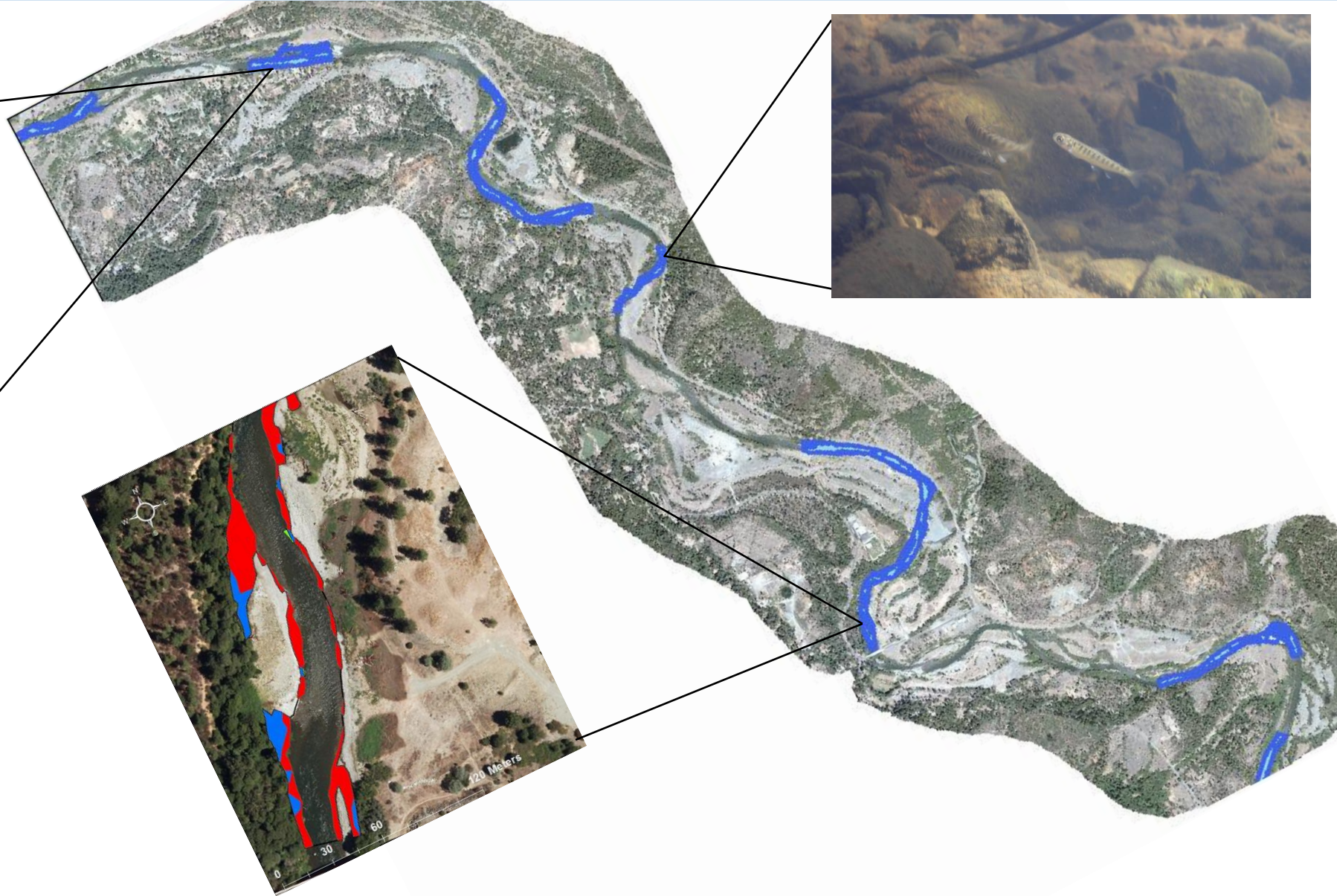


# Summer Base Flow Rearing Habitat in the TRRP Restoration Reach



Damon Goodman, Nicholas Som, Josh Boyce (USFWS)



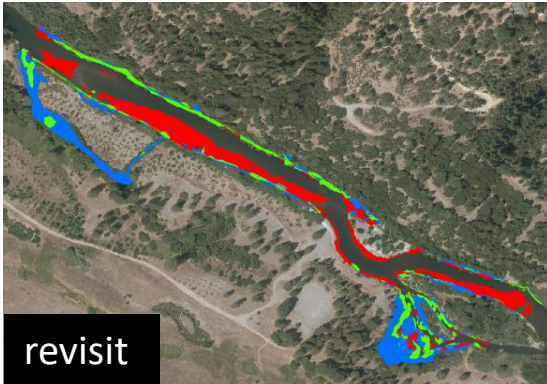
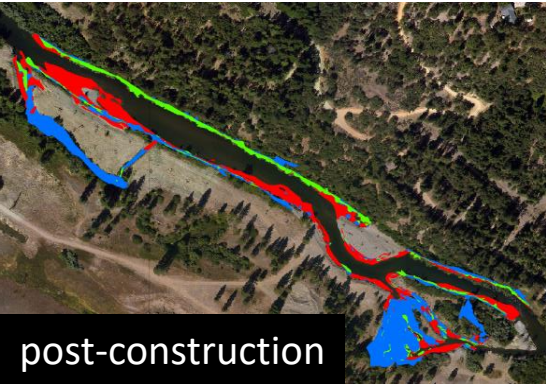
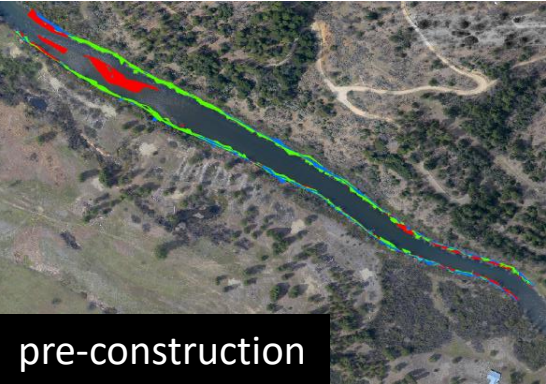
Aaron Martin (YTFD)



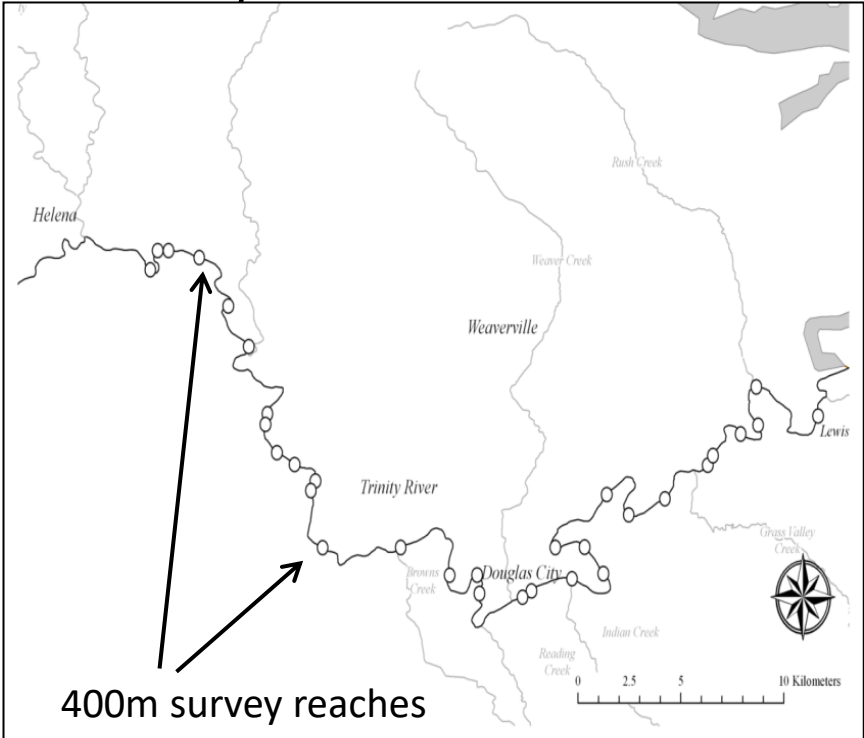
Justin Alvarez (HVTFD)

# Effectiveness Monitoring: multiple scales and methods

## Site Evaluation



## Systemic Evaluation



# Mapping Rearing Habitat

<p><b>Developmental</b> <b>Fry (&lt;50 mm)</b></p>		<p><b>Criteria</b> <b>Depth and Velocity</b> <b>&gt;0 to 0.6 m</b> <b>No DV)</b> <b>0 to 0.12 m/s</b></p>
<p><b>Cover (C)</b></p>	<p>Multiple Flows -300 (8.6 cms) <b>-450 (12.7 cms)</b> -700 (19.8 cms) -1,200 (33.9 cms) -2,000 (56.6 cms)</p>	<p>Suitable habitat</p>
<p><b>Presmolt (&gt;50 mm)</b> <b>Outside Cover (No C)</b></p>		<p><b>&gt;0 to 1 m</b> <b>0 to 0.24 m/s</b> <b>Unsuitable habitat</b> <b>0 to 0.6 m</b></p>



# Has restoration caused changes in salmonid rearing habitat at the restoration reach scale?

## Hypotheses\*

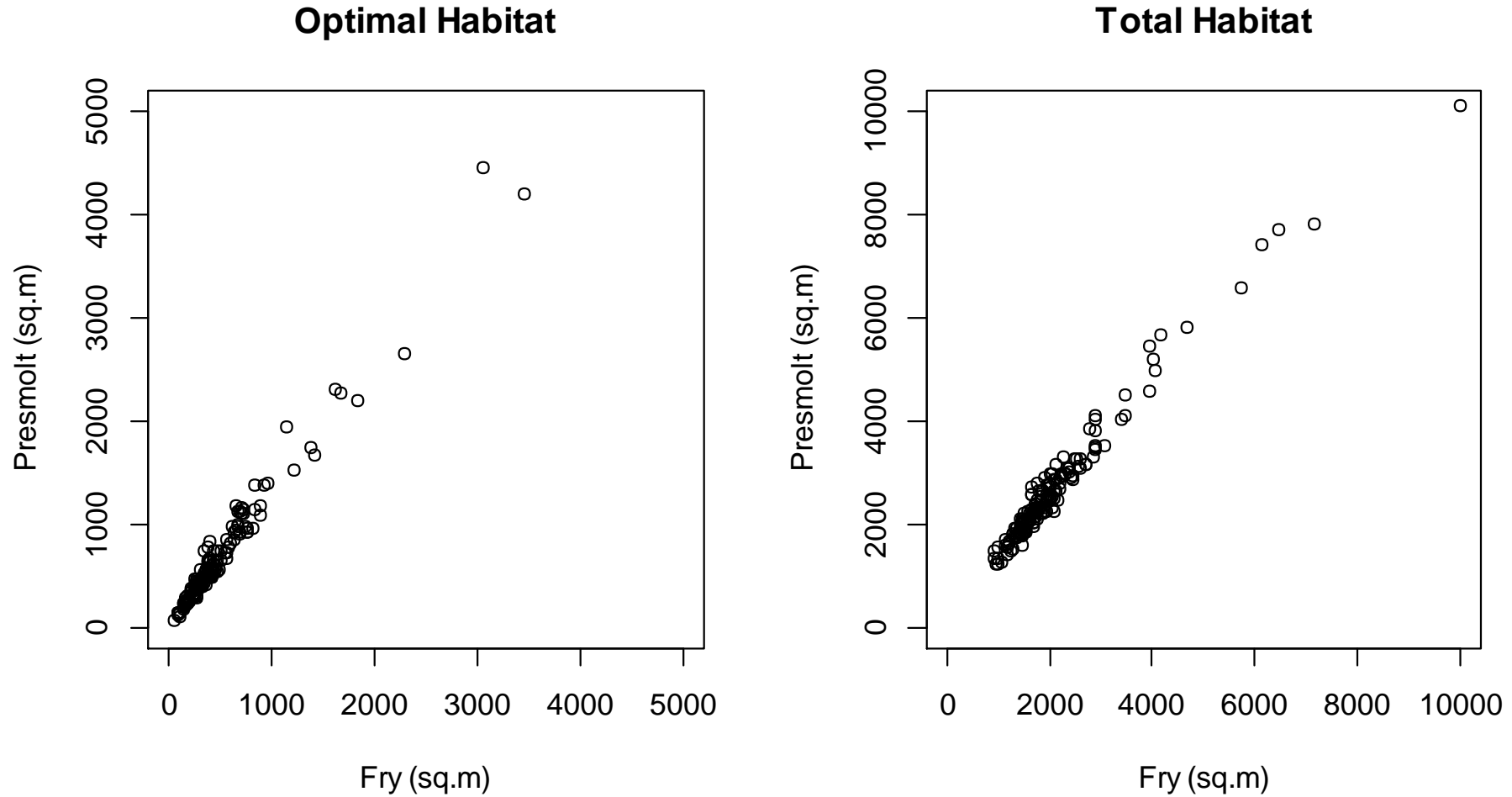
1. Restoration efforts create measureable improvements in rearing habitat area over a 5-year period at an index flow;
2. Annual peak streamflows, particularly those greater than 6,000 cfs ( $170 \text{ m}^3\text{s}^{-1}$ ), will improve rearing habitat with larger improvements stemming from higher magnitude events

\*Hypotheses derived from:

Trinity River Flow Evaluation Study (USFWS and Hoopa Valley Tribe 1999)

Integrated Assessment Plan (sub-objective 2.1) (TRRP and ESSA Technologies Ltd. 2009):

# Presmolt and fry habitat areas are highly correlated



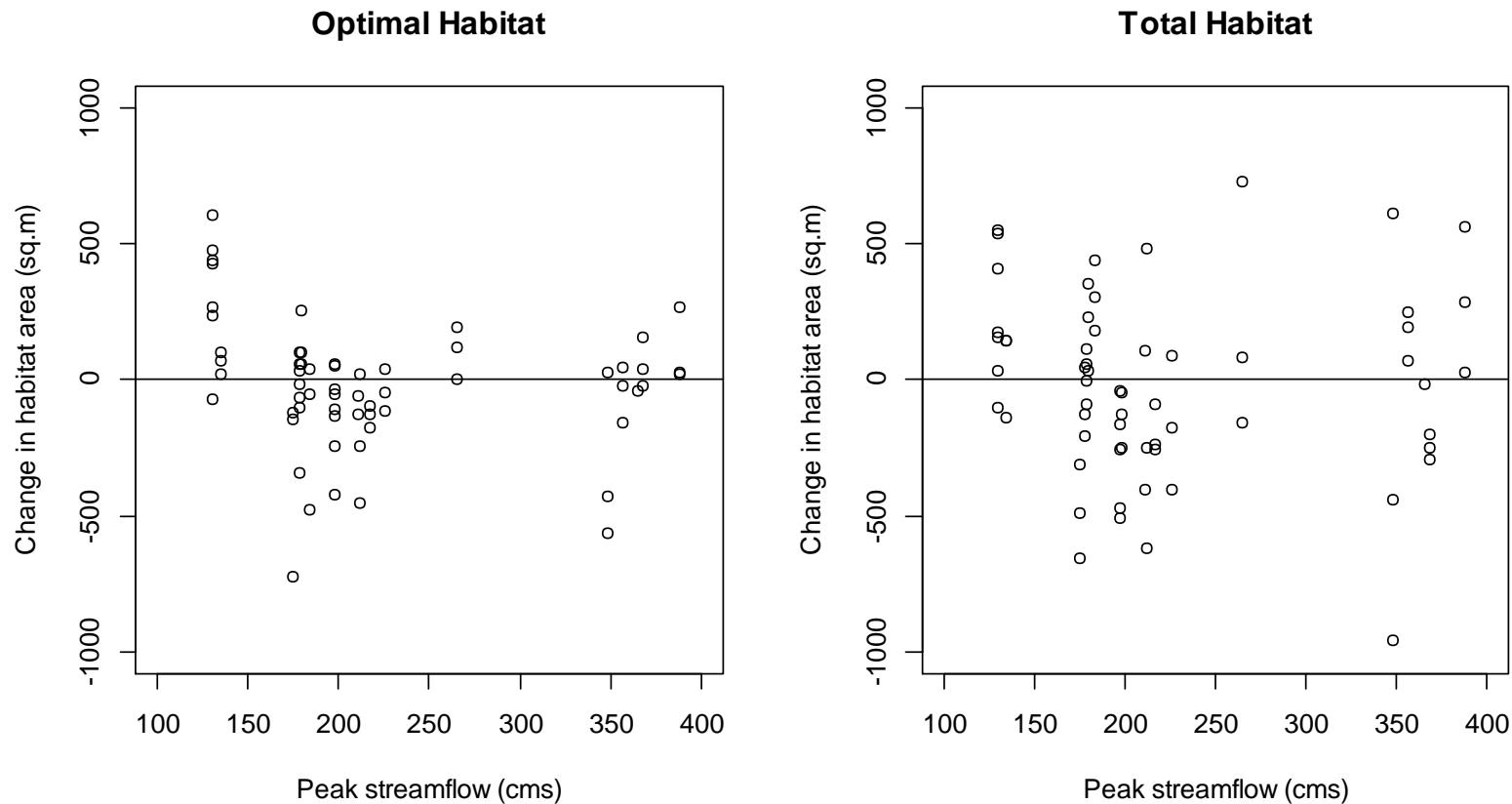
Pearson's product-moment correlation ( $\rho$ ) of 0.985 (optimal) and 0.983 (total)

# Summer baseflow rearing habitat did not increase between 2009 and 2013 \*

Indicator	Years	WY type	Q <sub>Peak</sub>	Panel	Median dif.	LCB	UCB	% Incr.
Optimal	2009-2010	Normal	212	2	<b>-96</b>	<b>-174</b>	<b>-44</b>	19
	2010-2011	Wet	348	3	-0.12	-204	66	44
	2011-2012	Normal	175	4	<b>-104</b>	<b>-271</b>	<b>-11</b>	31
	2012-2013	Dry	130	5	<b>186</b>	<b>88</b>	<b>316</b>	94
	2009-2013	Dry to Wet	348	1	<b>143</b>	<b>42</b>	<b>227</b>	68
Total	2009-2010	Normal	212	2	<b>-215</b>	<b>-356</b>	<b>-70</b>	19
	2010-2011	Wet	348	3	7	-250	248	44
	2011-2012	Normal	175	4	-67	-220	87	38
	2012-2013	Dry	130	5	<b>188</b>	<b>38</b>	<b>347</b>	81
	2009-2013	Dry to Wet	348	1	122	-14	489	63

\* Goodman, D.H., J. Alvarez, N.A. Som, A. Martin, and K. De Julio. 2016. The Effects of Restoration on Salmon Rearing Habitats in the Restoration Reach of the Trinity River at an Index Streamflow, 2009 to 2013. U.S. Fish and Wildlife Service. Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2016-25.

# Localized changes in habitat not related to magnitude of streamflow\*



Authors concluded habitat improvements could be increased by synchronizing dam releases with tributary streamflow events

\* Goodman, D.H., J. Alvarez, N.A. Som, A. Martin, and K. De Juilio. 2016. The Effects of Restoration on Salmon Rearing Habitats in the Restoration Reach of the Trinity River at an Index Streamflow, 2009 to 2013. U.S. Fish and Wildlife Service. Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2016-25.

# Rotating panel revisit design

Panel	Year									
	2009	2010	2011	2012	2013	2014	2015	2016	2017	
1	<b>X</b>				<b>X</b>					
2	<b>X</b>	<b>X</b>				<b>X</b>	<b>X</b>			
3		<b>X</b>	<b>X</b>				<b>X</b>			
4			<b>X</b>	<b>X</b>				<b>X</b>		
5				<b>X</b>	<b>X</b>					<b>X</b>

Sampling design change after 2013

Bold X's indicate the widest range of sampling efforts

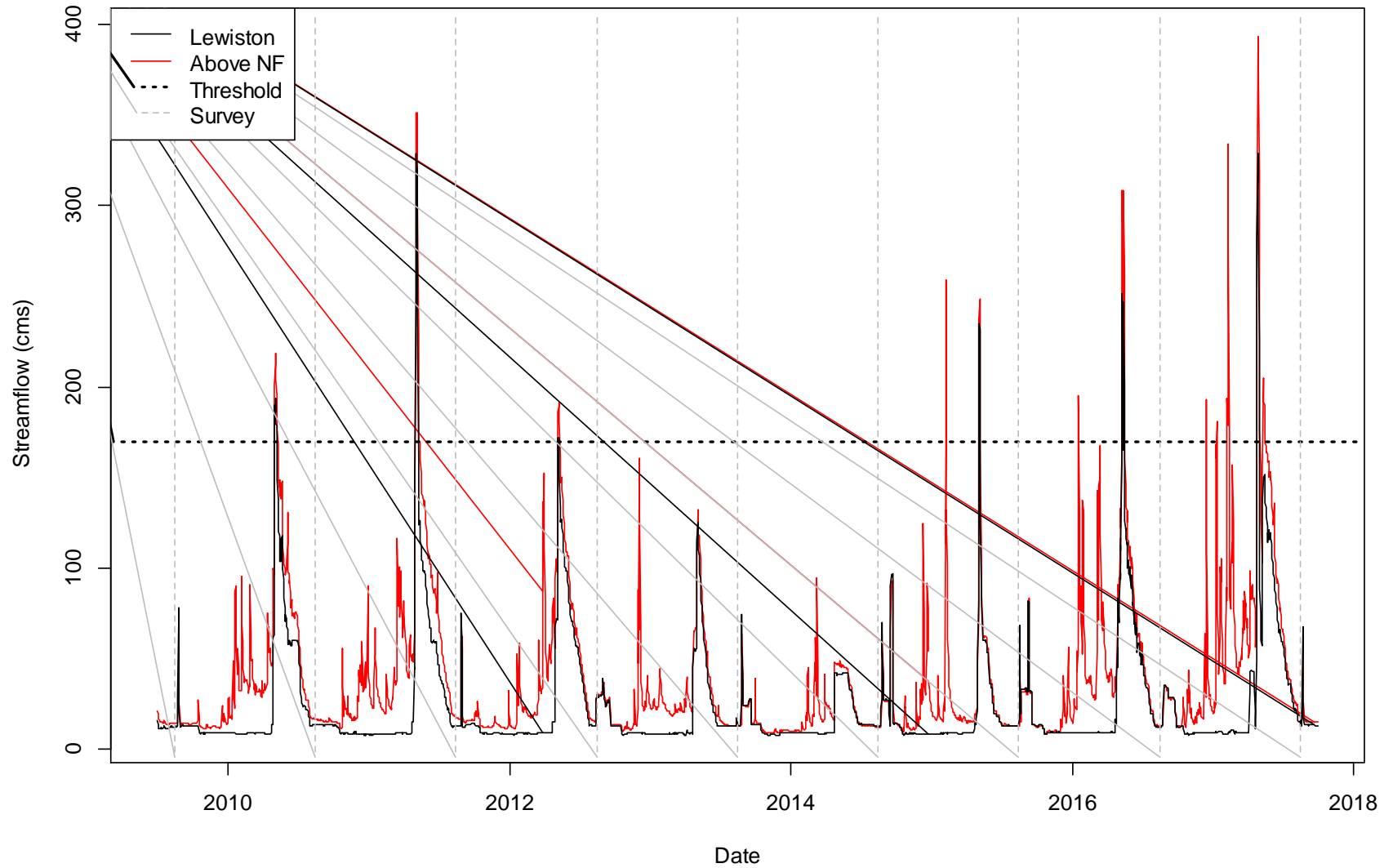
## Objectives:

- 1) identify predictors of habitat status at most recent survey (5 panels and 80 sites)
- 2) identify predictors of change in rearing habitat  
included the longest revisit interval (initial and most recent): range 4 to 6 years

## Predictors:

- channel rehabilitation (proportion of site; categorical: before, during, none)
- year of construction
- streamflow (magnitude/duration)
- course sediment (proximity)
- wetted area
- channel complexity
- wetted edge length

# Daily Average Streamflow Over Study Period



# Objective 1: model selection for status of presmolt habitat

	<b>Model</b>	<b>Model Variables</b>	<b>df</b>	<b>AIC score</b>	<b>Δ AIC</b>
Total habitat	1	Area	3	185	28
		Length	3	183	26
		Area + Complexity	4	160	3
		Area + Complexity + Year Constructed	5	157	0
		Area + Complexity + Proportion Constructed	5	158	1
		Area + Complexity + Coarse Sed.	5	161	4
		Area + Complexity + Coarse Sed.Tributary	5	162	5
	Optimal habitat	2	Area	3	205
		Area + DamDist	4	196	0
		Area + DamDist + Year Constructed	5	197	1
		Area + DamDist + Proportion Constructed	5	198	2
		Area + DamDist + Coarse Sed.Tributary	5	196	0

# Objective 1: parameter coefficients including interactions of selected models

	Model	Coefficient	Estimate	SE	t	p
Total habitat	1.1	Intercept	-114.81	48.38	-2.37	0.0202
		Area	0.56	0.07	7.88	< 0.0001
		Complexity	0.27	0.08	3.37	0.0012
		Year constructed	0.06	0.02	2.37	0.0202
		Area:Complexity	0.18	0.08	2.25	0.0274
Total habitat	1.2	Intercept	-0.04	0.07	-0.50	0.6157
		Area	0.57	0.07	8.03	< 0.0001
		Complexity	0.28	0.08	3.54	0.0007
		Proportion constructed	0.16	0.07	2.20	0.0312
		Area:Complexity	0.17	0.08	2.11	0.0387
Optimal habitat	2	Intercept	-0.07	0.09	-0.78	0.4393
		Area	0.44	0.09	5.02	< 0.0001
		Distance to dam	-0.28	0.09	-3.07	0.0030
		Area:Distance to dam	-0.27	0.08	-3.34	0.0013

\* Channel complexity defined as :

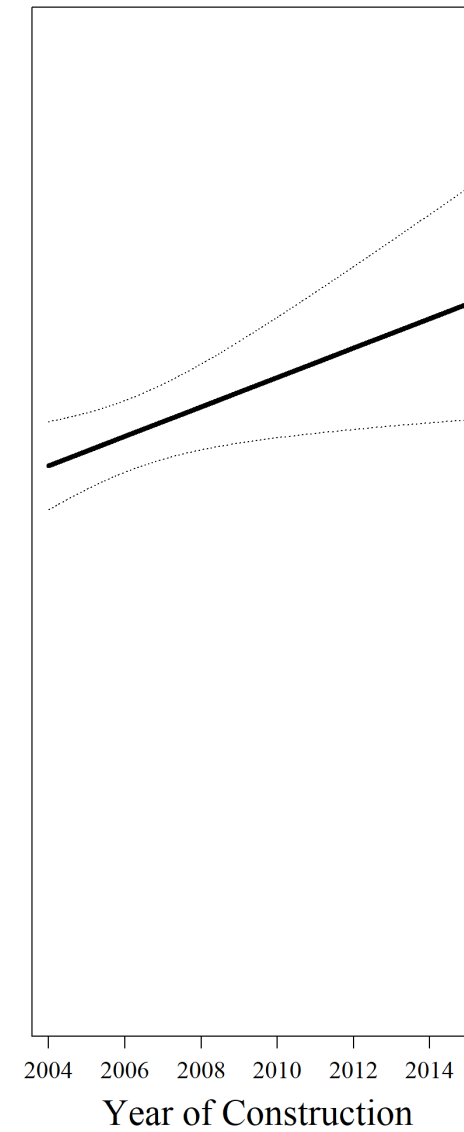
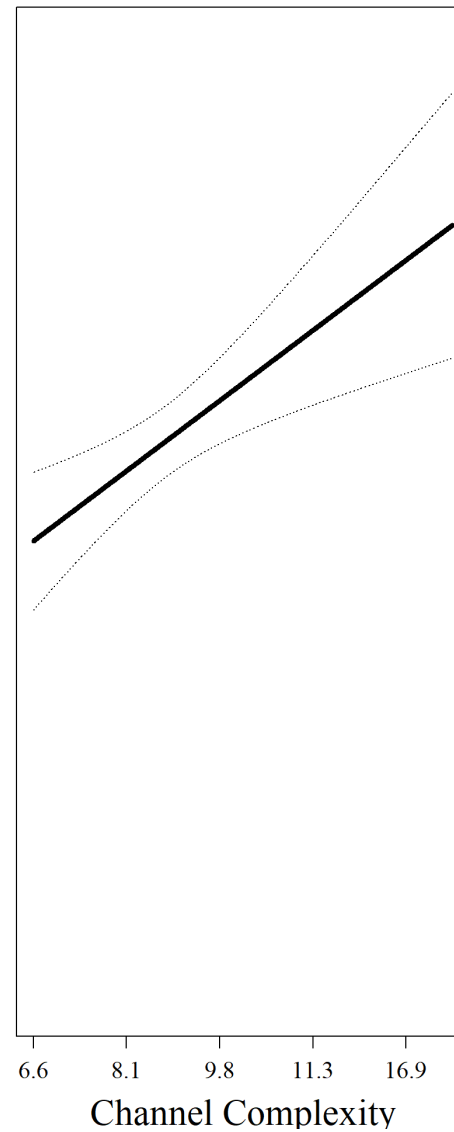
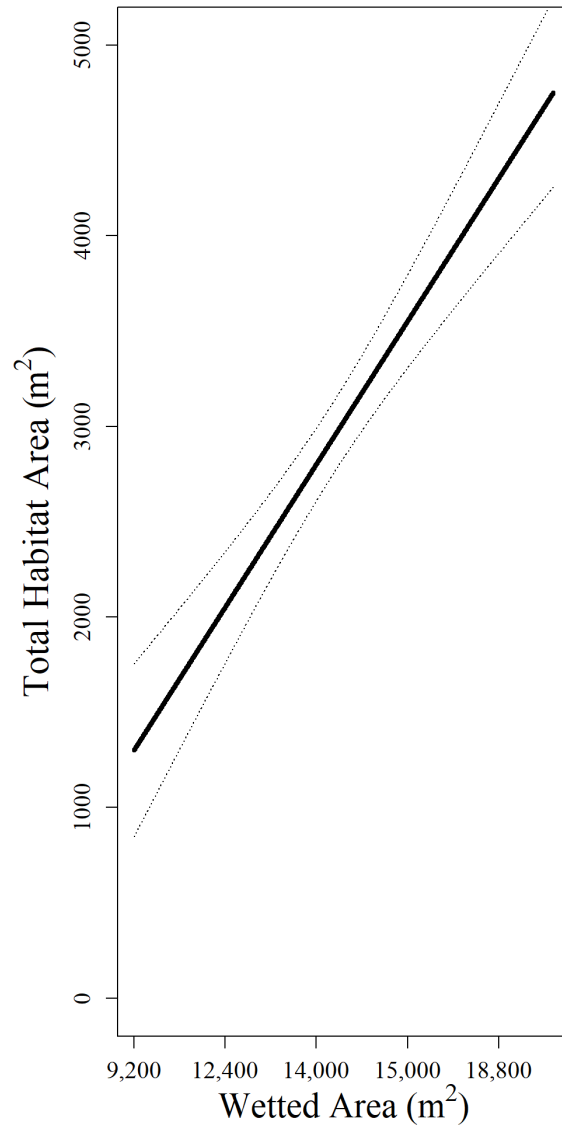
$$\text{complexity} = \frac{\text{edge length (m)}}{\sqrt{\text{wetted channel area (m}^2\text{)}}}$$

\* Buffington, J., C. Jordan, M. Merigliano, J. Peterson, and C. Stalnaker. 2014. Review of the Trinity River Restoration Program following Phase 1, with emphasis on the Program's channel rehabilitation strategy. Prepared by the Trinity River Restoration Program's Science Advisory

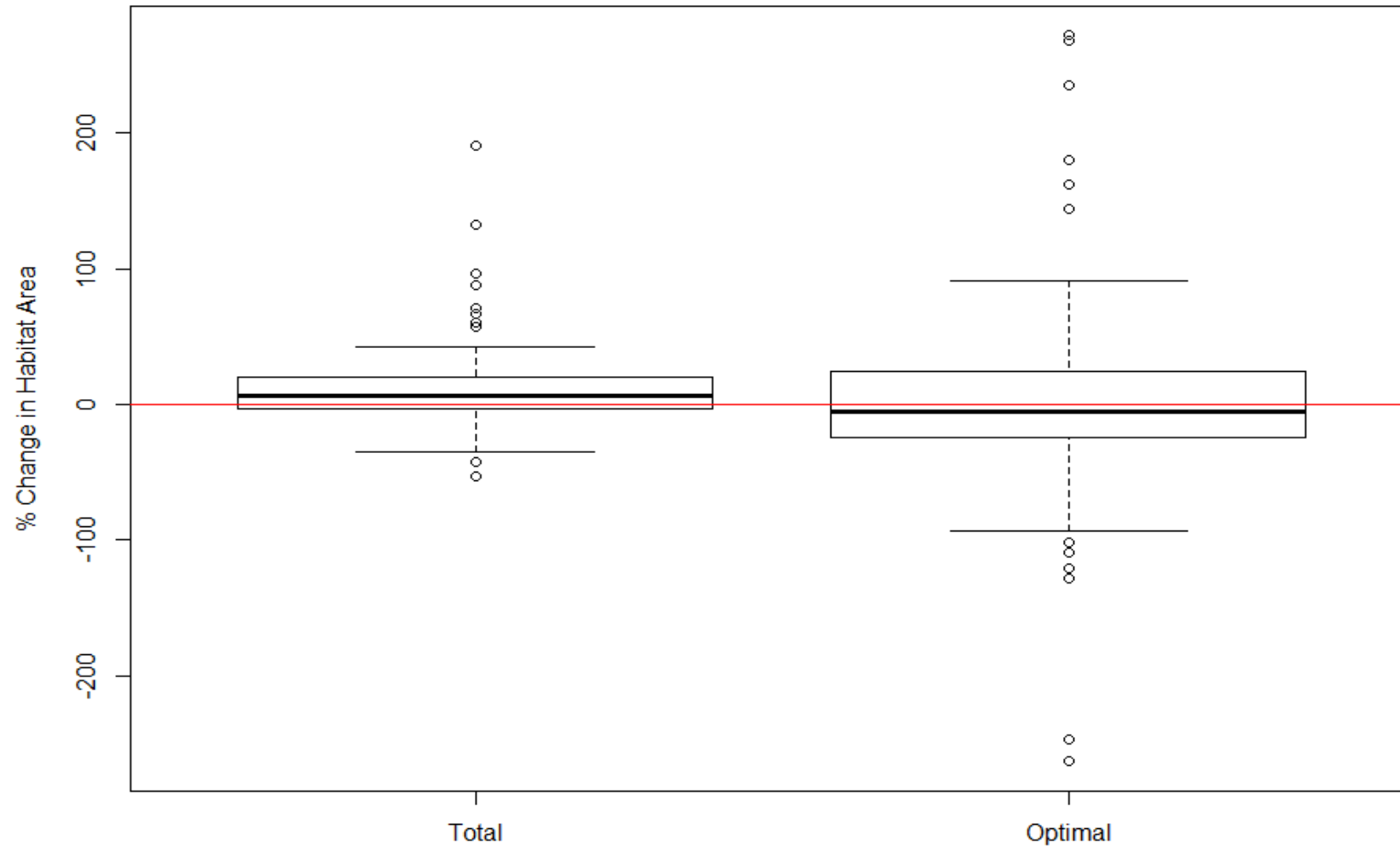
# Examples of simple and complex sample units



# Objective 1: relationship between total habitat and model variables



## Objective 2: total habitat increased between initial and most recent surveys



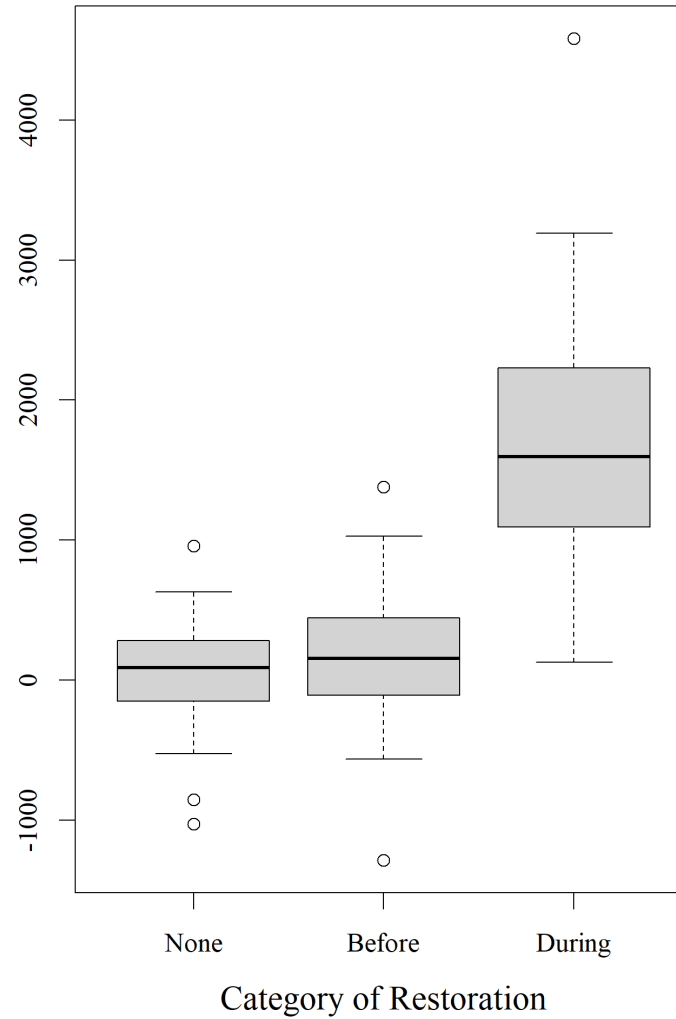
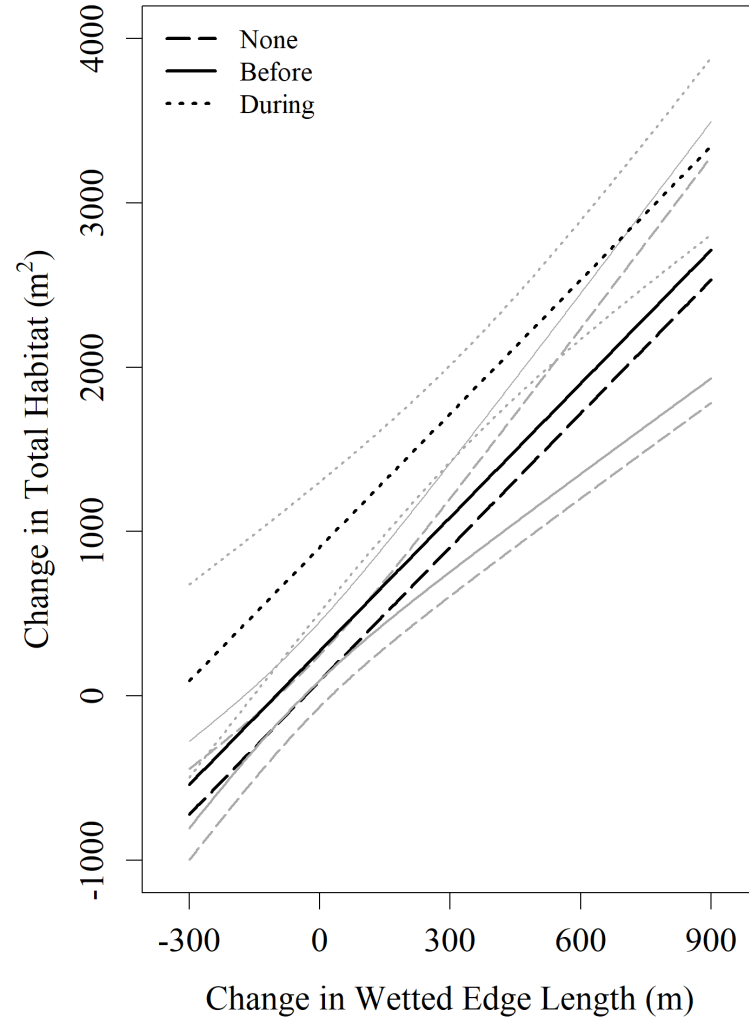
## Objective 2: Model selection for change in rearing habitat

Model	Model Variables	df	AIC score	$\Delta$ AIC
Total habitat	3 $\Delta$ Edge length	3	1234	11
	$\Delta$ Edge length + Construction cat.	5	1224	1
	$\Delta$ Edge length + Construction cat.+ Dist. to dam	6	1223	0
	$\Delta$ Edge length + Construction cat.+ Flow	6	1225	2
Optimal habitat	4 $\Delta$ Edge length	3	1163	0
	$\Delta$ Edge length + Length restored	4	1165	2
	$\Delta$ Edge length + Dist. to dam	4	1165	2
	$\Delta$ Edge length + Flow	4	1165	2

## Objective 2: parameter coefficients of best selected model

	<b>Model</b>	<b>Coefficient</b>	<b>Estimate</b>	<b>SE</b>	<b><i>t</i></b>	<b><i>p</i></b>
Total habitat	3	Intercept	142.47	80.40	1.77	0.0804
		$\Delta$ Length	508.46	75.37	6.75	< 0.0001
		Before construction	181.44	119.11	1.52	0.1318
		During construction	812.99	218.69	3.72	0.0004
Optimal habitat	4	Intercept	10.48	37.82	0.28	0.7820
		$\Delta$ Length	232.44	38.06	6.11	< 0.0001

# Modeled association of wetted edge length and restoration category on change in habitat area



## Conclusions:

Objective 1: habitat status (most recent) explained by  
wetter area  
channel complexity  
construction (proportion/year)

Objective 2:  $\Delta$  in habitat (initial to most recent) explained by  
 $\Delta$  in edge length (bank)  
construction category (during)  
total habitat increased

When considered as a main effect, streamflow magnitude and duration did not explain changes in habitat. But it is related to wetted area and a primary driver of fluvial processes that affect channel complexity