RCS Add-On: Purpose and Feasibility of Adding Treatments to RCS Study Design
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Introduction

The purpose of the Riparian Characteristics and Shade Response Experimental Research Study (Volke 2020) is to evaluate how stream shade responds to a range of riparian harvest treatments within environments common to commercial forestlands covered under the FPHCP (2005). The RCS will estimate stream shade response within a 100-ft wide RMZ with 9 different harvest treatment configurations that incorporate variable width no-cut core zones with two levels of inner zone thinning (Figure 1). Key outcomes of the study will be information about how well alternate riparian buffer prescriptions (Rx) provide shade and how shade response varies by stand composition/type. These findings are intended for informing policy decisions concerning the efficacy of different riparian management strategies.

The proposed range of RCS treatments will not only provide data for the prescriptions (Rx's) tested but would enable modeled estimates of shade response to other Rx's. However, confidence in shade estimates might be lower for buffer configurations that fall outside the range of RCS tested treatments (Volke 2020). Consequently, uncertainty about how RMZ width affects shade response for different levels of thinning remains unaddressed. Also, questions about thinning closer to the stream than proposed by RCS would not be addressed.

The robust experimental design and field layout structure of the RCS study could incorporate other alternate Rx's without compromising the existing study. However, field implementation logistics and data analyses would need to be revised to incorporate additional (Add-On) treatments. Also, the addition of treatments would constitute a change in scope and require approval by CMER and Policy. Therefore, to inform concerns about a potential RCS Add-On, this document provides a description of proposed Add-On treatments concerning field implementation and data analysis.

Purpose for Add-On

The conservation objective of the FPHCP (2005) "Riparian Strategy" is to restore riparian function to high levels on lands covered by the FPHCP and to maintain those levels once they are attained (WAC 222-30-010(2)). Shade has been identified as one of the critical riparian functions under the HCP and rules. Implementing a greater range of RMZ and thinning treatments in the RCS study will provide a more complete understanding of how shade varies among a wide range of RMZ widths and timber harvest configurations. In turn, the knowledge gained would inform a variety of scientific inquiries regarding the effectiveness of both Type Np and Type F stream buffers. For example, the WFFA proposed (Template Proposal letter to Forest Practices Board, January 21, 2015) a suite of alternate Rx's that included variable width RMZs with fixed-width no-cut buffers and no-cut core buffers with inner zone thinning (Figures 2). At the other end of the spectrum, the contribution to stream shade from trees beyond 100 ft is dependent on composition of the riparian stand both within and beyond 100 feet. Therefore, the purpose for the RCS Add-on is to provide empirical data that will reduce uncertainty regarding the effectiveness of the proposed WFFA thinning prescriptions as well as other potential riparian management options (e.g., forest health). Other AMP work that would potentially benefit from empirical shade data from the wider range of no-cut and thinning combinations in the RCS Add-on include: the Type F RMZ effectiveness study design; WMZ Effectiveness, EMEP; the Eastside Riparian

Forest Health Strategy; potential new RMZ prescriptions developed out of the ETHEP study; and studies testing the forthcoming revised Np RMZ rules.

Description of Add-On Treatments

The existing RCS study treatment and plot scheme with Add-On treatments are shown in Figure 1. The Add-On includes the following:

Add-On No. 1

Two additional thinning treatments within Plot 3; one with 75-ft RMZ (Sequence 2b) and one with 50-ft RMZ (Sequence 3b). These Add-On treatments would directly test the WFFA Template Proposal thinning prescription Options No. 1 and No. 3 (Figure 3).

Add-On No. 2

Two additional treatments (Sequence 5) to Plots 1 and 2; (called "additional") extend thinning to stream edge. The addition of these two treatments will increase both the precision and accuracy of the RCS response curve, including the slope and intercept.

Add-On No. 3

The added wider no-cut buffer treatments (i.e. 125, 150, 175, and 200 feet) encompass the full range of buffer widths occurring under current Washington Forest Practices Rules for all stream types. For the sake of consistency with the systematic buffer width treatments in the original study design, we opted to use 25-foot increments for the extended no-cut treatments instead of the irregular intervals associated with RMZ widths. These treatments are proposed in order to validate the assumption, based on extrapolation of limited study data from existing literature, that channel shading is not increased with buffers of any distance beyond 75 to 100 feet. For example, this assumption partially influenced the design of the original RCS plot dimensions and treatments. Adding these no-cut treatments will enable us to explore the shade responses for earlier and later times of the day, earlier and later in the year and among different channel orientations (see figures 4a and 4b of the RCS study design; figure 2 Type N Workgroup Report). The additional no-cut treatments appear to have the greatest potential to affect shading on N-S oriented channels at lower solar altitudes throughout the spring and summer and E-W oriented channels at higher solar altitudes during spring and fall (based on exploratory analysis using the interactive tool on Suncalc.org).

Note that because the RCS plot dimensions are based upon shadow lengths for solar altitudes greater than 40 degrees during summer time, there may be an influence from outside of a plot when examining shade earlier/later in the day and earlier/later in the year. Any positive or negative bias in shading from adjacent areas is expected to apply equally to all of the extended no-cut treatments on a plot. Such bias is not expected to influence any potential relative differences in shading among the four extended no-cut treatments on a plot as long as these are the first treatments applied among all adjacent plots at a study site.

Field Implementation

Field implementation of the RCS study requires a planned and coordinated effort among three technical disciplines (foresters, tree cutters, study scientists).

Table 1. List of field implementation pros and cons by including Add-On treatments to RCS study.

Task	Pro	Con
Plot and treatment layout structure (three plots 325 ft long X 100 ft wide, each plot with four subplots 25-ft wide)	Additional shade information will be collected.	*An additional 4100 feet of line marking would be added to the layout at each site.*
Full (100%) stand inventory of all 12 subplots	Additional shade information will be collected.	The acreage needing to be fully inventoried would increase from 2.2 acres to 5.2 acres, an increase of 3.0 acres.
Treatment prescription	Add-On treatments (i.e., thinning prescription) identical to RCS treatments	The wider treatments will add four crew days to the treatment schedule.
Marking trees within each subplot for specific thinning treatments	Add-On treatments can be included without compromising RCS layout structure. Trees in wider treatment areas will not have to be marked.	Requires marking trees at: 5 subplots for Add-On treatments and, 6 subplots for RCS treatments; total 11 subplots would be marked for thinning
Cutter labor	Cutting trees for Add-On treatments can be included without compromising RCS cutting treatments. Cutting trees in the wider treatment areas will add minimal effort.	Requires cutting trees during 4 Add-On Sequence intervals in addition to 3 RCS Sequence intervals. The wider treatments will add four crew days to the treatment schedule.
Post-cutting treatment inspection	Inspection of Add-On treatments can be performed separate from inspection of RCS cutting treatments; no interference	Requires inspection following: 5 Add-On subplot treatments and 6 RCS subplot treatments; total 11 subplots would be inspected
Hemi-photo collection	Photo collection following Add-On treatments can be performed separately from photos of RCS treatments; no interference	Requires photo collection following: 7 Add-On Sequence intervals in addition to 7 RCS Sequence intervals.

Analytical Approach

The analysis of Add-On treatment responses could be performed separately or the analysis of both RCS and Add-On responses could be combined in one analysis. The pro and con summary (Table 2) is based on technical feedback from Dr. Jeremy Groom (statistician for RCS study design proposal)

regarding the analytical feasibility and cost for revising the RCS study design (see Dr. Groom statements in Appendix A).

Table 2. List of analytical design/analysis pros and cons by including Add-On treatments to RCS study.

Element	Pro	Con
Implementation of existing RCS analysis design	Maintained	Lost opportunity for increased accuracy and for a wider range of treatments.
Integration of Add-On treatment to RCS analysis design	Add-On treatments are compatible with RCS design	Add-On requires alteration of analysis to add one new factor (RMZ width) to existing RCS two-factor analysis design (i.e., no-cut buffer width, harvest intensity)
Revision to RCS Study design	Small additional study design and report cost?	Requires revision/addition to analysis section of RCS Study Design

Appendix A

To address concerns raised by RSAG about how the Add-On may influence the RCS data analysis, Dr. Jeremy Groom (statistician for RCS design proposal) was asked three questions about the analytical feasibility and cost for revising the RCS study design. Below are the questions and responses (italic) we received from Dr. Groom (email 12/2/20) including one unsolicited comment (number 4) about an option for the Add-On analytical design.

1. Does the additional treatments prohibit implementation of the existing RCS proposed analysis design?
   No. It looks like the additional treatments are compatible with the RCS design. The logistics of the study will be altered, but the same RCS levels of treatment can be examined.

2. Does the analysis of additional treatments require a new or different analysis design?
   The analysis will require some alterations (or at least some consideration) to incorporate the new treatment levels. Add-on 1 adds a new dimension to the analysis, RMA width, which has only two representatives. Add-on 2 alters the study design less severely as it is an extension of moving the no-cut buffer inward.

3. What is approximate cost for designing new data analysis methods that include the additional treatments?
   I am fairly confident I can provide a brief write-up of the new analysis, referencing the proposed RCS analysis, with 8 hours of time ($125/hr = $1000).

4. Unsolicited comment.
   For Add-on 2, if it isn't too late, I'd recommend that the add-on include clear-cutting Plot 3 to the bank. One reason for doing so is aesthetics - the design (not considering Add-on 1) would remain a complete factorial design. The other is that the study would retain its own measurements of an extreme treatment to compare against other treatments. My intuition is that this sort of anchoring will prove useful.

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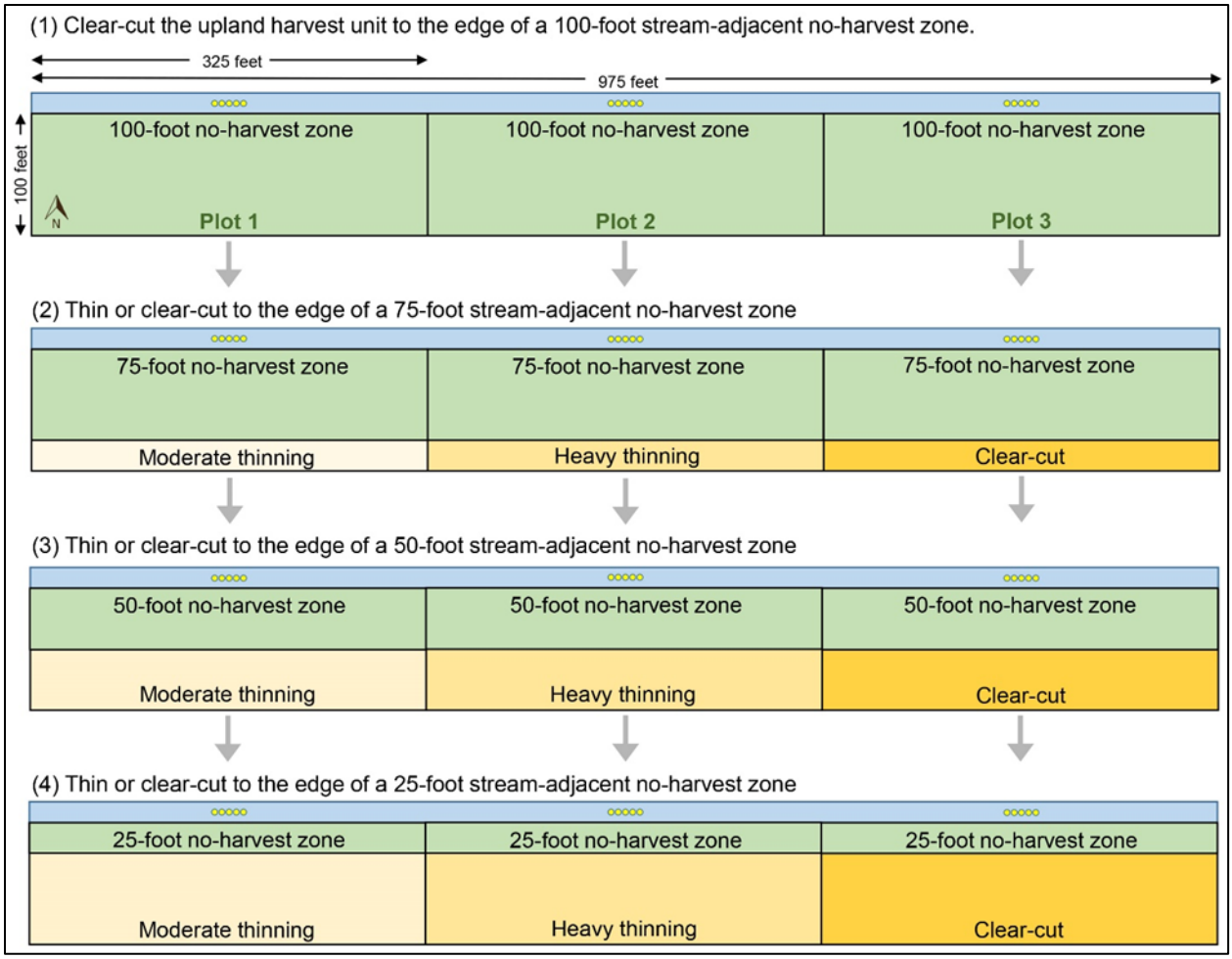

Figure 1. RCS study design showing site layout and the three harvest sequences (from Figure 1; Volke 2020).

RCS	**Sequence 2a: Thin or clear-cut to the edge of a 75-foot stream-adjacent no-harvest zone**			
		RCS Step 2	RCS Step 2	RCS Step 2/WFFA Opt 2
	0-25	75-foot no-harvest zone	75-foot no-harvest zone	75-foot no-harvest zone
	25-50			
	50-75			
	75-100	Moderate thinning	Heavy thinning	Clear-cut
		clearcut		
Add-on 1	**Sequence 2b: Thin Plot 3 to the edge of a 50-foot stream-adjacent no-harvest zone**			
				WFFA Opt 1
	0-25			50-foot no-harvest zone
	25-50			
	50-75			Heavy thinning
	75-100			Clear-cut
		clearcut		
RCS	**Sequence 3a: Thin or clear-cut to the edge of a 50-foot stream-adjacent no-harvest zone**			
		RCS Step 3	RCS Step 3	RCS Step 3/WFFA Opt 4
	0-25	50-foot no-harvest zone	50-foot no-harvest zone	50-foot no-harvest zone
	25-50			
	50-75			
	75-100	Moderate thinning	Heavy thinning	Clear-cut
		clearcut		
Add-on 1	**Sequence 3b: Thin Plot 3 to the edge of a 25-foot stream-adjacent no-harvest zone**			
				WFFA Opt 3
	0-25			25-foot no-harvest zone
	25-50			Moderate thinning
	50-75			
	75-100			Clear-cut
		clearcut		
RCS	**Sequence 4: Thin or clear-cut to the edge of a 25-foot stream-adjacent no-harvest zone**			
		RCS Step 4	RCS Step 4	RCS Step 4/WFFA Opt 6
	0-25	25-foot no-harvest zone	25-foot no-harvest zone	25-foot no-harvest zone
	25-50			
	50-75	Moderate thinning	Heavy thinning	
	75-100			Clear-cut
		clearcut		
Add-on 2	**Sequence 5: Thin plots 1 and 2 to the channel edge**			
		Additional Thin a	**Additional Thin b**	
	0-25	Moderate thinning	Heavy thinning	
	25-50	Moderate thinning	Heavy thinning	
	50-75			
	75-100			
		clearcut		

Figure 2. RCS study site layout with six harvest sequences that include four proposed Add-On treatments (outlined in red).

Figure 1. RCS study site layout with six harvest sequences that include six proposed Add-On treatments.

325 feet

975 feet

Proposal		Plot 1	Plot 2	Plot 3
RCS	**Sequence 1: Clear-cut the upland harvest unit to the edge of a 100-foot stream-adjacent no-harvest zone.**			
		RCS Step 1	RCS Step 1	RCS Step 1
	0-25	100-foot no-harvest zone	100-foot no-harvest zone	100-foot no-harvest zone
	25-50			
	50-75			
	75-100			
Add-on 3	**100-125**	125 Foot no harvest zone		
	125-150	150 Foot no harvest zone		
	150-175	175 Foot no harvest zone		
	175-200	200 Foot no harvest zone #		
		harvest clearcut		
	* Eastern Washington RMZ Widths equal increments of 25 feet to 150 feet.			
RCS	**Sequence 2a: Thin or clear-cut to the edge of a 75-foot stream-adjacent no-harvest zone**			
		RCS Step 2	RCS Step 2	RCS Step 2/WFFA Opt 2
	0-25	75-foot no-harvest zone	75-foot no-harvest zone	75-foot no-harvest zone
	25-50			
	50-75			
	75-100	Moderate thinning	Heavy thinning	Clear-cut
		clearcut		
Add-on 1	**Sequence 2b: Thin Plot 3 to the edge of a 50-foot stream-adjacent no-harvest zone**			
				WFFA Opt 1
	0-25			50-foot no-harvest zone
	25-50			
	50-75			Heavy thinning
	75-100			Clear-cut
		clearcut		
RCS	**Sequence 3a: Thin or clear-cut to the edge of a 50-foot stream-adjacent no-harvest zone**			
		RCS Step 3	RCS Step 3	RCS Step 3/WFFA Opt 4
	0-25	50-foot no-harvest zone	50-foot no-harvest zone	50-foot no-harvest zone
	25-50			
	50-75			
	75-100	Moderate thinning	Heavy thinning	Clear-cut
		clearcut		
Add-on 1	**Sequence 3b: Thin Plot 3 to the edge of a 25-foot stream-adjacent no-harvest zone**			
				WFFA Opt 3
	0-25			25-foot no-harvest zone
	25-50			Moderate thinning
	50-75			
	75-100			Clear-cut
		clearcut		
RCS	**Sequence 4: Thin or clear-cut to the edge of a 25-foot stream-adjacent no-harvest zone**			
		RCS Step 4	RCS Step 4	RCS Step 4/WFFA Opt 6
	0-25	25-foot no-harvest zone	25-foot no-harvest zone	25-foot no-harvest zone
	25-50			
	50-75	Moderate thinning	Heavy thinning	
	75-100			Clear-cut
		clearcut		
Add-on 2	**Sequence 5: Thin plots 1 and 2 to the channel edge**			
		Additional Thin a	**Additional Thin b**	
	0-25	Moderate thinning	Heavy thinning	25-foot no-harvest zone
	25-50	Moderate thinning	Heavy thinning	
	50-75			
	75-100			
		clearcut		

Figure 3. RCS study site layout with ten harvest sequences that include four proposed Add-On treatments (outlined in red) and four site tree potential treatments (shaded in pink).

Table 2. Decision-Logic for Westside Template

Table 2. Riparian Prescriptions by Stream Type and Bankfull Width

Decision Logic

If Water Type is:	And bankfull width is:	And flow is:	And seasonal reach is connected to F-stream:	Then the two-sided RMZ is:	Then the two-sided No-Cut Zone is:	And area for Thinning: (mostly conifers)	And area for Regeneration Harvest: (mostly hardwoods)	Prescription Option Number
	in feet			*in feet*				
S or F	>15	all seasons or seasonal	--	75	50	50 - 75 *(7)*	50 - 75	1
				75	75	beyond 75 *(1)*	40% of F **(9)*	2
	5 - 15	"	--	50	25	25 - 50 *(8)*	50% of F **(10)*	3
				50	50	beyond 50 *(2)*	beyond 50	4
				50	50	beyond 50 *(11)*	beyond 50	5
	<5	"	--	25	25	beyond 25 *(3)*	beyond 25	6
Np	> or = 5	all seasons	yes	25	25 x 300	beyond 300** *(4)*	"	7
		seasonal	yes	25	25 x 300	"	"	8
		"	no	0	0	beyond 0	beyond 0	9
	<5	all seasons	yes	25	0	beyond 0** *(5)*	beyond 25	10
		seasonal	yes	25	0	"	"	11
		"	no	0	0	beyond 0	beyond 0	12
Ns	--	seasonal	no	0	0	beyond 0 *(6)*	beyond 0	13

*Maximum length of individual patches is 500 ft; minimum thinnable width between patch cuts is 100 ft ; Cumulative total length of patch cuts along Type F streams within FPA: 40% (>15ft), 50% (<15ft)

**Remove larger trees (thin-from-above)

(Numbers in Italics) reference "situation numbers" in Table 2, Attachment 3 - Technical Assessment by Dr. Douglas Martin.

Figure 3. Table 2 from WFFA proposal to FPB dated Feb 10, 2015. Blue shaded prescriptions are included in existing RCS treatment design and pink prescriptions are proposed additional thinning treatments to RCS design.