralph. 1999. *Aquatic Habitat Indicators and their Application to Water Quality Objectives within the Clean Water Act, Section 3*. U.S. Environmental Protection Agency, Region 10. EPA 910-R-99-014; Oregon Department of Environmental Quality. No Date. *Water Quality Standards: Turbidity*. Available at: http://www.deq.state.or.us/wq/standards/turbidity.htm.

waters for bio-criteria, turbidity, and sediment. To support the development of the TMDL, the Oregon Department of Geology and Mineral Resources completed landslide inventory maps for two watersheds in the Mid-Coast Basin, finding hundreds of previously unidentified landslides.[49] As part of the TMDL, ODEQ will complete a source assessment of the landslides in relationship to the water quality impairments. NOAA and EPA encourage the State to complete the TMDL and include specific practices that landowners are required to follow in order to reduce pollutants causing impairments addressed in the TMDL.

If Oregon plans to rely on voluntary efforts, the State will need to (1) describe the full suite of voluntary practices it plans to use to address this management measure; (2) describe how it will ensure the use of these voluntary practices and track their implementation; and (3) provide a legal opinion that the State has backup authority to ensure implementation of the management measure and a commitment to use the backup authority, when needed.

Ensure Adequate Stream Buffers for Application of Herbicides, Particularly on Non-fish-bearing (Type N) Streams: In the January 1998 findings, the federal agencies noted that Oregon had adopted forest practices rules that require aerial spray buffers for most pesticide applications (OAR 629-620-0400(7)(b)). The rule changes, however, did not include spray buffers for the aerial application of herbicides along non-fish-bearing streams commonly found in headwaters. NOAA and EPA determined that additional management measures to protect non-fish-bearing streams during the aerial application of herbicides on forestlands were necessary to achieve and maintain water quality standards and to protect designated uses.

Since 1998, Oregon has provided to the federal agencies several documents describing the programs it uses to manage pesticides, most recently in March 2014. In addition to the FPA rule buffers noted above, the State also addresses pesticide issues through the Chemical and Other Petroleum Product Rules (OAR 629-620-0000 through 800) Pesticide Control Law (ORS 634); and best management practices set by the Oregon Department of Agriculture (ODA) and federal pesticide label requirements under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); as well as the State's Water Quality Pesticide Management Plan[50] and Pesticide Stewardship Partnership (PSP) program.[51] In its March 2014 submittal, Oregon noted that it specifically relies on best management practices set by ODA and EPA under FIFRA for the protection of small non-fish-bearing streams.

The aerial application of herbicides such as glyphosate, 2,4-D, atrazine, and others is a common practice in the forestry industry in Oregon.[52,53] Herbicides are sprayed to control weeds on recently harvested parcels to prevent competition with newly planted tree saplings. In 2008,

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[49] Burns, W. J., S. Duplantis, C. Jones, and J. English. 2012. *LIDAR Data and Landslide Inventory Maps of the North Fork Siuslaw River and Big Elk Creek Watersheds, Lane, Lincoln and Benton Counties, Oregon*. Open-File Report O-12-07, Oregon Department of Geology and Mineral Industries.
[50] State of Oregon (ODA, ODEQ, ODF, and OHA). 2011. *Pesticide Management Plan for Water Quality Protection*.
[51] ODEQ. 2012. *Fact Sheet: Pesticide Stewardship Partnerships in Oregon*. DEQ 12-WQ-021. Updated March 2012.
[52] Wagner, R. G., M. Newton, E. C. Cole, J. H. Miller, and B. D. Shiver. 2009. The role of herbicides for enhancing forest productivity and conserving land for biodiversity in North America. *Wildlife Society Bulletin* 32(4):1028-1041.
[53] Norris, L.A., H.W. Lorz, and S.V. Gregory. 1991. Forest chemicals. Influences of forest and rangeland management on salmonid fishes and their habitats. *American Fisheries Society Special Publication* 19:207-296.

more than 800,000 pounds of pesticides, the majority of which were herbicides (at least 700,000 pounds) were used for forestry purposes in Oregon.[54] Research has shown that herbicides may adversely impact water quality and designated uses to protect aquatic life.[55] Herbicides applied through the air commonly reach nearby streams through aerial drift[56] and runoff from the land.[57,58]

Oregon does not require spray buffers for aerial application of herbicides on small non-fish-bearing streams. Applicators can spray directly up to and over non-fish-bearing streams. In addition, there are no requirements for riparian harvest buffers along small non-fish-bearing streams. For example, in the Triangle Lake area in the Oregon coastal nonpoint management area, there are areas where aerial application of herbicides occurred in areas where timber was harvested to the stream edge.[59] Riparian harvest buffers could serve as defacto spray buffers since they would prevent timber harvesting up to the stream and, therefore, would not require herbicide spraying over the nonharvested area to control weeds. Riparian buffers can also help filter any herbicide pollutants from runoff before it reaches the streams.[60,61]

Given that non-fish-bearing streams comprise about 70 percent of the total stream length and feed fish-bearing streams, the wide use of herbicides by the forestry industry in coastal Oregon and the lack of any spray or riparian buffers that would help protect non-fish-bearing streams from adverse impacts due to the aerial application of herbicides threaten designated uses in Oregon coastal waters. Small, headwater non-fish-bearing streams play an important role in delivering cold, clean water to downstream fish-bearing streams.[62] Therefore, it is reasonably foreseeable that Oregon coastal waters are threatened by herbicide pollutants and that additional management measures that will provide greater protection of non-fish-bearing streams during the aerial application of herbicides are warranted to achieve water quality standards and protect designated uses (CZARA sec. 6127(b)(1)(B), 16 U.S.C. 1455b).

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[54] Oregon Department of Agriculture. 2009. *Pesticide Use Reporting System. 2008 Annual Report*. Available online at: http://www.oregon.gov/ODA/shared/Documents/Publications/PesticidesPARC/PesticideusereportingsystemAnnualreport2008.pdf

[55] Relyea, R.A. 2005. The impact of insecticides and herbicides on the biodiversity and productivity of aquatic communities. *Ecological Applications* 15:618–627; Relyea, R., and J. Hoverman. 2006. Assessing the ecology in ecotoxicology: a review and synthesis in freshwater systems. *Ecology Letters* 9:1157–1171; Battaglin, W.A., K.C. Rice, M.J. Focazio, S. Salmons, and R.X. Barry. 2009. The occurrence of glyphosate, atrazine, and other pesticides in vernal pools and adjacent streams in Washington, DC, Maryland, Iowa, and Wyoming, 2005-2006. *Environmental Monitoring and Assessment* 155(1-4): 281-307; Graymore, M., F. Stagnitti, and G. Allinson. 2001. Impacts of atrazine in aquatic ecosystems. *Environment International* 26(7-8):483-495.

[56] Majewski, M.S., and P.D. Capel. 1996. *Pesticides in the Atmosphere: Distribution, Trends, and Governing Factors*. U.S. Geological Survey. Open File Report 94-506. National Water-Quality Assessment Program; Van Den Berg, F., R. Kubiak, W.G. Benjey, M.S. Majewski, S.R. Yates, G.L. Reeves, J.H. Smelt, and A.M.A. Van Der Linden. 1999. *Emissions of Pesticides into the Air. Fate of Pesticides in the Atmosphere: Implications for Environmental Risk Assessment*. pp. 195-218; Pimentel, D., and L. Levitan. 1986. Pesticides: amounts applied and amounts reaching pests. *Bioscience* 36(2).

[57] Gilliom, R.J., J.E. Barbash, C.G. Crawford, P.A. Hamilton, J.D. Martin, N. Nakagaki, L.H. Nowell, J.C. Scott, P.E. Stackelberg, G.P. Thelin, and D.M. Wolock. 2006. *The Quality in Our Nation's Water: Pesticides in the Nation's Streams and Groundwater, 1992-2001*. Circular 1291.

[58] Larson, S.J., P.D. Capel, and M. Majewski. 1995. Pesticides in Surface Waters: Distribution, Trends and Governing Factors. *Volume 2 of Pesticides in the Hydrologic System Series. Ann Arbor Press, Inc*., Chelsea, MI.

[59] Leinenbach, P. 2015. *Images of forest harvest areas where herbicides were applied using aerial broadcast application methods with helicopters in the Triangle Lake region of the central coast range of Oregon*. Memorandum from P. Leinenbach to A. Henning. January 12, 2015.

[60] Welsch, D.J. 1991. *Riparian Forest Buffers: Function and Design for Protection and Enhancement of Water Resources*. USDA Forest Service. NA-PR-07-91.

[61] Kiffney. P.M., J.S. Richardson, and J.P. Bull. 2003. Responses of periphyton and insects to experimental manipulation of riparian buffer width along forest streams. *Journal of Applied Ecology* 40:1060-1076.

[62] Gomi, T., R.C. Sidle, and J.S. Richardson. 2002. Understanding processes and downstream linkages of headwater systems. *Bioscience* 52(10).

Other recent studies and reports also support NOAA and EPA's determination that additional management measures for forestry are needed to address aerial herbicide application due to a reasonably foreseeable threat to coastal waters and designated uses. One of the common indirect adverse effects on water quality and designated uses, particularly cold-water fisheries uses, occurs because herbicides can reduce the growth and biomass of primary producers (i.e., algae and phytoplankton) that form the base of the aquatic food chain. A decrease in primary production (e.g., plants and algae) can have significant effects on consumers, such as salmonids and other animals that depend on the primary producers for food.[63] The effects are often reported at herbicide concentrations well below levels that would have a direct effect on consumers. In addition, there are concerns about the increased toxicity of mixtures of herbicides and other pesticides to aquatic organisms.[64] Although it is difficult to predict the magnitude and duration of these impacts on juvenile salmon because the extent of salmonid effects often depend on the interaction with many different parameters (e.g., availability of alternative food sources, water temperature, and other abiotic factors), NMFS has found that some herbicides used in aerial application present risks to salmonid populations protected by Oregon water quality standards and the habitat necessary for life stages protected by those standards.[65]

A few studies have indicated that aerial application might not result in herbicides exceeding toxic thresholds for humans or aquatic life in fish-bearing and drinking water streams,[66] at the interface of fish- and non-fish-bearing streams,[67] or at drinking water facilities in Oregon.[68] None of the studies, however, were focused on impacts to non-fish-bearing streams and do not provide sufficient evidence, based on other information, that coastal waters and designated uses are not reasonably or foreseeably threatened by the aerial application of herbicides over non-fish-bearing streams. For example, an ODF study that looked at the effectiveness of FPA aerial spray buffers for herbicides and fungicides on fish-bearing streams stated that they could not draw any conclusions about the FPA's effectiveness at protecting water quality for non-fish-bearing streams.[69] A USGS study in the McKenzie River basin looked broadly at urban, forestry, and agriculture pesticide use and the impacts it had on drinking water.[70] The study, which took place outside the coastal nonpoint management area, also notes that forestry sampling was inconsistent because of irregular and intermittent pesticide application patterns among tributaries and the difficulty of capturing runoff events in the spring after application. A National Council for Air and Stream Improvement (NCASI) study in the Needle Branch in the Oregon Coast Range looked at how herbicide levels in streams varied during storm events at three sample sites in

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[63] Marczak, L.B., T. Sakamaki, S. L. Turvey, I. Deguise, S. L. R. Wood, and J. S. Richardson. 2010. Are forested buffers an effective conservation strategy for riparian fauna? An assessment using meta-analysis. *Ecological Applications* 20:126–134.

[64] Relyea, R.A. 2009. A Cocktail of Contaminants: How mixtures of pesticides at low concentrations affect aquatic communities. *Oecologia* 159(2):363-376; Gilliom et al., 2006; Carpenter, K.D., S. Sobeszczyk, A. Arnsberg, and F.A. Rinella. 2008. *Pesticide Occurrence and Distribution in the Lower Clackamas River Basin, Oregon, 2000-2005.* Scientific Investigations Report 2008-5027.

[65] NMFS. 2011. *National Marine Fisheries Service Endangered Species Act Section 7 Consultation Biological Opinion Environmental Protection Agency Registration of Pesticides 2,4-D, Triclopyr BEE, Diuron, Linuron, Captan, and Chlorothalonil.* NOAA National Marine Fisheries Service, June 30, 2011.

[66] Dent, L., and J. Robben. 2000. *Oregon Department of Forestry: Aerial Pesticide Application Monitoring Final Report*. Oregon Department of Forestry, Pesticides Monitoring Program. Technical Report 7.

[67] National Council for Air and Stream Improvement. 2013. *Measurement of Glyphosate, Imazapyr, Sulfometuron methyl, and Metsulfuron methyl in Needle Branch Streamwater*. Special Report No. 130-1.

[68] Kelly, V.J., C.W. Anderson, and K. Morgenstern. 2012. *USGS and Eugene Water and Electric Board. Reconnaissance of Land-Use Sources of Pesticides in Drinking Water, McKenzie River Basin, Oregon*. Scientific Investigations Report 2012-5091.

[69] Dent and Robben, 2000.

[70] Kelly et al., 2012.

harvest units downstream of non-fish-bearing areas where herbicides were applied aerially with no buffers.[71] The sample sites themselves were collected in fish-bearing streams with 50-foot riparian buffers. The study noted clear pulses of herbicides at each storm event with declining levels downstream and over several storms.

Oregon relies on the national best management practices established through the federal FIFRA pesticide labels to protect non-fish-bearing streams. Currently, EPA, NMFS, U.S. Fish and Wildlife Service, and U.S. Department of Agriculture are working to improve the national risk assessment process to include all ESA-listed species when registering all pesticides, including herbicides. Given the scale of this undertaking, the federal agencies are employing a phased, iterative approach during ongoing registration reviews. These ongoing federal processes, however, should not preclude Oregon from pursuing state-level improvements to manage herbicides in the context of its unique forestry landscape and sensitive species.

Oregon and other Pacific Northwest states have determined the importance of state action beyond the national FIFRA label requirements to protect water quality and designated uses, including salmon, in their respective states.[72] Oregon has 60-foot spray buffers for nonbiological insecticides and fungicides on non-fish-bearing streams (OAR 629-620-400(7)) and 60-foot spray buffers for herbicides on wetlands, and fish-bearing and drinking water streams (OAR 629-620-400(4)). Other Pacific Northwest states have established more stringent forestry spray buffer requirements for herbicides along non-fish-bearing streams. For example, for smaller non-fish-bearing streams, Washington maintains a 50-foot riparian and spray buffer (WAC-222-38-040). Idaho has riparian and spray buffers for non-fish-bearing streams of 100 feet (IAR 20-02-01). California sets riparian buffers for non-fish-bearing streams after consulting with the local forester, which implicitly restricts the aerial application of herbicides near the stream (14 CCR 4).

Though Oregon has neither spray nor riparian harvest buffers for herbicides that are aerially applied on small non-fish-bearing streams, the ODA Pesticide Division requires applicators to attend training and obtain licenses prior to spraying pesticides. ODF requires pesticide applicators to complete a Notification of Operation at least 15 days before applying on forestlands[73] and to maintain a daily chemical application form.[74] On the Notification of Operation form, the applicators must list which pesticides *might* be applied, the stream segments on which the pesticides *might* be applied, and when application *might* occur within a 2–3 month period. The notification form does not, however, specify when application will occur within a 1–2 week period or postapplication, the pesticides that were applied and how much. The form reminds the applicator of the required spray buffers for fish-bearing and drinking water streams, but does not specify protections for non-fish-bearing streams or voluntary best practices included in the OAR Guidance Manual for Chemicals and Other Petroleum Products (Division 620) that

[71] National Council for Air and Stream Improvement, 2013.
[72] Peterson, E. 2011. *Comparative Characterization of Pacific Northwest Forestry Requirements for Aerial Application of Pesticides*. Memorandum to Scott Downey, EPA and David Powers, EPA. August 30, 2011.
[73] Oregon Department of Forestry. 2015. Forest Activity Electronic Reporting and Notification System (FERNS). Available at: https://ferns.odf.state.or.us/E-Notification
[74] Oregon Department of Forestry. 2013. Daily Chemical Application Record Form. Revised September 2013. Available at: http://www.oregon.gov/odf/privateforests/docs/ChemicalApplicationForm_Final.pdf.

should be followed other than a general sentence that applicators should comply with rules under the Forest Practices Rule and label instructions.

Oregon's broader strategy for cross-program coordination on pesticides includes its Water Quality Pesticide Management Plan, Pesticide Stewardship Program, and Pesticide Analytical and Response Center (PARC). The Water Quality Pesticide Management Plan guides statewide actions to protect waters from pesticide contamination using water quality to drive adaptive management. Oregon's PSP is an ODEQ initiative that works with State and local partners to collect and analyze water samples in areas with the greatest potential for impacts to aquatic life and human health. PARC is a multistate agency group that coordinates investigations to collect and analyze information about reported incidents.

NOAA and EPA acknowledge the progress Oregon has made in establishing a multiagency management team and programs to assess and manage pesticide water quality issues. As these efforts apply to the aerial application of herbicides in the coastal nonpoint management area, however, the federal agencies note that water quality monitoring data on pesticides is still limited in the State and that, while Oregon has established ten PSP monitoring areas in nine watersheds, the State only launched two pilots within the coastal nonpoint management area very recently. While NOAA and EPA recognize that the PSP program targets the most problematic or potentially problematic watersheds and that Oregon received recent funding to expand into two new watersheds, the agencies believe that if monitoring data are to drive adaptive management, the State should develop and maintain more robust and targeted studies of the effectiveness of its pesticide monitoring and best management practices within the coastal nonpoint management area. The federal agencies encourage the State to design its monitoring program in consultation with EPA and NMFS.

NOAA and EPA believe that Oregon could develop additional management measures for forestry that will protect non-fish-bearing streams during the aerial application of herbicides to achieve and maintain water quality standards and protect designated uses through a variety of mechanisms. Some potential approaches could include one or more of the following actions:

- Adopt rules that would require spray buffers for the aerial application of herbicides along non-fish-bearing streams. Oregon may wish to look at spray buffer requirements that neighboring states have established for ideas;
- Adopt riparian buffer protections for timber harvest along non-fish-bearing streams that, by default, would also provide a buffer during aerial spraying;
- Expand existing guidelines for voluntary buffers for the aerial application of herbicides on non-fish-bearing streams;
- Educate and train aerial applicators of herbicides on the new guidance;
- Revise the ODF Notification of Operation form required prior to chemical applications on forestlands to include a check box for aerial applicators to indicate that they must adhere to FIFRA labels for all stream types, including non-fish-bearing streams;
- Track and evaluate the implementation of voluntary measures for the aerial application of herbicides along non-fish-bearing streams to assess the effectiveness of these practices and, if adjustments are needed, to achieve water quality standards and protect designated uses;

- Provide detailed maps of non-fish-bearing streams and other sensitive sites and structures to increase awareness of the areas that need protection among the aerial applicator community; and
- Encourage the use of global positioning system (GPS) technology, linked to maps of non-fish-bearing streams, to automatically shut off nozzles before crossing non-fish-bearing streams.

If Oregon chooses a voluntary approach, the State must also meet the other CZARA requirements for using voluntary, incentive-based programs as part of the State's coastal nonpoint program. This includes a description of the methods the State will use to track and evaluate the voluntary programs, a legal opinion stating it has the necessary backup authority to require implementation of the voluntary measures, a description of the process that links the implementing agency with the enforcement agency, and a commitment to use the existing enforcement authorities, where necessary.

II. CONDITIONS THAT ARE NO LONGER A BASIS FOR THIS DECISION

A. URBAN AREAS MANAGEMENT MEASURES—NEW DEVELOPMENT

PURPOSE OF MANAGEMENT MEASURE: The purpose of this management measure is 4-fold: (1) decrease the erosive potential of increased volumes and velocities of stormwater associated with development-induced changes in hydrology; (2) remove suspended solids and associated pollutants entrained in runoff that result from activities occurring during and after development; (3) retain hydrological conditions that closely resemble those of the predisturbance condition; and (4) preserve natural systems, including in-stream habitat.

CONDITION FROM JANUARY 1998 FINDINGS: Within 2 years, Oregon will include in its program: (1) management measures in conformity with the 6217(g) guidance; and (2) enforceable policies and mechanisms to ensure implementation throughout the coastal nonpoint management area (1998 Findings, section IV.A).

FINDING: Based on information provided in Oregon's March 2014 submission, NOAA and EPA now believe the State has satisfied this condition. The new development management measure is no longer a basis for finding that Oregon has failed to submit an approvable program under CZARA.

RATIONALE NOT INCLUDED: NOAA and EPA will provide a rationale for public comment if/when the federal agencies are in a position to propose full approval of Oregon's coastal nonpoint pollution control program at a later point in time.

B. OPERATING ONSITE SEWAGE DISPOSAL SYSTEMS

PURPOSE OF MANAGEMENT MEASURE: The purpose of this management measure is to minimize pollutant loadings from operating OSDS.

CONDITION FROM JANUARY 1998 FINDINGS: Within 2 years, Oregon will finalize its proposal to inspect operating OSDS, as proposed on page 143 of its program submittal (1998 Findings, section IV.C).

FINDING: Based on information provided in Oregon's March 2014 submission, NOAA and EPA now believe the State has satisfied this condition. The OSDS management measure is no longer a basis for finding that Oregon has failed to submit an approvable program under CZARA.

RATIONALE NOT INCLUDED: NOAA and EPA will provide a rationale for public comment if/when the federal agencies are in a position to propose full approval of Oregon's coastal nonpoint pollution control program at a later point in time.

III. ADDITIONAL COMMENTS

A. AGRICULTURAL MANAGEMENT MEASURES—EROSION AND SEDIMENT CONTROL, NUTRIENT, PESTICIDE, GRAZING, AND IRRIGATION WATER MANAGEMENT

As noted in the Foreword, the federal agencies invited public comment on the adequacy of the State's programs and policies for meeting the 6217(g) agriculture management measures and conditions placed on Oregon's Coastal Nonpoint Program.

PURPOSE OF MANAGEMENT MEASURES: The purposes of these management measures are to (1) reduce the mass load of sediment reaching a water body and improve water quality and the use of the water resource; (2) minimize edge-of-field delivery of nutrients and minimize leaching of nutrients from the root zone; (3) reduce contamination of surface water and ground water from pesticides; (4) reduce the physical disturbance to sensitive areas and reduce the discharge of sediment, animal waste, nutrients, and chemicals to surface waters; and (5) reduce nonpoint source pollution of surface waters caused by irrigation.

CONDITIONS FROM JANUARY 1998 FINDINGS: Within 1 year, Oregon will (1) designate agricultural water quality management areas (AWQMAs) that encompass agricultural lands within the coastal nonpoint management area, and (2) complete the wording of the alternative management measure for grazing, consistent with the 6217(g) guidance. Agricultural water quality management area plans will include management measures in conformity with the 6217(g) guidance, including written plans and equipment calibration as required practices for the nutrient management measure, and a process for identifying practices that will be used to achieve the pesticide management measure. The State will develop a process to incorporate the irrigation water management measure into the overall AWQMA plans.

Within 5 years, AWQMAPs will be in place (1998 Findings, section II.B).

DISCUSSION: In 2004, the federal agencies provided Oregon with an informal interim approval of its agriculture conditions, believing that the State had satisfied those conditions, largely though its Agriculture Water Quality Management Act (ORS 568.900-933, also known as SB 1010) and nutrient management plans (ORS-468B, OAR-603-074). At that time, the federal agencies found that those programs demonstrated that the State had processes in place to implement the 6217(g) management measures for agriculture as CZARA requires.

Although the federal agencies initially found that those programs enabled the State to satisfy the agriculture condition, prior to announcing the proposed decision, some specific concerns with the State's agriculture program were brought to the federal agencies' attention, such as:

- Enforcement is limited and largely complaint-driven; it is unclear what enforcement actions have been taken in the coastal nonpoint management area and what improvements resulted from those actions.
- The AWQMA plan rules are general and do not include specific requirements for implementing the plan recommendations (e.g., specific buffer requirements to adequately protect water quality and fish habitat).
- AWQMA planning has focused primarily on impaired areas when the focus should be on both protection and restoration.
- The State does not administer a formalized process to track implementation and effectiveness of AWQMA plans.
- AWQMA planning and enforcement does not address "legacy" issues created by agriculture activities that are no longer occurring.

Given these concerns, NOAA and EPA chose to solicit additional public comment on whether the State had satisfied the 6217(g) agriculture management measure requirements and the conditions related to agriculture placed on its program. The federal agencies appreciate the comments provided and are considering them closely. NOAA and EPA will work with the State, as necessary, to ensure it has programs and policies in place to satisfy all CZARA 6217(g) requirements for agriculture before proposing and making a final decision that the State has a fully approved coastal nonpoint program. For a summary of the comments received related to agriculture, see http://coast.noaa.gov/czm/pollutioncontrol/.

IV. LIST OF ACRONYMS AND ABBREVIATIONS

Acronym or Abbreviation	Definition
AWQMA	Agricultural water quality management area
AWQMAP	Agricultural water quality management area plan
BiOp	Biological opinion

Acronym or Abbreviation	Definition
Board	Board of Forestry
CMER	Cooperative Monitoring Evaluation and Research
Coastal Nonpoint Program	Coastal Nonpoint Pollution Control Program
CSRI	Coastal Salmon Restoration Initiative
CZARA	Coastal Zone Act Reauthorization Amendments of 1990
DBH	Diameter at breast height
EPA	Environmental Protection Agency
EQC	Environmental Quality Commission
ESA	Endangered Species Act
Federal agencies	National Oceanic and Atmospheric Administration and the U.S. Environmental Protection Agency
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FPA	Forest Practices Act
GIS	Geographic information system
GPS	Global Positioning System
ICS	Interagency Coordinating Subgroup
IMST	Independent Multidisciplinary Science Team
kPa	kiloPascal
NCASI	National Council for Air and Stream Improvement
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OAR	Oregon Administrative Rules
ODA	Oregon Department of Agriculture
ODEQ	Oregon Department of Environmental Quality
ODF	Oregon Department of Forestry

Acronym or Abbreviation	Definition
OPSW	Oregon Plan for Salmon and Watersheds
Oregon Plan	Oregon Plan for Salmon and Watersheds
OSDS	Onsite sewage disposal systems
PARC	Pesticide Analytical and Response Center
PCW	Protection of Cold Water
PSP	Pesticide Stewardship Partnership
RipStream	Riparian and Stream Temperature Effectiveness Monitoring Program
State	State of Oregon
TMDL	Total Maximum Daily Load
U.S.	United States
USGS	U.S. Geological Survey

From:	Karen Mitzner
To:	PUBLICCOMMENT PRIVATEFORESTS * ODF
Subject:	Private Forest Siskiyou SSBT Rulemaking
Date:	Sunday, September 27, 2020 4:48:13 PM

To: Greg Wagenblast, Oregon Department of Forestry

From: Karen Mitzner

Re: Stream Protection Rules

Please consider the following comments to be related to **stream protection generally**, and not specifically to the issue of Wildlife Food Plots.

As you are well aware, our streams are best protected with forest management practices and rules that insure that wildfires are kept to a minimum.

I ask that Oregon consider the value of using indigenous stewardship practices as pivotal in aiding conservation and management of resources.

Please consult with experts, such as Professor Don Hankins who is an indigenous climate scientist at the University of California, Chico, to develop strategies for Oregon on forest management in a time of critical climate change.

Professor Hankins has been involved in various aspects of land management and conservation. Indigenous practices include controlled burns to help develop resilience in the landscape and to present large wildfires. Professor Hankins could advise on how to use fire in the scale it needs to be to create good outcomes.

Many thanks,

Karen Mitzner, 136 SE 63rd Ave., Portland OR 97215
Phone: 971-221-2456

From:	WAGENBLAST Greg * ODF
To:	PUBLICCOMMENT PRIVATEFORESTS * ODF
Subject:	FW: Siskiyou SSBT Rule Comments
Date:	Monday, September 28, 2020 12:08:14 PM
Attachments:	OSPC comments on Siskiyou Rules September 28, 2020.pdf FINAL OSPC Comments on ODF SSBT Riparian Rule MS March 1, 2017.pdf ATTACHMENTS -12-TO OSPC COMMENTS.pdf Siskiyou Streamside Protections Review - Final Sept 2020.pdf PastedGraphic-4.png

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From: Mary Scurlock <Mary.Scurlock@comcast.net>
Sent: Monday, September 28, 2020 11:07 AM
To: WAGENBLAST Greg * ODF <Greg.WAGENBLAST@oregon.gov>
Subject: Siskiyou SSBT Rule Comments

Dear Mr. Wagenblast:

Please find herein four files: a brief comment letter on the rule proposal to expand the SSBT rules to the Siskiyou region and three separate attachments files.

Thank you,

Mary Scurlock

Comment Letter from Mary Scurlock:

Attachment 1: March 2017 OSPC Comment Letter on SSBT Rule with Attachments and Enclosures List (24 pp)
Attachment 2: Attachments to March 2017 OSPC Comments on SSBT Rule (12 documents, 78 pp)
Attachment 3: Siskiyou Streamside Protections Literature Review Summary from 9/9/20 Board of Forestry meeting packet (30 pp)

Mary Scurlock
Coordinator
Oregon Stream Protection Coalition
503-946-8628 (office)
503-320-0712 (mobile)
mary.scurlock@comcast.net

Oregon Stream Protection Coalition

By Electronic Mail

September 28, 2020

Greg Wagenblast, Hearings Officer
Private Forest Siskiyou SSBT Rulemaking
Oregon Department of Forestry
2600 State Street
Salem, OR 97310
Greg.WAGENBLAST@oregon.gov

Re: Public Comment on Proposed Amendment to OAR Chapter 629: Expanding water rules on small and medium salmon, steelhead, and bull trout Siskiyou Georegion streams

Dear Mr. Wagenblast:

I am the coordinator of the Oregon Stream Protection Coalition (OSPC), an ad hoc coalition of 26 non-profit organizations in Oregon and Washington united around the promotion of increased protection for freshwater aquatic ecosystems on nonfederal lands in Oregon. Thank you for the opportunity to provide public comment on the proposed rulemaking to apply the Salmon, Steelhead, and Bull Trout ("SSBT") stream buffer standards to the Siskiyou Georegion.

As a signatory of the Memorandum of Agreement implemented by SB 1602, I support the proposed rule change as part of a larger policy change package that includes future collaboration with private forest landowning entities to develop the framework for a statewide forest practices aquatic habitat conservation plan. Incorporation of the SBBT rule expansion to the Siskiyou into legislation helped expedite and streamline what could have been a lengthy and contentious rulemaking. This action effectively reverses a 2015 Board of Forestry decision to exclude small and medium streams that support salmon and steelhead in the Siskiyou region from stream protection requirements that became effective in July 2017 for the balance of western Oregon. OSPC has consistently advocated for inclusion of the Siskiyou in the SSBT rule since 2015. This rule change represents a modest improvement that brings stream buffer standards in the Siskiyou up to the same level as the rest of western Oregon

I would like to take this opportunity to clarify that in adopting this rule the Board was not required to make a specific finding about the adequacy of either the existing or proposed rules to meet water quality standards under the Clean Water Act or restoration targets under any of the six applicable Total Maximum Daily Load plans (TMDLs) for impaired water bodies in the Siskiyou region. Nor did the Legislature or the Environmental Quality Commission make such findings.

Likewise, this rulemaking is not accompanied by analysis that indicates it renders the Oregon Forest Practices rules to be an adequate foundation for the federally approvable Endangered Species Act habitat conservation plan aspired to by the parties to the MOU implemented by SB1602. As noted in the comments dated September 18, 2020 already submitted into this proceeding by Rogue Riverkeeper and Wild Salmon Center, which we endorse, additional protection of the small and

medium fish-bearing streams covered by this rule will be an important consideration in planned future collaborative policy discussions.

Therefore, we are submitting for this record as separate electronic files:

1. **Comments submitted by OSPC to ODF on the original SSBT rule change**

These comments argued that none of the four buffer designs provided under the western Oregon SSBT rule (no cut, partial cut, North-South or equity relief) are adequate to meet the Protecting Coldwater Criterion or the watershed-specific targets established by applicable temperature TMDLs. OSPC continues to find that available information supports the contention that larger buffers applied to more of the stream network are needed to achieve compliance with the Protecting Coldwater Standard and applicable TMDL/Human Use Allowance requirements.

2. **The final ODF report entitled "Siskiyou Streamside Protections Review: Summary of Literature Review" by Adam Coble, W. Terry Frueh, John Hawksworth and Ariel Cowan**

This report, provided in its final form to the Board of Forestry as an informational item at its September 6, 2020 meeting, generally informs policy considerations regarding attainment of DEQ water quality standards for temperature for small and medium fish-bearing streams in the Siskiyou geographic region.

This document includes a summary of available information relevant to the Siskiyou region about the adequacy of current forest practices water protection rules to meet stream temperature goals and relationships between riparian buffer width and basal area and prevention of stream temperature increases due to shade reduction. A primary finding is that: "[r]elevant literature (12 studies) suggests implementation of current FPA rules will not ensure maintenance of Protecting Cold Water standard or the Human Use Allowance." Siskiyou Review at iv. The review is notable for its discussion of the policy implications of applicable TMDLs for forest practices and for its evaluation of how these analyses may inform our understanding of riparian buffer design as it relates to effective stream shading.

Sincerely,

Mary Scurlock, Coordinator
Oregon Stream Protection Coalition

Attachment 1: March 2017 OSPC Comments on SSBT Rule (24 pp)
Attachment 2: Attachments to March 2017 OSPC Comments on SSBT Rule (78 pp)
Attachment 3: Siskiyou Streamside Protections Literature Review Summary from 9/9/20 Board packet (30 pp)

Oregon Stream Protection Coalition

March 1, 2017

Private Forest SSBT Rulemaking
Oregon Department of Forestry
2600 State Street, Oregon 97310
RiparianRule@oregon.gov

Re: Oregon Stream protection Coalition Comments on SSBT Riparian Rule to meet the Protecting Coldwater Criterion

To Whom it May Concern:

The 25 member groups of the Oregon Stream Protection Coalition strongly support the Board of Forestry's finding that Oregon's current forest practices cause excess water pollution and do not ensure full compliance with the Protecting Coldwater Criterion "to the maximum extent practicable."

The Board's stated purpose of the proposed rule is to prevent streams from warming when streamside shade trees are logged. Management measures to prevent warming are required to meet the Protecting Coldwater Criterion, a component of the state's water quality standard for stream temperature promulgated under the federal Clean Water Act.

The proposed new stream protection rules modestly increase restrictions on logging near some streams on some of Oregon's private forest land in Western Oregon. Although the proposed rule change is an improvement over the status quo and will likely lead to less stream warming than is currently taking place, it is not adequate to meet the Board's duty to protect cold water for fish. Specifically, given the quantitative analysis regarding the efficacy of buffer alternatives, the Board does not have an adequate basis to find that the proposed rule meets the target standard to the maximum extent practicable.

We recommend that the Board propose 90-120 foot no-cut riparian management areas on all small and medium fishbearing streams in all ecoregions of Western Oregon including the Siskiyou.

These comments address the following points:

1. **<u>The proposed buffers are too small to be effective</u>**. ODF analysis and other available information indicate that all four of the proposed buffer options are too narrow to reliably prevent prohibited warming.

2. **<u>Upstream reaches need protection</u>**. The proposed rule does not meet the Protecting Coldwater Standard's requirement that stream temperatures in reaches upstream of salmon, steelhead or bull trout habitat be protected. Rather, the proposed rule extends increased protection an arbitrary distance upstream "to the end of the unit."

3. **<u>There is no rational basis for excluding the Siskiyou</u>**. There is an adequate empirical basis to apply the improved buffers to the Siskiyou Region and no rational justification for excluding it. The proposed rules should apply to this region.

4. **<u>The " Partial Cut" (i.e. "Well-Distributed" or" variable retention") Option should be dropped</u>.** No-cut width, retention, and overall buffer size would need to increase for this approach to be effective. As written, the "partial cut option " allows logging too close to streams and should be dropped.

5. **<u>The North-sided Option too risky and should also be dropped</u>**. The Board should also drop the experimental idea of allowing smaller streamside buffers on the streams that run east-west. The effectiveness of this option to prevent steam warming is unproven, and we know it won't prevent sedimentation or logging of trees that are needed to form healthy instream habitats.

6. **<u>Unless the rule is strengthened, implementation of this rule should only proceed with intensive monitoring</u>.** The Board must closely monitor the effectiveness of the new rule because the Board chose risky prescriptions even though meeting the coldwater standard is legally required and extremely important to the survival of salmon and other freshwater species.

7. **<u>The "Equity" Exemption Policy Deserves Careful Re-consideration</u>**. The proposed rules allow some landowners to use smaller buffers, but logging should never be allowed to harm public waters and threatened and endangered species. We are concerned that the threshold triggering the weaker rules is not high enough but will still set precedent for and limit the effectiveness of future public policy changes.

8. **<u>Thinning and Release Loopholes Deserve Careful Re-consideration</u>**. Open-ended allowance of riparian thinning and release further erode efficacy of the proposed buffers. have shade Other loopholes also exist for near-stream management that may be harmful. For example, "pre-commercial thinning" or "release activities" still are allowed anywhere in any of the buffers. The rule does not inform the question of how these activities contribute to attainment of ecological or regulatory objectives, they are simply presumed to be

consistent.

9. **<u>The Protecting Coldwater Criterion is a duly promulgated water quality standard the attainment of which the Board has a duty to meet and which it must presume is necessary to fully protect beneficial uses</u>**

10. **<u>Riparian buffer rules must take existing stream water quality and Oregon Department of Environmental Quality rules and findings into account.</u>** The proposed rule focuses solely on attainment of the PCW and does not adequately consider the policy, legal or analytical relevance of Total Maximum Daily Loads established for stream temperature in western Oregon.

Lists of 12 Attachments and 35 Enclosures appear at the end of this document. The attachments are collected in and transmitted in a single accompanying pdf file (78 pages) while the generally longer enclosures have been transmitted as separate pdf files.

I. THE PROPOSED BUFFERS ARE TOO SMALL TO BE EFFECTIVE

The new rule was motivated by scientific research that shows current private lands logging rules don't prevent small and medium salmon, steelhead and bull trout streams from being warmed more than water quality standards allow.

- Groom J. D., L. Dent, L. and Madsen. 2011a. Stream temperature change detection for state and private forests in the Oregon Coast Range. Water Resources Research 47, W01501, doi:10.1029/2009WR009061;

- Groom J. D., L. Dent, L. Madsen, J. Fleuret. 2011b. Response of western Oregon (USA) stream temperatures to contemporary forest management. Forest Ecology and Management 262(8):1618–1629.

The Board of Forestry's rule proposal correctly recognizes that new mandatory, enforceable regulations are needed protect cold water from harmful logging.

The rule provides for two main buffer prescriptions: "no harvest" and "partial cut." Both options apply within 60 feet of small and 80 feet of medium "salmon, steelhead and bull trout" streams. A third prescription is allowed on some streams reaches of 200 feet or more that run east-west, and some landowners who are impacted the most by the new rule will be allowed to use a fourth less restrictive "equity exemption" option.

- <u>No cut buffers of 60 and 80 feet</u> on small and medium SSBT streams, respectively. The new buffers will extend upstream to the end of the unit on the mainstem stream, as defined in the rule.

- "Partial cut" buffers of 60 and 80 feet keep the small 20 foot no cut zone we have now and require that more trees be left (measured in conifer and hardwood basal area) outside this area.
    - Based on Board direction that the unlogged trees outside the no-cut area be "well-distributed," the rule requires that the basal area floors be calculated according to 500 foot lengths of stream instead of the 1000 feet now allowed, and that the unlogged trees must be spread around within the outer 40 and 60 feet. For example, the rule establishes "floors" of 50% for the amount of total required basal area must be in the middle zone, with a 25% minimum in the outer zone.
    - Unlike current rules, both conifers and hardwoods are counted for basal area calculations on the theory that hardwoods also provide shade to streams.
    - The currently required minimum number of live conifers will also be calculated per 500 feet of stream. Trees need only needs to be 8 inches in diameter to count, which is pretty small.
- Smaller "north-sided" buffers on stream reaches that run in an east-west direction. A 40-foot no cut buffer is considered adequate on the north side of these stream reaches. The minimum length of stream to which such a prescription may apply is 200 feet – there is no maximum reach length.
- The Equity Exemption Option allows eligible landowners to use 50 and 70 foot buffers, the same size as current RMAs, either as no cuts or as well-distributed partial cuts with somewhat more higher than current basal area retention standards.

The proposed rule change will add only 10 feet to current buffers on less than a third of the "small" and "medium" fish streams in Western Oregon (excluding the Siskiyou) and some harvest will still be allowed outside a small 20-foot no harvest area. The proposed buffers, while 10 feet larger than current overall riparian management areas for small and medium streams.

A. There is a large body of information indicating that the proposed buffers are too small to effectively meet the Protecting Coldwater Criterion.

The Board's decision is disconnected from the strong scientific basis available to guide it, including a regional literature review a multi-million dollar study, and a state-of-the-art predictive analysis of the likely effectiveness of riparian prescriptions. That science tells us that only 120 feet buffers will insure achievement of the PCW to the maximum extent -- or virtually 100% of the time. A 100 foot buffer gets us there about 80-85% of the time, and 90 feet limits stream warming to the low levels directed by the PCW only about 50% of the time. The Board chose to go even lower.

However, none of the effective buffer size alternatives has been demonstrated to be incapable of being implemented, i.e. impracticable.

Some of the information supporting the inadequacy of the proposed buffers to meet the Protecting Coldwater Criterion is cited below and attached to these comments

and/or incorporated by reference. In particular, the proposed buffers are inadequate to meet the Protecting Coldwater Criterion according to ODF Predictive Model Developed by RipStream Primary Investigator Jeremy Groom and the following documents:

- Oregon Department of Forestry. 2015. Riparian Rule Analysis: Methods for evaluating prescriptions and their geographic extent. Provided to the Oregon Department of Forestry at its April 22, 2015 meeting as Agenda Item 2, Attachment 3 (21 pp) (Enclosure 29);
- Oregon Department of Forestry. 2015. Riparian Rule Analysis: Analysis of riparian prescriptions and expected changes in restrictions. Provided as Attachment 1 to the Oregon Board of Forestry at its June 3, 2015 meeting under Agenda Item 7 (Developing Riparian Rule Prescriptions) (16 pp) (Enclosure 30);
- Oregon Department of Forestry. 2015. DETAILED ANALYSIS - PREDICTED TEMPERATURE CHANGE RESULTS. Provided to the Oregon Board of Forestry at its June 3, 2015 Meeting as Attachment 3 to Agenda Item 7 (12 pp)(Enclosure 31);
- ODF, 2016.: "Riparian Rule Analysis: Additional analyses of riparian prescriptions and considerations for Board decisions" Provided to the Oregon Board of Foretry at its July 23, 2016 meeting as (59 pp) (Enclosure 32);

The information considered by the Board of Forestry during the five-year rule development process includes a scientific assessment of how large buffers would need to be to reliably prevent stream warming from logging in riparian areas. This science clearly indicates that buffers need to be between 90-120 feet wide to have a high chance of preventing coldwater streams from heating up more than is allowed the Department of Environmental Quality's water quality rules. Oregon Stream Protection Coalition marked up one of the ODF graphs showing modeled efficacy of various buffer alternatives. The buffer sizes chosen by the Board are not predictd to perform well. We note that the analysis evaluated "NC" or "no cut" options, but the proposed rule allows partial cut.

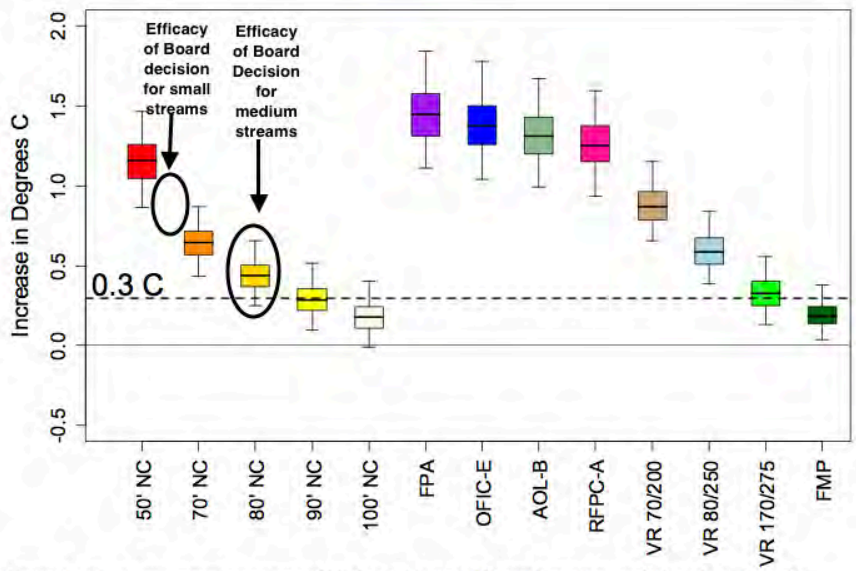


Figure 1. Mean temperature responses of 33 sites subject to different harvest prescriptions (see above for definitions). The 50, 70, 80, 90, and 100 foot NC prescriptions were subsets of the No-Cut prescription. The VR-170/275 values are specifically from the VR-170 prescription at a basal area retention value of 275 ft^2/1,000 feet of stream. The responses for two-entry prescriptions RFPC-B, OFIC-C, and AOL-A are not presented as predicted temperature increases could only be determined for a single side being harvest, not the effect of the entire harvest regime.

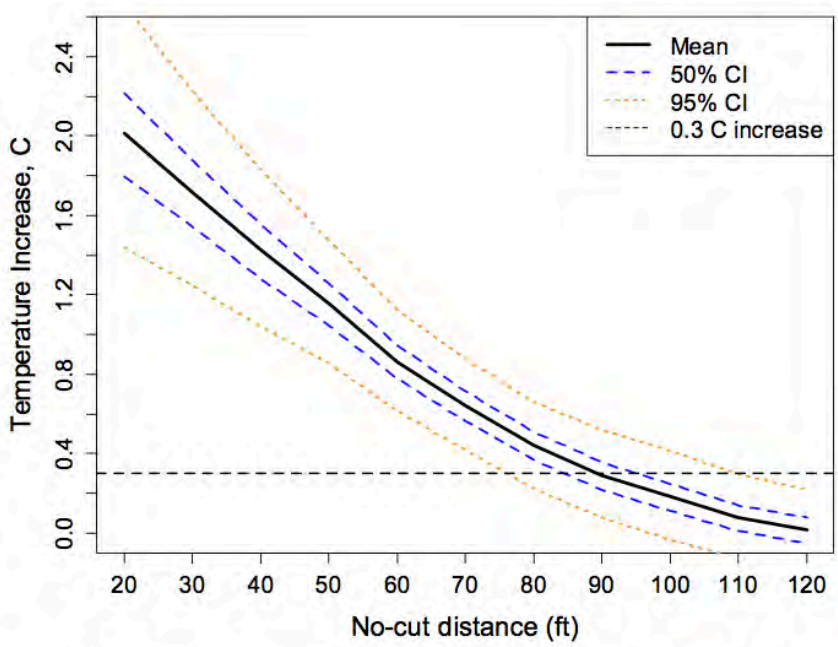


Figure 1. Mean temperature responses among all sites to simulated harvests at set slope distances from the stream. The black line indicates the mean response of the 33 sites, the dashed blue line represents a 50% Credibility Interval (CI) and the dashed orange line a 95% CI. The horizontal dashed black line indicates the PCW threshold of 0.3 °C.

At least the following information already provided to the Board and supplied in attachments and enclosures supports a finding that the proposed buffers do not meet the PCW:

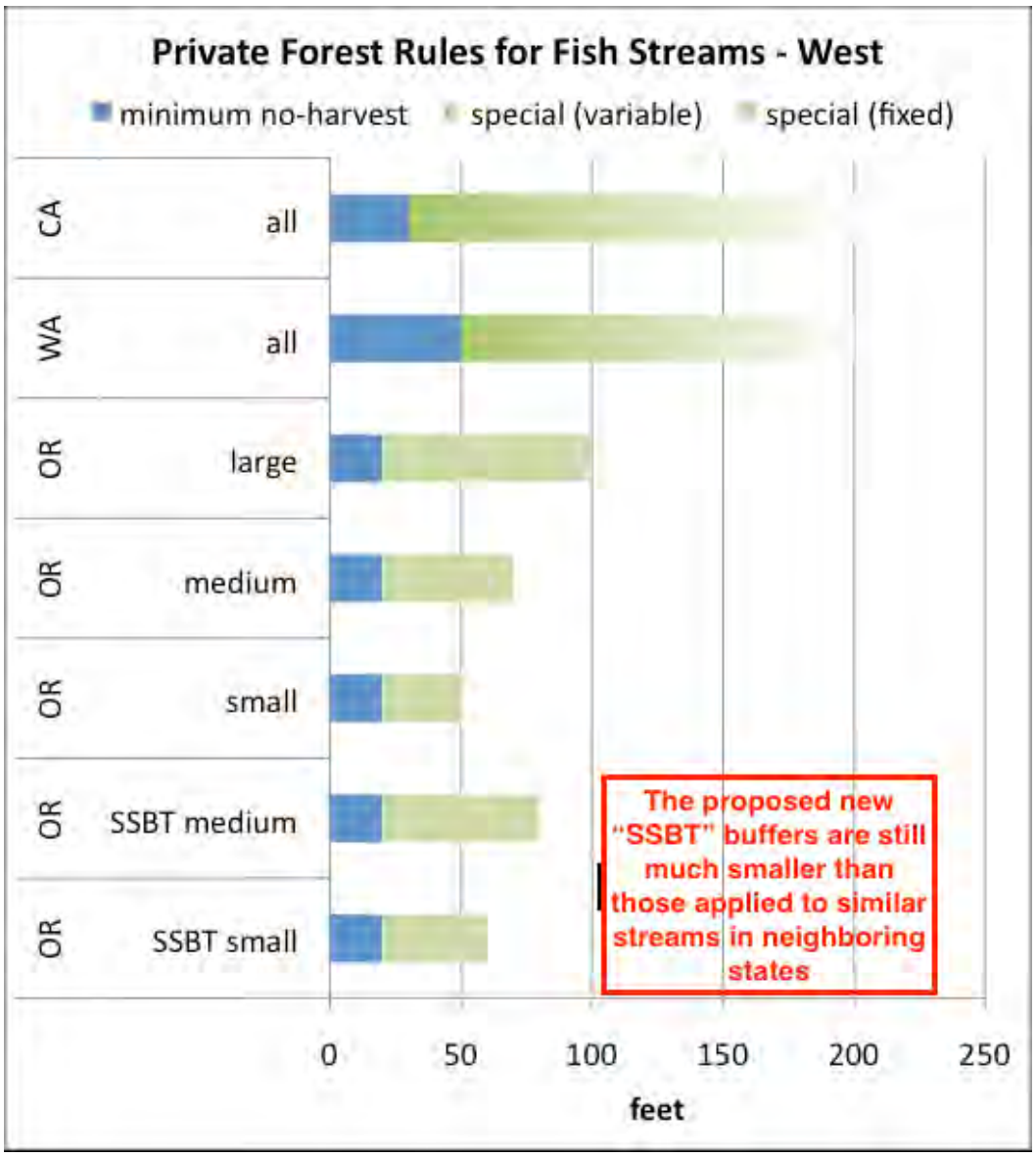
- Dr. Tim Beechie, NOAA Fisheries, Testimony to the Board of Forestry (Attachment 1)
- Dr. Phil Roni, NOAA Fisheries, Testimony to the Board of Forestry
- Peter Leinenbach, EPA, Testimony to the Board of Forestry (Attachment 11)
- Alan Henning, EPA, Testimony to the Board of Forestry (Attachments 6 &7)
- Dr. Chris Frissell, Testimony to the Board of Forestry (Attachment 4)
- Dr. Dale McCullough, Columbia River Intertribal Fish Commission, Testimony to the Board of Forestry (Enclosure 24)

Not only does the available evidence demonstrate that the proposed rules will be ineffective, there is no evidence that larger buffers are not economically feasible to implement. The ODF economic analysis of the proposed rule (Enclosure 33) and its alternatives showed harvest levels would not be significantly impacted by 90 foot buffers, and the ODF analysis demonstrates that buffers are necessary to protect coldwater. (We note the comments of Dr. Ernie Niemi finding that even the modest economic impacts of the proposed rule were exaggerated, Enclosure 28).

Instead, the proposed rule allows continued harmful logging in violation of state water quality standards developed and approved by EPA and the EQC to meet the federal Clean Water Act.

B. <u>Larger buffers are demonstrably feasible to implement</u>

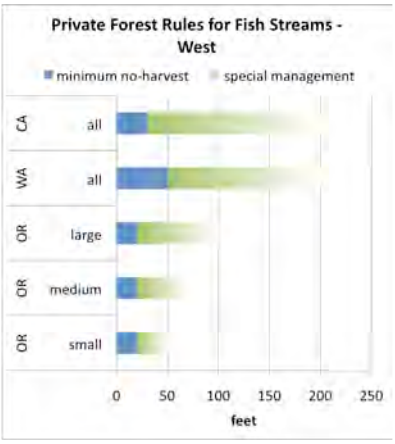
Other states have found significantly larger buffers are both necessary and practicable to meet equivalent water quality objectives. Oregon's current and proposed rules are significantly smaller than those in Washington[i] and California, as illustrated on the graphics appearing below. (Western Washington's stream protection standards are described at WAC 222-030-021; California's at Title 14 of the California Code of Regulations).


Private Forest Rules for Fish Streams - West
minimum no-harvest
special (variable)
special (fixed)
CA
all
WA
all
OR
large
OR
medium
OR
small
OR
SSBT medium
OR
SSBT small
The proposed new "SSBT" buffers are still much smaller than those applied to similar streams in neighboring states
0
50
100
150
200
250
feet

Private Forest Rules

Coastal / Western / Listed Salmon & Steelhead

Fish Streams



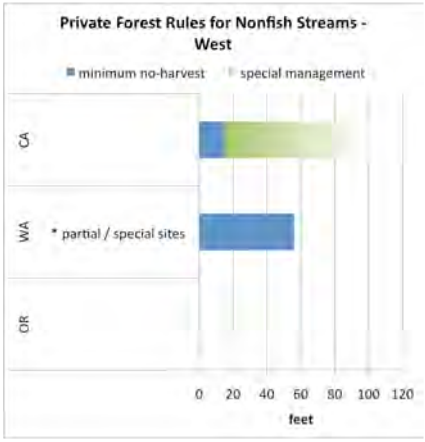
California. Buffer includes Channel Zone or Channel Migration Zone (variable, no-cut), Core Zone (min 30', no-cut), Inner Zone (min 70', 50-80% canopy & big tree retention), Outer Zone (even-aged units only, min 50', retain 50% canopy), Special Operating Zone (even-aged units only, 50', retain under- and mid-story trees).

Washington. Buffer starts at outer edge of channel or channel migration zone. Buffer includes Core Zone (50', no-cut), Inner Zone (10-100', thin from below or high retention) and big trees), Outer Zone (22-67', retain 20 trees per acre).

Oregon. Buffer starts at high water of channel. No overstory harvest within 20'. In RMA, retain trees > 6" dbh to meet BA targets.

large: 100' RMA, retain 40 conifers >11" dbh per 1000' stream.
medium: 70' RMA, retain 30 conifers > 8" dbh
small: 50' RMA, retain 40 sq. ft. basal area.

Non-fish Streams



California. Small Class II watercourses are protected by a Core Zone (15', no-cut) and an Inner Zone (35-85', retain 50% total canopy).

Washington. 50-56' no-cut buffers on 500' or 50% of nonfish stream length from confluence with fish streams, and on seeps, springs, and uppermost points of perennial flow.

Oregon. 20' RMA. Retain snags and understory vegetation.

II. THE PROPOSED RULE IS INCOMPLETE BECAUSE IT DOES NOT APPLY FARTHER UPSTREAM THAN THE END OF A LOGGING UNIT

The proposed rule applies to reaches identified as habitat for salmon steelhead or bull trout, and would only apply upstream of this habitat if the end of habitat occurs within the unit. In that case, the new rule will apply upstream to the logging unit boundary -- whatever that distance may be.

The science and the letter of the PCW water quality standard itself support the need for stronger prescriptions to protect cold water upstream from the end of salmon, steelhead and bull trout habitat. The proposed rule simply does not adequately recognize the extent to which temperature increases from riparian shade removal transfer downstream.

The Protecting Coldwater Criterion requires, as does the physics of stream warming, that upstream reaches receive protection from stream warming. Subsections (a) and (c) of OAR 340-041-0028 (11) [Protecting Cold Water] read as follows:

> (a) Except as described in subsection (c) of this rule, waters of the State that have summer seven-day-average maximum ambient temperatures that are colder than the biologically based criteria in section (4) of this rule, may not be warmed by more than 0.3 degrees Celsius (0.5 degrees Fahrenheit) above the colder water ambient temperature. This provision applies to all sources taken together at the point of maximum impact where salmon, steelhead or bull trout are present….
>
> *
>
> *
>
> *
>
> (c) The cold water protection narrative criteria in subsection (a) does not apply if:
> (A) There are no threatened or endangered salmonids currently inhabiting the water body;
> (B) The water body has not been designated as critical habitat; and
> (C) The colder water is not necessary to ensure that downstream temperatures achieve and maintain compliance with the applicable temperature criteria.

The rule language clearly indicates that the EQC intended to establish a <u>presumption that protection of colder water in upstream reaches is necessary to ensure attainment of all aspects of the temperature standard</u>. The Board, however, has chosen to flip the burden of proof and establish a presumption that the .3 degree warming prohibition does <u>no</u>t apply upstream of SSBT distribution. Lack of clarity on this issue led the Board to consider a set distance upstream that would receive the protection, but ultimately even this approach failed to make it into the rule.

Available science is in accord with the need for upstream protection from stream warming to meet downstream temperature objectives. Notably, a recent publication illustrates that only 50% of heat gain may be lost 900m (975 yards) downstream, so there is no way that just protecting SSBT reaches going to protect those reaches from

warming caused by un-buffered or poorly buffered harvests upstream. (See Attachment 2). This indicates that in order to ensure protection of most downstream reaches, larger buffers will be needed much further upstream than the 1600 feet buffer extension urged by the EPA during the rule development process. (Attachments 6-9). See also the study by Berger et. al. (Enclosure 26), water temperature modeling experts modeling riparian restoration activities and validating how thermal attenuation occurs and that while some thermal increase may be lost downstream, a signal of an the increase is still transferred far downstream

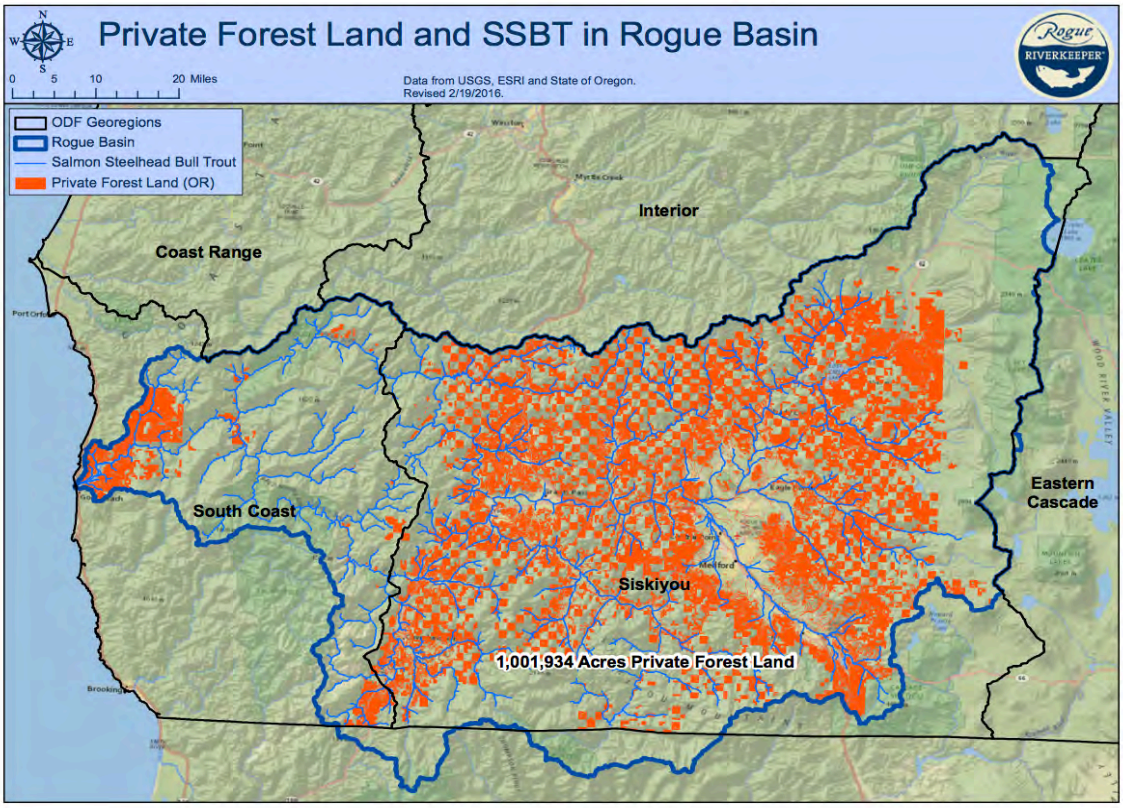
If the Board does not see fit to includes more upstream reaches in this rule, analysis should be begin immediately in support of a new rule proposal designed to protect coldwater upstream of SSBT reaches.

III. THE SISKIYOU WAS EXCLUDED WHEN THERE IS ADEQUATE INFORMATION AND URGENCY TO ACT

No logical reason has been provided as to why the Board is not also proposing a rule change to meet the Protecting Coldwater Criterion for the Siskiyou region or Southwest Oregon. Available evidence is more than adequate to overturn any presumption that current forest practices rules are adequate to protect coldwater on the valuable salmon and steelhead streams in the Rogue Basin.

In a memorandum provided to the Board of Forestry on November 2 by the Oregon Stream Protection Coalition aquatic ecologists Chris Frissell and and Rich Nawa support the contention that an entirely new "RipStream" study is not necessary to support a rule change to meet the Protecting Coldwater Criterion in the Siskiyou. "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." This document is included with these comments as Attachment 5.

We note that while the Board has directed the ODF Monitoring Unit to begin assembling information that could support a rule change in the Siskiyou and on the Eastside, the timeline for policy change is open-ended. We urge the Board to use its authority to extend the proposed westside protection to the Siskiyou under this proposal.



Over a million acres of private forest and 1500 miles of salmon and steelhead streams (SSBT) exist in the Rogue Basin. 317 miles of SSBT are the small and medium stream sizes that should have received increased protection under the new rule

IV. THE PARTIAL CUT OPTION DOES NOT MEET THE PCW; LOGGING SHOULD NOT BE ALLOWED WITHIN THE SMALL PROPOSED BUFFERS; THE VARIABLE RETENTION "WELL-DISTRIBUTED" ALTERNATIVE SHOULD BE DROPPED.

This rule proposal is already too weak to reliable attainment of the PCW because of the small size of the buffers proposed. The allowance of logging within these too-small buffers according to a minimum basal area floor, minimum tree, and distributional requirements adds to this already high risk that the coldwater standard will not be met. The Board should drop the partial cut option from the rule.

EPA Analysis of the variable retention partial cut option based on the 2015 ODF modeling estimates that this option will increase stream temperatures by 1.2 degrees C on small streams and .6 degrees C on medium streams. (P. Leinenbach, Attachment 10). The PCW prohibits any land use activity from warming streams by more than .3 degrees C.

V. THERE IS NO BASIS TO FIND THAT THE NORTH-SIDED OPTION IS EFFECTIVE

The north-sided buffer option is a risky experiment. It does not provide assurance that the PCW will be met: it allows even smaller buffers than the default buffers, which are already too small to reliably prevent stream warming. Even if these buffers did work to limit solar heating there is no question that 40 foot buffers can't meet sediment, wood and microclimate needs.

This option may also be difficult and expensive for the state to enforce: landowners are responsible to ensure that this prescription is only applied to qualified stream-reaches of at least 200 feet long (within 30 degrees of East/West), but Stewardship Foresters will need to verify these determinations.

There is no analytical basis to find that this buffer will be adequate according to the Department's own findings. For example, from the July 23, 2016 Board Materials entitled: "Riparian Rule Analysis: Additional analyses of riparian prescriptions and considerations for Board decisions" (59 pp). Enclosure 32).

South-sided riparian prescriptions

Temperature response

We did not explicitly model south-sided buffer prescriptions (AOL-C, OFIC-F, AND RFPC-C), as the predictive model was not informed by stream orientation. At the June meeting the Board requested an estimate for these prescriptions.

The ODF systematic review found that south-sided prescriptions had few studies with less rigorous study designs than the others, so these studies' had a high range of variability and the results were inconclusive. The systematic review (Czarnomski *et al.*, 2013) contained two references on one study that can provides information about south-sided buffer temperature results (two publications: Dent and Walsh, 1997; Zwieniecki and Newton, 1999). The study had three south-sided buffer sites with theses temperature responses (Table 1).

AGENDA ITEM 2
Attachment 2 *Revised*
Page 2 of 56

Table 1. South-sided buffer effectiveness (Dent and Walsh (1997), Zwieniecki, and Newton (1999)).

Stream	Buffer width (left, right; ft.)*	Change in 7-day maximum through the unit (°C)
Cascade	Not available	0.1
Mill	85, 82	0.0
Scheele	62, 31	1.4

*Report does not indicate stream azimuth.

These data range from a 0.0 to 1.4°C increase. This increase may be less than what would be expected from the south-sided buffer prescriptions in these analyses since the reported buffer widths for these study sites are larger than what would likely be implemented using the AOL-C, OFIC-F, or RFPC-C proposals (Attachment 1).

VI. PUBLIC POLICY DICTATES THAT RISKY APPROACHES BE MONITORED

Full compliance with the water quality rule that this rule is designed to meet is extremely important to fish and other aquatic life because it recognizes that harmful stream warming will occur across the landscape if even a small amount of warming is permitted on individual harvest units. Yet the Board has taken a risky approach to the detriment of public natural resources and in favor of a single economic sector.

If buffers are not enlarged and applied to upstream reaches, and/or if variable retention and north-sided buffers are not dropped, the Board must recognize the

riskiness of its approach by making effectiveness monitoring of this rule a top priority. Absent such a commitment, the Board must take a far more precautionary approach than it has been proposed. It would not be meaningful simply to hand wave in the direction of general adaptive management policies.

VII. THE EQUITY EXEMPTION POLICY DESERVES CAREFUL RECONSIDERATION

Landowners should not be allowed to provide weaker protection unless the new rule subjects them to a truly burdensome level of encumbrance -- i.e. more than 8% additional encumbrance.

The proposed rules allow some landowners to use smaller buffers, but logging should never be allowed to harm public waters and threatened and endangered species. We are concerned that the threshold triggering the weaker rules is not high enough and will still set precedent for and limit the effectiveness of future public policy changes.

The proposal allows alternate prescriptions on 147 miles of salmon, steelhead and bull trout streams (6% of SSBT) on the basis that it is unduly burdensome to ask for the new buffers on parcels whose regulatory burden is increased by 8% or more due to this new rule.

This is already an extremely modest rule proposal, with very limited impacts on the vast majority of landowners. As the ODF analysis indicates:

- About 90% of parcels will not be impacted by the proposed rule at all – only 11%, or 7885 parcels are even affected.
- 55% of those affected parcels have less than 2.1% greater encumbrance as a result of this rule.
- The average encumbrance per acre is .5% (6.1% for very small (2-10 acres) parcels and .5% for parcels over 5000 acres.
- Less than 1% of affected parcels have an increased encumbrance of 10% or more.

In our view, the modest change represented by the proposed rule prescriptions already reflects a tradeoff in favor of minimizing impacts to landowners.

We are extremely concerned that establishing an "8%" increase as a threshold that justifies exemption of landowners from new regulation needed to meet a water quality standards sets a dangerous precedent.

We urge the Board to reconsider how this proposal for regulatory relief is designed. For example, alternative buffers could be offered only to those very few landowners that have a very large amount of their land subject to riparian restrictions (e.g. 25% or more) or those that are willing to enter into long-term management planning arrangements that include lower impact harvest methods, small unit sizes, permanent large tree retention or other reasons.

VIII. THE BOARD SHOULD REVISIT THE RISKS ASSOCIATED WITH THE BLANKET ALLOWANCE FOR PRE-COMMERCIAL THINNING AND OTHE RELEASE ACTIVITIES IN THE SSBT RMA ("ALL OTHER RULES APPLY")

The proposed rule allows pre-commercial thinning and other release activities that "contribute to" and "are consistent with enhancing the stand's ability to meet the desired future condition." The rationale for including this language is that the Board instructed the Department to draft the new rule such that "all other rules apply" and this language appears now in the Type F rules.

We seriously question whether this existing rule should be presumed appropriate to protect SSBT streams. The Board has made no explicit finding that these activities are consistent with its protection goals for SSBT streams. Based on our understanding of the Department's position on these concerns we comment on each in turn below.

- ODF contends that the FPA rules have always allowed management of plantations within the RMA, and classify pre-commercial thinning as an operation requiring a written plan, (even though it's not commercial). However, we cannot support the Board's rubber-stamping this 22-year-old provision in this rulemaking – particularly without substantive deliberation based on best available science. We refer you to two prior submittals that we hope are considered to be in the record of this rulemaking regarding the lack of a scientific basis to find that thinning should be presumed to advance aquatic conservation goals: (See Attachment 12, The OSPC memo to the BOF Riparian Rule Subcommittee, 9/15/2015 (8 pages) and; Memorandum from Scurlock, Sando and Van Dyk to the Riparian Rules TAC on Defining Well-Distributed (April, 2016).
- ODF further contends that statutory written plan would be required for management activities such as pre-commercial thinning, chemical applications, or slash treatment within an RMA. This does not assuage our concern because there is no "approval" of such plans and no required finding that these activities promote water quality or fish protection goals.
- ODF staff has indicated that continued thinning of RMAs is appropriate because under the current rules there are "plantations" in the RMA, and there will continue to be areas that would benefit from management under the new rules. We don't question that there are still young plantation stands in RMAs: what we question is the clear presumption that the manipulation of these stands to favor conifer growth should be permitted as a matter of right without oversight and sideboards to ensure that attainment of water quality and fish goals is not impeded.
- Arguably the existing rules limits RMA manipulation because they require that "[s]uch activities shall contribute to and be consistent with enhancing the stand's ability to meet the desired future condition" and ODF opiones that the term "shall" equals "must." However, it is unclear how this determination is

made, and there is no basis to find either that we are attaining DFC, or that attainment of DFC as currently conceived of in the rules is an adequate proxy for a requirement that such activities be necessary to attain water quality and fish protection goals.

IX. THE PCW IS A DULY PROMULGATED WATER QUALITY STANDARD WHICH THE BOARD MUST MEET; ITS NECESSITY TO ATTAIN FULL PROTECTION OF BENEFICIAL USES MUST BE PRESUMED BY THE BOARD

The weakness of the Board's effort to meet the PCW impermissibly treats compliance with a duly promulgated water quality standard as discretionary.

The reasons for the PCW are multiple and strongly science-based -- and they are not as simple as some members of the regulated community appear to believe. For example, it is not valid to try to tie the .3 degree limit to some exact fish response at the site level when the purposes of the standard are, as DEQ and ODFW have stated

- Maintenance and restoration of natural thermal regimes across the landscape for all aquatic species.
  Prevention of short-term, reach level effects to fish are a goal to the standard, but are not the primary purpose.
- Preservation of waterbodies' capacity to assimilate natural temperature fluctuations due to climate variations and a warming climate (Bisson *et al* 2003, Mote 2003, INR 2009, Ruesch *et al* 2012). (*See* Attachment 3)

The Board cannot justify the weak effort it is making to actually meet the standard by fabricating uncertainty around the validity of the standard and ignoring its clear duty to meet it. In addition to being a question that is beyond the Board's legal authority or expertise to answer, there is simply as a matter of fact no reasonable doubt about the ecological basis for the standard, as indicated by the expert opinions including but not limited to those in Attachment 1 (NOAA Fisheries' Beechie); Attachment 3 (DEQ and ODFW experts Seeds et al.), Attachment 4 (consulting expert Frissell), and Attachment 11 (NOAA Fisheries' Phil Roni). Further understanding of the standard is also provided by Dr. Dale McCullough of Columbia River Intertribal Fish Commission (Enclosure 24).

The real issue is that the Protecting Coldwater Standard is a component of a duly promulgated water quality standard that the OFPA rules are legally required to meet, and the ODF modeling shows that this rule proposal will still not meet the standard with a high degree of certainty.

The most outrageous contention that the Board has been asked to entertain is the idea that temperatures can be raised with benefit to salmon populations where ambient temperatures are low (e.g. ≤ 16°C) is, in the words of Dr. Dale McCullough

"based on a misunderstanding of water temperature standards":

> The standards for salmonid rearing in Oregon's rule (12, 16, 18, 20°C) apply to geographic locations. Upstream of these locations, temperature increases are limited to 0.3°C so that cumulative effects will not lead to increases at points of maximum impact that will alter the ability to achieve the criteria at all checkpoints representing the historic thermal regime in the basin. Condoning temperature increases in headwater areas with the expectation that the population somehow benefits would require compensatory reductions in temperature downstream where temperatures exceed the natural regime. Aside from restoring all naturally occurring riparian vegetation (potential height and canopy cover), it would not be possible to re-establish natural thermal regimes and LWD delivery and maintenance processes. Realized growth rate depends upon the availability of food. Although there is always uncertainty in what food availability would be for any specific location, it is commonly thought that food is always limiting in stream environments. If food were very limiting at a specific location due to a history of logging that led to a fining of streambed substrates, for example, the temperature at which negative impacts of thermal increases would start to occur would decline. That is, under food limitation, growth rates could be negatively affected by riparian harvest at temperatures of 13°C rather than 16°C. The magnitude of this effect depends on food availability. Increased temperature due to shade loss results in reduction in growth above 16°C under full feeding levels and even more reduction in growth under typical, low food availability situations. (McCullough 1999, McCullough et al. 2001). " See Enclosure 24).

See also Enclosure 23 (Frissell et. al. 2014) explaining that the existing coldwater temperature criteria were established based on empirical evidence that temperature increases above the specified thresholds cause physiological and behavioral stress to fish that is not generally compensated or compensable by other potential effects such as locally increased productivity from sunlight: "the potential for increased sunlight and other factors to increase production in a way that biologically compensates for summer stream warming has already been factored into the coldwater criteria."

The Board has not adequately considered the fact that many western Oregon streams, and most lakes and rivers are already warm enough in midsummer that temperature optima for salmonid fishes are exceeded stresses impair growth and survival. Because Oregon's coldwater fish fauna inhabits a warming environment, any practice that warms streams beyond their existing or natural regime is simply going to be generally harmful. See Frissell et. al. , Enclosure 23.

Moreover, climate change further exacerbates the risk of stream warming in summer and through likely reductions in summer baseflows and increased fire risk. We simply do not need more human disturbance near streams, when canopy openings from fire, windthrow, landslides, floods, and other natural disturbances are sufficient

themselves to prevent streams from being completely shaded. Logging disturbance adds additional canopy opening that compounds and adds to the effects of these natural events, rather than mimicking or replacing them. It is not uncommon that windthrow in the stream buffers left after logging results in greatly reduced shade and harmful stream warming that would not have occurred had riparian forests been left largely intact. See Frissell et. al., Enclosure 23.

X. RIPARIAN BUFFER RULES MUST TAKE EXISTING STREAM WATER QUALITY AND DEQ RULES AND FINDINGS INTO ACCOUNT.

Riparian buffer rules must take existing stream water quality and Oregon Department of Environmental Quality rules and findings into account, which the proposed rule does not in focusing solely on attainment of the PCW.

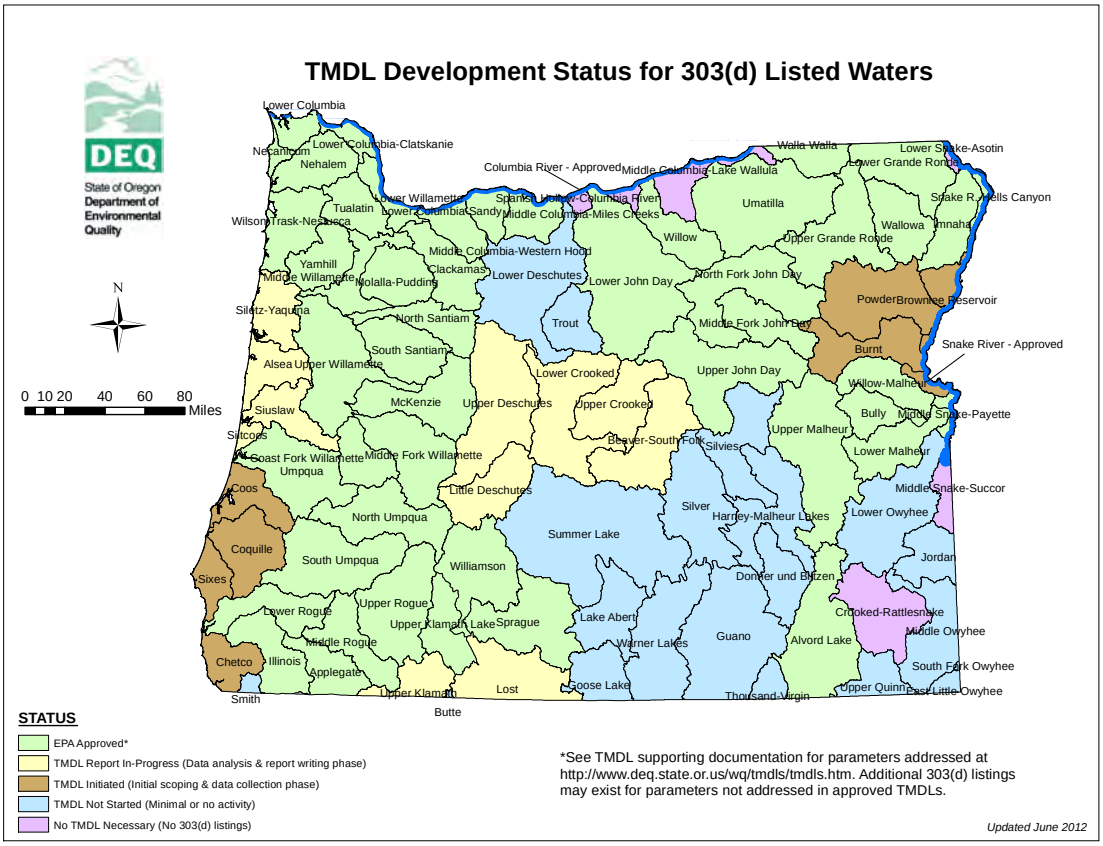
We strongly disagree with ODF's oft-repeated statement that consideration of meeting Total Maximum Daily Loads (TMDLs) can or should be postponed to a future date.

Among other reasons, the TMDLs are relevant to the proposed rule because they are based on the concept of restoring riparian vegetation to natural potential vegetation to meet temperature standards. We attach the following documents as relevant information to the Board's decision:

- Enclosure 4: TMDL for the Applegate (Rogue) Subbasin (2003)
- Enclosure 5: TMDL for Bear Creek (Rogue) watershed (2007)
- Enclosure 6:TMDL for the Clackamas Basin (Willamette) (2006)
- Enclosure 7: TMDL for the Lobster Creek (Rogue)watershed (2002)
- Enclosure 8: TMDL for the Lower Sucker Creek (Rogue) watershed (2002)
- Enclosure 9: TMDL for the McKenzie River (Willamette)(2006)
- Enclosure 10: TMDL for the Western Hood Watershed (Mid Columbia)
- Enclosure 11: TMDL for the Middle Willamette (Willamette) (2006)
- Enclosure 12: TMDL for the Rogue River Basin (2008)
- Enclosure 13: TMDL for the South Santiam (Willamette)(2006)
- Enclosure 14: TMDL for the Sandy River Basin (2005)
- Enclosure 15: TMDL for the Umpqua Basin (2006)
- Enclosure 16: TMDL for the Upper South Fork Coquille watershed (2001)
- Enclosure 17:TMDL for the Coast Fork Willamette Subbasin (2006)
- Enclosure 18: TMDL for the Middle Fork Willamette Subbasin (2006)
- Enclosure 19: TMDL for the Upper Willamette (2006)
- Enclosure 20: TMDL for the Lower Willamette (2006)
- Enclosure 21: TMDL for the North Santiam (Willamette) (2006)
- Enclosure 22: TMDL for the North Coast (2003)

We also attach a spreadsheet of temperature impairments for Oregon waters including both waterbody segments for which there are TMDLs as well as those

without TMDLs. (Enclosure 2). The status of TMDL completion is included as Enclosure 3 and illustrated below:



Justice et. al. (Enclosure 27) provides further information on the importance of restoring riparian cover to natural potential on a systemwide level and how much usable habitat it can generate.

The Board's rule proposal does not recognize fully the responsibility forestlands have to send cool water downstream from headwater streams to other forestlands and land uses. Until it does, the cumulative effects of riparian logging will prevent Oregon from meet its water quality and salmon recovery goals.

Respectfully submitted,

Mary Scurlock, Coordinator, Oregon Stream Protection Coalition
502.320.0712
mary.scurlock@comcast.net

LIST OF ATTACHMENTS TO OSPC COMMENTS
The below-listed documents are included in their entirety within the pdf file containing the body of these comments
(additional, generally longer supporting documents are described in a separate list of "Enclosures" and are being transmitted as individual electronic files)

Attachment 1: Beechie, T. 2015. *Letter dated July 21, 2015 from Dr. Timothy J. Beechie, Watershed Program, Fish Ecology Division, Northest Fisheries Science Center, NOAA Fisheries, Seattle, WA to Tom Imeson, Chairman of the Board of Forestry*. 4 pages.

Attachment 2: Davis, LJ, M Reiter and J Groom. 2016. *Modelling temperature change downstream of forest harvest using Newton's law of cooling.* Hydrological Processes, 30, 959-971 (2016). 13 pages.

Attachment 3: Department of Environmental Quality and Oregon Department of Fish and Wildlife. 2014. *Responses to Questions/Concerns Raised by Oregon Forest Industries Council Regarding the Protecting Coldwater Criterion of Oregon's Temperature Water Quality Standard dated 6-19-2014.* 10 pages.

Attachment 4: Frissell, C. 2015. Testimony for Oregon Board of Forestry, Salem, Oregon 3 June 2015 regarding *Key scientific aspects of the Oregon Department of Forestry Westside Rule Analysis*. 4 pages.

Attachment 5: Frissell, C. and Nawa, R. 2016. *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 and delivered to the Board in November, 2016). 11 pages.

Attachment 6: Henning, A. EPA. 2015a. *Testimony of Alan Henning, Forest Team, Watershed Unit, Environmental Protection Agency Region 10 Before the Oregon Board of Forestry*, *June 3, 2015.* 3 pages.

Attachment 7: Henning, A. EPA. 2015b. *Testimony of Alan Henning, Forest Team, Watershed Unit, Environmental Protection Agency Region 10 Before the Oregon Board of Forestry*, *November 5, 2015*. 2 pages.

Attachment 8: Leinenbach, P. 2015a. *Environmental Protection Agency testimony in Board of Forestry July 23, 2015, Meeting Minutes,* Attachment 25, Agenda Item A. 6 pages.

Attachment 9: Leinenbach, P. 2015b. *Memorandum from Peter Leinenbach, USEPA, to Alan Henning, USEPA, Regarding Topics Associated with upcoming Oregon Riparian Rule discussions dated July 13, 2015.* 3 pages.

Attachment 10: Leinenbach. P. 2016. *Memorandum from Peter Leinenbach, USEPA, to Alan Henning, USEPA regarding Shade loss and temperature increase resulting from the implementation of Option A and Option B of the proposed Oregon Forest Practices Rule for SSBT streams in sections of western Oregon dated January 27, 2016.* 11 pages.

Attachment 11: Roni, P. 2015. *Testimony of Phil Roni, Research Scientist/ Watershed Program Manager, Northwest Fisheries Science Center, NOAA Fisheries, Seattle, Washington Before the Oregon Board of Forestry, June 3, 2015.* 2 pages.

Attachment 12: Scurlock, M, C. Frissell and C. Mendoza. 2016. *Why leaving riparian forests unmanaged within ~100 feet can safely be presumed to be ecologically beneficial for Oregon's aquatic and terrestrial ecosystems on both wet and dry forests* (memo to Riparian Rule Subcommittee and Members of the Oregon Board of Forestry dated 23 September 2015). 8 pages.

ENCLOSURES LIST
OSPC COMMENTS ON SSBT RIPARIAN RULE
These documents are being provided as separate electronic files

Enclosure 1
List of Oregon TMDLs approved by EPA

Enclosure 2
TMDL Spreadsheet – Feb 2017 database of temperature impaired streams

Enclosure 3
Oregon TMDL Status Map

Enclosure 4
TMDL for the Applegate (Rogue) watershed;

Enclosure 5
TMDL for Bear Creek (Rogue) watershed

Enclosure 6
TMDL for the Clackamas Basin (Willamette)

Enclosure 7
TMDL for the Lobster Creek (Rogue)watershed

Enclosure 8
TMDL for the Lower Sucker Creek (Rogue) watershed

Enclosure 9
TMDL for the McKenzie River (Willamette)

Enclosure 10
TMDL for the Western Hood Watershed (Mid Columbia)

Enclosure 11
TMDL for the Middle Willamette (Willamette)

Enclosure 12
TMDL for the Rogue

Enclosure 13
TMDL for the South Santiam (Willamette)

Enclosure 14

TMDL for the Sandy River basin

Enclosure 15
TMDL for the Umpqua basin

Enclosure 16
TMDL for the Upper South Fork Coquille watershed

Enclosure 17
TMDL for the Coast Fork Willamette Subbasin

Enclosure 18
TMDL for the Middle Fork Willamette Subbasin

Enclosure 19
TMDL for the Upper Willamette

Enclosure 20
TMDL for the Lower Willamette

Enclosure 21
TMDL for the North Santiam (Willamette)

Enclosure 22:
TMDL for the North Coast

Enclosure 23:
Frissell, C. , Scurlock, M., Wright, B. The Western Oregon Paired Watershed Studies: Initial Results, Limitations (August 24, 2014) (16 pp)

Enclosure 24:
McCullough, D.A. "Critique and Observations on Evaluation of ODF Proposal for Changes in the Riparian Rules under the Forest Practices Act" (29 pp).

Enclosure 25:
NOAA Fisheries, 2016. Oregon Coastal Coho Recovery Plan.

Enclosure 26:
Berger C., S. Wells. & A. McCulla. 2009. The Impact of Idaho Power Company's Proposed Temperature Mitigation Projects on Temperatures in the Boise River and Snake River (24 pages).

Enclosure 27
Justice, C., S.M. White, D. A. McCullough, D. S. Graves, M.R. Blanchard. *Can*

stream and riparian restoration offset climate change impacts to salmon populations? Journal of Environmental Management 188 (2017) 212-227.

Enclosure 28

Comments of Ernie Niemi on Riparian Rules, February 8, 2017 (11 pages).

Enclosure 29

Oregon Department of Forestry. 2015. Riparian Rule Analysis: Methods for evaluating prescriptions and their geographic extent. Provided to the Oregon Department of Forestry at its April 22, 2015 meeting as Agenda Item 2, Attachment 3 (21 pp).

Enclosure 30

Oregon Department of Forestry. 2015. Riparian Rule Analysis: Analysis of riparian prescriptions and expected changes in restrictions. Provided as Attachment 1 to the Oregon Board of Forestry at its June 3, 2015 meeting under Agenda Item 7 (Developing Riparian Rule Prescriptions) (16 pp)

Enclosure 31

Oregon Department of Forestry. 2015. DETAILED ANALYSIS - PREDICTED TEMPERATURE CHANGE RESULTS. Provided to the Oregon Board of Forestry at its June 3, 2015 Meeting as Attachment 3 to Agenda Item 7 (12 pp).

Enclosure 32

Oregon Department of Forestry, 2016.: "Riparian Rule Analysis: Additional analyses of riparian prescriptions and considerations for Board decisions" (revised) July 23, 2016 (59 pp).

Enclosure 33

Kaetzel, Brandon R. 2017. Economic Analysis to Satisfy ORS 527.714(7). January 4. (29 pages)

Enclosure 34

ODF Staff Report to the Oregon Board of Forestry, Re: Private Forests Work Plan, "Riparian Protection Rule Analysis Update" (discussing meaning of maximum extent practicable) (8 pages)

Enclosure 35

Opinion of the Oregon Attorney General. 2005. "Legal Relationship Between ORS 527.765 and ORS 527.714 in Deciding Whether to Adopt BMPs Under the Oregon Forest Practice Act," Jas. Jeffrey Adams, Assistant Attorney-In-Charge, Natural Resources Section. August 23, 2005 (26 pages).

ATTACHMENT 1
Dr. Tim Beechie. 2015. 4 pages.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northwest Fisheries Science Center
Fish Ecology Division
2725 Montlake Boulevard East
Seattle, WA 98112-2097
(206) 860-3270

July 21, 2015

Tom Imeson, Chairman
Oregon Board of Forestry
Oregon Department of Forestry
2600 State Street
Salem, Oregon 97310
BoardofForestry@oregon.gov

Dear Chairman Imeson and Oregon Board of Forestry Members:

The National Marine Fisheries Service's Northwest Fisheries Science Center's (NWFSC) mission is to conduct the science necessary to conserve marine and anadromous species and their habitats off the Washington, Oregon, and northern California coasts and in freshwater rivers of Washington, Oregon, and Idaho. Our research provides reliable, relevant, and credible information to help decision-makers and natural resource managers build sustainable fisheries, recover endangered and threatened species, maintain healthy ecosystems, and protect human health. I'd like to take this opportunity to build upon the testimony provided by my NWFSC colleague, Phil Roni, PhD on June 3, 2015 and provide additional perspective for your consideration on the action titled "Developing Riparian Rule Prescriptions", which is scheduled for the Board of Forestry (Board) review on July 23, 2015.

Salmonids depend on many ecosystem functions for long-term survival and recovery, including riparian functions such as wood supply to the stream for habitat structure, shade to regulate stream temperature, retention of flood flows and sediment, and supply of leaf litter and nutrients that fuel the food web (citations). Many salmon species—including Chinook salmon, coho salmon, and steelhead—have an affinity for wood cover (e.g., Beechie et al. 2005), as well as for low velocity habitats such as pools that are created by wood (e.g., Bisson et al. 1998). Wood forms pools in a wide range of channel sizes, but is particularly effective in smaller streams where relatively small pieces of wood can form pools (Bilby and Ward 1989, Montgomery et al 1995, Beechie and Sibley 1997). As channel size increases, the size of wood required to form pools increases (Bilby and Ward 1989, Beechie and Sibley 1997, Abbe and Montgomery 2003). In larger rivers single wood pieces may not be large enough to create pools, and instead accumulations of wood anchored by large key pieces are a dominant pool-forming agent (Abbe

and Montgomery 2003). In all channel sizes, low velocity habitats and wood cover are important habitat features for listed salmon species, including Chinook salmon, coho salmon, and steelhead (Bisson et al. 1988, Beechie et al. 2005).

In the past, logging of riparian forests has contributed to significant declines in habitat function via loss of wood recruitment (Grette 1985; Andrus et al. 1988; Carlson et al. 1990; Bilby and Ward 1991; Ralph et al. 1994). This in turn has contributed to decreased availability of low velocity habitats (pools) (Bilby and Ward 1991; Ralph et al. 1994, Montgomery et al. 1995, Beechie and Sibley 1997), and also to declines in the capacity of rivers and streams to support salmon populations (e.g., Beechie et al 1994). Today, wood recruitment to streams is recognized as an important function of riparian forests, and the practice of leaving forested buffers along streams to protect this function is now common in the western US. It is well known that as distance to the stream increases the probability of a tree providing wood to the stream decreases (Van Sickle and Gregory 1990, McDade et al. 1990). Therefore, the portion of a forested buffer nearest the stream tends to provide more wood than the portion of the buffer farther away from the stream. **Models and field data for western Oregon forests indicate that 90% of wood recruited to streams from conifer forests originates from within 90-131 feet of the stream** (McDade et al. 1990) (modeled for 131 foot tall trees - 107 feet; modeled for 164 foot tall trees - 131 feet; field data for mature conifer - 90 feet; field data for old-growth conifer - 123 feet). **This suggests that most wood recruitment could be protected by leaving forested buffers 90 feet or greater in width**.

Chinook salmon, coho salmon, and steelhead are cold-water fish species that require cool water during all life stages, including adult migration to spawning areas and the summer rearing life stages (Groot and Margolis 1991, Richter and Kolmes 2005). In a literature review of temperature thresholds for salmonids, Richter and Kolmes (2005) found that coho salmon spawning migrations tend to occur at temperatures <16°C, and that reduced egg viability or thermal barriers for Chinook, coho and steelhead occurred at 20-21°C. For juvenile rearing, coho salmon tended to select habitats <14.8°C, and optimal growth for Chinook salmon and steelhead occurred between 14°C and 15.6°C. Lethal temperatures for Chinook, coho, and steelhead range from 23-25.8°C. These data suggest that temperatures <16°C are likely to protect salmon and steelhead during both the adult spawning migration period and the juvenile summer rearing period.

Stream temperatures are significantly influenced by shading from streamside forests (e.g., Brown 1970, Brown and Krygier 1970, Brazier and Brown 1973). Recent field evidence in British Columbia showed that stream temperature was 3°C higher with a forested buffer 33 feet wide than in the forested control site, and 1.6°C higher with a 98 foot forested buffer (Kiffney et al. 2003). **By contrast, a recent modeling effort showed that, on average, a 90 foot forested buffer in Oregon forests was likely to keep the temperature increase less than 0.3°C** (upper 95% confidence interval 0.6°C, based on modeled stream temperature using Ripstream, Groom et al. 2011). **This suggests that stream temperatures may still not be protected in many reaches even with a 90 foot buffer.**

In summary, a long history of research on the influences of forested riparian buffers on stream habitats and Pacific salmon species suggests that forested buffer widths necessary to protect wood recruitment and stream shading functions in the Pacific Northwest will likely exceed 90 feet.

Respectfully,

Timothy J. Beechie, Ph.D.
Watershed Program, Fish Ecology Division, Northwest Fisheries Science Center
NOAA Fisheries, Seattle, Washington

Cc: Peter Daugherty, Oregon Department of Forestry, Ex-officio Chief, Private Forests
Cc: F/NWC3 George Pess
F/NWC3 Rich Zabel

References cited

Abbe, T.B. and D.R. Montgomery. 2003. Patterns and processes of wood debris accumulation in the Queets River basin, Washington. Geomorphology 51:81-107.

Andrus, C.W., B.A. Long, and H.A. Froehlich. 1988. Woody debris and its contribution to pool formation 50 years after logging. Can. J. Fish. Aquat. Sci. 45:2080-2086.

Beechie, T., E. Beamer, and L. Wasserman. 1994. Estimating coho salmon rearing habitat and smolt production losses in a large river basin, and implications for habitat restoration. North American Journal of Fisheries Management 14:797-811.

Beechie, T.J. and T.H. Sibley. 1997. Relationships between channel characteristics, woody debris, and fish habitat in northwestern Washington streams. Transactions of the American Fisheries Society 126:217-229.

Beechie, T.J., M. Liermann, E.M. Beamer, and R. Henderson. 2005. A classification of habitat types in a large river and their use by juvenile salmonids. *Transactions of the American Fisheries Society* 134:717-729.

Bilby, R. E., and J. W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. Transactions of the American Fisheries Society 118:368-378.

Bilby, R. E., and J. W. Ward. 1991. Characteristics and function of large woody debris in streams draining old-growth, clear-cut, and 2nd-growth forests in southwestern Washington. Canadian Journal of Fisheries and Aquatic Sciences. 48:2499-2508.

Bisson, P.A., K. Sullivan, and J.L. Nielsen. 1988. Channel hydraulics, habitat use, and body form of juvenile coho salmon, steelhead, and cutthroat trout in streams. Trans. Am. Fish. Soc. 117: 262-273.

Brazier, J.R. and G.W. Brown, 1973. Buffer Strips for Stream Temperature Control. Research Paper 15, Oregon State University, Corvallis.

Brown, G.W. and J.T. Krygier, 1970. Effects of Clearcutting on Stream Temperatures. Water Resources Research 6:1133-1139.

Brown, G.W., 1970. Predicting the Effect of Clearcutting on Stream Temperature. Journal of Soil and Water Conservation 25:11-13.

Carlson, J.Y., C.W. Andrus, and H.W. Froehlich. 1990. Woody debris, channel features, and macroinvertebrates of streams with logged and undisturbed riparian timber in northeastern Oregon. Can. J. Fish. Aq. Sci. 47:1103-1111.

Grette, G. B. 1985. The role of organic debris in juvenile salmonid rearing habitat in small streams. M.S. Thesis, University of Washington, Seattle, WA. 105 pp.

Groom, J.D., L. Dent, L.J. Madsen, and J. Fleuret. 2011. Response of western Oregon (USA) stream temperatures to contemporary forest management. Forest Ecology and Management 262:1618-1629.

Kiffney, P.M., J.S. Richardson, and J.P. Bull. 2003. Responses of periphyton and insects to experimental manipulation of riparian buffer width along forest streams. Journal of Applied Ecology 40:1060-1076.

McDade, M.H., F.J. Swanson, W.A. McKee, J.F. Franklin, and J. Van Sickle. 1990. Source distances for coarse woody debris entering small streams in western Oregon and Washington. Canadian Journal of Forest Research 20:326-330.

Montgomery, D. R., J. M. Buffington, R. D. Smith, K. M. Schmidt, and G. Pess. 1995. Pool spacing in forest channels. Water Resources Research 31:1097-1105.

Ralph, S. C., G. C. Poole, L. L. Conquest, and R. J. Naiman. 1994. Stream channel morphology and woody debris in logged and unlogged basins of western Washington. Can. J. Fish Aquat. Sci. 51:37-51.

Van Sickle, J., and S. V. Gregory. 1990. Modeling inputs of large woody debris to streams from falling trees. Can. J. For. Res. 20:1593-1601.

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Modelling temperature change downstream of forest harvest using Newton's law of cooling

Lawrence J. Davis,[1] Maryanne Reiter[2]* and Jeremiah D. Groom[3]

[1] *D3 Scientific, Springfield, OR, USA*
[2] *Weyerhaeuser Company, Springfield, OR, USA*
[3] *Oregon State University, Corvallis, OR, USA*

Abstract:

We adapted Newton's law of cooling to model downstream water temperature change in response to stream-adjacent forest harvest on small and medium streams (average 327 ha in size) throughout the Oregon Coast Range, USA. The model requires measured stream gradient, width, depth and upstream control reach temperatures as inputs and contains two free parameters, which were determined by fitting the model to measured stream temperature data. This model reproduces the measured downstream temperature responses to within 0.4 °C for 15 of the 16 streams studied and provides insight into the physical sources of site-to-site variation among those responses. We also use the model to examine how the pre-harvest to post-harvest change in daily maximum stream temperature depends on distance from the harvest reach. The model suggests that the pre-harvest to post-harvest temperature change approximately 300 m downstream of the harvest will range from roughly 82% to less than 1% of that temperature change that occurred within the harvest reach, depending primarily on the downstream width, depth and gradient. Using study-averaged values for these channel characteristics, the model suggests that for a stream representative of those in the study, the temperature change approximately 300 m downstream of the harvest will be 56% of the temperature change that occurred within the harvest reach. This adapted Newton's law of cooling procedure represents a highly practical means for predicting stream temperature behaviour downstream of timber harvests relative to conventional heat budget approaches and is informative of the dominant processes affecting stream temperature. Copyright © 2015 John Wiley & Sons, Ltd.

KEY WORDS stream temperature; Newton's law of cooling; downstream; timber harvest; temperature modelling

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INTRODUCTION

Stream temperature change due to forest harvest has been widely studied at both local scales (e.g. Gray and Edington, 1969; Brown and Krygier, 1970; Baillie *et al*., 2005; Gomi *et al*., 2006; Gravell and Link, 2007; Groom *et al*., 2011a, b; Janisch *et al*., 2012; Rex *et al*., 2012; DaSilva *et al*., 2013; Kibler *et al*., 2013) and downstream scales (Brown *et al*., 1971; Caldwell *et al*., 1991; Zwieniecki and Newton, 1999; Story *et al*., 2003; Rutherford *et al*., 2004; Cole and Newton, 2013; Garner *et al*., 2014; Johnson and Wilby, 2015). This abundance of studies reflects the concern over stream temperature impacts to aquatic ecosystems and has led to the evolution of stream protection rules for managed forests (e.g. Hairston-Strang *et al*., 2008). In the Pacific Northwest, studies have shown that contemporary forest practices (e.g. Groom *et al*., 2011a,b) produce less warming on fish-bearing streams relative to earlier practices (e.g. Brown and Krygier, 1970), yet there remains concern over downstream thermal impacts. In their review of timber harvest effects on stream temperature, Moore *et al*. (2005) found that only a few of the numerous studies they reviewed attempted to quantify the processes governing water temperature as it flows downstream (Brown *et al*., 1971; Story *et al*., 2003; Johnson, 2004). They go on further to say 'Clearly, more research is required to clarify the mechanisms responsible for downstream cooling and how they respond to local conditions'.

Several studies examining downstream temperature response found general cooling trends as streams enter well-shaded reaches (e.g. Caldwell *et al*., 1991; Zwieniecki and Newton, 1999; Story *et al*., 2003), although both the direction and magnitude of temperature changes within individual streams are variable (e.g. Cole and Newton, 2013). Of the studies measuring downstream temperature, a few have attempted to quantify the mechanisms responsible for the observed variability in downstream responses. For example, some studies

*Correspondence to: Maryanne Reiter, Weyerhaeuser Company, 785 N 42nd St, Springfield, OR 97478, USA.
E-mail: maryanne.reiter@weyerhaeuser.com

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indicate that groundwater is an important component of observed cooling (e.g. Brown *et al*., 1971; Story *et al*., 2003), while others observed cooling in the absence of significant groundwater or tributary input (Cole and Newton, 2013; Garner *et al*., 2014). Achieving predictability in the physical processes governing reach-scale downstream temperature response to forest harvest and other events that reduce riparian canopy cover is an important step in understanding the thermal behaviour of streams at the watershed scale.

Modelling and predicting downstream temperature dynamics often rely on heat or energy budgets, which use a suite of at-a-site or proximal parameter values to quantify heat fluxes into and out of a stream (e.g. Brown, 1969; Sugimoto *et al*., 1997; Boyd and Kasper, 2003; Roth *et al*., 2010). These heat budget models are useful in determining the relative contributions of channel, stream-adjacent and atmospheric parameters to stream temperature and give insight into the mechanisms behind those factors (e.g. heat source; Boyd and Kasper, 2003). However, widespread practical application of these models may be hindered by their need for accurate measurement of a suite of site-specific parameters, many of which are often not available (Johnson and Wilby, 2015). Efforts to quantify these site-specific parameters necessary for estimating the heat flux components governing downstream temperature response have used combined reach-scale micrometeorological, hydrological and stream temperature measurements (e.g. Roth *et al*., 2010; Garner *et al*., 2014). While these studies provide deep insight into processes occurring at a reach scale, the measurements they require are difficult and costly to repeat across the landscape. In contrast, a calibrated Newton's law of cooling (NLC) model may also provide process-level insights and predictive power while requiring fewer and more readily obtained parameter measurements. The goals of this study are to (1) build a practical physical model that requires a minimum number of measured stream properties as inputs and (2) use the physical model to explain the individual temperature change behaviours of specific sites directly from their physical properties. The data we utilized are from a subset of Oregon Coast Range streams used in a previous study examining the effect of forest harvest on stream temperature (Dent *et al*., 2008; Groom *et al*., 2011a,b). We combined these data with readily measured stream characteristics to quantitatively analyse and predict pre-harvest to post-harvest temperature changes in the unharvested, high-shade reaches downstream of harvested reaches with buffers. This approach helps to clarify the mechanisms responsible for downstream cooling as called for by Moore *et al*. (2005) and provides an approach that might be adapted to investigate downstream processes across larger geographic regions.

FUNDAMENTAL PHYSICS OF STREAM TEMPERATURE DYNAMICS

In order to provide a basis of understanding of the physical principles used in our model, we first review some key fundamentals. *Equilibrium temperature*, denoted by T_{eq}, is the temperature at which the sum of all thermal energy fluxes (net flux) into the stream is zero ($\sum q = 0$). The difference between the temperature of an object and its equilibrium temperature determines the direction and rate of heat flux to/from an object. Objects will have either positive (heating) or negative (cooling) heat flux such that the temperature will trend towards T_{eq}. *Heat capacity*, denoted as C, quantifies the resistance of the object to temperature change and is calculated as the mass of the object multiplied by the specific heat of the material comprising the object. The rate of temperature change of the object will then be $\sum q/C$. For the specific case of water flowing in a stream, the net heat flux and T_{eq} depend on the stream and environmental temperatures in addition to the stream morphology, shade, stream bed material and all other factors influencing heat flux components in the area. Consequently, the temperatures of the stream water and the surrounding thermodynamic environment are not constant, resulting in a T_{eq} that also is not constant. The commonly observed diurnal stream temperature oscillations are a result of the stream water continuously trending towards this diurnally oscillating T_{eq}.

The processes involved in thermal energy exchange in a stream have been thoroughly discussed elsewhere (Edinger *et al*., 1968; Adams and Sullivan, 1989; Bogan *et al*., 2003; Caissie, 2006), and we only briefly reintroduce them here for the purpose of establishing a basis of comparison with our model. The basic factors influencing the total rate of energy transfer (q) into or out of a stream can be expressed as follows:

$$\sum q = q_{radiation} + q_{mixing} + q_{convection} + q_{conduction} \quad (1)$$

Here, $q_{radiation}$ includes the heat flux due to solar and blackbody radiation; q_{mixing} includes both surface and groundwater inputs; $q_{convection}$ includes the heat flux due to conduction–convection and evaporation–convection; and $q_{conduction}$ includes bed conduction. When $q_{radiation}$ and q_{mixing} are minimized because of high shading and few tributaries or groundwater sources, then the conduction and convection contributions to $\sum q$ dominate the total rate of energy transfer into or out of a stream. In this case, NLC may accurately describe the temperature behaviour of the system. NLC, described by Equation (2), is an empirical relationship, which states that the rate of temperature change of an object is proportional to the difference between the object temperature and the

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temperature with which the object is equilibrating (T_{eq}). Despite the name, NLC also properly accounts for positive $\frac{dT}{dt}$ (warming) when ($T < T_{eq}$) as can be seen from Equation (2) in the following:

$$\frac{dT}{dt} = \alpha\left(T_{eq} - T\right) \tag{2}$$

The temperature decay coefficient (α) in the preceding equation is given by $\alpha = hA/C$, where A is the surface area across which heat is exchanged, C is the heat capacity of the object and h is the heat transfer coefficient, which describes the ease with which an object exchanges heat with its environment. For the specific case of a *constant* equilibrium temperature, the solution to Equation (2) is the integrated form of NLC:

$$T(t) = T_{eq} + \left[T_0 - T_{eq}\right]e^{-\alpha t} \tag{3}$$

A previous work has shown that $q_{radiation}$ may be so reduced within heavily shaded reaches that it no longer dominates the net heat flux (e.g. Garner *et al*., 2014). Considering this result, we hypothesized that for sections of streams that are sufficiently shaded and lacking tributaries, the $q_{radiation}$ and q_{mixing} contributions to $\sum q$ may be so reduced relative to $q_{convection}$ and $q_{conduction}$ that NLC becomes applicable. We tested this hypothesis by applying an NLC-based model to predict temperature changes in the heavily shaded downstream study reaches that did not have significant surface water inputs from tributaries. We assumed that any groundwater mixing would be relatively constant from before to after forest harvest.

Finally, an important concept in discussing downstream temperature behaviour is the measurement frame of reference. Stream temperature is typically measured in the Eulerian frame of reference, which is based on measuring the value of parameters in a spatially bounded location (Doyle and Ensign, 2009). In the Eulerian frame, a temperature sensor is stationary, and the stream flows past it. A time series of temperature at a specific location in the Eulerian frame is produced by measuring temperatures at successive instances in time, and thus, each temperature measurement is made on a different volume of water. The Lagrangian frame, in contrast, is a reference frame attached to a specific volume of water as it travels downstream. In the Lagrangian frame, the water parcel is continuously arriving in new environmental conditions, and stream temperature is measured always within the same parcel at different instances in time (and thus at different locations within the Eulerian frame).

The use of the terms *heating* and *cooling* without specification of the reference frame in which these changes in temperature are measured can be a source of confusion and misconception because the observed condition of heating or cooling as measured in one frame does not necessarily coincide with a temperature change in the same direction as observed in the other frame. For example, a parcel of water may travel through an upstream, low-shade reach, warming along the way, before passing into a high-shade reach. Within the downstream reach, the parcel may continue to warm, likely at a significantly decreased rate. A later measurement of the parcel temperature would indicate downstream heating in the Lagrangian frame, because parcel temperature monotonically increased with time. However, while this first parcel was in transit through the downstream reach, solar radiation may have increased during the diurnal cycle so that a second parcel passing through the low-shade upper reach might warm at such a high rate relative to the first parcel, currently in the shaded reach and largely unaffected by the increase in solar radiation, that the second parcel temperature becomes greater than that of the first parcel. At this instant in time, the temperature measured at the downstream location would be less than the temperature at the upstream location; thus, measurement in the Eulerian frame would indicate stream cooling. Here, we see the direct contradiction in temperature change as measured in the two different reference frames.

In order to avoid future confusion, we suggest specifying either Lagrangian or Eulerian heating and cooling when describing stream temperature changes (e.g. Rutherford *et al*., 2004). Within this paper, we will only use the terms heating and cooling in reference to the Lagrangian frame. The Lagrangian frame is more naturally suited to modelling cause-and-effect behaviour in stream temperature dynamics because it tracks how the temperature of fluid in motion changes over time as it encounters new thermodynamic environments. In contrast, the Eulerian frame compares the temperature of two different parcels of water at an instant in time, and those two parcels may have experienced completely different and causally detached thermodynamic environments up to that point. In order to compare predictions provided by a Lagrangian model to data taken in the Eulerian frame, the transit time for parcels of water between Eulerian locations must be measured or modelled. The transit time information allows for Eulerian frame temperature measurement at a specific time and location to be attributed to the temperature of a specific parcel of water arriving at that location at that time. The term advection is often introduced to describe this transport of thermal energy from one Eulerian location to another via stream flow. However, we see that the effects of advection are intrinsically included in a Lagrangian frame model. In fact, for continuous flow situations without significant pooling or

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recirculation, the values in a time series of temperatures measured in the Eulerian frame are the temperatures, tracked in the Lagrangian frame, of successive parcels of water arriving at that location.

DATA COLLECTION METHODS

The pertinent information on field data collection for this analysis is described later. A full description of data collection and field protocols can be found in Groom *et al*. (2011b); also see Dent *et al*. (2008) for a map of the study area and full description of site selection criteria and Groom *et al*. (2011a) for a summary of the forest harvest reach site characteristics including channel and riparian vegetation statistics pre-harvest and post-harvest. The criteria for stream selection included no beaver influence (dams with ponds or disturbed vegetation), average annual flow rates of 283 l/s or less and treatment reaches harvested according to state and private forest prescriptions for fish-bearing streams, which require varying amounts of overstory tree retention depending on ownership and stream size.

Programmable, waterproof data loggers (referred to as 'probes' in this paper; 'W' indicates water probes as opposed to air probes) were installed in control reaches upstream of forest harvest (Figure 1; reach between probes 1W and 2W). These control reaches were established to provide a measure of year-to-year and spatial variability in stream temperature that occurs independent of harvest. The treatment reach (Figure 1; reach between probes 2W and 3W) was established to quantify stream temperature changes due to forest harvest. The downstream reach (Figure 1; reach between probes 3W and 4W) was established to examine potential downstream temperature responses to any temperature changes occurring within the harvest unit (Figure 1). The downstream reach was approximately 180 to 345 m below the treatment reach and had to be relatively homogeneous with intact riparian vegetation and no major tributaries in order to minimize confounding variables including mixing. These criteria resulted in only 18 of the 33 study sites having a downstream reach. Hourly stream temperature was monitored for 2 years before timber harvest and 5 years after harvest between 1 June and 30 September. Other data collected for the study include maximum stream depth, bank full and wetted width, shade and stream gradient. These parameters were measured within each reach at 60-m intervals. Channel metrics were collected according to Kaufmann and Robison (1998). Hemispherical photographs were taken using a self-levelling fish-eye camera 1 m above the stream surface using the protocol according to Valverde and Silvertown (1997). Solar radiation indices based on latitude, longitude and elevation were derived from these photographs using HemiView® software version 2.1 (Delta-T Devices, Ltd, Cambridge, UK). Shade was estimated by $1 - GSF$, where GSF (global site factor) is the ratio of direct plus diffuse solar power below canopy to direct plus diffuse power above canopy. Further detail on the processing of these data is described in Groom *et al*. (2011a).

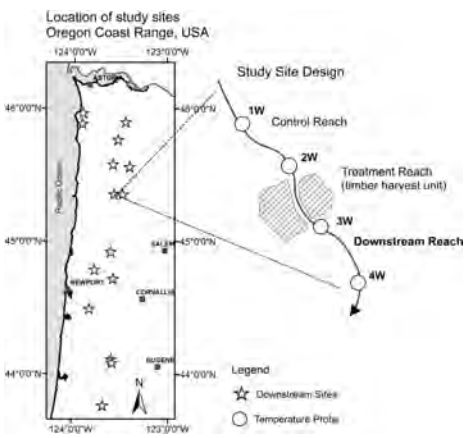

Figure 1. Location of study sites in the Oregon Coast Range. Inset shows field study design with relative locations of control, harvest and downstream reaches indicated. Temperature probes 1W and 2W are above and below the control reach, respectively; probe 3W is below the harvest reach; and probe 4W is approximately 300 m below the harvest reach

For this analysis, data from the summer immediately before and immediately after harvest were used. If data from only one of the immediate pre-harvest or post-harvest years were not available, then data from the next adjacent year were used for this analysis (e.g. 2 years pre-harvest or 2 years post-harvest). Sites with two consecutive years of unavailable data on either side of harvest were not used. As a result of these temporal data constraints, 16 of the 18 downstream sites were used in this analysis. The sites used in this analysis were an average of 5.0 m wide (range = 2.8–7.0 m) with a mean watershed area of 327 ha (range = 80–692 ha). The temperature metric analysed in this paper was the 40-day mean of maximum daily temperature computed from the daily maximum values from 15 July to 23 August. This metric was chosen because it aligns with a previous study using the same metric computed from these same data (Groom *et al*., 2011b). In contrast to Groom *et al*. (2011a,b), this work focuses on the downstream data. Specifically, this paper describes application of an NLC model to understand the dependence of downstream pre-

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harvest to post-harvest change in maximum temperature on change in harvest reach maximum temperature, as well as measured downstream stream properties and distance downstream of the harvest reach.

NLC MODEL DEVELOPMENT

Initial assumptions

We first assume that a parcel of water moving downstream in a highly shaded reach will follow NLC, and thus, the rate of temperature change for the parcel will be proportional to the difference between the parcel temperature and its unknown, environmentally influenced, equilibrium temperature. The equilibrium temperature may be correlated with, but is not entirely represented by, the temperature of any particular entity in the stream environment. Rather, the equilibrium temperature is a weighted average of the temperatures of all environmental entities with which the stream exchanges energy, with the weights being the rate at which energy can be exchanged with each entity. Therefore, the equilibrium temperature is constantly changing on diurnal and seasonal time scales.

To apply NLC to streams, the conditions that T_{eq} and α are constant require that the transit time, τ, is small compared with the time over which the downstream T_{eq} and α change appreciably. Thus, the reach length over which the NLC model is applied must be sufficiently short and/or fast flowing to meet the constant T_{eq} and α conditions (Rutherford *et al*., 2004). When using NLC to model a parcel of flowing water, the value of hA is anisotropic (dependent on direction) because the horizontal surface area is greater than the vertical surface area (e.g. the streams are wider than they are deep) and heat is exchanged with different materials by various different mechanisms in different directions, for example, conduction into the stream bed in the downward direction and convection with the air in the upward direction. To account for these complexities, we defined the effective decay coefficient, $\alpha' = \gamma/C$, where γ is the sum of the different hA terms for each direction.

One of the primary goals of this study was to reduce the number of stream parameters required for a predictive model; thus, the stream data necessary to accurately calculate the values of T_{eq} and γ from first principles were not provided by this study. Instead, the pre-harvest to post-harvest change in T_{eq} will be modelled using changes in control reach temperature, resulting in the first free parameter of the model, and γ will be incorporated into the second of the two free parameters. The values of the two free parameters in our NLC model are determined by fitting the model to the measured changes in maximum downstream temperature. However, we will show that for the set of streams used in this study, the free parameters are not *necessarily* site specific, and the lack of a priori calculation of T_{eq} and γ does not prevent the NLC model from accurately describing changes in maximum downstream temperatures between pre-harvest and post-harvest summers.

Applying the integrated NLC

First, we apply Equation (3) to a parcel of water in transit through the un-harvested downstream reach, between temperature probes 3W and 4W, as indicated in Figure 1. Setting $t = 0$ when the parcel passes temperature probe 3W at the end of the harvest reach and τ equal to the transit time between temperature probes 3W and 4W allows conversion from the Lagrangian frame to the Eulerian (thermistor data) frame. The correspondence between terms in Equation (3) and terms in the stream temperature model becomes $T3W \rightarrow T\,(t=0)$, $T4W \rightarrow T\ (t = \tau\ )$ and $T_{eq} \rightarrow T4W_{eq}$, where $T4W_{eq}$ represents the equilibrium temperature in the downstream reach, and finally, $\alpha \rightarrow \alpha'$ as discussed previously. Making these substitutions in Equation (3), we arrive at

$$T4W = T4W_{eq} + \left[T3W - T4W_{eq}\right] e^{-\alpha'\tau} \qquad (4)$$

This model treats the temperature measured at a specific probe location in the Eulerian frame as equal to the temperature of the water parcel passing over the probe at that time, which is modelled in the Lagrangian frame. This model also treats T_{eq} as constant in space across the downstream reach and constant over the transit time (τ). As discussed previously, this assumption requires that τ is small compared with the time over which $T4W_{eq}$ and α' change appreciably and that the length of the downstream reach is small compared with the distance over which $T4W_{eq}$ and α' change appreciably (Rutherford *et al*., 2004). Consequently, application of the model is restricted to $\approx$300 m, downstream of the harvest reach. Within this distance, shade values do not vary significantly, and the transit time is on the order of only 1 h, as indicated by an average flow speed of 0.1 m/s computed from dye-based velocity measurements performed on a subset of representative streams.

Deriving the across-harvest temperature change

The measured change in downstream temperature across the harvest period ($\Delta T4W$) is determined by subtracting $T4W$ during the summer prior to harvest from $T4W$ during the summer after harvest. This results in Equation (5).

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$$\Delta T4W = T4W_{post} - T4W_{pre} \quad (5)$$

With $T4W$ modelled by Equation (4) and given that downstream $T4W_{eq}$, α and τ in the un-harvested downstream reach are unaffected by the upstream harvest, the NLC model for Equation (5) becomes

$$T4W_{eq,post} + \left[T3W_{post} - T4W_{eq,post}\right]e^{-\alpha'\tau} - T4W_{eq,pre} + \left[T3W_{pre} - T4W_{eq,pre}\right]e^{-\alpha'\tau} \quad (6)$$

With some algebraic simplification, the change in downstream temperature $\Delta T4W$ can be written as follows:

$$\Delta T4W = \Delta T3We^{-\alpha'\tau} + \Delta T4W_{eq}\left[1 - e^{-\alpha'\tau}\right] \quad (7)$$

Here, $\Delta T3W$ and $\Delta T4W_{eq}$ are the across-harvest-year changes in temperature at the 3W probe and in the downstream reach equilibrium temperature, respectively. Within this model, the stream properties serving as the primary drivers of the measured variations in $\Delta T4W$ do so via their influence on α' and τ. Modelling the dependence of α' and τ on the site-specific stream properties allows for prediction of the measured variation in $\Delta T4W$ among the study streams.

Downstream transit time. The transit time of the downstream reach is modelled as $\tau = L/v$, where L is the downstream reach length and v is the flow speed in the downstream reach. We do not have direct flow speed measurements for all streams in the downstream reach, so we modelled the flow speed using gradient measurements together with Manning's formula (Subramanya, 2009), which states that $v \propto G^{1/2}$, resulting in Equation (8):

$$\tau \propto \frac{L}{G^{1/2}} \quad (8)$$

Here, G is the average gradient of the stream within the downstream reach, typically defined as length along the stream divided by change in elevation. The site-specific G values used in the model are an average of these gradient measurements for each downstream reach.

Heat capacity of the stream. The heat capacity (C) of the modelled parcel of water is proportional to the volume of the parcel and consequently the cross-sectional area of the stream. For streams approximated as triangular or trapezoidal, the volume is proportional to the maximum depth (D) multiplied by the wetted width (W). We use the average measurements W and D for each downstream reach (Equation (9)).

$$C \propto W\,D \quad (9)$$

Downstream shade factor. Shade and shelter provided by stream-side vegetation and local topography reduce solar heating during the day and radiative cooling at night and also reduce wind speed, and consequently conduction–convection and evaporation–convection. We hypothesize that through these processes, the level of downstream vegetation may influence the downstream temperature response to forest harvest. The site-specific downstream shade factor (S) was derived from the global site factor as discussed in the Section on Methods. However, uniformity in the un-harvested downstream canopy among the study streams produced a small range of S values (0.83 to 0.96), which was not sufficient to significantly affect the predictions of the model. This result suggests that a study incorporating a wider range of downstream canopy densities would be needed in order to provide the information required to evaluate and validate a downstream shade component in the model, as discussed further in the Section on Modelling Discussion.

Integrating site specificity

The dominant stream properties driving variation in $\Delta T4W$ are incorporated into our model by combining Equations (8) and (9) to arrive at

$$\alpha'\tau \propto \varphi\frac{L}{WDG^{1/2}} \quad (10)$$

Here, φ is a model parameter incorporating the proportionality constants associated with Equations (8) and (9). Given limited environmental and stream data, we initially assume that φ is approximately non-site specific for the streams in this study, which is supported by the success of the model when a general φ value is used.

Downstream equilibrium temperature. Finally, we model the yet-unknown changes in downstream equilibrium temperature ($\Delta T4W_{eq}$), which are not harvest related (e.g. climatic). Our model requires only the change in equilibrium temperature, so we are not forced to attempt a calculation of the absolute equilibrium temperature both pre-harvest and post-harvest. Instead, we use pre-harvest to post-harvest changes in the stream temperature measured at probes 1W and 2W, which lie upstream from harvest, to estimate $\Delta T4W_{eq}$ directly. In the context of our NLC model, year-to-year changes in the local climate will influence actual stream temperature by changing T_{eq}. From Equation (7), we see that the rate at which the change in downstream temperature varies as equilibrium temperature varies, $\frac{d(\Delta T4W)}{d(T4W_{eq})} = 1 - e^{-\alpha'\tau}$, is

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indicated by comparing observed *versus* predicted values in Figure 2. The *RMSE*s for the linear model and the NLC model were 0.48 and 0.18, respectively. Similarly, $AIC_c = 28.7$ for the linear model and -1.6 for the NLC model, indicating substantially greater support for the NLC model (Burnham and Anderson, 2002). The LOOCV procedure results in an *RMSE* value of 0.21, and imputed results (Figure 2) indicate that no particular point is driving the fit of the model or disproportionally influencing the free parameter values.

We see that the two-parameter NLC model outperforms the linear regression model at predicting the measured $\Delta T4W$ values, despite having the same number of free parameters (two). In Table I, the differences between modelled and measured $\Delta T4W$ values are all $\leq 0.4\,^{\circ}$C in magnitude, with the exception of site 7353. At this site, $\Delta T1W$, $\Delta T2W$ and $\Delta T3W$ (harvest reach) were all negative, and yet $\Delta T4W$ was positive. We therefore conclude that the increase in downstream temperature was not caused by harvest, but rather by some as-yet-unknown local effect occurring in the downstream reach. The model uses temperature data taken upstream of the harvest reach to account for the effects of non-harvest-related temperature fluctuations and thus cannot account for the behaviour of this site because of the localized nature of the downstream disturbance. Considering this result, site 7353 was not included in the fitting procedure used to determine φ and β; a model predicted value of $\Delta T4W$ for this site is not shown in Table I, and model data for this site are not shown in subsequent figures.

We quantify the relative rates at which the pre-harvest to post-harvest change in the temperature will diminish with distance travelled in the downstream reach at each site by removing the effect of the varying reach lengths. The exponent in the NLC model is normalized to the reach length L, and we calculate $(\alpha'\tau)/L = \varphi/[WDG^{1/2}]$. Relatively large values of $(\alpha'\tau)/L$ indicate that the magnitude of the temperature changes measured at a specific downstream locations will decrease in a shorter distance downstream compared with sites with small values of $(\alpha'\tau)/L$. Table I provides the site-specific values of $(\alpha'\tau)/L$. In order to further understand how the distance dependence of $\Delta T4W$ results in the observed values, the site-specific reach length, L, in Equation (12) is replaced with a general distance variable, x, to arrive at an expression for the distance dependence of a change in downstream temperature:

$$\Delta T4W(x) = \Delta T3We^{-\varphi\frac{x}{WDG^{1/2}}} + \beta\Delta T_{1W,2W}\left[1 - e^{-\varphi\frac{x}{WDG^{1/2}}}\right] \quad (15)$$

The range of behaviours produced by the variation in $(\alpha'\tau)/L$ are illustrated in Figure 3, which shows the calculated distance profiles of the downstream pre-harvest to post-harvest temperature change $\Delta T4W(x)$, along with

Table I. ISummarization of sites' experimental ΔT_{4W} values,[a] model error in predicting ΔT_{4W},[b] specific ΔT_{4Weq} values[c] and values of $\alpha'\tau/L$[d]

Site number identifier	$\Delta T4W$ (°C)	Model error	$\Delta T4W_{eq}$ (°C)	$\alpha'\tau/L$ (m^{-1})
5102	−0.37	−0.09	−0.22	0.0026
5104	0.22	−0.10	0.75	0.0021
5201	−0.89	−0.28	−0.36	0.0021
5205	2.09	0.13	0.54	0.0017
5206	1.00	−0.25	0.59	0.0015
5207	0.81	0.00	0.48	0.0011
5301	0.21	−0.16	−0.14	0.0016
5302	0.07	−0.12	0.20	0.0017
5502	−0.15	−0.12	0.25	0.0011
5506	0.66	0.21	0.22	0.0036
5556	0.97	−0.07	−0.64	0.0006
5558	0.20	0.40	−0.21	0.0042
7353[e]	0.86	—	—	—
7801	−0.16	0.14	−0.31	0.0056
7803	−0.69	−0.04	−0.67	0.0119
7854	−0.24	−0.19	−0.29	0.0078

[a] Calculated as the difference between T_{4W} measured before and after harvest.
[b] Measured value subtracted from NLC model values.
[c] Calculated using the NLC model determined parameter value $\beta = 1.1$.
[d] Calculated using the NLC model determined parameter value $\varphi = 2 \times 10^{-4}$ m.
[e] This site was not included in the model; see Section on Modelling Discussion.

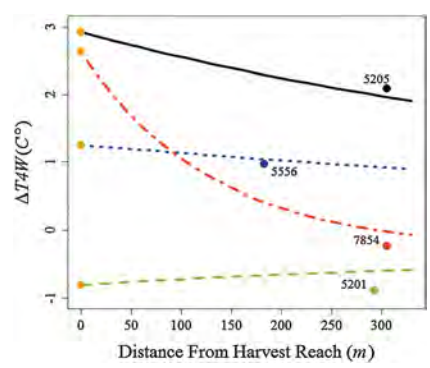

Figure 3. Change in temperature downstream of harvest reach, calculated as a function of distance from harvest reach using the Newton law of cooling model $\Delta T4W(x)$ for several example study sites (lines). Orange dots are measured temperature change at zero distance downstream, $\Delta T4W(x=0) = \Delta T3W$, and coloured dots are measured values of $\Delta T4W(x=L)$ for each site. In all cases, model parameter values were $\varphi = 2.2 \times 10^{-4}$ m and $\beta = 1.1$, and site-specific values of WD, G and $\Delta T_{1,2}$ were used

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the measured $\Delta T4W$ ($x = L$) data for a representative sample of the study streams. Note that these curves and measured data are not plots of the absolute stream temperature as a function of downstream location, but rather plots of the *change* in stream temperature from pre-harvest to post-harvest as a function of downstream location ($\Delta T4W(x)$).

MODELLING DISCUSSION

Model specificity

We see in Figure 2 that the $\Delta T4W$ data deviate from the simple linear model, suggesting that the across-harvest $\Delta T3W$ may not be the only source of the measured variation in across-harvest $\Delta T4W$ and that the behaviour of any particular site can be quite different from the overall behavioural trend. The NLC model we have applied predicts this site-specific variation, indicating a significant deterministic contribution to the variation, as originally hypothesized.

Model generality

The ability of the model to reproduce the measured downstream responses using non-site-specific values for model parameters φ and β indicates that these values are relatively constant across the streams selected for this study. This result further suggests that once these parameters values are determined by fitting of model to data for a given type of stream in a given geographic region, the model might be used to predict the future downstream response to harvest of similar streams in that region. This NLC model does not explicitly treat hyporheic flow or groundwater exchange; however, the effects of these processes on the stream temperature change are implicitly included in the fitted model parameter φ. The fact that φ was held constant in this study suggests that these effects are roughly equally influential across the streams in the study, to within the resolution of this model. The value of $\beta = 1.1$ suggests that for the specific types of reaches examined in this study, the downstream reach equilibrium temperature responds to changes in climatic conditions with roughly equivalent sensitivity to that exhibited by the upstream reaches, to within the resolution of this model.

Model predictive power

The NLC model allows for intuitive analysis of stream sites, which might appear to have outlying behaviour. For example, site 7854 (indicated in Figure 3) experienced a $-0.2\,^{\circ}$C change in downstream temperature even though the harvest reach temperature experienced a relatively large measured temperature increase of $2.6\,^{\circ}$C. The model was able to predict that this site would behave well outside of the general trend defined by other sites, even when this site was not included in the LOOCV parameter determination procedure, as indicated by the proximity of its imputed value relative to its observed value, as seen in Figure 2. Examination of the stream variables in the context of the NLC model reveals that site 7854 experienced an overall decrease in the local equilibrium temperature, as seen in Table I and indicated by negative upstream control reach temperature changes across harvest ($\Delta T_{1W,2W} = -0.2\,^{\circ}$C). Site 7854 also possessed the second smallest WD value among all sites. This combination resulted in a relatively high rate of reduction in the temperature change, as seen in Figure 3. The NLC model shows us that the outlying behaviour of this site was caused by this high rate of change coupled with a relatively long transit time for this site, due to a combination of long downstream reach length ($L = 305$ m) and third lowest gradient ($G = 0.023$). This result highlights the potential utility of the NLC model in predicting which sites may exhibit abnormal behaviour in response to harvest, before harvest ever begins.

In order to further leverage the predictive power of the NLC model, we examine how the across-harvest temperature change depends on the distance from the harvest reach, when that downstream change is caused purely by a change in the harvest reach temperature, in the absence of any climatic fluctuations. For this case, the change in equilibrium temperature is zero, leaving only the first term in the model:

$$\Delta T4W(x) = \Delta T3W e^{-\varphi \frac{x}{WDG^{1/2}}} \tag{16}$$

Intuitively, larger harvest reach temperature changes will lead directly to larger downstream temperature changes, as can be seen from Equation (16). In order to focus on site-specific downstream behaviour, we normalize the downstream change to the harvest reach change and thus define the distance dependent ratio of $\Delta T4W$ to $\Delta T3W$ as $R(x)$. For the case of 0 change in equilibrium temperature, $R(x)$ has the form

$$R(x) = \frac{\Delta T4W}{\Delta T3W} = e^{-\varphi \frac{x}{WDG^{1/2}}} \tag{17}$$

Using average values for G and WD will allow us to estimate a characteristic behaviour of the sites in our study. The solid green line in Figure 4 shows $R(x)$ for the average values of $G = 0.047$ and $WD = 0.53$ m^2. We see that for these average values, the across-harvest-year change in downstream temperature drops to 56% of that

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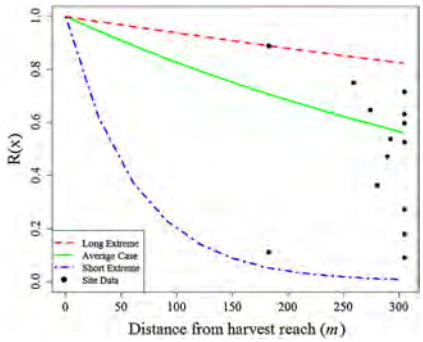

Figure 4. Calculated ratio of harvest reach and downstream temperature changes in the absence of stream equilibrium temperature fluctuations as a function of distance from harvest reach using maximum (red) minimum (blue) and average (green) measured values of G (0.047) and WD (0.53 m^2). Dots show this value calculated using site-specific values of G, WD and L for each site. In all cases, $\Delta T4W_{eq} = 0$ °C and model parameter values were $\varphi = 2.2 \times 10^{-4}$ m, $\beta = 1.1$

change occurring in the harvest reach after 300 m. These calculations are qualitatively supported by the result of the linear fit, which suggests a statistical 50% reduction in temperature change after ≈300 m. However, $R(x)$ is exponentially sensitive to G and WD, and consequently, the average or statistical result cannot be used to accurately describe the behaviour of a specific site, hence the utility of the NLC model.

In order to estimate bounding behaviours for the distance dependence of the change in temperature for sites similar to those in this study, we combined the extreme values of G and WD measured from all sites and used these in the model. The maximum measured values are $G = 0.11$ and $WD = 1.0$ m^2, and the minimal values are $G = 0.01$ and $WD = 0.12$ m^2. The bounding behaviours calculated from these two value sets are shown in Figure 4. For the long-distance extreme case, the downstream temperature change measured 300 m from the end of the harvest reach would be 82% of the temperature change that occurred at the end of the harvest reach ($R(x) = 0.82$). For the short-distance extreme case, $R(x)$ is less than 1% after 300 m. Values of $R(x = L)$ calculated using the specific stream property values and reach lengths at each study site are also shown for comparison with the bounding behaviour curves. We see that the behaviour of one site lies directly on the boundary curve because that site possessed the maximum measured values for both G and WD.

In order to examine the specific effects of a change to the downstream equilibrium temperature, $\Delta T4W_{eq}$, on the downstream temperature response, we calculate $R(x)$ for theoretical example cases when $\Delta T4W_{eq} \neq 0$. In this case, the form for $R(x)$ is more complex:

$$R(x) = e^{-\varphi \frac{L}{WDG^{1/2}}} + \frac{\beta \Delta T_{1W,2W}}{\Delta T3W}\left[1 - e^{-\varphi \frac{L}{WDG^{1/2}}}\right] \quad (18)$$

We see that calculating $R(x)$ for $\Delta T4W_{eq} \neq 0$ requires input values for $\Delta T3W$ and $\Delta T4W_{eq}$. As seen in Table I, the range of values for $\Delta T4W_{eq}$ extracted from the model was approximately −0.4 to 0.4 °C. Figure 5 shows $\Delta T4W$ calculated for $\Delta T4W_{eq}$ equal to the end-range values of −0.4 and 0.4 °C, each for two cases of the harvest-reach temperature change within the range typically observed, namely, 1 and 3 °C (solid green lines). We see that changes to $\Delta T4W_{eq}$ within this range do not significantly affect the dependence of $\Delta T4W$ on distance relative to the precision of typical temperature measurements. However, we see that integrated over distances of 300 m these relatively slight changes in distance dependence may affect the value of $\Delta T4W$ by detectable levels (≈ 0.3 °C).

Sensitivity to specific stream properties

The wide range of downstream behaviours encompassed by the bounding behaviours exemplifies the exponential sensitivity of $R(x)$ to G and WD. These sensitivities are illustrated with greater detail in Figures 6 and 7, which show $R(x)$ as a function of G and WD, respectively, at the reach end ($x = 300$ m) and half-length ($x = 150$ m) for comparison. We see that the slopes of these curves are significant within the range of measured values (indicated by the shaded grey regions in Figures 6 and 7) for these stream properties, and thus, the measured behaviour is highly sensitive to these properties. This analysis indicates that blanket statements about distance required for stream temperature to return to pre-harvest

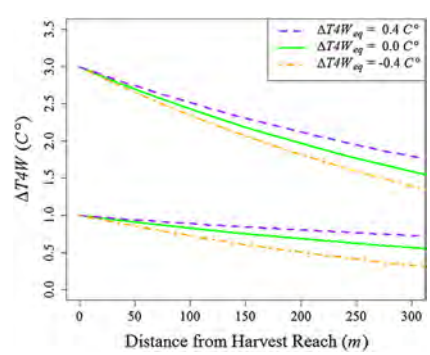

Figure 5. Distance dependence of $\Delta T4W$ calculated for $\Delta T4W_{eq}$ values of 0, −0.4 and 0.4 °C for the example cases of $\Delta T3W = 1$ °C and $\Delta T3W = 3$ °C. The legend designates these values used to produce each curve in the format ($\Delta T3W$, $\Delta T4W_{eq}$). The average of measured values for G (0.047) and WD (0.53 m^2) was used, and model parameter values were $\varphi = 2.2 \times 10^{-4}$ m, $\beta = 1.1$

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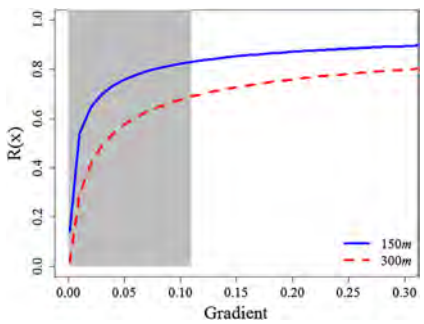

Figure 6. Calculated ratio of downstream to harvest reach temperature changes at distances of 150 and 300 m downstream from harvest reach as a function of downstream gradient in the absence of natural stream fluctuations. In all cases, the average measured values for *WD* (0.53 m^2) were used, $\Delta T4W_{eq} = 0$ °C, and model parameter values were $\varphi = 2.2 \times 10^{-4}$ (m), $\beta = 1.1$. The grey shaded area indicates the range of gradient values measured in this study

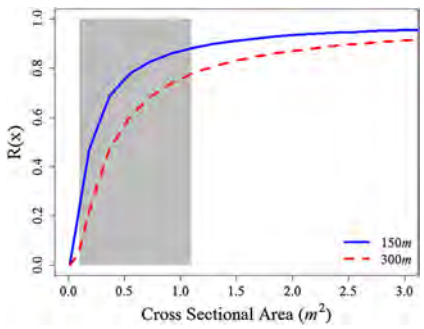

Figure 7. Calculated ratio of downstream to harvest reach temperature changes at distances of 150 and 300 m downstream from harvest reach as a function of downstream cross-sectional area in the absence of stream equilibrium temperature fluctuations. In all cases, the average measured values for *WD* (0.53 m^2) were used, $\Delta T4W_{eq} = 0$ °C, and model parameter values were $\varphi = 2.2 \times 10^{-4}$ (m), $\beta = 1.1$. The grey shaded area indicates the range of cross-sectional area values measured in this study

value ($\Delta T4W <$ thermistor resolution) and use of regional average or non-local variable values to model site-specific behaviour may lead to miscalculations.

For the narrow range of downstream shade factor values measured in the study streams, we found that shade had no significant effect on the behaviour of the model. Owing to all measured values of *S* being near one, modelling α' as proportional to or inversely proportional to *S* does not produce significantly different results in the performance of the model or the values of the parameters determined from fitting the model to data. Thus, the downstream shade data are not sufficiently ranged to

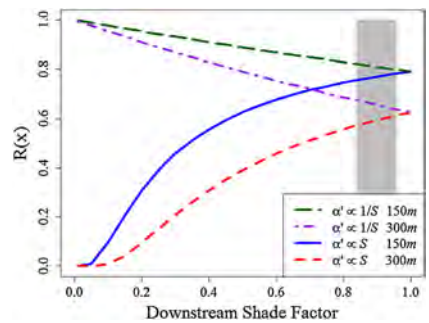

Figure 8. Calculated ratio of downstream to harvest reach temperature changes at distances of 150 and 300 m downstream from harvest reach as a function of downstream shade in the absence of stream equilibrium temperature fluctuations. Curves produced using both $\alpha' \propto 1/S$ and $\alpha' \propto S$ models are shown. Average measured values of *G* (0.047) and *WD* (0.53 m^2) were used. In all cases, $\Delta T4W_{eq} = 0$ °C, and model parameter values were stream equilibrium temperature fluctuations, $\beta = 1.1$. The grey shaded area indicates the range of shade factor values measured in this study

allow for evaluation of a shade component to model. Figure 8 shows $R(x = 150$ m) and $R(x = 300$ m) for both model types, $\alpha' \propto 1/S$ and $\alpha' \propto S$. We see that within the range of *S* values measured (indicated by the shaded grey region in Figure 8), the slope of these curves is small relative to that in Figures 6 and 7, which demonstrates the relative insensitivity of the model to the shade variable within that range. The success of the model at describing the data despite the model insensitivity to *S* indicates that for streams with relatively uniform and undisturbed riparian conditions downstream of harvest (high shade and shelter), the values of *G* and *WD* will primarily drive the variations in downstream temperature response

CONCLUSIONS

For the forested streams in our study, the model suggests that, on average, pre- to post-changes in downstream temperature exist at roughly 50% of those changes in the harvest reach after ≈300 m downstream, but that they do not persist indefinitely. The model also indicates that variation in stream morphology can lead to significant variability in this downstream temperature response to harvest, and it allowed us to estimate limiting-case behaviours. We estimated that for streams similar to those in this study, the across-harvest-year temperature change ≈300 m downstream of the harvest reach can range from 82% to less than 1% of the change in the harvest reach, in the absence of major tributaries, with a significant portion of that wide variation being predictable if a few specific and easily measureable stream properties are known.

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Additional application of NLC modelling methods to stream temperature data should help to improve the NLC model accuracy and determine the range of stream, environmental and treatment conditions under which the NLC model is valid and accurate. For example, data from a set of many temperature probes within individual reaches would allow us to fit the Lagrangian NLC model to the Eulerian temperature data at each site and determine reach-specific values for the model free parameters φ and β. Comparison of these parameter values to measured stream properties may allow us to identify those properties with greatest influence on φ and β so that we might model these values directly and reduce the number of free parameters in the NLC model and improve its accuracy. Analysis of data from a set of streams with a wider range of downstream shade values might permit the addition and validation of a downstream shade component in the model and allow for investigation of a minimum shade threshold required for the NLC model to maintain accuracy. Finally, analysis of data from streams with a wider range of morphologies and environments would test the generality of the NLC model and provide a greater range of input variables against which to test, refine and improve an NLC-based model.

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REFERENCES

Adams TN, Sullivan K. 1989. *The Physics of Forest Stream Heating: A Simple Model. TFW-WQ3-90-007*. Washington Department of Natural Resources: Olympia, Washington; 30.

Baillie BR, Collier KJ, Nagels J. 2005. Effects of forest harvesting and woody debris removal on two Northland streams, New Zealand. *New Zealand Journal of Marine and Freshwater Research* **39**(1): 1–15.

Bogan T, Mohseni O, Stefan HG. 2003. Stream temperature–equilibrium temperature relationship. *Water Resources Research* **39**: 1245. DOI:10.1029/2003WR002034.

Boyd M, Kasper B. 2003. "*Analytical Methods for Dynamic Open Channel Heat and Mass Transfer: Methodology for Heat Source Model Version 7.0*." Oregon Department of Environmental Quality: Portland, Oregon. Web site: http://www. deq. state. or. us/wq/TMDLs/tools. htm

Brown GW. 1969. Predicting temperatures of small streams. *Water Resources Research* **5**: 68–75.

Brown GW, Krygier JT. 1970. Effect of clear cutting on stream temperature. *Water Resources Research* **6**: 1133–1139.

Brown GW, Swank GW, Rothacher J. 1971. Water temperature in the steamboat drainage, Pacific Northwest forest and Range Expt. Sta., Forest Service, U.S. Department of Agriculture, Portland. Oregon. Research Paper PNW-1 19. 17 p.

Burnham KP, Anderson DR. 2002. *Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach*, 2nd edition. Springer-Verlag: New York; 488.

Caissie D. 2006. The thermal regime of rivers: a review. *Freshwater Biology* **51**13891406: . DOI:10.1111/j.1365-2427.2006.01597.x.

Caldwell JE, Doughty K, Sullivan K. 1991. *Evaluation of downstream temperature effects on type 4/5 waters, Timber/Fish/Wildlife Report #TFW-WQ5-91-004*. Washington Dept. of Natural Resources: Olympia, WA 71 p.

Cole E, Newton M. 2013. Influence of streamside buffers on stream temperature response following clear-cut harvesting in western Oregon. *Canadian Journal of Forest Research* **43**: 993–1005. DOI:10.1139/cjfr-2013-0138.

DaSilva A, Xu YJ, Ice G, Beebe J, Stich R. 2013. Effects of timber harvesting with best management practices on ecosystem metabolism of a low gradient stream on the United States Gulf Coastal Plain. *Water (Switzerland)* **5**(2): 747–766.

Dent L, Vick D, Abraham K, Schoenholtz S, Johnson S. 2008. Summer temperature patterns in headwater streams of the Oregon Coast Range. *Journal of the American Water Resources Association* **44**: 803–813. DOI:10.1111/j.1752-1688.2008.00204.x.

Doyle MW, Ensign SH. 2009. Alternative reference frames in river system science. *BioScience* **59**(6): 499–510.

Edinger JE, Duttweiler DW, Geyer JC. 1968. The response of water temperatures to meteorological conditions. *Water Resources Research* **4**: 1137–1143. DOI:10.1029/WR004i005p01137.

Garner G, Malcolm IA, Sadler JP, Hannah DM. 2014. What causes cooling water temperature gradients in forested stream reaches? *Hydrology and Earth System Sciences Discussions* **11**(6): 6441–6472.

Gomi T, Moore RD, Dhakal AS. 2006. Headwater stream temperature response to clear-cut harvesting with different riparian treatments, coastal British Columbia, Canada. *Water Resources Research* **42**W08437 DOI:10.1029/2005WR004162.

Gravell JA, Link TE. 2007. Influence of timber harvesting on headwater peak stream temperatures in a Northern Idaho watershed. *Forest Science* **53**: 189–205.

Gray JRA, Edington JM. 1969. Effect of woodland clearance on stream temperature. *Journal of the Fisheries Board of Canada* **26**(2): 399–403.

Groom JD, Dent L, Madsen L. 2011a. Stream temperature change detection for state and private forests in the Oregon Coast Range. *Water Resources Research* **47**W01501 DOI:10.1029/2009WR009061.

Groom JD, Dent L, Madsen L, Fleuret J. 2011b. Response of Western Oregon (U.S.A.) stream temperatures to contemporary forest management. *Forest Ecology and Management* **262**: 1618–1629. DOI:10.1016/j.foreco.2011.07.012.

Hairston-Strang AB, Adams PW, Ice GG. 2008. The Oregon forest practices act and forest research. In *Hydrological and Biological Responses to Forest Practices*. Springer: New York; 95–113.

Janisch JE, Wondzell SM, Ehinger WJ. 2012. Headwater stream temperature: interpreting response after logging, with and without riparian buffers, Washington, USA. *Forest Ecology and Management* **270**: 302–313. DOI:10.1016/j.foreco.2011.12.035.

Johnson SL. 2004. Factors influencing stream temperatures in small streams: substrate effects and a shading experiment. *Canadian Journal of Fisheries and Aquatic Sciences* **61**: 913–923. DOI:10.1139/f04-040.

Johnson MF, Wilby RL. 2015. Seeing the landscape for the trees: metrics to guide riparian shade management in river catchments. *Water Resources Research* **51**(5): 3754–3769.

Kaufmann PR, Robison EG. 1998. Environmental Monitoring and Assessment Program – Surface waters: field operations and methods

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for measuring the ecological condition of wadeable streams, pp 77–118 In: EPA/620/R-94/004F. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C.

Kibler KM, Skaugset A, Ganio LM, Huso MM. 2013. Effect of contemporary forest harvesting practices on headwater stream temperatures: initial response of the Hinkle Creek catchment, Pacific Northwest, USA. *Forest Ecology and Management* **310**: 680–691. DOI:10.1016/j.foreco.2013.09.009.

Moore RD, Spittlehouse DL, Story A. 2005. Riparian microclimate and stream temperature response to forest harvesting: a review. *Journal of the American Water Resources Association* **41**: 813–834. DOI:10.1111/j.1752-1688.2005.tb03772.x.

Rex JF, Maloney DA, Krauskopf PN, Beaudry PG, Beaudry LJ. 2012. Variable-retention riparian harvesting effects on riparian air and water temperature of sub-boreal headwater streams in British Columbia. *Forest Ecology and Management* **269**: 259–270. DOI:10.1016/j.foreco.2011.12.023.

Roth TR, Westhoff MC, Huwald H, Huff JA, Rubin JF, Barrenetxea G, Vetterli M, Parriaux A, Selker JS, Parlange MB. 2010. Stream temperature response to three riparian vegetation scenarios by use of a distributed temperature validated model. *Environmental Science & Technology* **44**(6): 2072–2078.

Rutherford JC, Marsh NA, Davies PM, Bunn SE. 2004. Effects of patchy shade on stream water temperature: how quickly do small streams heat and cool? *Marine and Freshwater Research* **55**(8): 737–748.

Story A, Moore RD, Macdonald JS. 2003. Stream temperatures in two shaded reaches below cutblocks and logging roads: downstream cooling linked to subsurface hydrology. *Canadian Journal of Forest Research* **33**: 1383–1396. DOI:10.1139/x03-087.

Subramanya V. 2009. *Flow in Open Channels*, 3rd edition. New Delhi: McGraw-Hill.

Sugimoto S, Nakamura F, Ito A. 1997. Heat budget and statistical analysis of the relationship between stream temperature and riparian forest in the Toikanbetsu River basin, northern Japan. *Journal of Forest Research* **2**: 103–107. DOI:10.1007/BF02348477.

Valverde T, Silvertown J. 1997. Canopy closure rate and forest structure. *Ecology* **78**: 1555–1562. DOI:10.2307/2266148.

Zwieniecki M, Newton M. 1999. Influence of streamside cover and stream features on temperature trends in forested streams of western Oregon. *Western Journal of Applied Forestry* **14**: 106–113.

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ATTACHMENT 3
DEQ and ODFW Briefing Document, 2014. 10 pages.

Responses to Questions/Concerns Raised by Oregon Forest Industries Council Regarding the Protecting Cold Water Criterion of Oregon's Temperature Water Quality Standard

Oregon Department of Environmental Quality
Oregon Department of Fish and Wildlife

Contacts: Josh Seeds (DEQ) 503-229-5081
Ryan Michie (DEQ) 503-229-6162
Dave Jepsen (ODFW) 541-7574263 x235
Gene Foster (DEQ) 503-229-5325

Date: 6/19/2014

Reasons for a Protecting Cold Water Criterion:

- A natural thermal regime provides best conditions for fish & other native aquatic organisms;*
- There is ecological value in a diversity of temperatures, including streams colder than BBNC, in part because thermal diversity promotes aquatic biological productivity;*
- Prevent accumulation of heat in fish-bearing reaches;*
- Retain assimilative capacity to buffer climate variation & climate change.

*From Summary of 2003 Technical Advisory Committee findings

Responses to Forest Industry Questions/Concerns:

1. Paired watershed studies add to the body of science on the association of new harvest treatments on stream temperature & short-term fish response, but not in a way that shows a lack of need for the Protecting Cold Water Criterion.
    a. Hinkle & Alsea studies show increases in fish-bearing streams within the range of responses from RipStream.
    b. Biological inference of WRC studies is correlative, short-term, and at the sub-catchment scale in lower order tributaries, and primarily within the distribution of resident cutthroat trout.
    c. The purpose of the standard is maintenance and restoration of natural thermal regimes across the landscape for all aquatic species.
    d. Prevention of short-term, reach level effects to fish are a goal to the standard, but are not the primary purpose.
    e. Meeting the standard preserves the capacity of waterbodies to assimilate natural fluctuations in temperature due to year-to-year climate variations & to better maintain cold-water communities in a warming climate (Bisson *et al* 2003, Mote 2003, INR 2009, Ruesch *et al* 2012).

2. Thermal diversity across the landscape is biologically necessary. Small increases in stream temperature can have negative effects on fish populations, particularly when occurring across the landscape.
    a. Temperature 303(d) listings & TMDLs exist across Oregon.
    b. Heating of headwaters reduces the extent of downstream waters at optimal growth & physiological temperatures & increases the extent at high-risk & lethal temperatures for rearing & migration.
    c. Temperature effects typically occur on a continuum; increases from natural thermal potential increase risk to fish (McCullough 1999, US EPA 2001).
    d. The natural thermal regime (NTR) is dynamic & variable, promoting biological diversity & resilience among fish populations & other native aquatic organisms (e.g. Watters *et al* 2003, Olden & Naiman 2010).
        i. Landscape alteration & climate change alter the mean & *the variance* of these temperature components (Steel *et al* 2012).
        ii. Timing of fish life history attributes (adult migration, spawning, fry emergence, smolt migration) is partially mediated by the NTR (Vannote & Sweeney 1980).
        iii. Homing to natal streams & natural selective forces (including those imposed by NTR) result in distinct, *locally adapted* populations (Hillborn *et al* 2003).
    e. Thermal diversity promotes aquatic biological productivity**.**
        i. Fish use thermal diversity (temporally & spatially) so impacts to the "pattern" of temperature can be as significant as changes to the mean or maximum temperature (see DEQ 2003).
        ii. Fish detect & exploit thermal heterogeneity to avoid heat stress & to meet metabolic & reproductive requirements (Berman & Quinn 1991, Hodgson & Quinn 1991, Ebersole *et al* 2003, Torgersen *et al* 2012).
        iii. Variation in thermal regimes directly influences:
            1. Metabolic rates, physiology, & life-history traits of aquatic ectotherms (see Holtby *et al* 1989 for salmonid example);
            2. Rates of important ecological processes such as nutrient cycling & productivity;
            3. Indirectly mediates biotic interactions (references in Olden & Naiman 2010).
    f. Heat accumulation (& other homogenizing effects) can alter thermal heterogeneity before "average" main channel temperatures change (Poole & Berman 2001).
    g. Multiple stressors in the environment must be considered. By preventing or reducing temperature stress, we reduce the risks due to multiple stressors on fish populations (e.g. OCCCP bottlenecks; e.g. Laetz *et al* 2014, Ray *et al* 2014).
    h. When there is uncertainty, DEQ must make conservative choices to ensure protection of the resource.

3. Thermal loads do move downstream, heat loss mechanisms are much less efficient than heat gain by solar radiation, & dilution of thermal loads is not the same as dissipation, especially with multiple harvests.
    a. In open canopy streams, input of solar radiation typically composes about 50% – 90% of the total heat energy flux (Figures 1 & 2; see Johnson 2004, Benyahya *et al* 2012).
    b. A single source's temperature effects become hard to track downstream, but DEQ calculates thermal loads for TMDLs & permits.
    c. DEQ HeatSource modeling indicates long distances (>1000 meters) are required to lose thermal energy via evaporation & longwave radiation (when tributary & groundwater inputs are held constant).
        i. HeatSource modeling on 2 RipStream sites (5556 & 7854) shows persistent temperature increases a kilometer or more from the end of harvest units (Figures 3, 4, & 5); and
        ii. Harvest of an additional downstream unit on 5556 creates greater increase at confluence with Drift Creek (Figure 6).
    d. Cole & Newton (2013) showed that with uncut units interspersed with harvest units, stream reaches showed overall increases in temperature trends post-harvest for 3 of 4 study reaches.

4. The current disturbance regime is very different than the pre-settlement disturbance regime in both frequency & type of disturbance.
    a. Thermal recovery post-disturbance is 7-15 years, with 10 years as a reasonable mid-range value (Johnson & Jones 2000; D'Souza *et al* 2011; Rex *et al* 2012; RipStream data, *unpublished*).
    b. With a 40-year rotation (assuming steady yearly harvest rate), 25% of the private industrial forestland base would be in thermal recovery.
    c. Based on change in Landsat land cover from 1985-2009 (Figure 7), the average percentage of private forestland (65.1% of total land area) in the MidCoast basin in the 10-yr thermal recovery period is 17% for the time period 1994-2009.
        i. The total for all land uses combined is 10%.
        ii. Varies over time & space.
            1. In 2008, 39.9% of private forestland in the Middle Siletz River watershed was in thermal recovery.
            2. In 1996, 5.3% of private forestland in the Drift Creek watershed was in thermal recovery. [Maximum of 34.9% in 2008]
    d. Based on change in Landsat land cover from 1985-2009, the average percentage of private forestland riparian areas in the MidCoast basin (43.8% of total riparian area (within 100ft of streams)) in the 10-yr thermal recovery period is 14.1% for the time period 1994-2009.
        i. The average for private industrial forestland is 15.6% (36.2% of total riparian area) & for private nonindustrial forestland is 10.2% (7.6% of total riparian area).

ii. The percentage of recently+chronically disturbed riparian areas is 20.7% for private forestlands during the same time period (20.4% & 21.8% for industrial & nonindustrial, respectively).
iii. The average recent disturbance for riparian areas of all land uses collectively is 8.7%. The average chronic disturbance for riparian areas of all land uses collectively is 14.0%.
iv. Varies over time & space.
    1. In 2008, 36.7% of private industrial forestland riparian area in the Middle Siletz River watershed was in thermal recovery (maximum). The minimum of 14.1% occurred in 1994 (Figures 8 & 9).
    2. In 1996, 0.2% of private industrial forestland riparian area in the Drift Creek watershed was in thermal recovery (minimum). The maximum of 25.8% occurred in 2008 (Figures 10 & 11).
    3. In 1999, 9.7% of private industrial forestland riparian area in the Lake Creek watershed was in thermal recovery (minimum). The maximum of 34.5% occurred in 2008 (Figures 12 & 13).

e. Agee (1990) estimates that historically (prior to Euro-American settlement) an average 0.24% and 0.67% of cedar/spruce/hemlock and western hemlock/Douglas-fir forests, respectively, burned annually.
    i. Gives an average area in thermal recovery estimate of 2.4% for cedar/spruce/hemlock & 6.7% for western hemlock/Douglas-fir.
f. Wimberly (2002) estimates that a median of 17% of Oregon's coastal province would be in early successional condition (<30 years since fire of varying severity).
    i. Using 10 years as above, Wimberly's estimate gives 5.7% of forestlands historically in thermal recovery.
g. High-severity fires leave more wood & live vegetation than clearcut harvest, and there are differences between unmanaged terrestrial & riparian early succession compared to clearcut harvest & replanting methods (Reeves *et al* 1995, Reeves *et al* 2006, Swanson *et al* 2011).
h. Fire return intervals in western Oregon range from 100-400 years. Shorter intervals typically are associated with less severity (Morrison & Swanson 1990).
i. Fire return for high severity fires is typically 200 years (Wimberly 2002), compared to harvest rotation of 40 years.
j. Periodic large scale disturbances create a mosaic of riparian & aquatic habitats (Bisson *et al* 2003). Pulses of sediment & large wood are delivered by post-fire erosion, in contrast to chronic inputs.
    i. It is important to conserve & restore processes by managing for natural disturbances or like natural disturbances, not merely by creating structures or conditions.
k. Generally, riparian areas along streams higher in watersheds tend to burn along with upland forests, while riparian areas lower in watersheds are less likely to burn & more prone to flood disturbance (Reeves *et al* 2006, Pettit & Naiman 2007).

i. Fire can be less common in riparian areas due to higher moisture content & humidity.
ii. Some studies (e.g. Tollefson *et al* 2004, Olson & Agee 2005) have found no difference between upland & riparian fire frequency, particularly when riparian vegetation is similar to upland vegetation.
iii. Riparian areas often have higher fuel loads (higher productivity) & in prolonged drought can become more fire-prone.
iv. Riparian fires tend to be very patchy, primarily burning fine fuels. Conditions retard fuel drying & decrease severity. Extent & spread are complicated by ecosystem heterogeneity.
v. In very dry climatic conditions, riparian corridors can act as a route for fire to spread (wind tunnel effect). More often, riparian areas act as a natural fire break.
vi. Harvesting increases fuel loads & opens up the canopy, allowing faster drying of fuels.
vii. Riparian vegetation diversity & adaptations along with better access to water lead to faster recovery.

5. If taking a non-conservative approach to the effects of a single harvest, then we must address actual landscape conditions & the effects of multiple harvests.

References:

Agee, James K. 1990. The historical role of fire in Pacific Northwest forests, p. 25-38. *In* Walstad, JD, SR Radosevich, and DV Sandberg (*eds.*) Natural and Prescribed Fire in Pacific Northwest Forests. Oregon State University Press, Corvallis, Oregon. 317pp.

Arrigoni, AS, GC Poole, LAK Mertes, SJ O'Daniel, WW Woessner, and SA Thomas. 2008. Buffered, lagged, or cooled? Disentangling hyporheic influences on temperature cycles in stream channels. Water Resources Research 44: W09418, doi:10.1029/2007WR006480.

Armstrong, JB, DE Schindler, CP Ruff, GT Brooks, KE Bentley, and CE Torgersen. 2013. Diel horizontal migration in streams: Juvenile fish exploit spatial heterogeneity in thermal and trophic resources. *Ecology* **94**: 2066-2075.

Baird, DJ & GA Burton, Jr. (eds.) 2001. Ecological Variability: Separating Natural from Anthropogenic Causes of Impairment. Pensacola, Florida , USA: SETAC Press. 307pp.

Benyahya, L, D Caissie, MG Satish, and N El-Jabi. 2012. Lon-wave radiation and heat flux estimates within a small tributary in Catamaran Brook (New Brunswick, Canada). *Hydrological Processes* **26:** 475-484.

Berman, CH, and TP Quinn. 1991. Behavioural thermoregulation and homing by spring chinook salmon, *Oncorhynchus tshawytscha* (Walbaum), in the Yakima River. *Journal of Fish Biology* **39**: 301-312.

Bilby, RE. 1984. Characteristics and frequency of cool-water areas in a western Washington stream. *Journal of Freshwater Ecology* **2:** 593-602.

Bisson, PA, BE Rieman, C Luce, PF Hessberg, DC Lee, JS Kershner, GH Reeves, and RE Gresswell. 2003. Fir and aquatic ecosystems of the western USA: current knowledge and key questions. *Forest Ecology and Management* **178:** 213-229.

Cole, E, and M Newton. 2013. Influence of streamside buffers on stream temperature response following clear-cut harvesting in western Oregon. *Canadian Journal of Forest Research* **43:** 993-1005.

Davis, LJ, J Groom, and M Reiter. *in review*. A Newton's Law of Cooling for modeling downstream temperature response to timber harvest.

DEQ. 2003. Summary of the Discussion and Findings of DEQ's Technical Advisory Committee on Water Quality Criteria for Temperature. http://www.deq.state.or.us/wq/standards/docs/temperature/TACsummaryTemp2003.pdf

D'Souza, L, M Reiter, LJ Six, & RE Bilby. 2011. Response of vegetation, shade and stream temperature to debris torrents in two western Oregon watersheds. *Forest Ecology and Management* **261:** 2157-2167.

Ebersole, JL, WJ Liss, and CA Frissell. 2003. Thermal heterogeneity, stream channel morphology, and salmonid abundance in northeastern Oregon streams. *Canadian Journal of Aquatic and Fisheries Sciences* **60**: 1266-1280.

Hannah, DM, IA Malcolm, C Souslby, and AF Youngson. 2008. A comparison of forest and moorland stream microclimate, heat exchanges and thermal dynamics. *Hydrological Processes* **22:** 919-940.

Hillborn R, TP Quinn, DE Schindler, and DE Rogers. 2003. Biocomplexity and fisheries sustainability. *Proceedings of the National Academy of Science of the United States* **100:** 6564-6568.

Hodgson S, and TP Quinn. 2002. The timing of adult sockeye salmon migration into fresh water: adaptations by populations to prevailing thermal regimes. *Canadian Journal of Zoology* **80:** 542-555.

Holtby, L. B. 1988. Effects of logging on stream temperatures in Carnation Creek, British Columbia, and associated impacts on the coho salmon (Oncorhynchus kisutch). *Canadian Journal of Fisheries and Aquatic Sciences* **45**: 502-515.

Holtby LB, TE McMahon, and JC Scrivener. 1989. Stream temperatures and inter-annual variability in the emigration timing of coho salmon (*Oncorhynchus kisutch*) smolts and fry and chum salmon (*O. keta*) fry from Carnation Creek, British Columbia. *Canadian Journal of Fisheries and Aquatic Sciences* **46**: 1396-1405

INR (Institute for Natural Resources at Oregon State University). 2009. Managing for climate change in an ecosystem dynamics framework: Recommendations from April 16, 2009 seminar. *Dynamic Ecosystem Policy Project (Oregon Department of Forestry).* http://www.oregon.gov/odf/resource_planning/docs/inr_climate_change_white_paper.pdf

Johnson, Sherri L. 2004. Factors influencing stream temperatures on small streams: substrate effects and a shading experiment. *Canadian Journal of Fisheries and Aquatic Sciences* **61:** 913-923.

Johnson, SL, and JA Jones. 2000. Stream temperature response to forest harvest and debris flows in western Cascades, Oregon. *Canadian Journal of Fisheries and Aquatic Sciences* **57(Suppl. 2):** 30-39.

Jones, JA, and DA Post. 2004. Seasonal and successional streamflow response to forest cutting and regrowth in the northwest and eastern United States. *Water Resources Research* **40:** W05203, doi:10.1029/2003WR002952.

Kibler, KM, A Skaugset, LM Ganio, and MM Huso. 2013. Effect of contemporary forest harvesting practices on headwater stream temperatures: Initial response of the Hinkle Creek catchment, Pacific Northwest, USA. *Forest Ecology and Management* **310:** 680-691.

Laetz, CA, DH Baldwin, and VR Hebert. 2014. Elevated temperatures increase the toxicity of pesticide mixtures to juvenile coho salmon. *Aquatic Toxicology* **146:** 38-44.

McCullough, DA. 1999. A review and synthesis of effects of alterations to the water temperature regime on freshwater life stages of salmonids, with special reference to Chinook salmon. *United States Environmental Protection Agency Publication* EPA 910-R-99-010. 279pp.

Montgomery, DR, TB Abbe, JM Buffington, NP Peterson, KM Schmidt, and JD Stock. 1996. Distribution of bedrock and alluvial channels in forested mountain drainage basins. *Nature* **381:** 587-589.

Morrison, PH, and FJ Swanson. 1990. Fire history and pattern in a Cascade Range landscape. US Forest Service General Technical Report: PNW-GTR-254. 77pp.

Mote, Philip W. 2003. Trends in temperature and precipitation in the Pacific Northwest during the twentieth century. *Northwest Science* **77:** 271-281.

Murphy, ML, C P Hawkins, and NL Anderson. 1981. Effects of canopy modification and accumulated sediment on stream communities. *Trans. Am. Fish. Soc.* **110:** 469-478.

Nierenberg, TR, and DE Hibbs. 2000. A characterization of unmanaged riparian areas in the central Coast Range of western Oregon. *Forest Ecology and Management* **129:** 195-206.

Olden, JD, and RJ Naiman. 2010. Incorporating thermal regimes into environmental flows assessments: modifying dam operations to restore freshwater ecosystem integrity. *Freshwater Biology* **55**: 86-107.

Olson, DL, and JK Agee. 2005. Historical fires in Douglas-fir dominated riparian forests of the southern Cascades, Oregon. *Fire Ecology* **1:** 50-74.

Oregon Coastal Coho Conservation Plan. http://www.oregon.gov/OPSW/cohoproject/pdfs/november2007_pdfs/coho_plan.pdf

Pettit, NE, and RJ Naiman. 2007. Fire in the riparian zone: characteristics and ecological consequences. *Ecosystems* **10:** 673-687.

Poole, GC, and CH Berman. 2001. An ecological perspective on instream temperature: natural heat dynamics and mechanisms of human-caused thermal degradation. *Environmental Management* **27**: 787–802.

Rashin, EB, CJ Clishe, AT Loch, and JM Bell. 2006. Effectiveness of timber harvest practices for controlling sediment related water quality impacts. *Journal of the American Water Resources Association* **42:** 1307-1327.

Ray, RA, RW Perry, NA Som, and JL Bartholomew. 2014. Using cure models for analyzing the influence of pathogens on salmon survival. *Transactions of the American Fisheries Society* **143:** 387-398.

Reeves, GH, LE Benda, KM Burnett, PA Bisson, and JR Sedell. 1995. A disturbance-based ecosystem approach to maintaining and restoring freshwater habitats of evolutionarily significant units of anadromous salmonids in the Pacific Northwest. *American Fisheries Society Symposium* **17:** 334-349.

Reeves, GH, PA Bisson, BE Rieman, and LE Benda. 2006. Postfire logging in riparian areas. *Conservation Biology* **20:** 994-1004.

Rex, JF, DA Maloney, PN Krauskopf, PG Beaudry, and LJ Beaudry. 2012. Variable-retention riparian harvesting effects on riparian air and water temperature of sub-boreal headwater streams in British Columbia. *Forest Ecology and Management* **269:** 259-270.

Robison, E.G., K. Mills, J. Paul, L. Dent, and A. Skaugset. 1999. Oregon Department of Forestry Storm Impacts and Landslides of 1996: Final Report. Forest Practices Technical Report No. 4. Oregon Department of Forestry, Salem, Oregon.

Ruesch, AS, CE Torgersen, JJ Lawler, JD Olden, EE Peterson, CJ Volk, and DJ Lawrence. 2012. Projected climate-induced habitat loss for salmonids in the John Day River network, Oregon, U.S.A. *Conservation Biology* **26:** 873-882.

Ruff, CP, and co-authors. 2011. Temperature-associated population diversity in salmon confers benefits to mobile consumers. *Ecology* **92**: 2073-2084.

Servizi, JA, and DW Martens. 1991. Effect of temperature, season, and fish size on acute lethality of suspended sediments to coho salmon (*Oncorhynchus kisutch*). *Can J Fish Aquat Sci* **48:** 493-497.

Steel, EA, A Tillotson, DA Larsen, AH Fullerton, KP Denton, and BR Beckman. 2012. Beyond the mean: The role of variability in predicting ecological effects of stream temperature on salmon. *Ecosphere* **3**: 1-11.

Story, A, ED Moore, and JS Macdonald. 2003. Stream temperatures in two shaded reachesbelow cutblocks and logging roads: downstream cooling linked to subsurface hydrology. *Canadian Journal of Forest Research* **33:** 1383-1396.

Surfleet, CG, and AE Skaugset. 2013. The effect of timber harvest on summer low flows, Hinkle Creek, Oregon. *Western Journal of Applied Forestry* **28:** 13-21.

Swanson, ME, JF Franklin, RL Beschta, CM Crisafulli, DA DellaSala, RL Hutto, DB Lindenmayer, and FJ Swanson. 2011. The forgotten stage of forest succession: early-successional ecosystems on forest sites. *Frontiers in Ecology and the Environment* **9:** 117-125.

Thompson, JR, KN Johnson, M Lennette, TA Spies, and P Bettinger. 2006. Historical disturbance regimes as a reference for forest policy in a multiowner province: a simulation experiment. *Canadian Journal of Forestry Research* **36:** 401-417.

Tollefson, JE, FJ Swanson, and JH Cissel. 2004. Fire severity in intermittent drainages, Western Cascade Range, Oregon. *Northwest Science* **78:** 186-191.

Torgersen, CE, JL Ebersole, and DM Keenan. 2012. Primer for identifying cold-water refuges to protect and restore thermal diversity in riverine landscapes. *United States Environmental Protection Agency Publication* EPA 910-C-12-001. 78pp.

Trotter, P. C. 1989. Coastal Cutthroat Trout: A Life History Compendium. Trans. Am. Fish. Soc. 118:463-473.

US EPA, Region 10. 2001. Temperature Project Technical Issue Papers. http://yosemite.epa.gov/r10/water.nsf/6cb1a1df2c49e4968825688200712cb7/5eb9e547ee9e111f88256a03005bd665!OpenDocument

Vanotte, RL, and BW Sweeney. 1980. Geographic analysis of thermal equilibria: A conceptual model for evaluating the effect of natural and modified thermal regimes on aquatic insect communities. *American Naturalist* **115**: 667-695.

Watters, JV, SC Lema, and GA Nevitt. 2003. Phenotype management: a new approach to habitat management. *Biological Conservation* **112**: 435-445.

Wimberly, MC. 2002. Spatial simulation of historical landscape patterns in coastal forests of the Pacific Northwest. *Canadian Journal of Forest Research* **32:** 1316-1328.

ATTACHMENT 4
Dr. C. Frissell, 2015. 4 pages.

Memo 3 June 2015

Christopher A. Frissell, Ph.D.
Frissell and Raven Hydrobiological and Landscape Sciences
Polson, Montana

Testimony for Oregon Board of Forestry, Salem, Oregon 3 June 2015

Subject: Key scientific aspects of the Oregon Department of Forestry Westside Riparian Rule Analysis

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1) **Meeting the Protecting Cold Water Criterion is of critical importance for Oregon's biological resources.** There are at least two fundamental reasons for this. First**, salmon, trout, and stream-dwelling amphibian species evolved in coldwater environments and existing summer temperature in western Oregon are for the greater part already exceed their biological optima.** These species attained their present distribution in cold waters as mountain and continental glaciers and snowfields were receding. Some of these species can persist in warmer waters, but for the most part at greatly reduced productivity that cannot support fisheries and severely reduces their ability to survive natural and human disturbances. **Considering the whole, any warming of summer maximum water temperature substantially harms coldwater species.** Cooling of winter temperatures and cumulative changes in spring temperatures can also disrupt life history and survival of these species, but riparian forest buffers sufficient to protect against summer time warming are for the most part sufficient to also mitigate impact to winter and summer stream temperatures.

Second, temperature standards to limit warming are applied on a per-action basis—in this case, a particular timber cutting unit. If measurable increases were allowed on this basis, the cumulative increase in summer temperature that could arise from multiple actions in the same watershed could produce much greater cumulative impact on stream temperatures. Of course, cumulative temperature increases arising from multiple projects remain a potential problem even with temperature increases at less than the PCW detection level of 0.3 degrees C, but at that level the potential for cumulative temperature effects emerging is greatly reduced. **Unless the State of Oregon is able and willing to adopt some sort of effective regulatory control of logging and other forest management actions at the watershed scale on private timberlands that also accounts for cutting history on adjacent pubic lands, a conservative coldwater protective standard will be necessary.**

2) The reports prepared by DOF give a very informed, substantive, and credible analysis of the likely effects of various proposed streamside logging prescriptions. In

my opinion **the core analysis of effects of tree removal on stream temperature is a state-of-art quantitative effort, well-grounded in field studies, that has never been paralleled.** The relative consistency of results in RipStream analyses across drafts I have seen in recent years is further evidence of the veracity of its findings. In other words, adding more data from more streams does not change the results. The results show, broadly speaking, that only two alternatives reduce violations of the PCW criterion to low levels of likely occurrence: The no cut buffer alternative of 90 feet or greater distance from stream margin, and the Oregon State Forests Management Plan. However, see my comments below regarding the sufficiency of the 90 foot distance.

3) However, it is alarming and objectionable that the documents prepared by DOF summarizing the temperature analysis presume, without evident technical or policy justification, that "average" temperature increases of 0.3 degrees C or less constitute compliance with Oregon's Protecting Cold Waters Criterion. In that case, around half of modeled sites and cases are in fact predicted to warm greater than 0.3 C and therefore violate the stream temperature standard. Biologically effective coldwater protection should logically protect all or at least nearly all affected waters from measureable warming. Although not reflected in the text, analyses and graphs presented by DOF in the memos for Board present well-developed, state-of-art information to ascertain the difference between "average compliance" and something nearer full compliance. Given the distribution of the data evident in those graphs, **"average" compliance means nearly half of affected streams will likely be measurably warmed by logging practices. Certainly other parties regulated by water quality standards in the state of Oregon do not routinely assume that they are in compliance if they meet the standards barely more than half the time.** I think the general public would find this notion outrageous.

The consequences of this magnitude of adverse impact need to be clearly recognized in the analysis, and the basis for using average responses as the measure of effectiveness requires justification. The difference is significant. For example, based on Figure 1 in the document "DETAILED ANALYSIS- PREDICTED TEMPERATURE CHANGE RESULTS**" to attain something nearer 95 percent compliance with PCW would require no-cut buffers of about 110 feet in width, compared to "average" compliance at 90 feet.** From Figure 8, attaining 95 percent compliance with the PCW would require a retained basal area of near 365 square feet per 1000 lineal feet of stream, rather than the average PCW attainment near 275 feet. In my opinion, it does no one good to "shave the numbers" in the text that interprets their significance for policy decisions, especially without a clearly articulated rationale and an explanation of what the consequences are likely to be on the ground. My point is that while the analysis and data graphs are excellent, the text of the report appears inappropriately phrased to blunt, if not distort, the full significance of the scientific information for the regulatory decision.

4) ODF's"DETAILED ANALYSIS" report notes that "the thermal protection offered by increasing buffer widths begins to decline beyond 50-60 feet.' Again, I am concerned some could be mislead by this rather casual characterization of the

relationship graphed in Fig. 1. Yes, the line fitted to the modeled data does begin to gently inflect beyond 60 feet, so that incrementally each additional foot of riparian area width confers somewhat less contribution to total shade. But the most important feature of the analysis in Fig. 1 is that it clearly shows that **as a percentage of total existing shade, the removal or loss of trees in the 100-120 feet from the stream still can measurably reduce shade and increase water temperature, even to the extent that the PCW is violated in many cases.** The text of the report in appropriately minimizes this very important finding.

5) In my opinion, this analysis does include sufficient information to conclude that **prescription alternatives that rely on staggered" alternate-stream-side logging with "four years of greenup" to recover shade would be woefully inadequate to attain PCW compliance.** For example, the analysis in Fig. 1 of the "DETAILED ANALYSIS" report makes it abundantly clear: trees at greater than 90-100 feet distance are contributing shade that significantly influences stream warming. Thus we can infer that tall, large trees standing at some distance from the streams are contributing that effective shade. If a prescription allows those large, tall streams in beyond 60 or 75 feet to be cut, it will not be four years before that shade is replaced by equally tall—rather it will be 20-40 years. Staggered prescription concept appears to be based on a fundamental misunderstanding and unrealistic assumptions about the science of thermally effective forest shade contribution. Interested parties need to recognize that ODF's RipStream research gives us a relatively fine-grained and well-informed understanding of shade contribution and that contravenes many long-held, simplistic beliefs about stream shade, many of which were based on short-term studies with small sample size, inadequately controlled or characterized treatments, and loosely contrived thermal response criteria.

6) **It appears very likely that the relative strong influence of trees beyond 75 feet from the stream to shade and stream warming demonstrated in the RipStream study results in part from the legacy of past logging impacts.** The study sites incorporated are representative of riparian areas of western Oregon riparian that remain to an extreme extent depleted of mature and old growth stands and trees from first and sometimes second-rotation logging. Because large, mature trees remain relatively depleted in the immediate streamside zone, more of those trees standing farther from the stream now more often make up some of the shade that was formerly provided by near-stream trees. It's important to note the same historical effect prevails with large wood recruitment. That is, trees standing farther from the stream may be proportionately more important for wood debris contribution and other stream ecosystem and habitat functions than they formerly might have been when abundant large confers occurred in the near-stream zone.

After a century or more of riparian forest recovery-- assuming riparian forests are fully protected to allow for natural successional processes--options could re-emerge for selective harvest of trees 50-120 feet from streams with much lesser incremental impact on water temperature and wood debris recruitment. The take-home message is that present-day rules must be more far-reaching because past logging and timber

management practices failed to be adequately protective of streamside forests. **Future rules could need to be even more restrictive if today we do not adopt practices that successfully promote the full natural successional recovery of riparian forests.**

7) **Fully protective streamside rules should be applied to all of western Oregon including the Siskiyou region.** I have conducted stream temperature and related stream habitat studies in this region, as well as elsewhere in western Oregon. Despite geologic, climate, and vegetation differences, nothing about the hydrology and physics of forest shade and stream warming changes significantly or consistently within that region compared to western Oregon as a whole.

8) To be fully protective, to provide broadly for restoration of riparian and aquatic habitats and water quality (including not just temperature but sediment and nutrient concerns), **a riparian rule sufficient to ensure attainment of the PCW should be applied to all small and medium streams in western Oregon, not just those stream segments considered to contain salmon, steelhead, or bull trout** (SSBT). While there seems to be continuing ambiguity about the specific proportion of streams in western Oregon that would be protected if a new riparian rule would only be applied to SSBT stream segments, it is clear that most small and many medium streams are not SSBT waters. It is highly likely in most field situations some magnitude of thermal impact in headwater streams propagates downstream (either via surface or subsurface pathways); this is the logical and most defensible assumption based on first principles of physics and a wide range of scientific literature. Hence, logging upstream from SSBT segments can warm SSBT waters beyond the PCW standard. Anecdotal accounts from a few small-watershed paired basin studies should not be relied on to assume that temperature impacts do not propagate downstream, because in most cases their design does not allow for unambiguous conclusions about incremental warming. Moreover, warming less that that readily detectable in headwater streams can still accumulate to detectable levels in downstream receiving waters (it may be more accurate to characterize the most biologically important effect as a reduction of the cooling influence of headwaters on receiving waters).

A conservative coldwater protective standard applied to streams contributing to SSBT waters will be necessary to assure compliance with the PCW. Unless the State of Oregon is able and willing to adopt some sort of effective regulatory control of the pattern, extent, and sequence of logging and other forest management actions at the watershed on private timberlands that also accounts for cutting history on adjacent pubic lands, a conservative coldwater protective standard applied to contributing segments to SSBT waters (both fish and non-fish) will be necessary to assure PCW compliance.

ATTACHMENT 5
Frissell & Nawa, 2016. 11 pages.

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

Christopher A. Frissell, Ph.D.
Frissell & Raven Hydrobiological and Landscape Sciences, LLC

Richard K. Nawa, M.S.
Klamath-Siskiyou Wildlands Center

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.

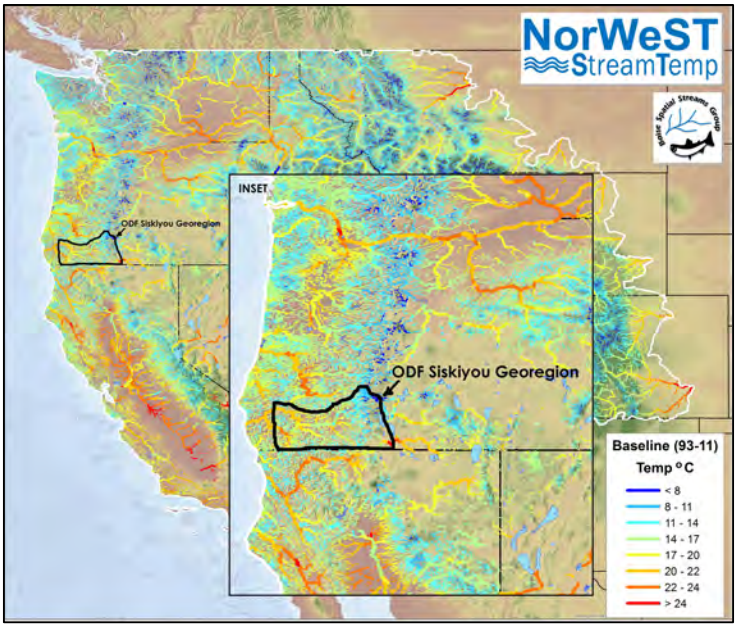

Figure 1. "Thermalscape Map "of stream temperatures synthesized from a spatially explicit model calibrated to an extensive set of temperature site data across the Pacific Northwest. Graphic modified to depict approximate area of the ODF Siskiyou Georegion from http://www.fs.fed.us/rm/boise/AWAE/projects/NorWeST/images/ThermalscapeWesternUS_StreamTemperatures0820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

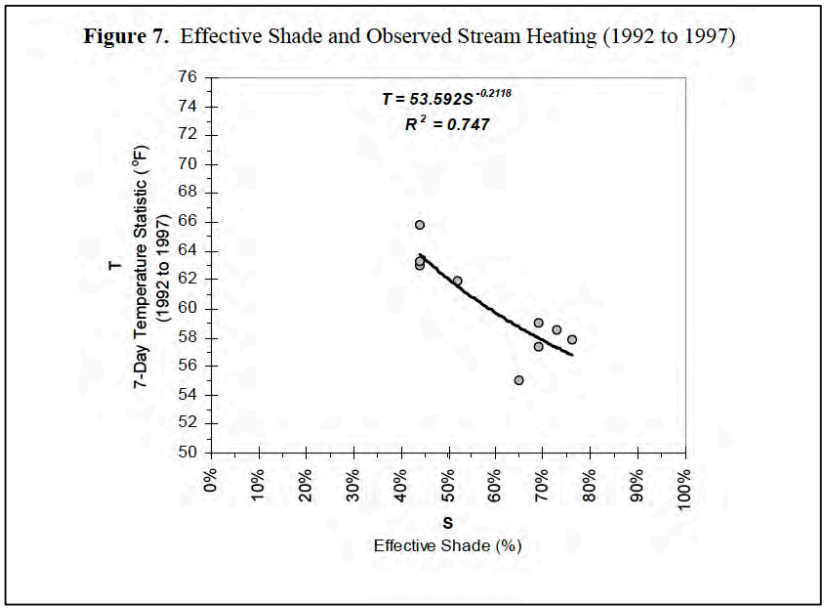

Fig. 2. Excerpt from Appendix G of the Sucker Creek TMDL Report (Siskiyou National Forest and ODEQ 1999, p. G-18) displays the relationship between field-measured 7-day maximum stream temperature and percent effective canopy shade across 10 stream reaches in the Sucker Creek Watershed. This data set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

LITERATURE CITED

Dent, L. 2001. Harvest Effects on Riparian Function And Structure Under Current Oregon Forest Practice Rules ODF Technical Report, 12 July 2001. Oregon Department of Forestry, Salem, OR. 82 pp.

ODF (Oregon Department of Forestry). 1994. Forest Practices Technical Note Number 1 Water Classification Effective April 11, 1994. 12 pp. Online at https://www.oregon.gov/ODF/Documents/WorkingForests/WaterClassificationTechNote1.pdf

ODEQ (Oregon Department of Environmental Quality). 2002. Lower Sucker Creek Illinois River Subbasin Total Maximum Daily Load and Water Quality Management Plan. Portland, OR. 122 pp. Online at https://ofmpub.epa.gov/waters10/attains_impaired_waters.show_tmdl_document?p_tmdl_doc_blobs_id=75245

ODEQ (Oregon Department of Environmental Quality). 2003. Applegate Subbasin Total Maximum Daily Load (TMDL) HUC # 17100309, Appendix A: Applegate Subbasin Temperature Assessment. Portland, OR. 93pp. Online at http://www.deq.state.or.us/wq/tmdls/docs/roguebasin/applegate/tmdlappxa.pdf

ODEQ (Oregon Department of Environmental Quality). 2007. Bear Creek Watershed TMDL, Appendix A: Bear Creek Watershed Temperature Assessment. Portland, OR. 36 pp. Online at http://www.deq.state.or.us/wq/tmdls/docs/roguebasin/middlerogue/bearcreek/appxa.pdf

Olson, D.H., P.D. Anderson, C.A. Frissell, H.H. Welsh, Jr., and D.F. Bradford. 2007. Biodiversity management approaches for stream-riparian areas: perspectives for Pacific Northwest headwater forests, microclimates, and amphibians. *Forest Ecology and Management* 246(1):81-107.

Poole, G.C. and C.H. Berman. 2001. An ecological perspective on in-stream temperature: natural heat dynamics and mechanisms of human-caused thermal degradation. *Environmental Management* 27(6):787–802.

Siskiyou National Forest and ODEQ (Oregon Department of Environmental Quality). 1999. Water Quality Management Plan, Rogue River Basin, Illinois River Sub Basin (Sucker Creek), Appendix G: Supporting Documentation for Development Of Temperature Load Allocation. Portland, OR. 37pp. Online at http://www.deq.state.or.us/wq/tmdls/docs/roguebasin/illinois/uppersucker/tmdlappxg.pdf

ATTACHMENT 6
Henning, EPA, 2015a. 3 pages.

TESTIMONY OF
ALAN HENNING, FOREST TEAM, WATERSHED UNIT,
ENVIRONMENTAL PROTECTION AGENCY, REGION 10

BEFORE THE OREGON BOARD OF FORESTRY, JUNE 3, 2015

Good morning, Chair Imeson and Board Members. My name is Alan Henning. I'm one of the Forest Team representatives for the Watershed Unit for the US Environmental Protection Agency's Region 10 Office. Thank you for the opportunity to share my thoughts with the Board Members.

Today, I'm going to talk about EPA's role as it relates to water quality and fish in Oregon, our support for the Riparian Rule and why it's important, what we believe the rule should address, and how this relates to the approvability of the Oregon's Coastal Nonpoint Program.

EPA's Role. EPA implements the Clean Water Act in partnership with states and tribes. This includes acting on the state's water quality standards, 303(d) Integrated Report, total maximum daily loads (TMDLs), the state's nonpoint source control programs and overseeing NPDES permits issued by the state. We work closely with the Oregon Department of Environmental Quality (DEQ) and other state agencies on these efforts. EPA is also responsible for overall implementation of the Safe Drinking Water Act in partnership with the Oregon Health Authority and DEQ.

EPA gives technical and financial support to states and tribes to help them implement programs that protect and restore surface and drinking water. Where states and tribes fail to carry out Clean Water Act responsibilities, or when directed by the Courts, EPA is required to take the actions needed to meet national water quality goals.

Why the Riparian Rule is Important. There are 12 million acres of non-federal forest land in Oregon. The management of these lands affects drinking water sources, water quality, and aquatic habitat for several species of threatened and endangered fish, including salmon, steelhead and trout. . Because forest practices have direct and important effects on water quality and fish habitat, the riparian rule analysis has significant implications for EPA's work to protect human health and the environment, and we have closely tracked and reviewed this rule development process.

EPA recognizes that Oregon was one of the first states in the country to develop forest practice rules and regulations. . The current riparian rule analysis is the culmination of a process that started in the

late 1990s and includes the 1997 Oregon Coastal Salmon Restoration Initiative[1], Oregon's 1999 IMST report[2], the 2002 Sufficiency Analysis[3], and the recent Ripstream studies[4]. Collectively, these efforts have found that existing forestry practices do not ensure that streams in managed forests will consistently meet water quality standards, or fully provide for riparian functions important to water quality and fish. With stream temperature directly affecting fish health and behavior, a revised riparian rule with adequately larger buffers on small and medium fish-bearing streams will ensure stream temperature provide the cold stream temperatures critical to fish health. The revised riparian rules will also improve drinking water and surface water quality by reducing runoff from other pollutants such as fine sediment, toxics, and nutrients.

What the Rule Should Address. EPA supports a Rule that includes all small and medium fish-bearing streams to ***protect existing*** cold water and ***restore*** cold water in streams that currently exceed temperature standards. EPA also believes greater protection for non-fish bearing streams is warranted, especially where non-fish bearing streams contribute pollutants to fish bearing streams.

7732 miles of Western Oregon streams and rivers have been or are currently impaired for temperature which impacts fish and other organisms that rely on cold water to live and grow. EPA strongly supports a Riparian Rule that includes all small and medium fish-bearing streams, regardless of their status under section 303 of the Clean Water Act. A Riparian Rule with a scope limited to streams that are listed as unimpaired, or to streams without a TMDL in place would exclude a large universe of streams with high temperatures that need to be restored. It would be counterproductive to continue to implement existing forest practices on streams with temperature impairments when it has been demonstrated that those practices are not adequately protective of cold water.

Type "N" Streams. There are over 73,000 miles of fish and non-fish bearing streams in Western Oregon of which, only 8,351 miles or approximately 11% are Salmon, Steelhead and Bull Trout streams (SSBT). While EPA supports riparian rule revisions that will provide greater buffer protections for all

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[1] http://www.oregon.gov/OPSW/docs/ocsri_mar1997ex.pdf

[2] Independent Multidisciplinary Science Team. 1999. Recovery of Wild Salmonids in Western Oregon Forests: Oregon Forest Practices Act Rules and the Measures in the Oregon Plan for Salmon and Watersheds. Technical Report 1999-1 to the Oregon Plan for Salmon and Watersheds, Governor's Natural Resources Office, Salem, Oregon. http://www.fsl.orst.edu/imst/reports/1999-1.pdf

[3] The Oregon Department of Forestry and Department of Environmental Quality. 2002. Sufficiency Analysis: A Statewide Evaluation of FPA Effectiveness in Protecting Water Quality. Available at: http://www.odf.state.or.us/DIVISIONS/protection/forest_practices

[4] Groom, J.D., L. Dent, and L.J. Madsen. 2011. Response of western Oregon stream temperatures to contemporary forest management. Forest Ecology and Management, doi:10.1016/j.foreco.2011.07.012

small and medium fish bearing streams, EPA also believes greater protection must be provided for non-fish bearing streams (Type N streams), especially perennial "N" streams. Type N streams are often head water streams that provide critical cold water and large wood for meeting water quality standards, supporting beneficial uses and enhancing downstream fish habitat. Where Type N streams are not protected by adequate buffers and are impacted by increased temperature loading, that pollutant load can be delivered to the downstream type F streams, e.g., SSBT streams.

Streams in Eastern Oregon. EPA recognizes that the focus of the State's riparian rule analysis has been on streams in Western Oregon and appreciates the level of ODF's effort in its work. However, 303(d) temperature listings exist throughout the Oregon and where these listings occur, greater riparian protection may be needed as well.

How Does This Relate to the Coastal Nonpoint Program/CZARA? The Riparian Rule also overlaps with EPA and NOAA's recent disapproval action in January 2015 of Oregon's coastal nonpoint program. While EPA and NOAA acknowledged significant progress in Oregon's nonpoint coastal program, we also identified gaps in Oregon's forestry program as a basis for the disapproval. One of these was the inadequacy of current forest riparian buffers on small and medium fish bearing and non-fish bearing streams. While the current riparian rule revision process is not considering greater protection for non-fish bearing streams, a Riparian Rule with an appropriate buffer width applied to all small and medium fish bearing streams would be significant progress toward moving the State's program to approvability. Although other areas in forestry would need to be addressed for full approval of Oregon's forestry measures, the rule would fill a significant gap identified in EPA and NOAA's evaluation of Oregon's forestry program in our agencies' disapproval action. If the Board of Forestry would like to hear more information on our CZARA findings on forestry at another meeting, we would be very happy to have a dialogue with more detail on the other areas that EPA and NOAA identified.

Closing Words. Riparian management areas on small and medium fish bearing streams and non-fish streams that are important cold water sources for fish bearing streams provide protection and restoration of riparian functions important for fish and water quality. We applaud the Board of Forestry for considering amending the Forest Practices Act regulations to provide greater protections on Oregon streams and urge you to move forward on adoption of such rules.

I want to thank you again for the opportunity to provide this testimony and would be happy to answer questions you may have at this time.

ATTACHMENT 7
Henning, 2015b. 2 pages.

TESTIMONY OF
ALAN HENNING, FOREST TEAM, WATERSHED UNIT,
ENVIRONMENTAL PROTECTION AGENCY, REGION 10
BEFORE THE OREGON BOARD OF FORESTRY, November 5, 2015

Good morning, Chair Imeson, and Board Members. My name is Alan Henning. I'm one of the Forest Team representatives for the US Environmental Protection Agency's Region 10 Office and I work on the review of Oregon's Coastal Non-Point Pollution Control Program as it relates to meeting requirements under the Coastal Zone Act Reauthorization Amendments, CZARA. Thank you for the opportunity to share my thoughts with you.

EPA has provided written and oral testimony on:

a. The need for greater riparian protections for streams in both Western and Eastern Oregon;
b. the need for greater protection on all fish bearing and non-fish bearing streams, not just SSBTs;
c. the importance of the State's Protecting Cold water Criterion; and
d. the high value of ODF's analysis of Ripstream results.

Today, I want to touch on a couple of key points in the Packages developed by the Board's Subcommittee.

However, before doing so, EPA would like to express its sincere thanks to the Board and ODF's management and staff for the work you have done on the entire riparian rule review process. I am sure you and the staff have put in countless hours beyond the call of duty in addressing this critical issue.

Key elements of the Subcommittee's Packages

Package 1

1. EPA appreciates the fact that the Geographic regions covered in the Package 1 proposal include those areas needing to be addressed under CZARA.

2. We also appreciate that Package 1 includes protections for streams above the SSBT streams, however we are concerned that 1000' will not be enough distance to attenuate heat loading from waters above SSBTs.
3. While we think that the 90' no cut buffers on S&M SSBT streams moves in the right direction, 100' and 110' no cut buffers provide a much greater certainty that the State's water quality standard, Protecting Cold Water Criterion, will be met.
4. Package 1, Option B, provides a thinning prescription for a 100' RMA. At the September Board meeting, ODF indicated that a .33*C. increase would result from the application of this prescription. EPA's analysis, using ODF's methodology, shows that an increase of .56* C. would occur. I would be happy to provide you with a copy of our analysis.

<u>Package 2</u>

1. Package 2 does not include the Siskiyou Geographic Region. The Siskiyou Geographic Region is part of the State's Coastal Non-Point Pollution Control Program and is covered by CZARA. If this region is not included in the riparian rule revisions, other steps would have to be taken to address the need for greater riparian protections in this area to meet the CZARA requirements.
2. EPA is concerned that Package 2 includes no increased riparian protections for waters above SSBTs.
3. EPA is concerned that the no-cut riparian buffers of 50' and 70' for small and medium sized fish bearing streams respectively will not meet the State's Protecting Cold Water Criterion.

I thank you again for the opportunity to provide this testimony.

ATTACHMENT 8
Leinenbach, 2015a. 6 pages.

TESTIMONY OF PETER LEINENBACH, AQUATIC AND LANDSCAPE ECOLOGIST

ENVIRONMENTAL PROTECTION AGENCY, REGION 10

BEFORE THE OREGON BOARD OF FORESTRY, July 23, 2015

Good morning, Chairman Imeson, and Board Members. My name is Peter Leinenbach. I am employed as an ecologist with the EPA Region 10 Forest Team. Based on concepts brought up during previous Board of Forestry meetings, it is our conclusion that many features in Package 1 of the staff report, particularly the 90 foot no-cut buffer provision, will promote the protection of water quality and fish in Oregon. However, ODF research used to inform the development of Package 1 has shown that the proposed 1,000 foot upstream extent distance will need to be increased to fully protect water quality. I will present three points which support this conclusion.

The **first point** is that the ODF staff have presented strong evidence through the Ripstream analysis that **a minimum of a 90 foot intact "no-harvest" riparian buffer** is needed to ensure that streams exposed to FPA rules do not violate the PCW rule. It is important to point out that this finding is supported by other research on this subject that has been done in the Pacific Northwest over the past several decades (**Figures 1a. and 1b.**).

The **second point** is that the ODF staff have presented strong evidence that the stream reach extent above SSBT streams needs to be greater than 1,000 feet in the revised FPA rule. Specifically, the ODF analysis clearly shows that **a minimum of a 1,600 foot upstream extent** is needed to ensure that the water temperatures entering into SSBT streams do not, on average, violate the PCW rule

(**Table 1**). However, it is important to point out that even greater stream reach extent distances are needed for streams with multiple harvest units, which is often occurring along streams in Oregon.

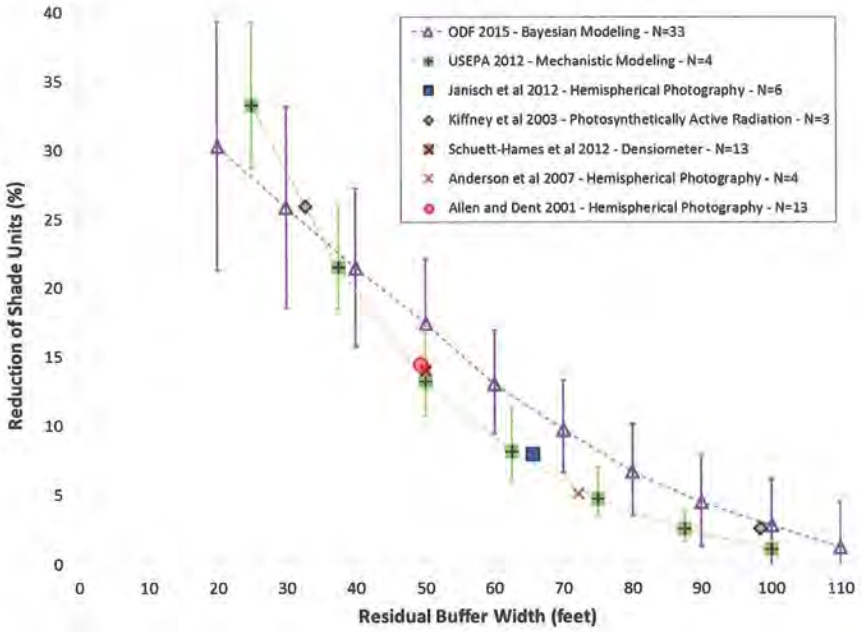
The **third point** is to briefly highlight that the revised rules should apply to all forests in the "western region". The Ripstream sites were collected over a large spatial range in both the Coast Range and South Coast. Similar responses should be expected in nearby geographic regions. There are numerous 303(d) temperature listings all throughout western Oregon which indicate more protection is needed throughout the region.

We would like to make an additional comment regarding the so called "South-sided" prescriptions. ODF staff have presented evidence that "south-sided riparian prescriptions" **do not** ensure the protection of the PCW rule. Specifically, the ODF "Systematic Review" reported that only a few, less rigorous, south-sided prescription studies were available for review and that the study results were inconclusive. Finally, this ODF review stated that south-sided riparian prescriptions "appear to not achieve the PCW criterion". We therefore do not support further consideration of the "south-sided riparian prescriptions" as a viable component for a revised rule.

We want to thank you for the opportunity to provide this testimony. We are also providing the Board of Forestry a hard copy of this testimony. We would be happy to answer questions you may have at this time.

Figure 1a. Observed mean stream shade response associated with "no-cut" riparian buffers with adjacent clearcut harvest.

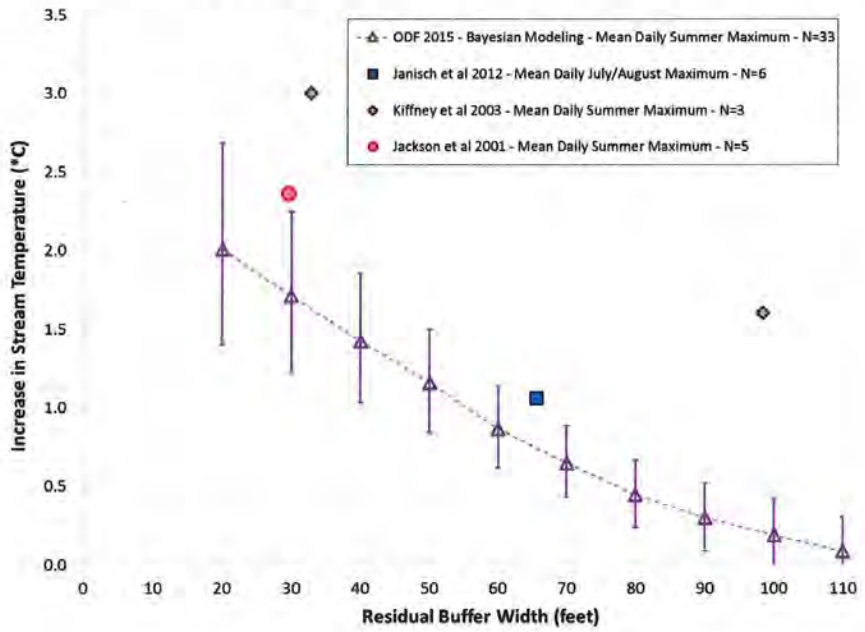
[Only studies that employed a BACI (Before After Control Impact) design within forests of the Pacific Northwest were included in these figures. ODF Bayesian modeling was derived from data collected as part of Ripstream (Groom et al 2011)[1]. The bars associated with ODF Bayesian temperature model results represent the Bayesian 98.5% and 2.5% credibility intervals of the mean, which are analogous to confidence intervals in frequentist statistics. The bars associated with the USEPA mechanistic modeling results represent the range of estimated values.]



[1] Bayesian modeling results are predictions based on data collected at the 33 Ripstream field sites. The modeled values are estimated mean response based on these sites, however the individual site response may range outside of the credibility intervals based on unique site characteristics present at the individual site.

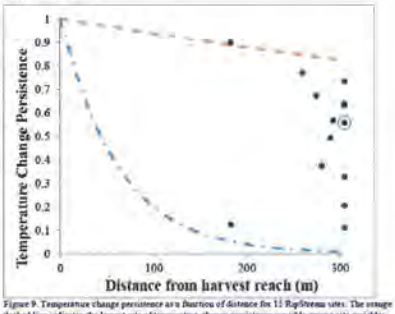
Figure 1b. Observed mean stream temperature response associated with "no-cut" riparian buffers with adjacent clearcut harvest.

[Only studies that employed a BACI (Before After Control Impact) design within forests of the Pacific Northwest were included in these figures. ODF Bayesian modeling was derived from data collected as part of Ripstream (Groom et al 2011)[2]. The bars associated with ODF Bayesian temperature model results represent the Bayesian 98.5% and 2.5% credibility intervals of the mean, which are analogous to confidence intervals in frequentist statistics.]



[2] Bayesian modeling results are predictions based on data collected at the 33 Ripstream field sites. The modeled values are estimated mean response based on these sites, however the individual site response may range outside of the credibility intervals based on unique site characteristics present at the individual site.

Table 1. Methods used to estimate the upstream extent

Previously Presented Information
ODF calculated that the temperature response associated with the application of the FPA private land buffers was a 1.45*C temperature increase. (see the June 3, 2015 Matrix presented by ODF to the BOF)
ODF staff also showed that average temperature change resulting from harvest activities at the Ripstream sites was 50% persistence at 1000 feet downstream of the end of harvest activities. (see April 22, 2015 presentation by ODF to the BOF)
Calculations
The temperature increase associated with FPA harvesting (i.e., 1.45*C) will still result (**on average**) in a 0.72*C temperature increase 1000 feet downstream of the harvest activities. (i.e., 1.45*C * 0.5 = 0.72*C)
If one assumes that the temperature dissipation loss continues linearly at the same rate downstream of 1000 feet of the harvest activities associated with , it would take 1,597 feet (1,600 feet) to reach a 0.3*C temperature increase: $$\left(\frac{1000\ ft}{0.72\ °C}\right) = \left(\frac{X\ feet}{1.15°C}\right)$$ (Note: 1.15°C was calculated as 1.45 °C – 0.3 °C = 1.15°C)
It is important to point out that there is a tremendous amount of variation around this reported response observed in the Ripstream data and in literature: The observed variability is in response to localized conditions at each site. In other words, this estimated 1,600 foot recovery distance is an average recovery distance – many sites will require a much longer recovery distance, while others will require less.    Figure 9. Temperature change persistence as a function of distance for 15 RipStream sites. The orange dashed line indicates the lowest rate of temperature change persistence possible among site variables while the blue line represents the fastest. Black dots are individual site data. The blue circle highlights an example site discussed in the text.

ATTACHMENT 9
Leinenbach. 2015b. 3 pages.

Memorandum **July 13, 2015**

To: Alan Henning

From: Peter Leinenbach

Subject: Topic associated with upcoming the Oregon Riparian Rule discussions

Topic One - South- Side Buffers

Temperature Response

- There are very few examples in literature of temperature and shade response to "south-side" buffer treatment.
- The one often cited study contains only three sites and is reported in two documents (i.e., Dent and Walsh (1997) and Zwieniecki and Newton (1999)).
- ODF reviewed these studies and concluded that "Considering the difference in results, the range of variability for shade measures and the low sample size, these results are relatively inconclusive." From page 43 of ODF Report – Czarnomski and Hale 2013.
- Large stream temperature increases (i.e., 1.4*C) have been reported for one "true" partial application of south side buffers (i.e., Sheele Creek (buffer widths of 62 and 31 feet for left and right buffers)).
- Although the other two sites did not have a large temperature response, it appears from the Dent and Walsh (1997) report that Mill Creek **was not** an application of a south-side buffer (reported buffers widths of 85 and 82 feet, for left and right respectively (From Appendix A in Dent and Walsh (1997)). In other words, the buffer width was similar between these two sides and there was not difference between the two buffer sides. In addition, it is important to point out that buffer width was much wider for both buffer sides than reported targets in these reports (i.e., 12 meters (39.3 ft) of either shrubs or trees were left for the south side only and clearcut on north side – Zwieniecki and Newton (1999)), and therefore for another reason this is not an application of a "south-side" treatment.
- The other site (Cascade) did not reported buffer widths in Appendix A in Dent and Walsh (1997), however the reported shade loss for this site (i.e., 7) was the greatest for all of the sites despite the very low temperature response (0.1*C). Thus is appears that there may be some unique site characteristics affecting the response at this location (i.e., high groundwater flow, high gradient, low or high flow volumes, etc.).

Accordingly, field data have not supported to the notion that south-side buffers provide protection against large temperature increases resulting from harvest in the north-side buffer.

Shade Response

The effects of north-side buffer width loss in a south-side buffer treatment needs to added to the estimated effects associated with narrowing both sides of the buffer (i.e., north and south side). For example, a south-side buffer treatment which narrows the buffer on the south-side to 80 feet and allows the buffer to narrow to 20 feet on the north-side will have two shade loss estimates: 1) the estimated shade loss associated with narrowing the buffer to 80 feet which was estimated to be 7% shade loss (from the matrix from ODF BOF meeting materials); and 2) the shade loss associated further narrowing the north-side buffer from 80 feet to 20 feet – lets estimate that a 6% shade loss. Accordingly, that would result in a 13% shade loss with this treatment (7 +6 = 13%).

Also, recall that ODF determined that a measurable temperature increase (0.3*C) resulted from around a 6 units of shade loss to a stream, and therefor north-side vegetation removal (i.e., from 20 feet to 80 feet, or 20 feet to 70 feet, etc.) can, by itself, result in stream temperature increasing greater than the PCW.

Accordingly, shade modeling has shown that loss of shade loss resulting from "additional" north-side buffer harvest could potential result in violation of PCW standard, even without the effects of shade loss associated with the south-side harvest.

Topic Two – Stream Reach Extent

ODF calculated that the temperature response associated with the application of the FPA private land buffers was a 1.45*C temperature increase (see the June 3, 2015 Matrix presented by ODF to the BOF). In addition, ODF staff also showed that average temperature change resulting from harvest activities at the Ripstream sites was 50% persistence at 1000 feet downstream of the end of harvest activities (see April 22, 2015 presentation by ODF to the BOF). In other words, the temperature increase associated with FPA harvesting (i.e., 1.45*C) will still result (**on average**) in a 0.72*C temperature increase 1000 feet downstream of the harvest activities (i.e., 1.45*C * 0.5 = 0.72*C). If one assumes that the temperature dissipation loss continues linearly at the same rate downstream of 1000 feet of the harvest activities associated with , it would take 1,597 feet (1,600 feet) to reach a 0.3*C temperature increase:

$$\left(\frac{1000\ ft}{0.72\ ^{\circ}C}\right) = \left(\frac{X\ feet}{1.15^{\circ}C}\right)$$

It is important to point out that there is a tremendous amount of variation around this reported response observed in the Ripstream data[1] and in literature: The observed variability is in response to localized conditions at each site. In other words, this estimated 1,600 foot recovery distance is an average recovery distance – many sites will require a much longer recovery distance, while others will require less.

Accordingly, the science very clearly provides conclusive support for downstream recovery distances for SSBT streams <u>that are much greater than 1,600 feet</u> in order to ensure that FPA harvest activities will not provide SSBT streams with source waters heated greater than 0.3 ^{0}C.

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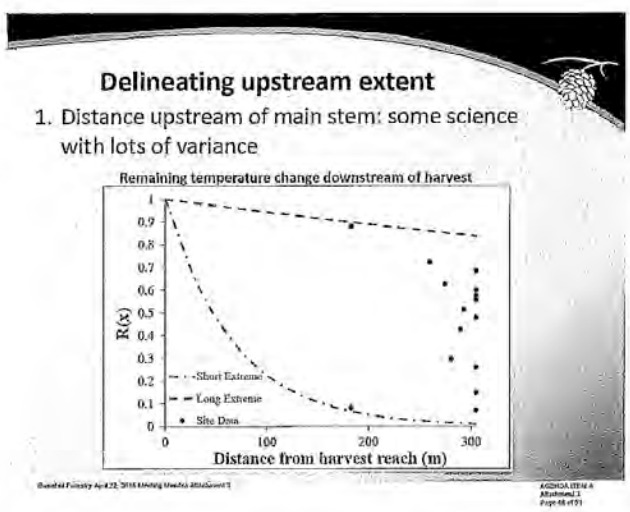


ATTACHMENT 10
Leinenbach. 2016. 11 pages.

Memorandum **January 27, 2016**

To: Alan Henning, USEPA

From: Peter Leinenbach, USEPA

Subject: Shade loss and temperature increase resulting from the Implementation of Option A and Option B of the proposed Oregon Forest Practices Rule for SSTB streams in sections of western Oregon.

Results

Medium SSBT Streams - Option A (Two Bank Harvest)

Category	Shade Loss (97.5% Credibility Interval)	Source	Temperature Increase (97.5% Credibility Interval)	Source
Clearcut Effect	6.7% (3.6 to 10.1)	2015 ODF Bayesian Modeling	0.4*C (0.2 to 0.7)	2015 ODF Bayesian Modeling
Option A Total Effect	**6.7%**		**0.4*C**	

Medium SSBT Streams - Option B (Two Bank Harvest)

Category	Shade Loss (97.5% Credibility Interval)	Source	Temperature Increase (97.5% Credibility Interval)	Source
Clearcut Effect	6.7% (3.6 to 10.1)	2015 ODF Bayesian Modeling	0.4*C (0.2 to 0.7)	2015 ODF Bayesian Modeling
Thinning Effect	2.7%	2016 USEPA Shade Modeling	0.2*C (0.0 to 0.4)	Utilizing relationships from 2015 ODF Bayesian Modeling
Option B Total Effect	**9.4%**		**0.6*C**	

Small SSBT Streams - Option A (Two Bank Harvest)

Category	Shade Loss (97.5% Credibility Interval)	Source	Temperature Increase (97.5% Credibility Interval)	Source
Clearcut Effect	13.1% (9.5 to 16.9)	2015 ODF Bayesian Modeling	0.9*C (0.6 to 1.1)	2015 ODF Bayesian Modeling
Option A Total Effect	**13.1%**		**0.9*C**	

Small SSBT Streams - Option B (Two Bank Harvest)

Category	Shade Loss (97.5% Credibility Interval)	Source	Temperature Increase (97.5% Credibility Interval)	Source
Clearcut Effect	13.1% (9.5 to 16.9)	2015 ODF Bayesian Modeling	0.9*C (0.6 to 1.1)	2015 ODF Bayesian Modeling
Thinning Effect	4.8%	2016 USEPA Shade Modeling	0.3*C (0.1 to 0.5)	Utilizing relationships from 2015 ODF Bayesian Modeling
Option B Total Effect	**17.9%**		**1.2*C**	

Methods

Option A – The effect of narrowing of the riparian buffer on both stream shade and temperature conditions resulting from the implementation of Option A were calculated using the Bayesian models developed by Oregon Department of Forestry (ODF) Staff, which they presented to the Board of Forestry (ODF 2015) (**Figures 1 and 2**).

Figure 1. Modeled[1] mean stream shade response associated with "no-cut" riparian buffers with adjacent clearcut harvest.

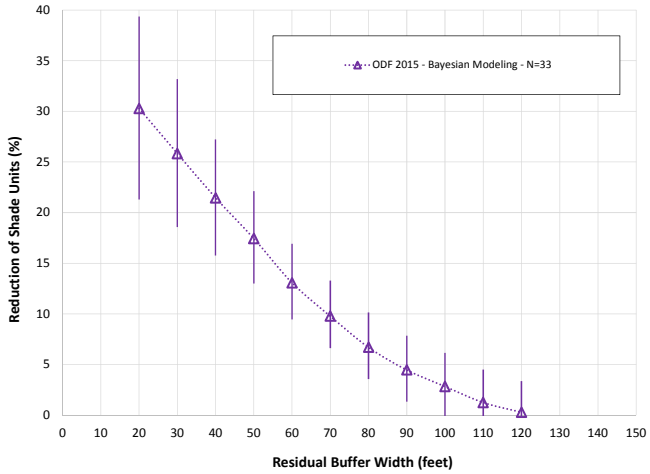
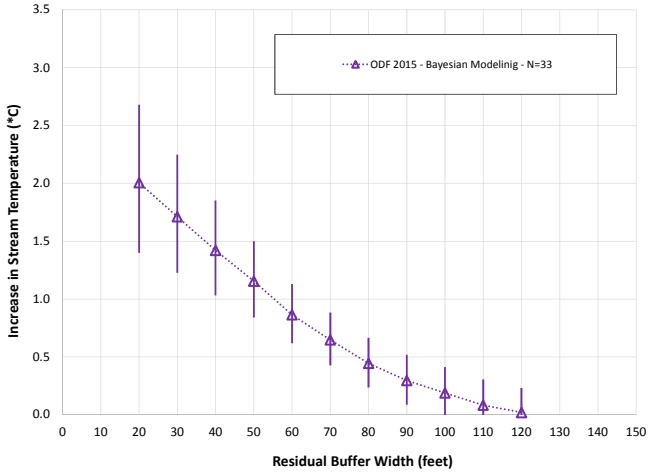


Figure 2. Modeled mean stream temperature response associated with "no-cut" riparian buffers with adjacent clearcut harvest.



[1] Bars associated with the Bayesian model results represent the 98.5% and 2.5% credibility intervals of the mean. Modeled values are estimated mean response calculated from data collected at the 33 Ripstream sites, however the individual site response may range outside of the credibility intervals based on unique site characteristics present at the individual site.

Option B – Because Option B has the same clearcut harvest actions as prescribed in Option A, the same Bayesian models were used to evaluate the effect of riparian buffer width narrowing on stream shade and temperature conditions. However, Option B contains an additional thinning harvest within the outer portion of the remaining riparian buffer.

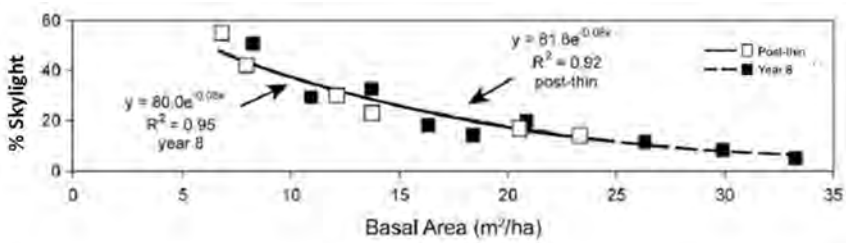
Estimating Shade Loss Resulting from Thinning Activities (Option B)

Riparian thinning activities will reduce the "quality" of the shade produced by riparian vegetation. In other words, the riparian stand will become more transparent as fewer trees become available to block light transporting through the stand. Specifically, thinning activities will result in: 1) a direct loss of canopy within the outer thinned zone; and 2) an indirect loss of canopy within the inner no-harvest buffer.

Direct Loss of Canopy within the Outer "Thinned" Zone

The amount of riparian canopy cover loss associated with thinning activities was determined using a relationship between basal area and % skylight (i.e., canopy openness) as presented in Chan et al (2006) (**Figure 3**)[2]. This relationship indicated that canopy openness in the outer "thinned" zone will increase by 15.2% (or 15.2% openness units) and 9.6% for small and medium streams, respectively (**Table 1**). Note that the larger of canopy openness for small class streams is a direct result of greater thinning levels allowed for this stream class.

Figure 3. The association between basal area and percent skylight (i.e., openness) in forest stands.



[2] Specifically, preharvest basal area conditions were developed from the preharvest RipStream field data obtained from Terry Frueh at ODF on 1/15/2016. Post-thinning-harvest basal area was estimated from reported basal area targets for the "outer" zone in the proposed rule (i.e., 73 sq. ft./1,000 feet for the 20 to 60 foot zone along small streams and 138 sq. ft./1,000 feet for the 20 to 80 foot zone along medium streams). Both pre-harvest and post-harvest basal area conditions were converted into units of m^2/ha in order to incorporate into the Chan et al model presented in **Figure 3**.

Table 1. Basal Area and Estimated % Skylight within Thinned Riparian Areas		
Category	Basal Area (m2/ha)	Estimated % Skylight
Small Streams (60'RMA)		
Pre-Harvest	38.7	3.7
Post-Thinning-Harvest	18.3	18.9
% Skylight Increase within the 20- 60' zone		15.2
Medium Streams (80'RMA)		
Pre-Harvest	40.0	3.3
Post-Thinning-Harvest	23.0	13.0
% Skylight Increase within the 20- 80' zone		9.6

Indirect Loss of Canopy within the Inner "No-Harvest" Zone

The riparian buffer width and the riparian vegetation density influences the "quality"(or the density) of the shade produced by the riparian buffer. That is, the potential number of trees the solar load travels through decreases as the buffer width narrows as a result of clear-cut riparian harvest, along with less trees the solar load travels as a result of riparian thinning harvest (**Figure 4**). Beschta et al 1987 reported that the effectiveness of a buffer strip in providing stream shade can be determined by measuring the angular canopy density (ACD)[3]. **Figure 5** illustrates the relationship between ACD and the riparian buffer width (Brazier and Brown, 1973). While it is theoretically possible for natural forest vegetation to have ACDs of 100%, indicating complete shading from incoming solar radiation, the ACD of mature undisturbed stands generally falls between 75 and 95% (Park et al., 2006, Brazier and Brown 1973, Steinblums et al., 1984, Erman et al., 1977). In addition, ACD increases become negligible at some buffer strip width as a result of a "tree behind a tree" situation, and/or the vegetation in distant portions of the riparian stand not being tall enough to cast a shadow over the stream surface. Accordingly, for modeling activities associated with this document, it was assumed that the effect of harvest activities (i.e., thinning) did not influence the "inner zone" canopy cover for the 120ft wide "no touch" scenarios. The trend line presented in **Figure 5** can be used as a tool to evaluate the influence that riparian buffer width reductions have on the riparian canopy density (**Table 2**).

Estimated canopy density reductions at the new buffer widths presented in **Table 2** represent the expected loss associated with "clear-cut" harvest; for example, there is an expected 20 units of Canopy Density loss as the buffer width narrows from 80 feet to 20 feet (i.e., 74 to 54). However the proposed riparian rule for medium stream will only result in a 13% loss of the canopy density as a result of thinning activities (i.e., 9.6 (see Table 1)/ 74 (see Table 2) = 13%). Accordingly, the proportional loss of ACD within the inner "no-harvest" buffer resulting from thinning activities along medium size stream classes will be 2.6% (or 2.6 units) (i.e., 20 * 0.13 = 2.6). Similarly, the ACD loss within the inner "no-harvest" buffer along small stream classes will be 3.5%.

[3]ACD evaluates the horizontal plane of canopy density for the portions of the riparian stand which provide shade during the mid part of the day (usually between 10 am and 2 pm).

Figure 4. Illustration of how the Riparian Buffer Width and Vegetation Density Impact Shade Density

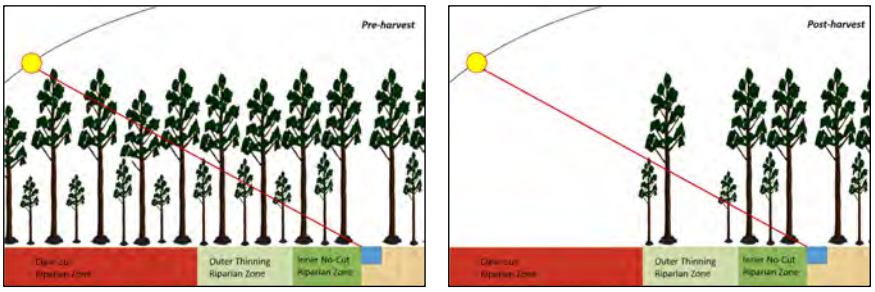


Figure 5. The relationship between measured Angular Canopy Density (ACD) and buffer strip width (Data from Table 1 in Brazier and Brown 1973)

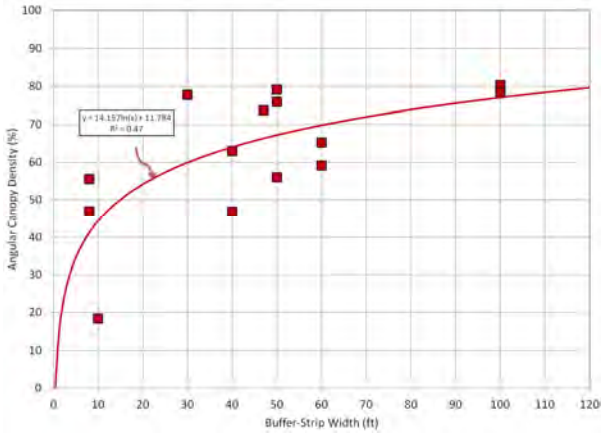
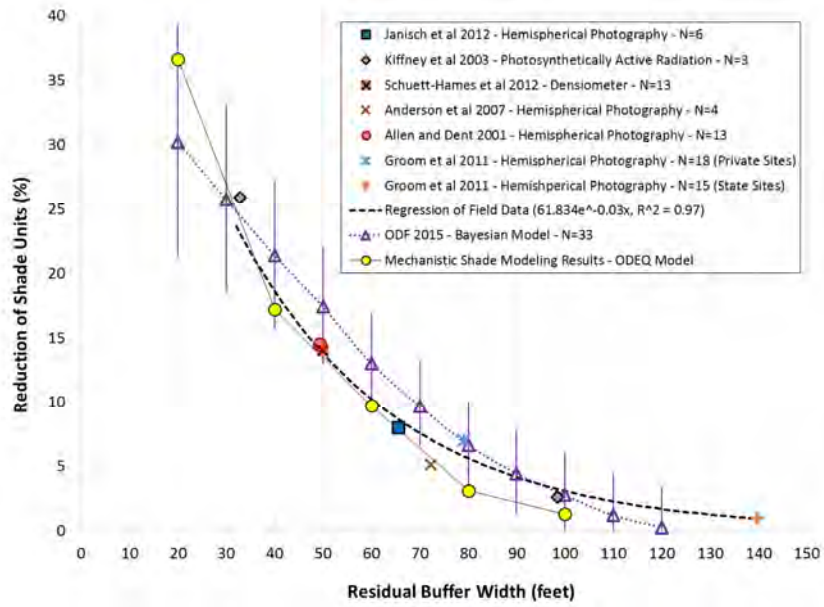


Table 2. Calculated Effect of Buffer Width on Canopy Density		
Buffer Strip Width (feet)	Percent Reduction from 120' buffer	Estimated Canopy Density
120	0%	80
100	3%	77
80	7%	74
60	12%	70
40	20%	64
20	32%	54

Calculated Shade Loss Resulting from Thinning Activities (Option B)

Using the average observed height conditions for the Oregon Ripstream sites (25.7m) and canopy densities presented in **Table 2**, the "shade.xls" model[4] was used to evaluate the effects of narrowing of the riparian buffer on stream shade. This built "shade.xls" mechanistic model predicted a similar pattern between buffer width reductions and stream shade loss as predicted by both a statistical linear regression model built from field data (i.e., $61.834e^{-0.03X}$, $R^2 = 0.97$), and the Bayesian Modeling results (**Figure 6**). Accordingly, this indicates this built mechanistic model is adequately representing processes associated with shade loss response to riparian buffer width reductions.

Figure 6. Measured and Predicted Shade Loss Resulting from a Narrowing of the Riparian Buffer Width.
[Only field studies that implemented a BACI design within forested areas of the Pacific Northwest were included.]



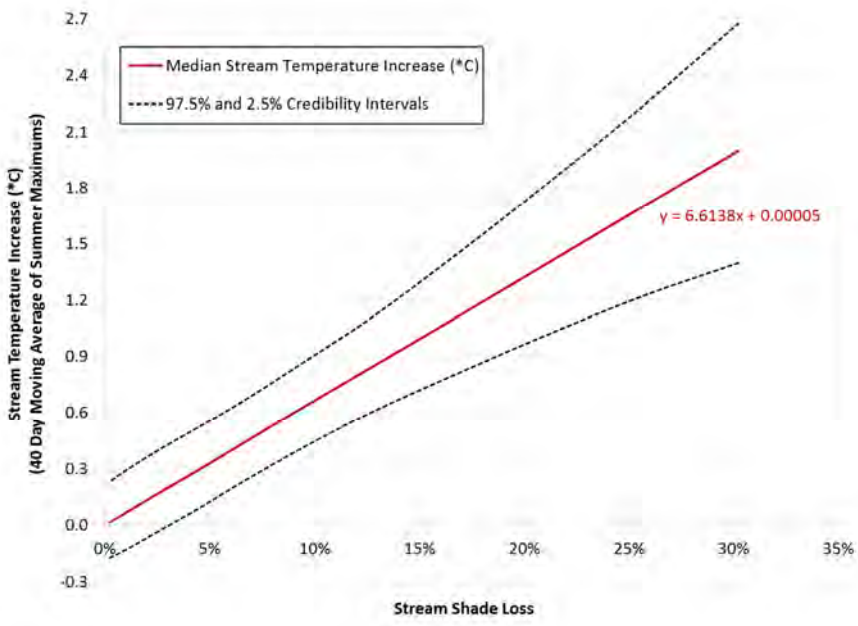
The expected shade loss associated with riparian thinning was estimated using the developed "ODEQ" mechanistic shade model presented in **Figure 6**. Specifically, the estimated canopy loss directly resulting from thinning activities within the outer buffer (i.e., 20ft to 80ft for medium stream, and 20ft to 60ft for small streams) was applied to the model. In addition, the indirect canopy loss within the inner buffer (i.e., 0 to 20 ft) resulting from thinning activities within the outer buffer was also applied to this model. In summary, this model estimated a 2.7% and 4.8% shade loss resulting from proposed FPA thinning activities along medium and small streams, respectively.

[4] The "Shade.xls" model utilizes the same shade algorithms included in the Oregon Department of Environmental Quality HeatSource temperature model - www.ecy.wa.gov/programs/eap/models.html

Estimated Temperature Increase Resulting from Thinning Activities (Option B)

Using the results in the two ODF Bayesian models, it is possible to develop a relationship between stream shade loss and expected stream temperature increases (**Figure 7**) [5] (y = 6.6138x+0.00005). For example, this relationship shows that stream temperatures are expected to increase by 0.3*C (with a 97.5% Credibility Interval between 0.1*C and 0.5*C) when riparian management reduces stream shade by 4.8%. Similarly, this relationship indicates that a 2.7% shade loss will result in a stream temperature increase of 0.2*C (ranging from 0*C to 0.4*C).

Figure 7. Predicted Stream temperature increase resulting from stream shade loss



[5] The x-axis values in **Figure 5** were obtained from shade model results (i.e., **Figure 1**) and the y-axis values in **Figure 5** were obtained from the corresponding temperature modeling results (i.e., **Figure 2**).

Summarizing the Effects of Thinning Activities and Buffer Width Reduction Associated with Option B

Table 3. Total Stream Shade Loss Associate with Option B

Category	Shade Loss Result from Buffer Width Reduction	Shade Loss Result from Thinning Activities	Total Stream Shade Loss Associated with Option B
Small Streams	13.1%	4.8%	**17.9%**
Medium Streams	6.7%	2.7%	**9.4%**

Table 4. Total Stream Temperature Increase Associate with Option B

Category	Temperature Increase Result from Buffer Width Reduction	Temperature Increase Result from Thinning Activities	Total Stream Temperature Increase[6] Associated with Option B
Small Streams	0.9*C	0.3*C	**1.2*C**
Medium Streams	0.4*C	0.2*C	**0.6*C**

[6] The median temperature increase.

Cited Literature

Allen M., and L. Dent. 2001. Shade Conditions Over Forested Streams In the Blue Mountain and Coast Range Georegions of Oregon – ODF Technical Report #13.

Anderson P. D., D. J. Larson, and S.S Chan. 2007. Riparian Buffer and Density Management Influences on Microclimate of Young Headwater Forests of Western Oregon ***Forest Science*** 53(2):254-269.

Beschta, R. L., R. E. Bilby, G. W. Brown, L. B. Holtby, and T. D. Hofstra. 1987. Stream temperature and aquatic habitat: Fisheries and forestry interactions. Pages 191-232 in E. O. Salo and T. W. Cundy, editors. Streamside management: Forestry and fishery interactions. University of Washington, Institute of Forest Resources, Seattle, USA

Brazier, J. and G. Brown 1973. Buffer strips for stream temperature control. Res Pap. 15. Forest Research Laboratory, Oregon State University. 9p.

Chan S.S., D.J. Larson, K. G. Maas-Herner, W.H. Emmingham, S. R. Johnston, and D. A. Mikowski. 2006. Overstory and understory development in thinned and underplanted Oregon Coast Range Douglas-fir stands. ***Can. J. For. Res.*** 36:2696-2711.

Erman, D. J. Newbold, and K. Roby. 1977. Evaluation of streamside buffer strips for protection aquatic organisms. Contribution 165. California Water Resources Center, University of California, Davis. 48 p.

Groom J. D., L. Dent, L. Madsen, J. Fleuret. 2011. Response of western Oregon (USA) stream temperatures to contemporary forest management. *Forest Ecology and Management* 262(8):1618–1629.

Jackson, C.R., C.A. Sturm, and J.M. Ward. 2001. Timber harvest impacts on small headwater stream channels in the Coast Ranges of Washington. *JAWRA* 37(6):1533–1549.

Janisch J.E., S.M. Wondzell, and W.J. Ehinger. 2012. Headwater stream temperature: Interpreting response after logging, with and without riparian buffers, Washington, USA. *Forest Ecology and Management*

Kiffney, P. M., J. S. Richardson, J. P. Bull. 2003. Responses of periphyton and insect consumers to experimental manipulation of riparian buffer width along headwater streams. *Journal of the American Water Resources Association* 40:1060-1076.

Macdonald, J.S., E.A. MacIsaac, and H.E. Herunter. 2003. The effect of variable-retention riparian buffer zones on water temperatures in small headwater streams in sub-boreal forest ecosystems of British Columbia. Canadian Journal of Forest Research 33(8): 1371–1382.

ODF 2015. The material in the folder titled "BOF_Handout_Material" was obtained from the Oregon Board of Forestry (BOF) website listing the June 2015 meeting materials - www.oregon.gov/ODF/Board/Documents/BOF/20150603/BOFATTCH_20150603_07_02.pdf, www.oregon.gov/ODF/Board/Documents/BOF/20150603/BOFATTCH_20150603_07_03.pdf www.oregon.gov/ODF/Board/Documents/BOF/20150603/BOFATTCH_20150603_07_01.pdf. More recent detailed modeling results were obtained from ODF staff (Groom) via emails in July 2015.

Park., C., C. McCammon, and J. Brazier. 2008. Draft Report - Changes to Angular Canopy Density from Thinning with Varying No Treatment Widths in a Riparian Area as Measured Using Digital Photography and Light Histograms.

Schuett-Hames., D., A. Roorbach, and R. Conrad. 2011. Results of the Westside Type N Buffer Characteristics, Integrity and Function Study – CEMR Final Report. December 14, 2011.

Steinblums, I., H. Froehlich, and J. Lyons. 1984. Designing stable buffer strips for stream protection. J. For. 82(1):49-52

ATTACHMENT 11
Roni, P. 2016. 2 pages.

Testimony of Phil Roni, Research Scientist/Watershed Program Manager, Northwest Fisheries Science Center, NOAA Fisheries, Seattle, Washington.

Before the Oregon Board of Forestry, June 3, 2015

Good afternoon, Chairman and Board Members. My name is Phil Roni. I'm a research scientist with the NOAA Northwest Fisheries Science Center where I lead (and have led for last 20 years) a group of 20 scientists working on freshwater habitat, forestry, land-use, and restoration issues as they relate to salmon and steelhead. I wanted to testify from a scientific perspective regarding the Riparian Rule as it pertains to water quality and fish, particularly salmon.

Specifically, I want to touch on three things: 1) buffer widths needed to protect temperature, 2) extent of those buffers with particular reference to fish-bearing and non-fish bearing streams, and 3) Protecting Cold Water (PCW) criterion.

First, in regards to riparian buffers needed to protect stream temperature, the proposal for 90 to 100 ft. no-cut buffers to protect stream temperature is well supported by past and current science. For many years, the science has suggested that buffers anywhere from one to two potential tree heights are needed on fish-bearing streams to protect a variety of stream functions. This is quite a large range (100 to 300 feet in some cases) and I was excited to see the results of the RipStream study, which is an extremely well-designed study, that focused specifically on buffers needed to protect stream temperatures and on PCW criterion. It is clear from the RipStream and other studies that a no-cut buffer of 90 to 100 feet is needed to protect shade and temperature (PCW). Moreover, the Oregon Department of Forestry has analyzed the data in many different ways and came up the same answer of 90 to 100 ft. no-cut buffers. This should also protect a variety of other functions (micro-climate, nutrients, etc.); even larger buffers may be needed to fully protect some other functions such as providing large wood to the stream.

Second, the science is clear that protection is needed for non-fish bearing perennial streams as well. Non-fish bearing streams make up the majority of stream miles in any watershed and are drivers of the productivity of the system. They transmit temperatures downstream. It should be noted that the science on how far downstream the temperature effects from non-fish bearing streams are transmitted is variable ranging anywhere from a few hundred meters to a kilometer. Regardless, non-fish bearing streams provide important sources of wood, sediment, nutrients and gravels to fish-bearing streams and are drivers of productivity of downstream fish habitat and a watershed. The stream network is similar to your circulatory system. It would be a mistake to only protect your arteries and ignore your capillaries or assume that anything injected into your arterioles or capillaries would have no effect on your body or wouldn't be transmitted to your major arteries. It is similar with non-fish bearing streams and fish bearing streams. They are interconnected. and interdependent and protecting both non-fish bearing and fish bearing streams is important.

The third and final area I want to comment on is the PCW criterion of 0.3° C. This is well based in science that changes larger than this can have significant impacts on salmonid fishes. This can be either directly by making streams inhospitable for salmon and trout, or indirectly by affecting growth, feeding and reproduction. For example, small changes in temperature can significantly impact fish metabolism and their ability to feed and grow or, similarly, make them more susceptible to disease. It should also be noted that many streams, particularly at lower elevations, are on the edge of the limits of suitability for salmon and trout (particularly bull trout but also coho and cutthroat) and even small changes can make these streams or stream reaches inhospitable for salmonids. Finally, stream temperatures in many areas are predicted to increase with climate change and further increases in temperature due to removal of trees is of great concern and could further reduce suitable habitat for listed (and unlisted) salmon and trout.

In summary, 1) the science supports no-cut buffers of 90 of 100 ft. for PCW criterion, 2) this should be applied to fish-bearing and non-fish bearing streams, and 3) the PCW criterion of 0.3° C is scientifically sound and should not be increased.

I want to thank the Board for the opportunity to testify and I'm happy to answer any questions.

ATTACHMENT 12
Scurlock, Mendoza and Frissell. 2016. 8 pages.

Oregon Stream Protection Coalition

M E M O R A N D U M

TO: **Riparian Rule Subcommittee and other Members of the Oregon Board of Forestry**

FR: **Mary Scurlock, Chris Frissell and Chris Mendoza**

RE: **Why leaving riparian forests unmanaged within ~100 feet can safely be presumed to be ecologically beneficial for Oregon's aquatic and terrestrial ecosystems on both wet and dry forests**

DT: **23 September 2015**

Some Board members have expressed reservations about designating riparian areas as "no harvest" to meet the Protecting Coldwater Criterion because of a misguided belief that this will prevent needed, ecologically beneficial silvicultural treatments in these areas. A related concern is that instream placement of large wood will be discouraged.

This memo summarizes some key reasons why we believe these are not valid concerns that undermine the benefits of requiring substantially unmanaged buffers in either wetter Westside forests or the drier forest of the Siskiyou and the eastside.

1. ***Scientific perspectives on the ecological benefits of riparian thinning in westside forests have changed to recognize that management intended to speed large tree growth does not advance what is the more broadly important goal of dead wood production.***

A seminal recent analysis by researchers at the National Marine Fisheries Service Science Center in Seattle concluded:

> "Because far more vertebrate species utilize large deadwood rather than large live trees, allowing riparian forests to naturally develop may result in the most rapid and sustained development of structural features important to most terrestrial and aquatic vertebrates." Pollock and Beechie (2014).

Spurred by debate around large scale federal lands ESA consultations on riparian thinning practices, an interagency panel[1] reviewed current models for LWD delivery to streams within wetter forests, and determined that riparian thinning reduces LWD pieces and volumes entering streams for up to 90+ years. Only after that were remaining trees within the recruitment zone appreciably larger.

This view is consistent with research conducted as part of the Adaptive Management Program of the Washington State Habitat Conservation Plan for private forests (WDNR, 2005) where researchers concluded that "active management" (thinning) resulted in riparian stands accruing *less* basal area per acre (BAPA) than stands that were left unmanaged when modeled out to age 140 years in order to achieve Desired Future Condition (DFC) basal area targets.[2] McConnell (2007). The Board may rely on these findings: McConnell's modeling of BAPA to Desired Future Conditions at age 140 were similar to actual BAPA in riparian stands that were field validated in a related Washington research and monitoring study (*Validation of the Western Washington riparian Desired Future Conditions (DFC) performance targets*, Schuett-Hames et al. 2005).

An Oregon State University study of riparian thinning with the intent to improve conifer establishment and growth (Emmingham et al. 2000) concluded that very aggressive tree removal and soil disturbance measures are necessary to hasten the establishment of Douglas-fir and other conifers in Oregon Coast Range riparian areas. Where protection of water quality and stream habitat for salmonids and amphibian species are recognized to be of paramount importance, such aggressive silvicultural measures fundamentally conflict with the overarching objectives of maintaining shade and water temperature, and minimizing erosion and sedimentation to streams. Halfway silvicultural measures are highly likely to both impose some harms to aquatic habitat and fail to hasten conifer establishment or growth. **The Ripstream studies conclusively demonstrate that with regard to stream shade and temperature, the zone where this balance of risks most acutely applies is the area within 100-120 feet of perennial streams**.

Three decades of research have failed to clearly demonstrate that environmentally acceptable riparian stand thinning prescriptions reliably result in increased tree growth that confers net benefit to aquatic (or terrestrial) conservation objectives. Forest policymaking should not be premised on the opposite assumption and wishful thinking.

2. "No harvest" zones without human intervention will be static and unhealthy

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[1] The "Large Wood Elevation Team" report was published as Spies, T., M. Pollock, G. Reeves and T. Beechie. 2013. Effects of Riparian Thinning on Wood Recruitment: A Scientific Synthesis. Report of the Science Review Team, Wood Recruitment Subgroup. USDA Forest Service Forestry Sciences Laboratory, Corvallis, OR, and Northwest Fisheries Science Center, Seattle, WA. 46 pp.)

[2] McConnell (2007) states: "DFC Model outputs were analyzed using data from 150 randomly selected, approved Forest Practices Applications (FPAs) in which timber harvest was proposed along west-side Type F streams. Stand age 140 bapa (average and standard deviation) for each prescription, for all FPAs, across all Site Classes, stream sizes and other possible covariates was: **no-cut, 364.1 ± 43.7** (emphasis added), Option 1 (thinning), 335.5 ± 45.9, and Option 2 (leave trees closest to stream), 301.1 ± 40.8 with the trees in the outer part of the inner zone excluded and 333.0 ± 31.4 with the trees in the outer part of the inner zone included." (emphasis added).

It is important to recognize that without timber harvest riparian areas will still be subject to a variety of natural disturbances that will create a mosaic of conditions within these areas. Even in the absence of human manipulation, natural disturbances such as wind, fire, insects, disease, flooding and landslides will continue to affect riparian areas, ensuring riparian forest diversity. These same disturbances are the means by which riparian areas interact with the stream to provide large wood and other organic inputs. Research indicates that self-thinning processes operating over decades in second-growth riparian forests result in mature forest conditions without thinning treatment (Pollock et al. 2012).

Silvicultural intervention is, as a general matter, simply not necessary for the attainment of natural vegetation successional pathways and mature forest conditions in riparian areas**.**

3. Given the large ecological burden being placed on relatively small protected riparian areas, it is important to maximize the ecological function from riparian buffers. This is best achieved by a presumptive no harvest prescription.

It is important to remember that riparian areas receive protection because they directly influence the quality and quantity of habitat available to aquatic and riparian-dependent species. (*See e.g.* IMST, 1999, Gregory et al. 1991, and many others). But because of this rule's focus on the shade function alone, even the largest buffers being considered comprise but a fraction of the functional riparian area that contributes to aquatic and riparian health. The important functions performed by riparian forest include shade and temperature control, erosion prevention and sediment filtration, nutrient retention, and woody debris production (Gregory et al. 1991, Spence et al. 1996, IMST 1999, Frissell et al. 2014). Yet, these relatively small areas are being tasked – perhaps impossibly -- with mitigating the landscape-scale effects of industrial logging.

By taking what is essentially a "stream buffer only" approach we are already taking extreme risks with aquatic ecosystems on private lands because it is well-established that the physical and biological attributes of riparian landforms are shaped by the geomorphic processes at work within the entire watershed (Sullivan et al. 1987; Featherston et al. 1995). As Oregon's Independent Multidisciplinary Science Team observed in 1999, the dispersal of sustained short-rotation logging activity over large areas of the landscape does not emulate natural disturbance patterns, nor does the retention of skinny strips of forest along some stream channels. Nonetheless, the current policy framework effectively limits us to a site-by-site mitigation approach that effectively proposes to use riparian functionality as a proxy for watershed functionality. It stands to reason that in order for this type of mitigation scheme to be at all effective, riparian function must be maximized.

Yet the areas that should be considered "riparian" from an ecological perspective extend well beyond the widths of restricted management areas currently being considered by the Board. If Oregon were to pursue ESA-sufficient forest practices rules on fish-bearing streams– perhaps through a statewide Habitat Conservation Plan such as Washington state private forest lands is implementing – the stream protection rules would need to restrict harvest within approximately <u>one site potential tree-height-sized distance from the stream.</u>

(Washington State Department of Natural Resources, Forest Practices Habitat Conservation Plan, 2005)

Furthermore, unstable areas should be also included in riparian delineation, such as inner gorges and other steep, unstable areas because they are an an integral part of the functional riparian area due to their tight connection to physical stream processes. In fact, in many managed steep and moderately steep coastal tributary streams in central to northwestern Oregon, the best chance of large "key pieces" of LWD getting to the stream, floodplains, and riparian areas is via debris flows, unstable or potentially unstable slope failures or larger landslides. Reeves et. al. (2003).[3]

5. ***Post-fire and other post-disturbance "salvage" logging is inconsistent with ecological restoration even outside of riparian areas – it is double true inside them.***

A no-harvest presumption in riparian areas is justified even in the face of widespread fire or insect mortality in riparian areas. There is overwhelming consensus in the scientific literature that that post-disturbance logging is not restorative and should be excluded from terrestrial and aquatic conservation emphasis areas. This most certainly includes near-stream riparian areas according to numerous sources, including: Beschta et. al. 2004, Karr et al. 2004, Lindenmayer et al 2004, Lindenmayer and Noss 2006, Donato et al. 2006, Noss et al. 2006. These studies conclude that logging after fire, windstorms, or insect outbreaks compounds the harm the initial disturbance can cause to watershed, soils, and hydrologic functions, and equally important, curtails or delays natural recovery processes that often create high-quality stream and riparian habitat after forest natural disturbances.

In drier forests, wildfire can't always be considered a threat to native fish, amphibians and other aquatic species, and this subject remains a subject of both debate and uncertainty. In every region, native species are adapted to be resilient or resistant to wildfire effects, else they would not have survived to the present day. Too often high severity fire is assumed to be a "disaster" to aquatic resources, without actual monitoring and evaluation. Many scientists argue that the variety of threats that restrict a species' range, fragment populations, and curtail recolonization are the primary causes of local extinction, and wildfire is best viewed as merely one among many proximal triggers of an inevitable response. The extensive forest treatments that disturb soils and vegetation in riparian over large areas that would be necessary in order to have the desired impact on ameliorating

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[3] This research also shows that it may not be only total wood delivery that is important. Reeves et al. (2003) findings in Cummins Creek, Western Oregon, that: "About 65% of the number of pieces and 46% of the estimated volume of wood were from upslope sources. Streamside sources contributed about 35% of the number of pieces and 54% of the estimated volume of wood." Thus, LWD delivery from upslope areas outside the 1-tree-height distance for coastal 4th order streams (Cummins Creek is an unlogged reference system) may not be the "rare occurrence." Further, the location of the LWD from upslope sources appears to have high ecological value that exceeds its volume.

fires that with certainty affect only a very limited portion of the treated area is a good example of a poor tradeoff: the certainty of harm over a large area in exchange for the possibility of reduced fire severity in some small portion of the impacted area.
Others suggest that disproportionately large or intense wildfire can cause patterns of impact that were seldom seen under historical conditions. But efforts to reduce wildfire impact by thinning or other silvicultural treatments are not proven to be effective in the case of large fires that burn the most acres, and they bring undesired impacts, particularly when implemented within riparian areas and slopes near streams and wetlands.

With regard to conservation implications, however, it is now well established that climate change and weather drive increased fire size and severity regardless of any appreciable or manageable fuels accumulation effect. The specific roles of fuels and fire management within aquatic reserves – such as no harvest buffers on private forestlands - remain unresolved. For example, while consensus exists that restoration of something akin to natural fire regime is desirable for ecological and other reasons, the extent and the exact nature of pre-fire fuels treatment necessary to effectively manage fire is unknown; research results on the effectiveness of fuels treatments and forest thinning are extremely variable. Proposed actions on federal lands range widely from intensive mechanical treatments intended to "mimic or replace" fire or to impose artificial large-scale firebreaks, to expansive lighter, more spatially limited fuels manipulations such as lopping of low branches and local raking of ground fuels immediately prior to prescribed fire treatments. Extensive and sustained high-investment fuels management programs almost certainly necessitate road access, in particular close to streams, with the roads themselves bringing substantial impact that would not occur had fire been allowed to burn without an attempt to manage fuels. For these critical reasons, the tradeoffs between watershed impacts and benefits of fuels treatments and their putative effect on ameliorating fire remain unresolved.

6. If alternative riparian management (e.g. silvicultural treatments) or instream placement of large wood is ecologically desirable in specific locations, there are other policy mechanisms that can be brought to bear.

Any information before the Board about how larger buffer requirements would affect large wood placement projects is anecdotal and speculative at best, and as such is a distraction from the central objective of this rulemaking. Furthermore, even if this issue were relevant, there is no rational way for the Board to weigh the tradeoffs between more retention of standing riparian forest and the benefits of hypothetical wood placement projects at unspecified locations with unmeasured benefits to aquatic species and no connection whatsoever to attainment of the PCW.

As a matter of public policy, instream wood placement and those specific cases where riparian forest management is actually needed because it is demonstrably beneficial to aquatic resources, are both better addressed through policies external to the OFPA's programmatic stream protection rules which are the state's compliance mechanism for attaining water quality standards under the federal Clean Water Act. These include plans

for alternate practices under the OFPA, and numerous state and federal restoration programs specifically designed to fund such efforts.

CONCLUSION

It is understandable that the Board may be confused as to how and whether it should consider a new rule's effect on the availability of active management, either in riparian areas or to place large wood. But in our view these concerns have been given a more elevated status as a "consideration" that they should have been given the Board's nondiscretionary duty to meet water quality standards. The rules' effectiveness to meet the water quality compliance goal must drive the Board's selection of broadly applicable steam protection rules.

Nonetheless, some Board members have expressed hesitancy to declare riparian areas off limits to timber harvest citing active management needs and large wood placement concerns. This memo has tried to explain that there is no basis in the scientific literature to presume that active riparian management is ecologically beneficial.

In sum, concerns about a perceived need for active riparian management do not provide Board with a sound basis to oppose no-harvest buffers of 120 feet or less for at least the following three reasons:

1. The Board's need to implement rules that meet water quality standards trumps these considerations because attainment of these standards constitutes a mandatory statutory duty under ORS 527.765.

2. As ODF's July 2015 staff report observes "active management" is merely "encouraged" by rule "where appropriate." The science indicates that active management as a rule is not appropriate or generally justified in riparian areas (see above).

3. Large wood placement and ecologically restorative riparian silviculture activities (such as that dropping trees onto the forest floor) cannot be effectively or fully directed solely through the Board's stream protection rules. Both activities should be conducted in conjunction with watershed-specific restoration plans, Oregon Department of Fish and Wildlife and other experts in the art and science of ecosystem restoration.

REFERENCES

Beschta, R. L., C. A. Frissell, R. Gresswell, R. Hauer, J. R. Karr, G. W. Minshall, D. A. Perry, J. J. Rhodes. 1995. Wildfire and salvage logging: recommendations for ecologically sound post-fire treatments on federal lands in the West. Pacific Rivers Council. Available online at www.pacificrivers.org).

Beschta, R. L., J. J. Rhodes, J. B. Kauffman, R. E. Gresswell, G. W. Minshall, J. R. Karr, D. A. Perry, F. R. Hauer, C. A. Frissell. 2004. Postfire management on forested public lands of the Western United States. Conservation Biology, 18(4): 957-967.

Donato, D.C., J.B. Fontaine, J.L. Campbell, W.D. Robinson, J.B. Kauffman, and B.E. Law. 2006. Postwildfire logging hinders regeneration and increases fire risks. Science 313: 615.

Featherston, K. L., R. J. Naiman, and R. E. Bilby. 1995. Large woody debris, physical processes, and ripar- ian forest development in montane river networks of the Pacific Northwest. Geomorphology 13:133– 144.

Gregory, S.V., Swanson, R.J., McKee, W.A., and Cummins, K.W. 1991. An ecosystem perspective of riparian zones: focus on links between land and water. Bioscience, 41: 540-551.

Independent Multidisciplinary Science Team. 1999. Recovery of Wild Salmonids in Western Oregon Forests: Oregon Forest Practices Act Rules and the Measures in the Oregon Plan for Salmon and Watersheds. Technical Report 1999-1 to the Oregon Plan for Salmon and Watersheds, Governor's Natural Resources Office, Salem, Oregon.

Karr, J. R., et.al. 2004. The Effects of Postfire Salvage Logging on Aquatic Ecosystems in the American West. Bioscience 54,1029-1033. http://www.sierraforestlegacy.org/Resources/Conservation/FireForestEcology/SalvageLoggingScience/Salvage-Karr04.pdf

Leinenbach,P., G. McFadden and C. Torgersen. 2013. Effects of Riparian Management Strategies on Stream Temperature. Science Review Team Temperature Subgroup

Lindenmayer, D.B., D. Foster, J.F. Franklin, M. Hunter, R. Noss, F. Schiemegelo, and D. Perry. 2004. Salvage logging after natural disturbance. *Science* 303:1303.

Lindenmayer, D.B., P. Burton, and J. Franklin. 2008. S*alvage Logging and Its Ecological Consequences*. Island Press.

Lindenmayer, D.B., and R.F. Noss. 2006. Salvage Logging, Ecosystem Processes, and Biodiversity Conservation. Conservation Biology 20(4): 949–958,

McConnell, S. 2007. An Overview of the DFC Model, and an Analysis of Westside Type F Riparian Prescriptions and Projected Stand Basal Area per Acre. Cooperative Monitoring Evaluation and Research Committee, Washington State Dept. of Natural Resources, Olympia WA.

Noss, Reed F (editor), Jerry F. Franklin, William L. Baker, Tania Schoennagel, and Peter B. Moyle. Ecology and Management of Fire-prone Forests of the Western United States. (Society for Conservation Biology, August 2006) (addresses the ecological science relevant to forest

restoration and fuel management policy development in light of ecological variability within and among forests, concluding, inter alia that restoration priorities should be determined by ecological considerations and urgency, with areas of highest current biological value taking precedence over areas most out of kilter with historical forest conditions and that we should take care of other stressors first, before taking management actions to correct fire regime/past management, i.e. invasives and grazing pressures)

Pollock, Michael M. and Timothy J. Beechie, 2014. Does Riparian Forest Restoration Thinning Enhance Biodiversity? The Ecological Importance of Large Wood. Journal of the American Water Resources Association (JAWRA) 50(3): 543-559. DOI: 10.1111/jawr.12206

Pollock, Michael M., Timothy J. Beechie, and Hiroo Imaki, 2012. Using reference conditions in ecosystem restoration: an example for riparian conifer forests in the Pacific Northwest. Ecosphere 3.11: art98. http://www.esajournals.org/doi/full/10.1890/ES12-00175.1

Rhodes, J.J. 2007. The Watershed Impacts of Forest Treatments to Reduce Fuels and Modify Fire Behavior. A report for Pacific Rivers Council, Eugene, OR. 94 pp. available at www.pacificrivers.org

Rhodes, Jonathan J., and William L. Baker. 2008. Fire probability, fuel treatment effectiveness and ecological tradeoffs in western US public forests." *The Open Forest Science Journal* 1.1: 1-7.http://www.energyjustice.net/files/biomass/library/Rhodes-Baker.pdf

Schuett-Hames, D., R Conrad and A. Roorbach. 2005. Validation of the Western Washington riparian Desired Future Conditions (DFC) performance targets in Washington State Forest Practices Rules with data from mature, unmanaged, conifer-dominated riparian stands. Northwest Indian Fisheries Commission, Olympia, WA.

Spence, Brian C., and Robert M. Hughes, 1996. *An ecosystem approach to salmonid conservation*. TR-4501-96-6057. ManTech Environmental Research Services Corp., Corvallis, OR. (Available from the National Marine Fisheries Service, Portland, Oregon). http://www.calwater.ca.gov/Admin_Record/D-051874.pdf

Spies, T., M. Pollock, G. Reeves, and T. Beechie. 2013. Effects of riparian thinning on wood recruitment: a scientific synthesis. Science Review Team Wood Recruitment Subgroup. USDA FS, Pacific Northwest Science Laboratory, Corvallis, OR, and NOAA Fisheries Northwest Fisheries Science Center, Seattle, WA

Sullivan, K., Lisle, T.E., Dollof, C.A., Grant, G.E., and Reid, L.E. 1987. Stream channels: the link between forests and fishes. *In* Streamside management: forestry and fishery interactions. *Edited by* E.O. Salo and T.W. Cundy. College of Forest Resources, University of Washington, Seattle, WA. pp. 39-97.

Siskiyou Streamside Protections Review: Summary of Literature Review

Adam Coble, W. Terry Frueh, John Hawksworth, Ariel Cowan

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Main Findings

Stream temperature

- Relevant literature (12 studies) suggests implementation of current FPA rules will not ensure maintenance of Protecting Cold Water standard or the Human Use Allowance.
- Results from existing literature indicate that harvested sites infrequently exceeded the Biologically-based Numeric Criterion.
- A paucity of data, combined with complex spatial and temporal dynamics of heat transport, present many challenges in quantifying cumulative effects from multiple upstream timber harvests. The only component of these dynamics for which there were data showed no consistent trends in warming downstream of harvest units.

Shade

- Results from TMDL modeling and from existing literature (4 studies) suggest that shade increases with buffer width, and trees within ~50 and ~70 feet, respectively, of streams provide the most shade to streams.
- In the 50-70 feet range of buffer widths, additional trees appear to increase shade by a few percent, and not at all beyond approximately 80-100 feet range of buffer widths.

1. Background

1.1 Policy

In January 2012, the Oregon Board of Forestry (Board) found degradation of water quality for small and medium streams based on an Oregon Department of Forestry (ODF) study (Groom *et al.*, 2011a), which initiated the Riparian Rule Analysis. In 2017, the Board adopted additional riparian rules for small and medium streams with salmon, steelhead, and bull trout ("SSBT rules"). The Board voted to apply these rules in all of western Oregon except in the Siskiyou geographic region.

In March 2018, the Board directed ODF to assess the sufficiency of Forest Practices Act (FPA) rules to meet riparian goals along small and medium fish streams in the Siskiyou, and thereby commencing the Siskiyou Streamside Protections Review ("Siskiyou Project"). These goals were Desired Future Conditions (DFC) and Oregon Department of Environmental Quality (DEQ) water quality standards for stream temperature. In 2019, ODF staff completed a systematic review of literature to inform these Board sufficiency decisions (Cowan *et al.*, 2019). The geographic scope of this review was included studies from the Siskiyou and adjacent areas of northern California with similar forests.

Based on the results of this initial review, the Board found in June 2019 there was insufficient evidence to make a decision on the sufficiency of the Forest Practices Act (FPA) rules to protect stream temperature and DFC. The Board directed the department to formulate a range of approaches to study sufficiency of rules, including additional work with DEQ and further evaluation of Total Maximum Daily Load (TMDL) information. In September 2019, the Board directed ODF staff to draft an executive summary of relevant scientific literature with an expanded geographic scope to include forests similar to those of the rest of western Oregon (Appendix I, Figure I.1).

In February 2020, a group of environmental and forest industry stakeholders signed a Memorandum of Understanding (MOU) requesting the legislature revise the FPA and pass permanent rules for small and medium SSBT streams in the Siskiyou georegion. Although a bill in support of this MOU and legislation was drafted, the legislature did not vote on this bill. In order to support the work of this MOU, signatories of the MOU requested the Board: 1) pass a temporary rule extending the SSBT rules to the Siskiyou, and 2) pause the Siskiyou Project. The Board approved these recommendations on June 3, 2020, when the report was nearly completed. At their special session in late June 2020, the legislature passed Senate Bill 1602 which directed the Board to begin permanent rulemaking for SSBT streams in the Siskiyou Georegion.

1.2 Science: Stream Temperature and Shade

Since the 2013 systematic review on stream temperature and shade in forestry (Czarnomski *et al*., 2013), a number of publications have reported results on harvesting effects on stream temperature and shade throughout western Oregon including paired watershed studies (Bladon *et al*., 2016; Bladon *et al*., 2018; Reiter *et a*l., 2020), ODF's Riparian Function and Stream Temperature study ("RipStream"; Davis *et al*., 2016; Groom *et al*., 2017; Groom *et al*., 2018; Arismendi and Groom, 2019), the Density Management and Buffer Study (Anderson and Poage, 2014; Leach *et al*., 2017), and the work of Cowan et al. (2019). There were also similar experiments in other areas of the Pacific Northwest relevant to this summary, including northern

California (Jones *et al*. 2013), western Washington (McIntyre *et al.* 2018), and British Columbia (Guenther *et al*. 2014)[1].

A common theme among many of these studies is that riparian buffers provide shade to streams, which is important for preventing substantial increases in stream temperature associated with forest harvest. For example, the paired catchment studies observed greater increases in stream temperature following harvesting for headwater streams with no buffers as compared to buffered streams (Bladon *et al*., 2018; Reiter *et al*., 2020). RipStream papers addressed DEQ water quality standards, including the frequency of exceedances of the Biologically Based Numeric Criteria ("NC"; Groom *et al*., 2017), and buffer width requirements to maintain stream temperature from exceeding the protecting cold water (PCW) criterion (Groom *et al*., 2018). RipStream papers also evaluated harvesting effects on downstream temperature (Davis *et al*., 2016; Arismendi and Groom, 2019). A few studies (Gomi *et al*., 2006; McIntyre *et al*., 2018) outside of Oregon provide results that are used in this summary, even though these studies did not explicitly test DEQ standards.

This summary informs the Board's policy considerations regarding attainment of DEQ water quality standards for temperature for small and medium fish-bearing streams in the Siskiyou geographic region. The following sections address relevant findings to two DEQ water quality standards[2]: 1) Protecting Cold Water Criterion (PCW); and, 2) NC. We also include a third section that summarizes findings that address the cumulative effects of multiple timber harvest units throughout a watershed. Not all studies directly assessed whether FPA rules are effective in meeting DEQ water quality standards, which presents a challenge in addressing questions that were not specifically in the original analysis. We have included results from these studies as they provide insight into potential harvesting effects on stream temperature and shade, as well as effects of harvesting on downstream temperature.

Most studies included in this analysis measured stream temperature and shade adjacent to or downstream of clearcuts with a hard-edged, unthinned buffer, unless otherwise noted. This summary combines the information on stream temperature and shade described in Czarnomski *et al.* (2013), Cowan *et al*. (2019), and any publications completed since 2013 relevant to this summary. The similarity of forests, and their resultant shade and stream temperature dynamics, between the Siskiyou and the rest of western Oregon are not evaluated in this paper. This report is a summary, and therefore is not exhaustive.

2. Analysis

2.1 Protecting Cold Water and Human Use Allowance

The PCW prohibits human activities, including harvesting, from increasing stream temperatures by more than 0.3 °C. From the RipStream study, Groom *et al.* (2011a) found that clearcut harvesting and retaining buffers on privately owned lands showed a 40% probability of exceeding the PCW. For the aforementioned Riparian Rule Analysis, ODF had a systematic science review drafted (Czarnomski *et al*., 2013), along with additional technical evaluations.

Czarnomski *et al*. (2013) found that exceedances of the PCW occurred in other studies in the Interior geographic region in Oregon with riparian buffer widths that were consistent with FPA

[1] For a complete list of publications used in this report, see Appendix III.
[2] Oregon Administrative Rule (OAR) 340-041-0028

rules[3] for fish streams. Building on the results of Czarnomski *et al*. (2013), we show that, on average, studies within a number of regions in the Pacific Northwest (Fig. 1) observed harvest-associated changes in stream temperature (ΔT) that exceeded the PCW criterion. Data in Figure 1 include study sites with buffer widths ranging from 20' to 70', which reflects the minimum width (20') that would contain sufficient basal area to meet targets in the FPA, and the widest required possible buffer width (70') required by the FPA for medium streams with insufficient conifer basal area.

We make the distinction between two types of study designs (i.e., upstream/downstream and paired catchment designs) due to differences in how data were collected and locations of reference stream locations (Fig. 1). The upstream/downstream design typically involved stream temperature sensor placement above and below a treatment reach with additional sensors in a control reach further upstream. Paired catchment designs had stream temperature sensors located within and below treatment reaches, which had corresponding reference locations in a different stream catchment prior to and following harvest.

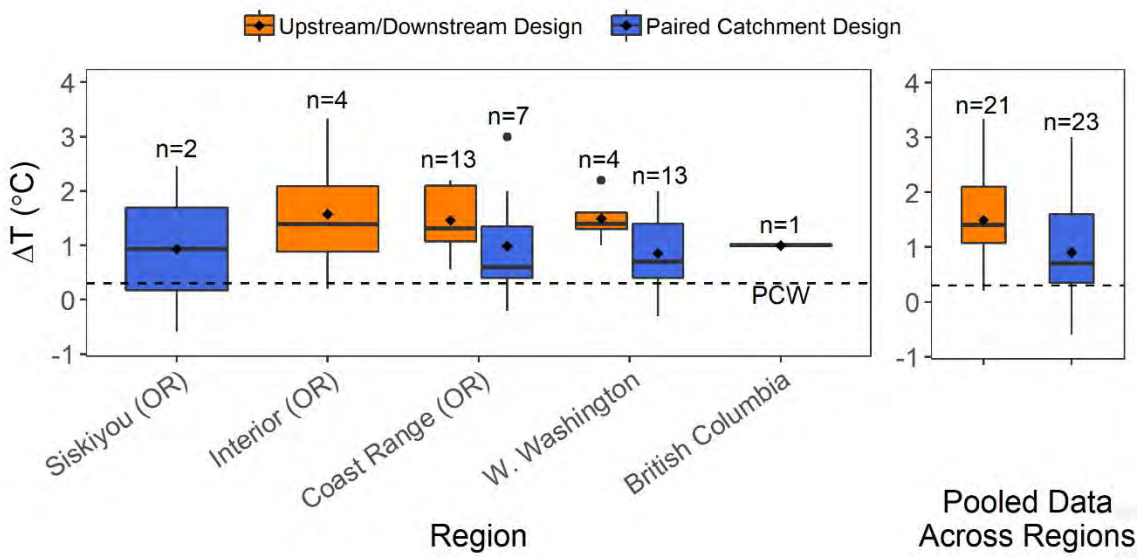


Figure 1. Boxplots of harvest-associated changes in stream temperature (ΔT, °C) by FPA geographic regions (e.g., Siskiyou, Interior, and Coast Range) and other regions of the Pacific Northwest (e.g., western Washington, British Columbia). The one site in British Columbia used a paired catchment design. Mean values by study design across regions are shown in the right panel. The dashed line corresponds with the Protecting Cold Water criterion of 0.3 °C. Each box shows the interquartile range from the 25th to 75th percentile represented by the bottom and top, respectively, of the box. The median is the horizontal line near the center of the boxes and the mean is the point within the box. The maximum and minimum are the ends of each vertical line, and outliers are points above or below the maximum and minimum. The number of sites (n) per region are provided above each boxplot.

[3] Note: Most studies available for this review looked at buffer widths as the controlling variable on stream temperature or shade. Those widths which do not correspond precisely with FPA fish stream rules, which have a 20 foot no cut buffer, plus requirements for basal area retention out to 50 feet and 70 feet for small and medium streams, respectively.

Given the Board's decision to expand the geographic scope of literature included in this summary for their consideration, a central question in consideration is the extent to which ΔT may differ between geographic regions. When viewing our findings within each study design, mean ΔT were fairly consistent across the regions. For example, ΔT ranged from 1.46 to 1.58 °C for upstream/downstream designs, whereas ΔT ranged from 0.85 to 1.00 °C for paired catchment designs.

Our analysis suggests study design influences ΔT measured in a study (Fig. 1). On average, paired catchment study designs found smaller ΔT. After pooling data across regions, we found mean ΔT was 1.5 and 0.9 °C for upstream/downstream and paired catchment designs (Fig. 1), respectively, despite the upstream/downstream designs having a greater mean buffer width (48 feet) than the paired catchment designs (40 feet).

Figure 2a shows site-specific relationships between ΔT and buffer width[4], from data across a broad geographic range in the Pacific Northwest (Fig. I.2.A, Appendix I), but with only a few points representing the Siskiyou region (Volpe, 2009). As buffer width increases, ΔT decreases, highlighting the importance of riparian buffers in moderating stream temperature. This trend is apparent despite the relatively large spread in the data, some of which may be an artifact of differing study designs and reported metrics. Similar to our analysis in Figure 1, study design appeared to influence the relationship between ΔT and buffer width. When fitting a curve (e.g., quadratic function) to the data in Figure 2, we found that the curve crossed the PCW threshold at a narrower buffer width for the paired catchment studies, as compared to studies that used an upstream/downstream design (data not shown).

Based on a Bayesian model using RipStream data, Groom *et al*. (2018) predicted riparian buffer widths of 90 feet to maintain ΔT below the PCW threshold of +0.3 °C (Fig. 2b). Because basal area was often maintained above the FPA requirements at RipStream sites, ODF staff estimated buffer widths under the scenario of landowners harvesting down to minimum FPA basal area requirements (Oregon Department of Forestry, 2015a, b). These widths averaged 23 and 41 feet for small and medium streams, respectively. These widths correspond with increases in ΔT of 1.9 and 1.4 °C, respectively (Fig. 2b). In contrast, significant increases in ΔT were not found along streams with riparian buffers (~50 feet) in Alsea Watershed Studies (Revisited) in western Oregon (Bladon *et al.*, 2016).

Basal area of riparian stands is another important factor in influencing shade, and therefore, stream temperature. Groom *et al.* (2011b) show that basal area and mean tree height were strong predictors of stream shade, and explain more variation in shade as compared with buffer width. Similar to the Bayesian modeling approach in Groom *et al.* (2018), ODF staff predicted a stand total basal area[5] (conifers and hardwoods) of 280 ft^2 per 1000 ft. to maintain ΔT below the PCW threshold of +0.3 °C (Fig. 2c). Note that this prediction only used data from no-cut buffers adjacent to clearcuts, and thus we cannot determine how appropriate the predictions are for thinned buffers or uplands.

[4] Appendix III provides details on how these data were obtained and/or calculated.

[5] Note that the basal area standard targets for fish streams in the FPA (OAR 629-642-0100(6)) are based primarily on conifers, and only allow up to 10% of hardwood basal area to count towards these targets.

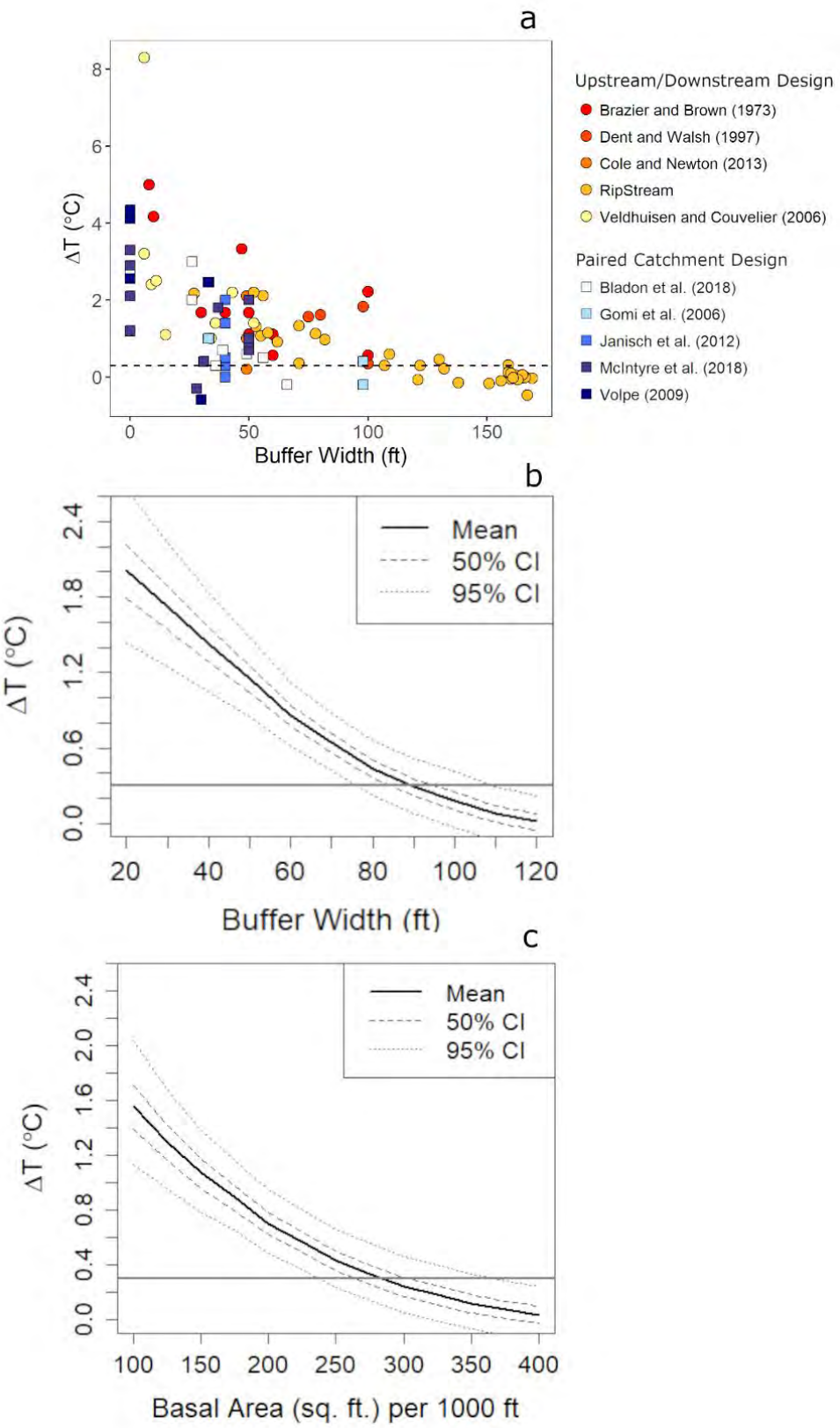


Figure 2. Post-harvest changes in stream temperature (ΔT, °C) as a function of: buffer width using literature (Panel a), buffer width as predicted by Groom *et al.* (2018)(Panel b), and basal area as predicted by Groom *et al.* (2018) (Panel c). Data points (Panel a) are color-coded by study that used an upstream/ downstream design (circles) and a paired catchment design (squares). The dashed line crosses the y-intercept at the PCW threshold (+0.3 °C). The dashed and dotted lines (Panel b and c) represent the 50% and 95% credible intervals (CI), respectively. A 95% credible interval indicates there is a 95% probability that the mean will fall within that interval.

Stream temperature TMDLs are implementation plans for how to achieve DEQ water quality standards (PCW and NC). These TMDLs prescribe the amount of heat that a water body can receive in order to attain the water quality standards. Private forest landowners must meet the requirements set by a human use allowance (HUA) if a temperature TMDL has been established in their watershed. Under current EPA approved plans, private forests landowners are expected to meet this requirement by following stream protection rules in the Forest Practices Act rules. In the Siskiyou geographic region, six temperature TMDLs have been established: the Rogue River Basin TMDL, Upper Sucker Creek Watershed TMDL, Lower Sucker Creek Watershed TMDL, Applegate Subbasin TMDL, Bear Creek Watershed TMDL, and the Upper Klamath and Lost River Subbasins TMDL. The HUA for all of these waterbodies is 0 °C, except for the Rogue Basin, which is 0.04 °C. Thus, for these watersheds, there are greater restrictions for stream temperature than that of the PCW. Where the PCW is not met, HUA is also not being met given its lower temperature threshold. For western Oregon, the modeling conducted by Groom *et al.* (2018) suggests that a buffer width of 120 feet or more would be required to prevent $\Delta T > 0$ °C (Fig. 2b).

Because shade is the major human-influenced control on stream temperature, and is the surrogate measure used in TMDLs to assess proper implementation, we examined shade data from the literature[6]. Based on studies that reported shade as a function of buffer width in the Coast Range geographic region (Allen and Dent, 2001; Reiter *et al.*, 2020), there is an increasing trend in shade with increasing buffer width (Fig. 3a). This trend is most apparent for the RipStream data, which covered a range of buffer widths from 27 to 168 feet. There is evidence that Reiter *et al.* (2020) and McIntyre *et al.* (2018) (77-80%) measured greater shade for a given buffer width (20-70 feet) than the other studies (69-71%). Reiter *et al.* (2020) and McIntyre *et al.* (2018) were conducted on non-fish-bearing streams that were likely narrower, and therefore have more canopy cover due to its overhanging streams more than the fish-bearing streams studied in Allen and Dent (2001) and in the RipStream study.

Comparing pre- and post-harvest shade also provides insight on harvest-associated changes in stream temperature. Three studies reported both pre-and post-harvest shade (RipStream; Reiter *et al.*, 2020; McIntyre *et al.*, 2018) with which to evaluate harvest-associated changes in shade (Fig. 3b). The change in percent shade ranged from -31% to +4 percent. The 18 sites with buffer widths greater than 120 feet, on average, experienced no net loss of shade, whereas the remaining thirteen sites (< 120 feet) experienced an average change in shade of -19%. Buffers in the Trask Watershed Study (Reiter *et al.*, 2020) showed a smaller decrease in shade for a given buffer width. This smaller decrease in shade may be a result of aforementioned narrower channel widths at the Trask Watershed study sites.

[6] Note that most studies assessed sites with forests less than 80 years old, and thus these sites were not at either the FPA's desired future condition, or DEQ's site potential vegetation.

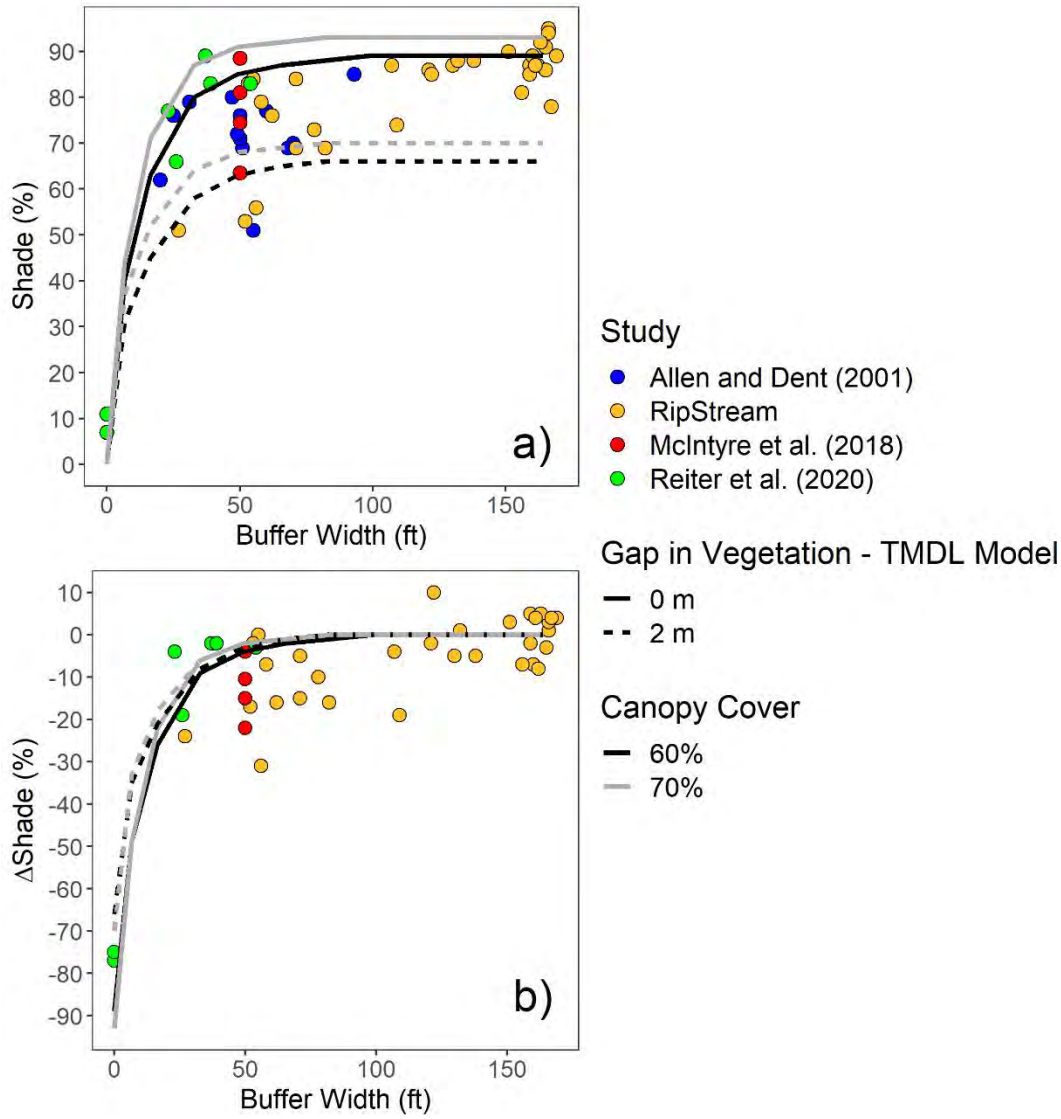


Figure 3. Shade (Panel a) and changes in shade (ΔShade; Panel b) as a function of buffer width from the literature and TMDL model shade data for riparian stands. The TMDL model used in this analysis was calibrated for mid-Coast, which is in proximity to most of the field data.

To gain a sense of what shade might be expected to be at these sites, we show predicted shade and change in shade (Δshade) values as a function of buffer width from the DEQ TMDL heat source model ("TMDL values") in Figures 3a and b, assuming a 0 and 2 m gap[7] in vegetation

[7] For comparison, Groom et al (2011b) reported an average wetted channel width of 2.1 meters (Range 1.0-3.7 m).

(i.e., directly above the stream)[8]. In Figure 3a, most field data fall within the range of the 0 and 2 m gap TMDL shade values, which appear to provide a reasonable approximation of shade values observed in western Oregon.

TMDL Δshade values show steep declines in the 0-40 foot buffer range, with small changes in the 50-80 foot buffer range (Fig. 3b). Field data approximately follow the TMDL values for change in shade (Fig. 3b), except they are more negative than the TMDL curves in the 50-80 foot range of buffer widths. Discrepancies between field data and TMDL values may be explained by a number of factors. First, the model assumes a uniform vertical and horizontal distribution of leaves (i.e., cover) within the canopy, which may not be the case for riparian stands in western Oregon. Second, RipStream stands might not be consistent with DEQ's recommended model input parameter of 60-70% canopy cover. Finally, canopy cover input values used in the TMDL shade modeling are based on measurements occurring in the riparian area (outside of stream), whereas our RipStream measured 90% canopy cover a directly above the streams.

DEQ policy on HUA in the Siskiyou watersheds states that there can be no increase in stream temperature from forestry activities, and thus any reduction in shade can cause a stream to not meet the HUA (R. Michie, personal communication). In Fig. 3b, a 0% change in shade (Δshade) for 3 of 4 modeled curves correspond with a buffer width of 80 feet, and the remaining curves reaches 0% Δshade at a buffer width of 100 feet. These TMDL values are presented without uncertainty that is inherent in the natural world, and thus we have also considered TMDL Δshade values that are from 0 to -5% to account for some degree of uncertainty around a 0% change in shade (i.e., the value required by the HUA). These Δshade values reach this -5% threshold at a buffer width of 50 feet for all curves.

2.2 Biologically Based Numeric Criterion (NC)

In the Rogue Basin, the NC prohibits human activities, including harvesting, from increasing the seven-day-average maximum stream temperature above 16 °C for streams that have core cold water habitat, and above 18 °C for streams that have salmon and trout rearing and migration use.

Cowan *et al.* (2019) reported results from one study (Volpe, 2009) that evaluated NC. The study's treatments were thinning of wildfire fuels in riparian areas, and thus their shade dynamics are significantly different than unthinned buffers adjacent to clearcuts (i.e., the treatments from the other studies assessed in this summary). Volpe (2009) reported the number of days that exceeded NC for: 1) untreated ("control") catchments; 2) catchments that experienced thinning and prescribed fire to the stream edge; and, 3) catchments that retained a no cut buffer with upland thinning and prescribed fire. Regarding the control watersheds, one site had zero days exceeding the NC both pre- and post-harvest, and the other site decreased by a few days from pre- to post-harvest years. Of the three thinned buffer sites, one increased from 36 to 56 days/summer, one had a small increase, and one went from zero to 49 days/summer. For the

[8] The TMDL shade values in Figure 3 are based on approximations of pre-harvest stand conditions in order to compare with similar field data. These data do represent stand conditions and not site potential vegetation as used by DEQ to estimate shade targets to achieve heat load allocations set by TMDLs. Figure 3 uses shade predictions from the Mid-Coast TMDL model, and not from TMDLs in the Siskiyou region, since most of the field data are from the Coast Range. DEQ said for these TMDL models, to use 25 m tall trees, and 65% canopy cover for the mid-Coast.

no cut buffer sites, one site remained at zero days/summer pre- and post-harvest, and the other increased from three to 70 days/summer.

In extending the geographic scope, we found two additional studies that specifically address harvesting effects on NC in western Oregon (Bladon *et al.*, 2016; Groom *et al*., 2017). Groom *et al*. (2017) showed that on private land, exceedances of the NC associated with harvesting occurred at 3 sites out of a total of 18. For these three sites, daily exceedances occurred during 6 to 16% of the time over the course of one post-harvest summer (e.g., year 1 post-harvest in July and August). Buffer widths for the 3 sites with NC exceedances ranged from 56 to 82 feet with an average buffer width of 67 feet. The remaining 15 sites had buffer widths that ranged from 27 to 159 ft. with an average buffer width of 78 feet. In contrast to sites on private land, 0 sites exceeded the NC following state forest prescriptions. Furthermore, exceedances were generally only observed within the first two years following harvesting. Groom *et al*. (2017) also found exceedances of NC pre-harvest, and thereby highlighted the challenge in identifying specific causes of NC exceedances.

In the Alsea watershed, the numeric criterion for core cold-water fish (16 °C), non-core juvenile rearing and migration (18 °C), and migrating salmon and trout (20 °C) were never exceeded along stream reaches within the harvested area with a riparian buffer and downstream (~1600-2000 feet) of the harvest unit (Bladon *et al.* 2016). Reiter *et al*. (2020) also evaluated duration of stream temperature above three thresholds (15, 16, and 18 °C), which represent the thermal niche for coastal giant salamanders (15 °C) and coastal tailed frogs (16 °C), as well as the threshold for mortality of coastal tailed frog eggs (18 °C). Streams with FPA buffers did not experience changes in the duration of temperature above either threshold as a result of harvesting, which indicates harvest did not cause exceedances of NC since these thresholds are at or below those of the NC.

2.3 Cumulative Effects

The PCW indicates that water flowing into salmon, steelhead or bull trout (SSBT) stream reaches require protection so that the receiving stream does not increase ΔT more than 0.3 °C at the point of maximum impact (POMI) [9]. Additionally, HUAs[10] in temperature TMDLs have the same restriction. This measure indicates that multiple harvest units, as well as management activities on other land uses such as agricultural or urban land, may exceed the PCW and HUA downstream if their combined heat loads resulted in a ΔT > 0.3 °C at the POMI due to cumulative effects. This exceedance might occur even if ΔT at each location (e.g., harvest unit or farm) was below the 0.3 °C threshold.

Rigorously quantifying cumulative ΔT at a POMI presents many challenges, such as:

1) identifying the specific location of the POMI for a given set of harvest units throughout a small watershed;
2) quantifying the heat load for each harvest unit; and,

[9] In OAR 340-041-0028 (11), the PCW "…applies to all sources taken together at the point of maximum impact where salmon, steelhead or bull trout [SSBT] are present".

[10] OAR 340-041-0028 (12); note that stream temperature TMDLs focus on heat load as the pollutant, but temperature is the metric for attainment.

3) quantifying heat dissipation downstream of harvest units intermixed with additional heat load from other sources, which requires knowing transit times of diurnal heat pulses.

Quantifying cumulative effects, and subsequent regulation of those effects, would also require predicting when and where timber harvests are occurring within a watershed, which is not within ODF's statutory authority. Overall, development of a model to rigorously analyze cumulative effects would require many assumptions, potentially leading to spurious model results. However, we can gain some insight into the downstream heat dissipation using existing literature that involved stream temperature measurements downstream of harvests.

In western Oregon, a few studies evaluated the effects of harvesting on stream temperature further downstream from individual harvest units (Cole and Newton, 2013; Davis *et al.,* 2016; Arismendi and Groom, 2019) and paired watershed studies (Bladon *et al.* 2018). An additional study assessed cumulative effects by implementing treatments with no buffers, partial buffers, and FPA buffers intermixed with non-treatment reaches (Newton and Cole, 2013). They observed temperature decreases approximately 260 feet downstream of all treatments. However, three of four streams experienced elevated downstream temperatures relative to that of pre-harvest.

Using RipStream data, Davis *et al.* (2016) modeled ΔT 1000 feet downstream of harvest, and found the range of downstream ΔT was 82 to 1% (56% on average) of that at the downstream end of the harvest reach. The primary factors that influenced the downstream temperature changes included stream width, depth, and gradient.

Arismendi and Groom (2019) further evaluated these same RipStream data. They observed mixed findings with regard to downstream ΔT. For example, 50% of the sites showed increases and the other 50% showed decreases in the difference between the downstream and harvest reaches first summer post-harvest. Across all post-harvest years, the downstream ΔT increased 0.2 °C on average. The greatest differences between the treatment and downstream reaches were observed during the first and second year post-harvest (Arismendi and Groom, 2019). By year 5 post-harvest, temperature patterns downstream were most similar to pre-harvest conditions, which may partially be explained by increasing understory vegetation near the channel in response to greater light availability following harvesting. Overall, their results suggests streams may warm or cool downstream prior to and after harvesting. As described above, there is evidence other factors (e.g., stream morphology) likely play an important role in determining temperature response of reaches downstream of harvesting.

From the paired catchment studies, Bladon *et al.* (2018) evaluated downstream ΔT for sites that ranged from 50 to 4659 feet from the downstream boundary of harvest units. There was strong evidence that downstream cooling did occur once streams exited the harvested unit and entered into unharvested areas, and no evidence for warming at downstream sites. Downstream transport of ΔT was primarily controlled by bedrock characteristics and percentage of harvested area within the catchment. In catchments with a less permeable bedrock, the thermal regime appeared to be more tightly coupled with the effective shade provided by vegetation (i.e., greater temperature increases in response to harvesting). Bladon *et al.* (2018) suggested geology played an important role in influencing downstream transport of heat due to the role of the underlying lithology in determining the relative proportions of surface flow, groundwater, and subsurface flow. In more permeable geology, streamflow is primarily dominated by groundwater, which tends to be cooler and thermally stable compared to surface water during the summer.

Data gaps

There were no analyses of:

- Heat transport downstream of harvests (only temperature down stream of harvests was analyzed)
- The effect of thinned buffers adjacent to clearcuts, on stream shade or temperature
- The impact on stream shade or temperature due to differences in:
  - stand density
  - stream flow for small vs. medium streams or
  - stream width

Limitations

Out of scope for this report were:

- Additional impacts of climate change on stream temperature and shade
- Assessment of the extent, if any, of different harvest-related impacts on stream temperature and shade from different forest types in the Siskiyou vs. those of the rest of western Oregon, or the resulting confidence in extrapolating results from western Oregon to the Siskiyou
- A rigorous analysis of variables that explain outcomes of studies

3. Conclusions

In extending the geographic scope of the Siskiyou Streamside Protections Review we reviewed recent literature in addition to literature that was reviewed in Czarnomski *et al.* (2013) and Cowan *et al.* (2019). Our review of relevant literature suggests implementation of current FPA rules likely do not meet the PCW ($\Delta T \leq 0.3$ °C) criterion of water quality standards. For example, studies with buffers similar to those of the FPA had ΔT in the 0.9-1.5 °C range. This conclusion is further supported by Groom *et al.* (2018), who show that buffer widths less than 90 feet are likely to result in exceedances of the PCW. Previous work by ODF staff also show implementation of minimum FPA requirements for vegetation retention would result in buffer widths of 23 and 41 feet along small and medium streams, respectively, in the Coast Range. These widths correspond to ΔT of 1.9 and 1.4 °C, respectively.

Furthermore, we show 88% of sites with buffers widths 20 to 70 feet and 73% sites of sites with buffers >70 feet appear to exceed the PCW (Table 1) for most relevant studies that involved implementation of FPA rules for vegetation retention along streams during logging operations. It is worth noting Groom *et al.* (2011a) applied a more rigorous approach to evaluating PCW for RipStream sites and found sites on private land had a 40% probability of exceeding the PCW. The discrepancy between Groom *et al.* (2011a) and our analysis may be due to a few reasons including the larger geographic used in this analysis and the use of multiple post-harvest years by Groom *et al.* (2011a).

There is evidence that clear-cut harvesting under FPA rules for fish streams resulted in a net loss of shade as a result of harvesting, which likely explains exceedances of the PCW ($\Delta T \leq 0.3$ °C), and therefore also the HUA ($\Delta T = 0$ °C).The DEQ TMDL modeling predicts 0% Δshade as a

result of harvesting when buffer widths are ~80 feet or greater, and less than a 5% Δshade when buffer widths are ~50 feet or greater. Results from recent studies partially confirms the model projections from the TMDL model, although there are a few inconsistencies. For example, the RipStream study showed greater actual post-harvest decreases in Δshade than that of the TMDL model for buffer widths of 50 to 80 feet.

In contrast to the PCW, sites appeared to infrequently exceed the NC. We found that 17% of sites with buffer widths of 20-70 feet, and 9% of sites with buffer widths >70 feet, exceeded the NC. All exceedances were observed in the RipStream study, whereas the five sites in the Alsea and Trask Watershed studies did not appear to exceed the NC (Table 1). Considering shade, most of these field data are in the range of TMDL shade values, which likely explains why NC is met at most sites harvested following the FPA.

Table 1. Summary of data from relevant studies that identify whether the FPA is meeting water quality standards. This table includes studies that implemented current FPA prescriptive rules on vegetation retention along streams[11]. The number of sites that appeared to meet or not meet the PCW and NC, as well as total number of and percentage of sites, are provided.

Study	**# of Sites**	**= FPA or > FPA**	**Buffer width (ft.) Mean (Range)**	**Appear to Meet PCW? (# of Sites)**		**Appear to Meet NC? (# of Sites)**	
				Yes	No	Yes	No
Dent and Walsh (1997)	4	> FPA	88 (75 – 100)	0	4	-	-
Newton and Cole (2013)	3	= FPA	49	1	2	-	-
RipStream: Groom *et al.* (2011); Groom *et al.* (2017)	7	= FPA	52 (27 – 62)	0	7	5	2 [a]
	11	> FPA	107 (71 – 159)	4	7	10	1 [a]
Bladon *et al.* (2016)	2	= FPA	49	-	-	2	0 [b]
Bladon *et al.* (2018)	7	= FPA	43 (26 – 66)	1	6	-	-
Reiter *et al.* (2020)	3	= FPA	43 (37 – 54)	-	-	3	0 [c]
		= FPA	***Total:***	***2***	***15***	***10***	***2***
			Percentage:	***12%***	***88%***	***83%***	***17%***
		> FPA	***Total:***	***4***	***11***	***10***	***1***
			Percentage:	***27%***	***73%***	***91%***	***9%***

[a]Numeric criterion included a 16 °C criterion for sites with salmon and anadromous trout core cold-water habitat and an 18 °C criterion for sites used for non-core juvenile rearing and migration by salmon and trout.

[b]Stream temperature never exceeded the 16 °C criterion for salmon and anadromous trout core cold-water habitat, the 18 °C criterion for sites for rearing and migration by salmon and trout, or the 20 °C for migrating salmon and trout.

[c]Although the numeric criterion was not explicitly tested, Reiter *et al.* (2020) show that stream temperature of buffered streams never exceed 15, 16 or 18 °C, which corresponds with the upper thermal niche for coastal giant salamanders (15 °C) and coastal tailed frogs (16 °C), as well as the threshold for mortality of coastal tailed frog eggs (18 °C).

[11]Not including sites that implemented additional forest management plans (e.g., ODF State Forest Northwest Forest Management Plan)

In consideration of TMDL shade values, our results suggest that assuming a 0-meter gap in vegetation with DEQ's recommended 60-70% canopy cover for a 50 year-old Douglas fir stand sets a high shade target of 91% that are achieved by about thirty percent of pre-harvest sites (Table 2). In contrast, all pre-harvest stands were capable of achieving a shade value of 68%, which was the TMDL shade value for a 2-meter gap. Most of these stands continued to provide post-harvest shade equaling or exceeding 68% (Table 3). While maximizing shade and canopy cover for streams is an important goal, it is important to identify inherent limitations of riparian stands in providing shade to streams. In some cases, stream temperature decreased further downstream for some sites, but it also increased downstream for other sites. In the paired watershed Studies in western Oregon, there was strong evidence that downstream cooling of harvest units occurred[12].

Table 2. Pre-harvest comparison of treatment sites with DEQ effective shade lookup tables for 82 foot tall vegetation, at 65% riparian canopy density.

Study	**# of Sites**	**Buffer width (ft.) Mean (Range)**	**Meet 0-m gap TMDL curve max (91%)? (# of Sites)**		**Meet 2-m gap TMDL curve max (68%)? (# of Sites)**	
			Yes	No	Yes	No
McIntyre (2018)	4	NA	2	2	4	0
Reiter (2020)	5	NA	1	4	5	0
RipStream[a]	31	NA	9	22	31	0
	7[b]	NA				
		Total:	***12***	***28***	***40***	***0***
		Percentage[c]:	***30%***	***70%***	***100%***	***0%***

[a] Groom *et al.* (2011; 2017)
[b]Sites listed in Table 3 (subset of 31 listed in previous line).
[c]For sites listed in Table 3, 16/16 (100%) meet 68% shade criterion.

[12]Not including sites that implemented additional forest management plans (e.g., ODF State Forest Northwest Forest Management Plan)

Table 3. Post-harvest comparison of treatment sites with DEQ effective shade lookup tables for 82 foot tall vegetation, at 65% riparian canopy density.

Study	# of Sites	Buffer width (ft.) Mean (Range)	Meet 0-m gap TMDL curve max (91%)? (# of Sites)		Meet 2-m gap TMDL curve max (68%)? (# of Sites)	
			Yes	No	Yes	No
Allen and Dent (2001)	12	48 (20 – 70)	8	4	11	1
McIntyre (2018)	4	50	0	4	3	1
Reiter (2020)	5	36 (23 – 54)	0	5	4	1
RipStream: Groom *et al.* (2011) Groom *et al.* (2017)	7	52 (27-62)	0	7	4	3
		Total:	***8***	***20***	***22***	***6***
		Percentage:	***29%***	***71%***	***79%***	***21%***

*Of studies with pre-harvest data, 69% (11/16) of post-harvest treatments meet the TMDL value of shade for 2-m gap.

4. References (includes citations in appendices)

Allen M, Dent L., 2001. Shade conditions over forested streams in the Blue Mountain and Coast Range georegions of Oregon. Oregon Department of Forestry. Technical Report #13.

Anderson, P.D., Larson, D.J., Chan, S.S., 2007. Riparian buffer and density management influences on microclimate of young headwater forests of western Oregon. Forest Science 53, 254–269.

Anderson, P.D., Poage, N.J., 2014. The Density Management and Riparian Buffer Study: A large-scale silviculture experiment informing riparian management in the Pacific Northwest, USA. Forest ecology and management 316, 90–99.

Arismendi, I., Groom, J.D., 2019. A novel approach for examining downstream thermal responses of streams to contemporary forestry. Science of The Total Environment 651, 736–748.

Bateman, D.S., R.E. Gresswell, D. Warren, D.P.Hockman-Wert, D.W. Leera, J.T. Light, J.D. Stednick, 2018. Fish response to contemporary timber harvest practices in a second-growth forest from the central Coast Range of Oregon. Forest Ecology and Management 411 (2018) 142–157. https://doi.org/10.1016/j.foreco.2018.01.030

Bladon, K.D., Cook, N.A., Light, J.T., Segura, C., 2016. A catchment-scale assessment of stream temperature response to contemporary forest harvesting in the Oregon Coast Range. Forest ecology and management 379, 153–164.

Bladon, K.D., Segura, C., Cook, N.A., Bywater-Reyes, S., Reiter, M., 2018. A multicatchment analysis of headwater and downstream temperature effects from contemporary forest harvesting. Hydrological Processes 32, 293–304.

Brazier JR, Brown G.W., 1973. Buffer strips for stream temperature control. OSU School of Forestry: Corvallis, OR

Cole, E., Newton, M., 2013. Influence of streamside buffers on stream temperature response following clear-cut harvesting in western Oregon. Canadian Journal of Forest Research 43:993-1005.

Cole E, Newton M., 2015. Relationships between radiation and canopy closure estimates in streamside buffers in western Oregon. For. Sci. 61(3):559–569.

Cowan, A.D., Frueh, W.T., Allen, M., 2019. Siskiyou Streamside Protections Review: A Systematic Review on Stream Temperature, Shade, and Desired Future Condition: Report. Oregon Department of Forestry.

Czarnomski, N.; Hale, C.V.; Frueh, W.T.; Allen, M.; Groom, J.D. 2013. Effectiveness of Riparian Buffers at Protecting Stream Temperature and Shade in Pacific Northwest Forests: A Systematic Review. Final Report September 2013.

Davis, L.J., Reiter, M., Groom, J.D., 2016. Modelling temperature change downstream of forest harvest using Newton's law of cooling. Hydrological Processes 30, 959–971.

Dent, L.F., Walsh, J.B.S., 1997. Effectiveness of riparian management areas and hardwood conversions in maintaining stream temperature. Oregon Department of Forestry, Forest Practices Technical Report 3.

Gomi, T., Moore, R.D., Dhakal A.S., 2006. Headwater stream temperature response to clear-cut harvesting with different riparian treatments, coastal British Columbia, Canada. Water Resources Research 42, W08437.

Groom, J.D., Dent, L., Madsen, L.J., 2011a. Stream temperature change detection for state and private forests in the Oregon Coast Range. Water Resources Research 47, W0151.

Groom, J.D., Dent, L., Madsen, L.J., Fleuret, J., 2011b. Response of western Oregon (USA) stream temperature to contemporary forest management. Forest Ecology and Management 262:1618-1629.

Groom, J.D., Johnson, S.L., Seeds, J.D., Ice, G.G., 2017. Evaluating links between forest harvest and stream temperature threshold exceedances: The value of spatial and temporal data. JAWRA Journal of the American Water Resources Association 53, 761–773.

Groom, J.D., Madsen, L.J., Jones, J.E., Giovanini, J.N., 2018. Informing changes to riparian forestry rules with a Bayesian hierarchical model. Forest ecology and management 419, 17–30.

Guenther, S.M., Gomi, T., Moore, R.D., 2014. Stream and bed temperature variability in a coastal headwater catchment: influences of surface-subsurface interactions and partial-retention forest harvesting. Hydrological Processes 28, 1238–1249.

Hairston, A.B., 1996. Response to water protection rule changes in the Oregon Forest Practices Act: Landowner/operator opinions and streamside conditions. PhD Dissertation. Oregon State University. September 27, 1996.

Heimann, D.C., 1988. Recruitment trends and physical characteristics of coarse woody debris in Oregon Coast Range streams. MS thesis. Forest Engineering, Oregon State University. August 9, 1988.

Janisch, J.E., Wondzell S.M., Ehinger W.J., 2012. Headwater stream temperature: Interpreting response after logging, with and without riparian buffers, Washington, USA. Forest Ecology and Management 270: 302-313.

Jones, B.E., Krupa, M., Tate, K.W., 2013. Aquatic ecosystem response to timber harvesting for the purpose of restoring Aspen. PloS one 8.

Kaylor, M.J., Warren, D.R., 2017. Linking riparian shade and the legacies of forest management to fish and vertebrate biomass in forested streams. Ecosphere 8(6):e01845. 10.1002/ecs2.1845.

Kibler, K.M., Skaugset, A., Ganio, L.M., Huso M.M., 2013. Effect of contemporary forest harvesting practices on headwater stream temperatures: Initial response of the Hinkle Creek catchment, Pacific Northwest, USA. Forest Ecology and Management 310 (2013) 680–691.

Leach, J.A., Olson, D.H., Anderson, P.D., Eskelson, B.N.I., 2017. Spatial and seasonal variability of forested headwater stream temperatures in western Oregon, USA. Aquatic sciences 79, 291–307.

McIntyre, A.P., Hayes, M.P., Ehinger, W.J., Estrella, S.M., Schuett-Hames, D., Quinn, T., 2018. Effectiveness of Experimental Riparian Buffers on Perennial Non-fish-bearing Streams on Competent Lithologies in Western Washington (Technical Report No. CMER 18-100), Cooperative Monitoring, Evaluation and Research Report. Washington Department of Natural Resources, Olympia, Washington.

Morman, D., 1993. Riparian rule effectiveness study report. Forest Practices Program, Oregon Department of Forestry [online] Available from: http://www.getcited.org/pub/100206391 (Accessed 19 February 2013)

Newton M., Cole E.C., 2013. Stream temperature and streamside cover 14-17 years after clearcutting along small forested streams, western Oregon. Western Journal of Applied Forestry 28: 107–115.

Oregon Department of Environmental Quality, 2008. Rogue River Basin TMDL.

Oregon Department of Forestry, 2015a. Riparian Rule Analysis: Methods for evaluating prescriptions and their geographic extent. Board of Forestry Meeting, April 22. Attachment 3.

Oregon Department of Forestry, 2015b. Decision Matrix. Board of Forestry Meeting, July, 23. Attachment 1.

Piccolo, J.J., Wipfli, M.S., 2002. Does red alder (*Alnus rubra*) in upland riparian forests elevate macroinvertebrate and detritus export from headwater streams to downstream habitats in southeastern Alaska? Can. J. Fish. Aquat. Sci. 59: 503–513 (2002) DOI: 10.1139/F02-019.

Reiter, M., Johnson, S.L., Homyack, J., Jones, J.E., James, P.L., 2020. Summer stream temperature changes following forest harvest in the headwaters of the Trask River watershed, Oregon Coast Range. Ecohydrology, e2178. DOI: 10.1002/eco.2178

Ridgeway, J., 2019. An analysis of changes in stream temperature due to forest harvest practices using DHSVM-RBM. M.S. Thesis, California Polytechnic State University. June 2019.

Steinblums, I.J., 1977. Streamside buffer strips: Survival, effectiveness, and design. M.S. Thesis, Oregon State University. June 22, 1977.

Steinblums, I.J., Froehlich, H.A., Lyons, J.K., 1984. Designing stable buffer strips for stream protection. Journal of Forestry 82: 49–52.

Veldhuisen, C., Couvelier, D., 2006. Summer Temperatures of Skagit Basin Headwater Streams: Results of 2001 – 2003 Monitoring.

Volpe, C.J., 2009. Effects of prescribed riparian fire in small headwater streams in the Rogue River basin, southwest Oregon. USDI-BLM agency report. Bureau of Land Management, Medford, OR.

Warren, D.R., Keeton, W.S., Bechtold, H.A., Rosi-Marshall, E.J., 2013. Comparing streambed light availability and canopy cover in streams with old-growth versus early-mature riparian forests in western Oregon. Aquat Sci (2013) 75:547–558 DOI 10.1007/s00027-013-0299-2.

Appendix I. Geographic Area Covered by Report

This appendix shows the geographic scope, per Board direction, for studies to be considered relevant for this report (Figure I.1), and sites from studies included in the report (Figure I.2).

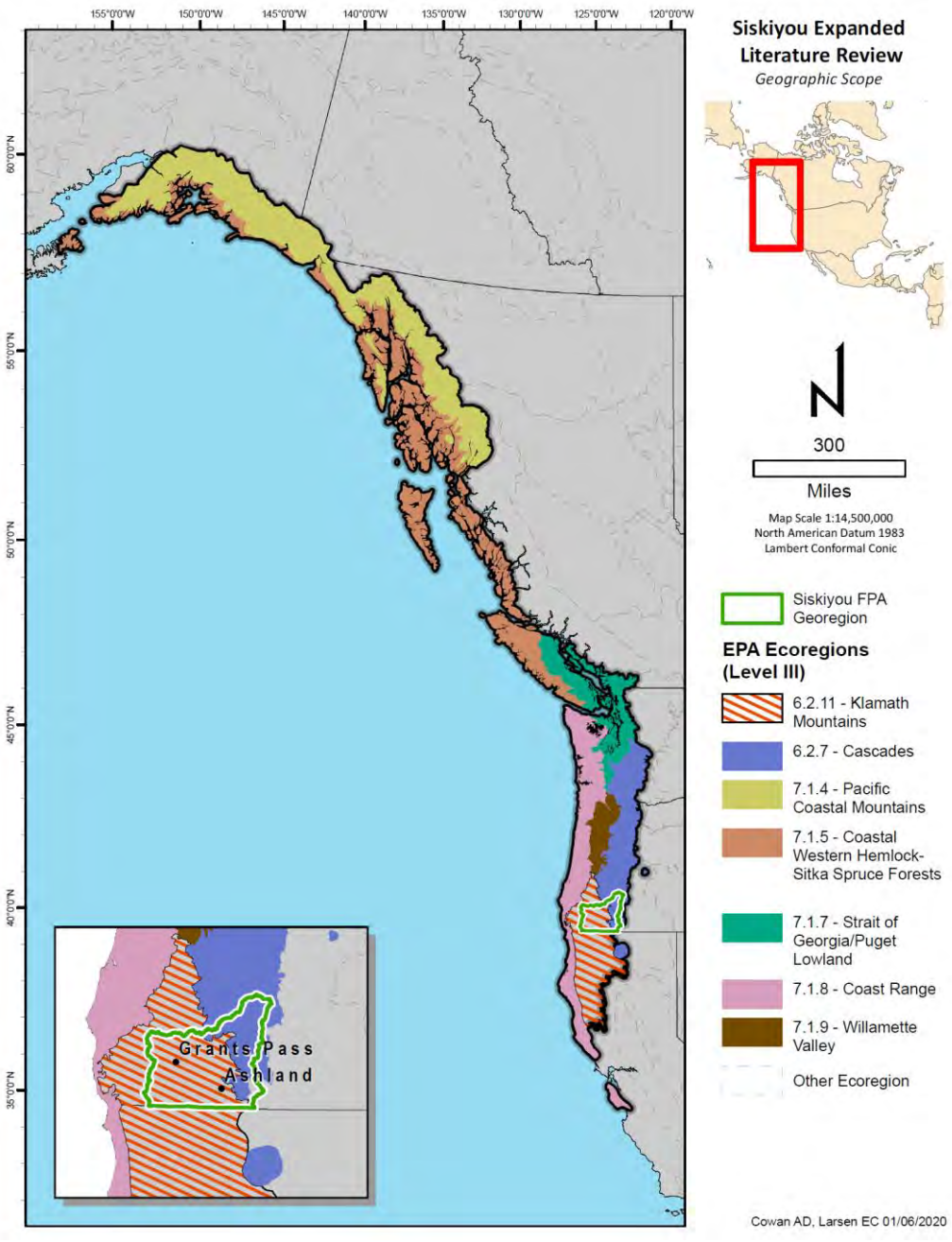
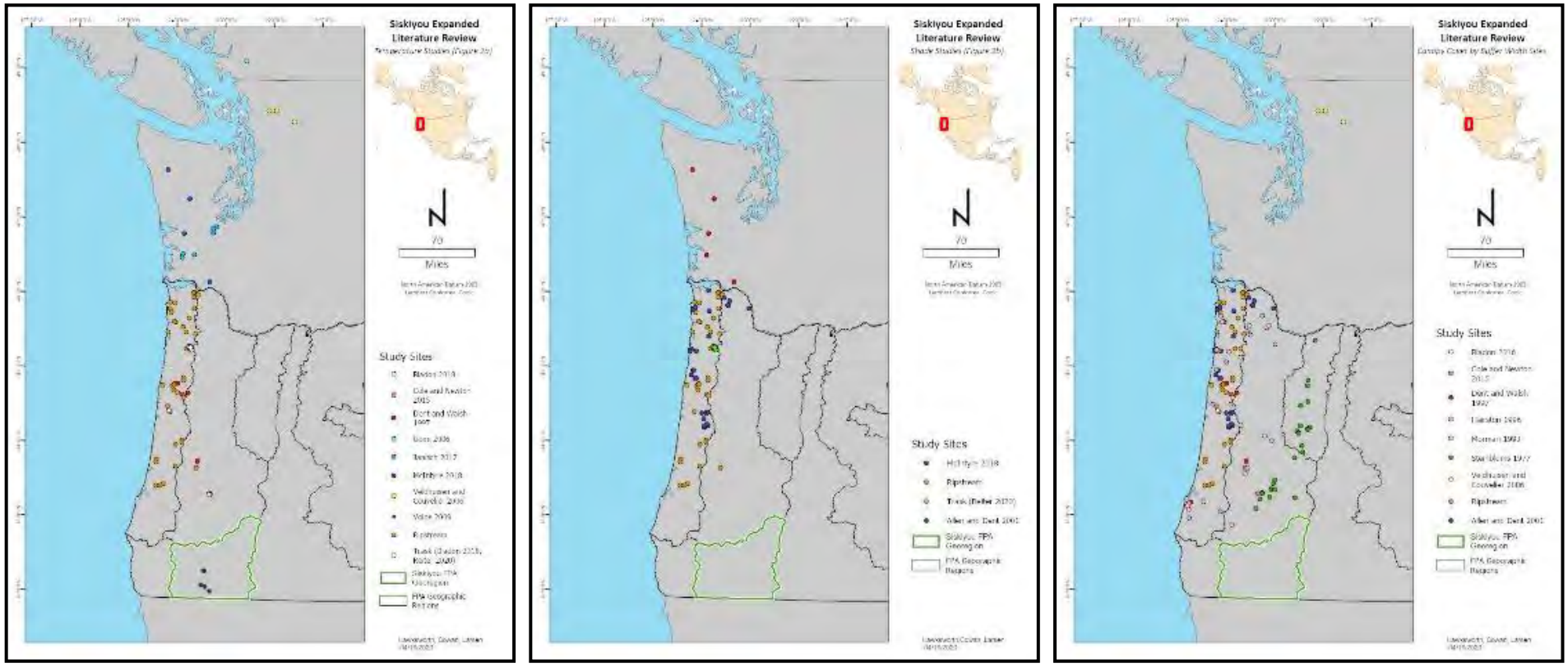


Figure I.1. Map of expanded geography, per Board direction, for studies to be considered in this summary. Map credits: Ariel D. Cowan and Erik C. Larsen.



A. B. C.

Figure I.2. Distribution of survey sites for studies in the literature review, relative to the Siskiyou FPA Geographic Region. A). Temperature studies listed in Report Figure 2a. B). Shade studies listed in Report Figure 3. C). Studies that reported both canopy cover and buffer width. Brazier and Brown (1973) was not included in panel A because of uncertainty in site locations.

Appendix II. Instream Canopy Cover

To understand the range of instream canopy covers experienced in the field, we analyzed data from the literature. This resulted in a median estimate of 79% (Range 37%-96%; Bateman *et al.* 2018, Bladon *et al.* 2016, Anderson *et al.* 2007), with most of the data from Oregon (mostly, Coast Range, some west Cascades). The largest single dataset came from RipStream (Figure II.1). Most of these stands exceeded 90% instream canopy cover, with few stands less than 80%. These estimates can assist with understanding the range of variability in natural riparian stands, and can be used for comparison with the Siskiyou Forest Practices Geographic Region.

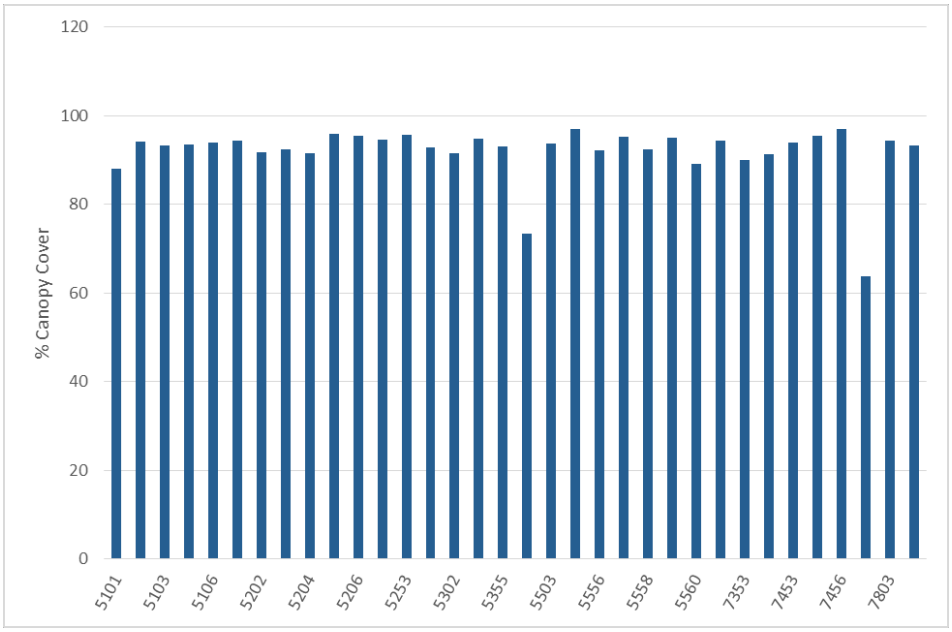


Figure II.1. Pretreatment mean instream canopy cover at RipStream sites. Mean 92%, Median 94%, Range 64-97%.

We further estimated instream canopy cover with age from a subset of eight studies representing 134 sites (Figure II.2). This estimation was considered important to determine how quickly baseline characteristics might be achieved, and whether there was a peak age for riparian canopy cover. Figure II.2 indicates that cover similar to baseline may be achieved by 20 years of age, although 30 may be a more conservative estimate. Once this age is achieved, there is little systematic variation in canopy cover.

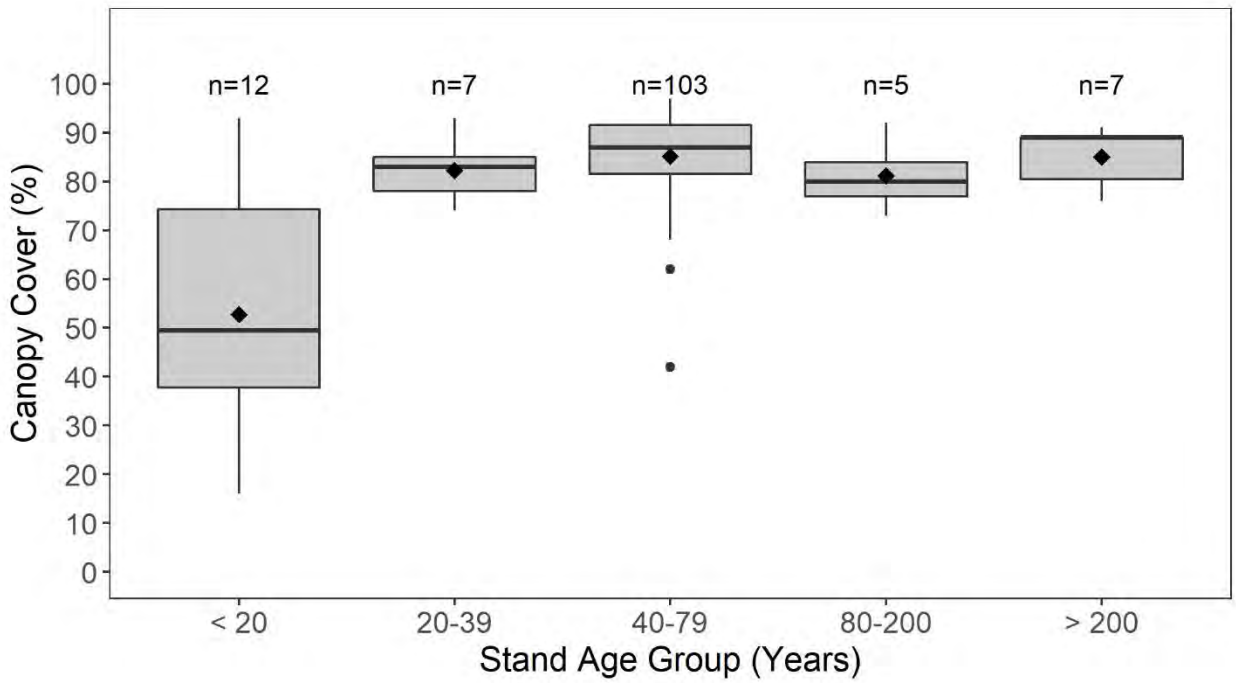


Figure II.2. Box plots of instream canopy cover as a function of stand age. "n" represents the number of sites within each age group; boxes represents the 25th to the 75th percentile of the data. The central line represents the median, while the central dot represents the mean; vertical lines represent the minimum and maximum ranges, except for dots beyond these lines that represent outliers. Stands in this figure exceeding 20 years of age had a median canopy cover[13] of 87%. Source: Allen and Dent, 2001; Bladon *et al.*, 2016; Brazier and Brown, 1973; Cole and Newton, 2015; Dent and Walsh, 1997; Hairston, 1996; Heimann, 1988; Kaylor and Warren, 2017; Kibler *et al.*, 2013; Morman, 1993; Newton and Cole, 2013; Piccolo and Wipfli, 2002; RipStream; Steinblums *et al.,* 1984; Veldhuisen and Couvelier, 2006; Warren *et al.*, 2013. In general, a number of studies have indicated a weak increasing trend of canopy cover with increasing buffer width. In our analysis, canopy cover was highly variable for buffer widths less than 75' across all data sets (data not shown). For example, instream canopy cover at a 50' buffer width ranged from 15%-95%, while buffers approximating 100' ranged from 60%-93%. Similar to shade, we found that decreases in canopy cover from pre- to post-harvest were greatest for smaller buffer widths (data not shown).

[13] Canopy cover is the percentage of visible sky blocked by vegetation (foliage, branches, stems) or topographic features, whereas effective shade is the percent reduction of potential daily solar radiation load delivered to the stream surface (DEQ 2008).

Appendix III. Methods

In the process of summarizing and extracting data from the literature, we also noted stream temperature and shade metrics used in the relevant papers, data sources within each paper, and how ODF staff or authors of the paper calculated changes in stream temperature (Tables III.1 and III.2). One challenge in analyzing and comparing results among different studies is in using multiple sources of data that have different metrics, as well as differences in study design.

The temperature metric most appropriate for evaluating PCW and NC is the 7-day moving average of daily maximum. In this analysis, we included results from studies that did not use this metric (Table III.1) because we felt that this information still provided valuable insight into the effects of harvesting on stream temperature. In summarizing exceedances of DEQ water quality standards in Table 1, most studies used the 7-day moving average of daily maximum, with two exceptions. Cole and Newton (2013) reported average daily maximum values, and Reiter *et al.* (2020) reported 30-minute stream temperature data. The Cole and Newton (2013) paper was used to assess PCW exceedances, whereas Reiter *et al.* (2020) was used to evaluate NC exceedances.

Regarding the use of daily maximum versus 7-day moving average of daily maximum, it is likely that both metrics will yield similar results, especially when these values are averaged over a period of a month or so, a common approach for studies used in the analysis. To test whether metrics would yield different results, we randomly generated stream temperature daily maximum values over a period of a month. We then compared a monthly average daily maximum values and a monthly average of 7-day moving average of daily maximum. Both approaches resulted in nearly identical values, which suggests that results from Cole and Newton (2013) are appropriate for testing exceedances of the PCW.

Regarding the use of 30-minute data vs. 7-day moving average of daily maximum stream temperature data to test the NC, Reiter *et al.* (2020) did not detect exceedances. A series of 30-minute stream temperature data over a period of a day or more includes daily maximums. Therefore, if no 30-minute stream temperature measurements exceed the NC, neither the daily maximum or 7-day moving average of daily maximum would have exceeded the NC.

Another caveat to the analysis in this report is that a few studies did not report pre-harvest stream temperature results (Brazier and Brown, 1973; Veldhuisen and Couvelier, 2006) or did not report pre-harvest data for sites that could be used in this analysis (Dent and Walsh, 1997). Pre-harvest measurements are used to account for inter-annual variability in stream temperature, which can potentially influence the change in stream temperature through a harvest unit. Note that Dent and Walsh (1997) was used in Table 1 due to geographic relevance and implementation of FPA buffers. Results from Brazier and Brown (1973) and Veldhuisen and Couvelier (2006) were only used in Figures 1 and 2.

In the shade analysis (Fig. 3a, b), we included predicted shade values from the Mid-Coast TMDL model, assuming 82-foot tall trees (mean tree height from RipStream; Groom *et al.*, 2011b) and riparian canopy cover of 60-70%. The 0-meter gap was chosen because that was the only assumption that matched DEQ system potential shade as quantified in shade curves in their

TMDLs (under system potential tree height and canopy density conditions, e.g., Rogue River TMDL (DEQ, 2008)) The 2-meter gap was also selected since Groom *et al.* (2011b) found that wetted width of streams studied in the RipStream study were 2 m on average, and DEQ uses wetted width as an approximation of vegetation gaps in the canopy above a stream.

Table III.1 Summary information for studies used in the stream temperature analysis of this report including stream temperature metrics, specific location of the data sources, and a brief description of how ΔT was calculated[14]e

Study	Geographic Region	Study Design	Water Quality Standard	Stream Temperature Metrics	Data Source	Calculation of ΔT
Bladon *et al.* (2016)	Coast Range, Oregon	Paired Catchment	NC	7-day moving average of daily maximum	Text of discussion, pg. 161	--
Bladon *et al.* (2018)	Coast Range, Oregon	Paired Catchment	PCW	7-day moving average of daily maximum	Figure 3* (data extracted)	1
Brazier and Brown (1973)	Coast Range and Interior, Oregon	Upstream/downstream	PCW	Average	Table 1 (Observed Temperature)	2
Cole and Newton (2013)	Coast Range and Interior, Oregon	Upstream/downstream	PCW	Daily maximum	Authors provided requested data to ODF	3
Dent and Walsh (1997)	Coast Range and Interior, Oregon	Upstream/downstream	PCW	7-day moving average of daily maximum	Table 3	2
Gomi et al. (2006)	Coastal British Columbia	Paired Catchment	PCW	Daily maximum	Table 3 (C, D, & H; Summer)	4
Janisch et al. (2012)	Western Washington	Paired Catchment	PCW	Daily maximum	Figure 3b (Continuous buffers)	4
McIntyre *et al.* (2018)	Western Washington	Paired Catchment	PCW	Daily maximum	Table 7-6 (OLYM, CASC, WIL1, WIL2); July and August	4, 5
Reiter *et al.* (2020)	Coast Range, Oregon	Paired Catchment	NC	30-min. stream temperature	Text of results and discussion	-
RipStream Groom *et al.* (2011, 2017, & 2018)	Coast Range and Interior, Oregon	Upstream/downstream	PCW, NC	7-day moving average of daily maximum	2014 Board of Forestry Workshop	3
Veldhuisen and Couvelier (2006)	Western Washington	Upstream/downstream	PCW	7-day moving average of daily maximum	Appendix 2, 3, 4b	2
Volpe (2009)	Siskiyou, Oregon	Paired Catchment	PCW, NC	7-day moving average of daily maximum	Table 2 (US2, F2, B1, LS2, F1)	1

[1]$\Delta T = (T_{Post.treatment} - T_{Pre.treatment}) - (T_{Post.reference} - T_{Pre.reference})$

[2]$\Delta T = T_{upstream} - T_{downstream}$

[3]$\Delta T = (T_{Post.downstream} - T_{Post.upstream}) - (T_{Pre.downstream} - T_{Pre.upstream})$

[4]$\Delta T = T_{Observed} - T_{Predicted}$; Regression analysis used to develop equations that described relationship between pre-harvest treatment vs. control. Equations were then used to predict post-harvest temperature ($T_{Predicted}$) at treatment reaches using control post-harvest. Observed values ($T_{Observed}$) included measured post-harvest stream temperature.

[5]Daily ΔT was averaged for each month to obtain a mean monthly temperature response.

[14] Note: a publication came to our attention from the Siskiyou Advisory Committee's review for the first draft of this report, "An analysis of changes in stream temperature due to forest harvest practices using DHSVM-RBM" by Ridgeway (2019). Whereas it passed all the inclusion criteria, we decided not to include it since the analysis only included modeled stream temperature values that were not validated at the location of the harvest in California, and would have therefore required its own distinct section and discussion, and cannot be rigorously compared with field data.

Table III.2. Summary information for studies used in the shade and canopy cover analysis of this report including timing of measurement relative to harvesting, specific location of the data sources, and a brief description of methodology and measurements.

Study	Geographic Region	Study Design	Parameter	Measurement Timing	Data Source	Measurement Method
Allen and Dent (2001)	Coast Range, Oregon	Multiple Watershed	Shade, Canopy cover	Postharvest, with unharvested controls	Tables A-1 and B-1	Hemispherical Photos; Densiometer
McIntyre *et al.* (2018)	Western Washington	Paired Catchment	Shade, Canopy cover	Preharvest, Postharvest	Appx Table 7-B-1, 7-B-2, 7-B-5	Hemispherical Photos; Densiometer
Reiter *et al.* (2020)	Coast Range, Oregon	Paired Catchment	Shade	Preharvest, Postharvest	Table 1	Hemispherical Photos
RipStream	Coast Range and Interior, Oregon	Upstream/downstream	Shade, Canopy Cover	Preharvest, Postharvest	ODF Data	Hemispherical Photos; Densiometer
Bladon *et al.* (2016)	Coast Range, Oregon	Paired Catchment	Canopy Cover	Preharvest, postharvest	Text of discussion, pg. 154	Densiometer
Brazier and Brown (1973)	Coast Range and Interior, Oregon	Upstream/downstream	Canopy Cover	Postharvest	Table 1 (Angular Canopy Density)	Angular Can. Densiometer
Cole and Newton (2015)	Coast Range and Interior, Oregon	Upstream/downstream	Canopy Cover	Preharvest, Postharvest	Table A-1	Multiple, Densiometer numbers used.
Dent and Walsh (1997)	Coast Range and Interior, Oregon	Upstream/downstream	Canopy Cover	Postharvest with control reach, 1 site preharvest	Appendix A.	Densiometer, Fisheye lens camera
Hairston 1996	Western Oregon	Paired Catchment	Canopy Cover	Postharvest	Appendix A	Densiometer
Heimann (1988)	Coast Range, Oregon	Multiple Watershed	Canopy Cover	Postharvest	Table 7 (page 44)	Densiometer
Kaylor and Warren(2017)	HJ Andrews, WC, Oregon	Upstream/Downstream	Canopy Cover	Preharvest, Postharvest	Table 1 (page 5)	Densiometer
Kibler et al (2013)	Hinkle Cr, Interior, Oregon	Paired Catchment	Canopy Cover	Preharvest, Postharvest	Table 5 (p 688), and text on pages 686-687	Densiometer

Table III.2. *cont.*

Study	Geographic Region	Study Design	Parameter	Measurement Timing	Data Source	Measurement Method
Morman. (1993)	Western Oregon	Multiple Watershed	Canopy Cover	Preharvest, Postharvest	Section 3: pages 47-149	Densiometer
Newton and Cole (2013)	Coast Range, Interior, Oregon	Upstream/Downstream	Canopy Cover	Postharvest	Table 4	Densiometer
Piccolo and Wipfli (2002)	Prince of Wales Is., SE Alaska	Multiple Watershed, replicated	Canopy Cover	Postharvest	Table 1 (p 506)	Viewing Tube
Steinblums (1977)	Western Cascade and Interior, Oregon	Multiple Watershed	Canopy Cover	Postharvest	Table 2 (US2, F2, B1, LS2, F1)	Angular Can. Densiometer
Veldhuisen and Couvelier (2006)	Western Washington	Upstream/downstream	Canopy Cover	Postharvest	Appendix 4a	Densiometer
Warren et al (2013)	HJ Andrews, WC, Oregon	Upstream/Downstream	Canopy Cover	Postharvest, SG with OG reference	Table 2 (p 552)	Densiometer

Appendix IV. Stakeholder Feedback on Draft Report

Comments from all stakeholders are compiled into themes, along with their respective ODF responses.

Theme: How are Desired Future Conditions (DFC) being addressed in this report?

Response: In addition to temperature, this review covered information on the shade component of DFC. The other components of DFC will be addressed in a separate forthcoming report.

Theme: Please provide detailed comparisons between the design and location of the studies included in this report.

Response: Based on previous stakeholder feedback and limited time, the Monitoring unit elected to use a less intensive version of a systematic review. As a result, detailed information comparing each study was out of scope. However, the report discusses the relevance of each study to the Forest Practices Act (FPA) rules.

Theme: Be clearer about what conclusions are statistically-based and reword references to magnitude of evidence without statistical results.

Response: The discussion and conclusion sections were reworded to address this concern. The methods outlined before starting the literature review stated that no new analysis would be conducted with this review (only use statistical results provided in the included literature).

Theme: The point of maximum impact (POMI) and analysis of the Numeric Criterion (NC) exceedances needs further addressing.

Response: The ODF Monitoring unit is currently working with DEQ to discuss related topics, and we appropriately modified wording in the report related to NC and POMI.

Theme: Why is flow not included in this report?

Response: The current scope of this rule review does not consider flow. However, the Board of Forestry can request a review on impacts of rules regarding flow.

Theme: Why is climate change not mentioned in this report?

Response: Climate change is not addressed in the FPA and this review specifically assesses the rule's goals as they were written in the FPA. Per the Board's direction, the Monitoring Unit provided contextual information to the Board on climate change in the Siskiyou by inviting experts to present on the subject at the June 2020 Board of Forestry meeting.

Theme: Why are geology, stream size, width, basal area and other variables not part of the analysis?

Response: Stream characteristics like size and geology are considered important effects modifiers. However, extensive analysis of these characteristics was not one the objectives of the rule review, although we acknowledge it in the report as data gaps. The format of this review

did not include any new analysis. A figure with additional discussion on basal area was added to the report.

Theme: "ODF states that 17% of sites with buffer widths of 20-70 feet and 9% of sites with buffer widths less than 70 feet exceeded the NC. We are concerned that evidence of exceedances of the NC (17% of sites with buffers 20-70 feet) has been characterized as "little evidence." Under the Clean Water Act, any exceedance of the water quality standard would be a violation."

Response: The report has been updated to address these concerns.

Theme: ODF should provide more context on limitations and assumptions for this report.

Response: The report has been updated to address these concerns.

Theme: ODF should more specifically address how RipStream field data shows the PCW is likely not met with buffer widths less than 90 feet (Groom *et al.* 2018) and buffer widths >50 feet are important for achieving the PCW.

Response: The report has been updated to address these concerns.

Theme: Do not conflate second-growth forest conditions with mature forest conditions in the results.

Response: Language was added to the report to address this concern.

Theme: Consider riparian stocking density within the reviewed datasets.

Response: We do not have studies published with this information. Riparian stocking densities, if found in the literature and relevant to the view, may be compared in the forthcoming report on DFC. Language was added to the temperature/shade report to clarify this.

Theme: Are the assumptions of the Human Use Allowance (HUA) appropriate/adequate?

Response: It is outside the scope of this review to question the assumptions of the HUA.

Theme: A 5-10% reduction in shade can cause a riparian area not to meet the HUA based on RipStream results and TMDL analysis.

Response: The report was modified to include this information.

Theme: Using a 90% canopy cover is too high in the model context. Use a canopy cover in the 60-70% range for the Siskiyou region.

Response: 90% canopy cover was measured at RipStream sites. However, per direction from DEQ on using their TMDL model information, we included shade curves from the look-up table using 60-70% canopy cover.

Theme: If the shade allocations are not attainable because the site does not support the type of vegetation that would provide that shade, then there should be no loss of shade from pre- to post- harvest for meeting the intent of the TMDL shade targets.

Response: The report was modified to address this information.

Theme: Most sites included in the Groom et al (2011a) study retained post-harvest basal area above ODF prescribed minimum targets, and therefore did not represent potential shade loss associated with FPA prescriptions. If FPA riparian basal area retention requirements allow for a buffer that is narrower than the buffer widths in the studies considered, then the change in temperature found in these studies is likely to be less than it would be under minimum retention requirements. Therefore, fixed buffer widths should not be used as an explanatory variable.

Response: The report specifies what the average buffer widths would be for small and medium streams if landowners removed all the basal area allowed per the FPA, and the associated temperature increases.

Theme: Include the temperature response and expected temperature increase associated with the application of FPA rule on private forest lands with small and medium fish streams.

Response: The report was modified to address this information.

Theme: The presented "Shade Curve" results are different than the Bayesian model, DEQ model, and field data, therefore the "Shade Curve" results are not correctly assessing the effect of buffer width reduction on stream shade conditions.

Response: The "Shade Curve" results are from the DEQ model, and are compared with field data in nearby forests to place the data in context.

Theme: Current management to meet FPA rules in the Siskiyou may not match the default FPA buffer widths. Monitoring (field data collection) is needed to identify whether water quality standards are being met in this region.

Response: New collection of field data is out of scope for the review at this time.

Theme: Include the study on Caspar Creek in Northern California.

Response: Addressed with a footnote in Table III.1.

Theme: Why are there different responses and what is the significance for interpretation of buffers meeting stream temperature criteria?

Response: This report was a summary of literature, and thus detailed analysis as to why the different responses was outside the scope of the work.

Theme: Are the studies included applicable to the rule review for the Siskiyou region?

Response: The geographic extent of the review was widened at the request of Board members. We acknowledge the risk of extrapolation in exchange for more information.

Theme: Canopy cover and shade is difficult to measure with significant possible variations between observers and equipment/methods.

Response: We assume that methods for collecting field data, within a given study, were consistently applied per their stated methods narratives. We acknowledge in the report that between-study variations in methods presents a challenge when comparing them.

From:	MOORE Bill L.
To:	PUBLICCOMMENT PRIVATEFORESTS * ODF
Cc:	WAGENBLAST Greg * ODF
Subject:	re: Private Forest Siskiyou SSBT Rulemaking
Date:	Monday, September 28, 2020 4:31:59 PM
Attachments:	DEQ comment letter on ODF proposed rules on SSBT in Siskiyou Georegion 9.28.20.pdf

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Good afternoon Mr. Wagenblast,

Would you please see the attached comment letter on Oregon Department of Forestry proposed rules for the SSBT in the Siskiyou Georegion.

Thank you for your attention to this matter.

Best regards,

Bill

Bill Moore
Oregon Department of Environmental Quality
Assistant to Justin Green, Water Quality Division Administrator, and
Jennifer Wigal, Water Quality Division Deputy Administrator

700 NE Multnomah, Portland, OR 97232
Office: 503.229.6853

Pronouns: he/him/his

Oregon
Kate Brown, Governor

Department of Environmental Quality
Agency Headquarters
700 NE Multnomah Street, Suite 600
Portland, OR 97232
(503) 229-5696
FAX (503) 229-6124
TTY 711

September 28, 2020

Sent via email to privateforests.publiccomment@oregon.gov

Greg Wagenblast
Private Forests
Oregon Department of Forestry
2600 State Street
Salem, OR 97301

Re: Comments on Proposed rulemaking hearing for Siskiyou SSBT stream protection rules

Dear Mr. Wagenblast:

Thank you for the opportunity to comment on the Oregon Department of Forestry (ODF) proposed permanent rules for expanding water quality protections on small and medium size salmon, steelhead, and bull trout (SSBT) streams in the Siskiyou Georegion.

These rules are proposed in response to Senate Bill 1602 (2020), which directs the Board of Forestry (Board) to "adopt rules to make 2017 board rules regarding salmon, steelhead and bull trout applicable for the Siskiyou Georegion". These rules will replace the temporary rules adopted by the Board earlier this year, and become effective on Jan. 1, 2021.

DEQ supports the extension of the SSBT rules to the Siskiyou Georegion. This action will improve the level of water quality protection for these streams. However, for the record, ODF and the Board should be aware that DEQ's existing Total Maximum Daily Loads (TMDLs) for watersheds in the Rogue and Applegate generally indicate that even with this action many watersheds are unlikely to achieve the conditions (and load allocations) needed to improve stream temperatures in watersheds that are currently already too warm to meet applicable water quality standards. What this means is that there is additional and ongoing work to be done between the Department of Environmental Quality (DEQ) and ODF, above and beyond this rulemaking, to detail the management measures that will ultimately achieve Oregon's federally-approved water quality standards for temperature. DEQ and ODF are working together to specify how we will complete this work, just as DEQ is working with other partners with responsibilities for TMDL implementation on other (non-forest lands) to do the same.

The SSBT rules that ODF is proposing to extend to the Siskiyou Georegion were analyzed in an ODF staff report to the BOF for agenda item two, at the Board's meeting on July 23rd, 2015. Using the data and information from the Ripstream study, and working with ODF and ODFW, DEQ also analyzed various scenarios during the SSBT rule development process. Based on those analyses, DEQ has some continuing concerns about the adequacy of the SSBT rules to

meet the protecting cold water component of Oregon's water quality standard for temperature. These concerns focus on predicted outcomes from individual forest operations, and are distinct from the watershed-scale TMDL issues described above. As ODF and DEQ work through TMDL implementation issues in the Rogue/Applegate and elsewhere, we also will continue to work with ODF assuring that the outcome is consistent with the requirements embodied in the protecting cold water standard. |In EPA's recently established Columbia and Lower Snake Rivers Temperature TMDL, EPA found a strong link between regional air temperature and Columbia River water temperature. EPA's TMDL showed long-term increases in regional air temperature and Columbia River water temperature since the 1960's. In the TMDL EPA states, "A growing body of research has produced and is continuing to produce evidence that changes to regional climate are contributing to an increase of stream temperatures in the Columbia and Snake Rivers". DEQ expects that these same effects may be occurring in the Siskiyou Georegion, along with other climate-related changes including changes in forest vegetation, stream flows, and wildfire return intervals. As DEQ and the Environmental Quality Commission assess these changes in future TMDLs and TMDL updates, there may be further implications for management measures necessary to meet both the PCW standard and load allocations in TMDLs.

Finally, ODF's Fiscal Impact Analysis for the proposed rules should consider economic benefits from additional riparian protections, not just the negative economic impacts to the industry and landowners. The economic value of fisheries, drinking water provision, stormwater and erosion control, and other ecosystem services should be considered. For example, additional recruitment of large woody debris over time and retained shade can be compared to the cost to replicate or restore those services.

We appreciate the opportunity to comment on this important water quality issue and look forward to continuing our collaboration with the Oregon Department of Forestry.

Sincerely,

Jennifer Wigal
Deputy Water Quality Administrator