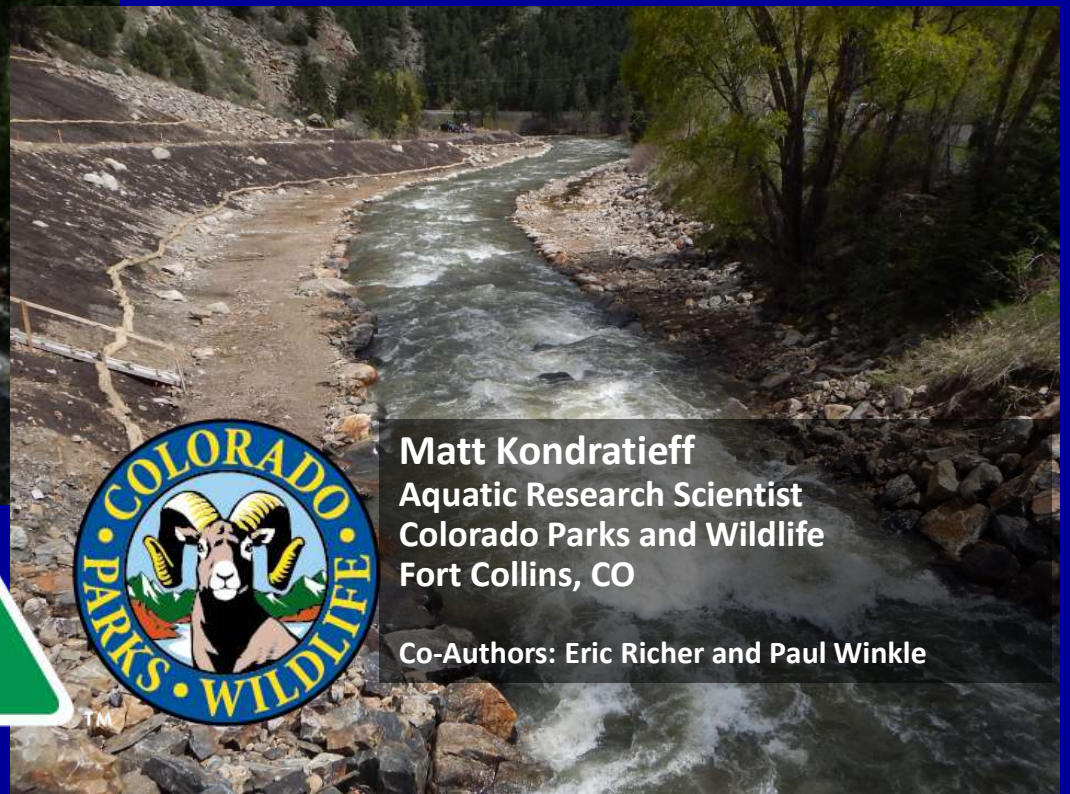
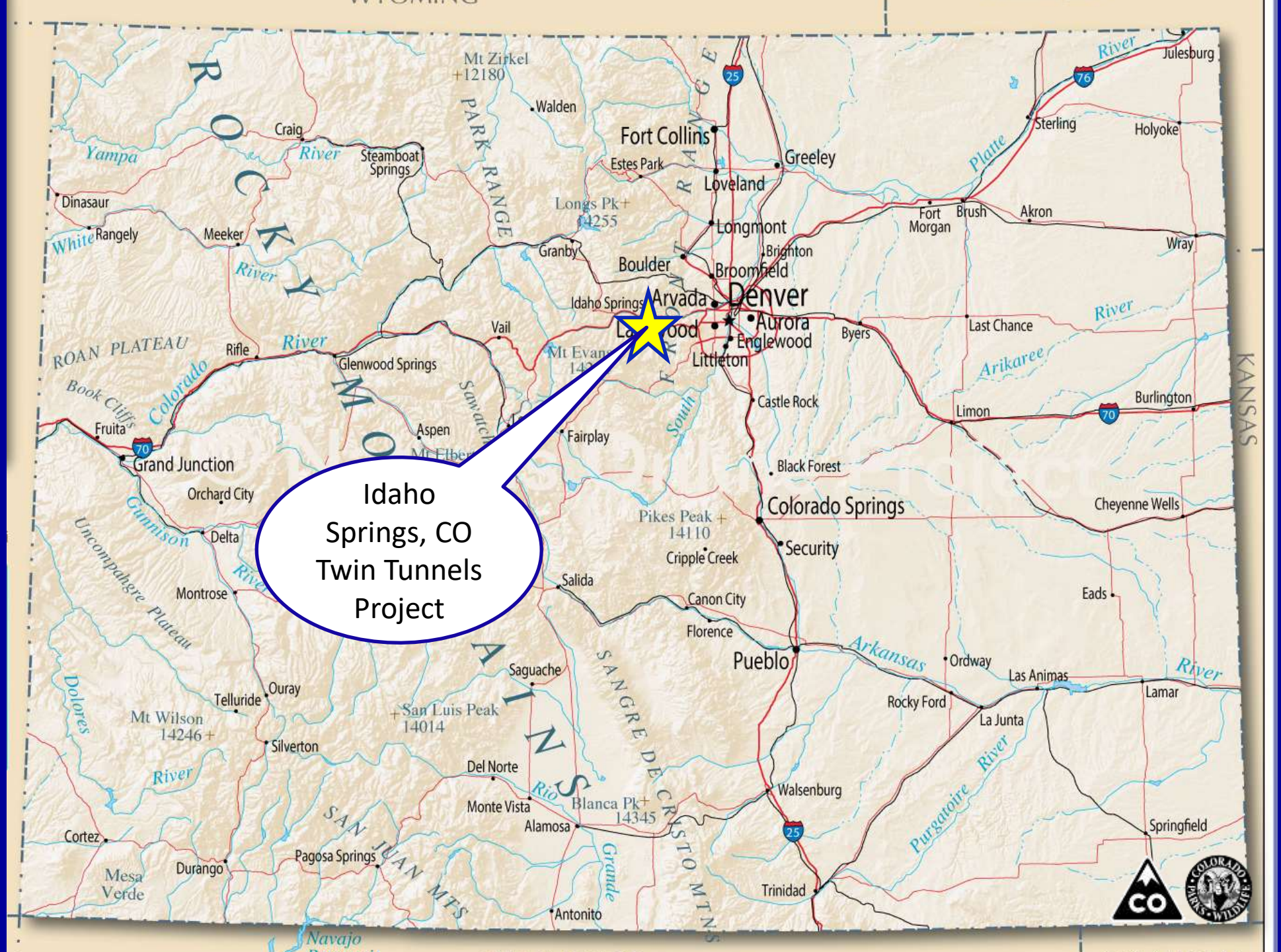
Response of Trout Populations to Restoration of a Single-Stage Channelized Stream



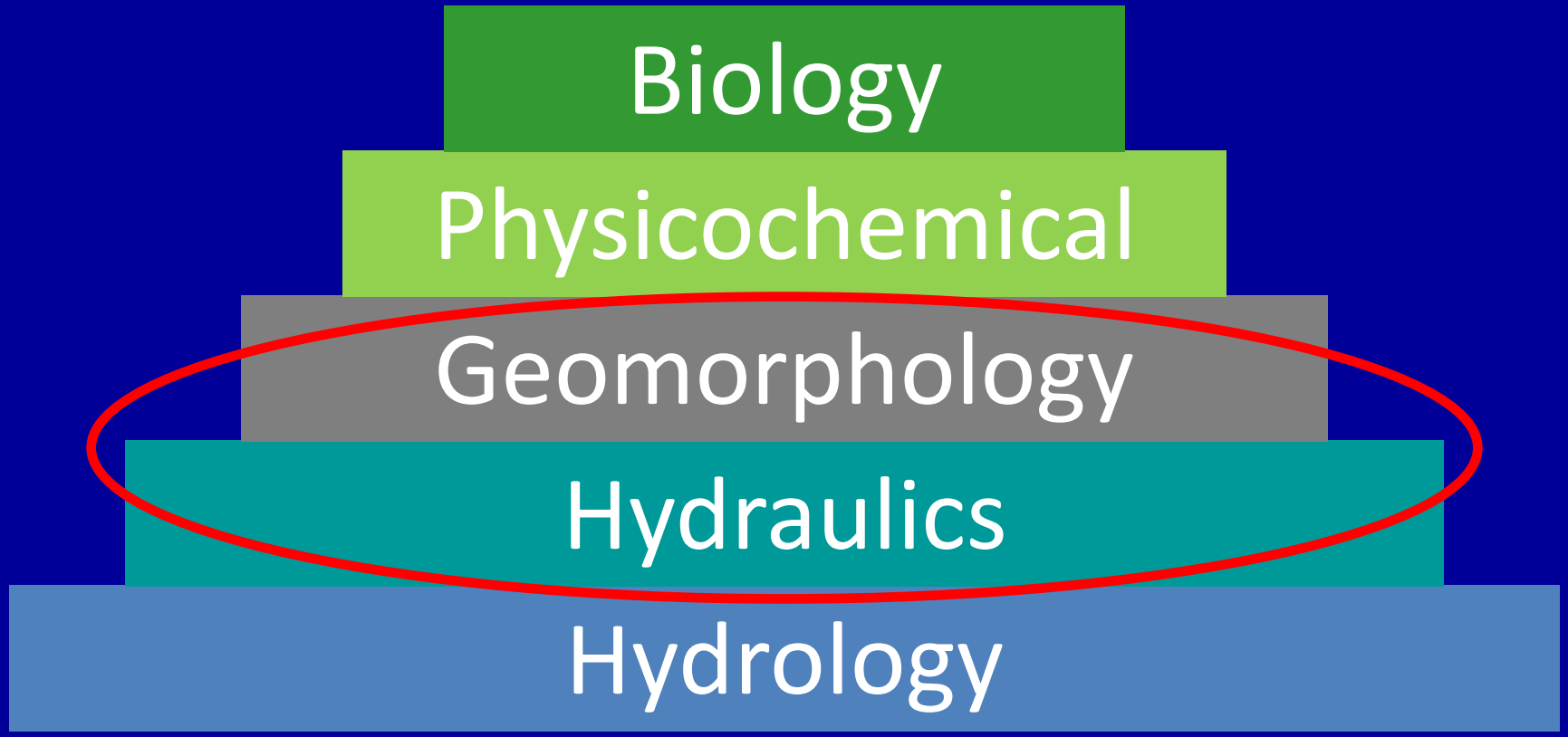
Matt Kondratieff
Aquatic Research Scientist
Colorado Parks and Wildlife
Fort Collins, CO

Co-Authors: Eric Richer and Paul Winkle

Clear Creek


Idaho Springs, CO Twin Tunnels Project
Denver
Colorado Springs
Pueblo
Fort Collins
Greeley
Boulder
Longmont
Loveland
Aurora
Arvada
Englewood
Littleton
Broomfield
Brighton
Castle Rock
Grand Junction
Glenwood Springs
Aspen
Vail
Rifle
Fruita
Montrose
Delta
Telluride
Durango
Cortez
Silverton
Ouray
Salida
Canon City
Florence
Walsenburg
Trinidad
Alamosa
Monte Vista
Del Norte
Pagosa Springs
Antonito
Saguache
Fairplay
Idaho Springs
Estes Park
Steamboat Springs
Craig
Walden
Meeker
Rangely
Dinasaur
Fort Morgan
Brush
Akron
Sterling
Julesburg
Holyoke
Wray
Last Chance
Byers
Limon
Burlington
Cheyenne Wells
Eads
Lamar
Las Animas
Ordway
Rocky Ford
La Junta
Springfield
Black Forest
Security
Cripple Creek
Pikes Peak + 14110
Mt Zirkel +12180
Longs Pk+ 14255
Mt Evans 14264
San Luis Peak 14014
Blanca Pk+ 14345
Mt Wilson 14246 +
ROCKY MOUNTAINS
PARK RANGE
FRONT RANGE
SANGRE DE CRISTO MTNS
SAN JUAN MTS
ROAN PLATEAU
Uncompahgre Plateau
Book Cliffs
Mesa Verde
Yampa River
White River
Colorado River
Gunnison River
Dolores River
Rio Grande
Arkansas River
South Platte River
Arikaree River
Purgatoire River
KANSAS
CO

Limiting Factors:
Stream Functions Pyramid



Courtesy Will Harmon, USFWS


I-70
To Idaho Springs
To Denver
North
Clear Creek
Clear Creek Rafting Co
Raft trip outfitter
Sewer Plant
Doghead Rail Bridge
Trailhead Parking
Clear Creek
Clear Creek
East Idaho Springs Road
East Idaho Springs Road
Mountain Mini Storage
Scott Lancaster Memorial Trail
CO
COLORADO
PARKS • WILDLIFE

Restoration Project Goals

1) **Remove armored rip rap**

Restoration Project Goals

1) **Remove armored rip rap**

2) **Improve floodplain connectivity**

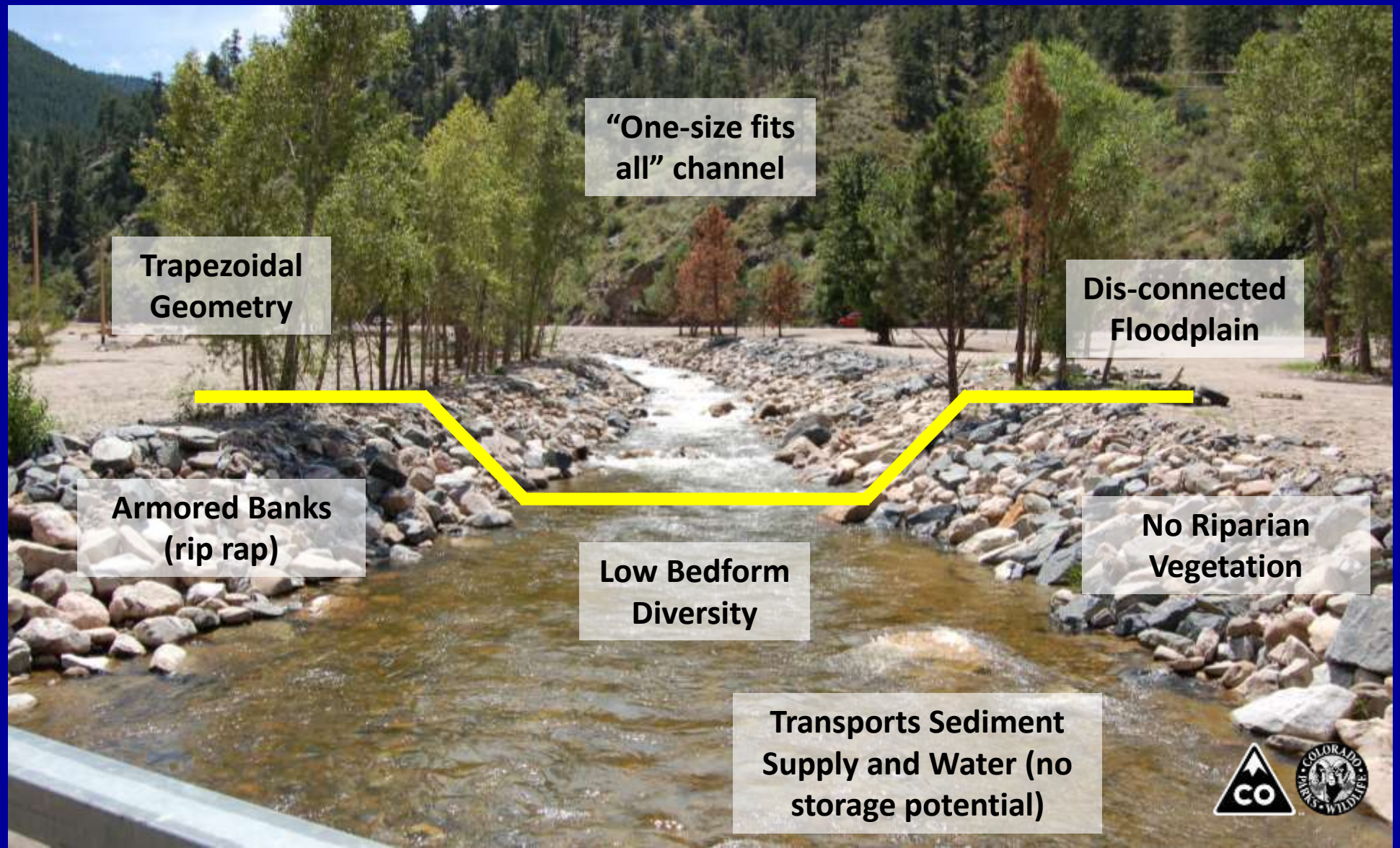
Restoration Project Goals

1) Remove armored rip rap

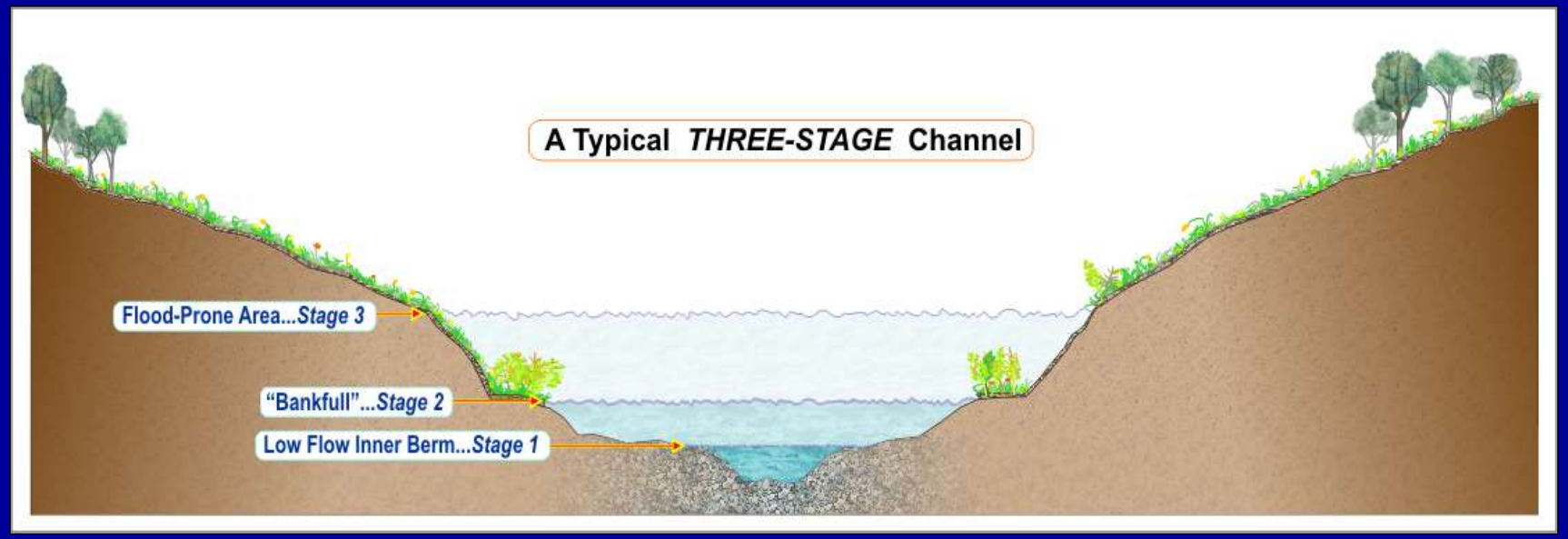
2) Improve floodplain connectivity

3) Convert single-stage to three-stage (Rosgen F → Bc)

Single-Stage Channel



Three-Stage Channel



- **Stage 1** – The low flow or inner berm channel (thalweg)
- **Stage 2** – The bankfull stage channel
- **Stage 3** – The flood-prone area or active floodplain starting at the incipient point of flooding

(Used with permission from D.L. Rosgen)

Restoration Project Goals

1) Remove armored rip rap

2) Improve floodplain connectivity

3) Convert single stage to three-stage (F → Bc)

4) Establish riparian vegetation

Restoration Project Goals

1) Remove armored rip rap

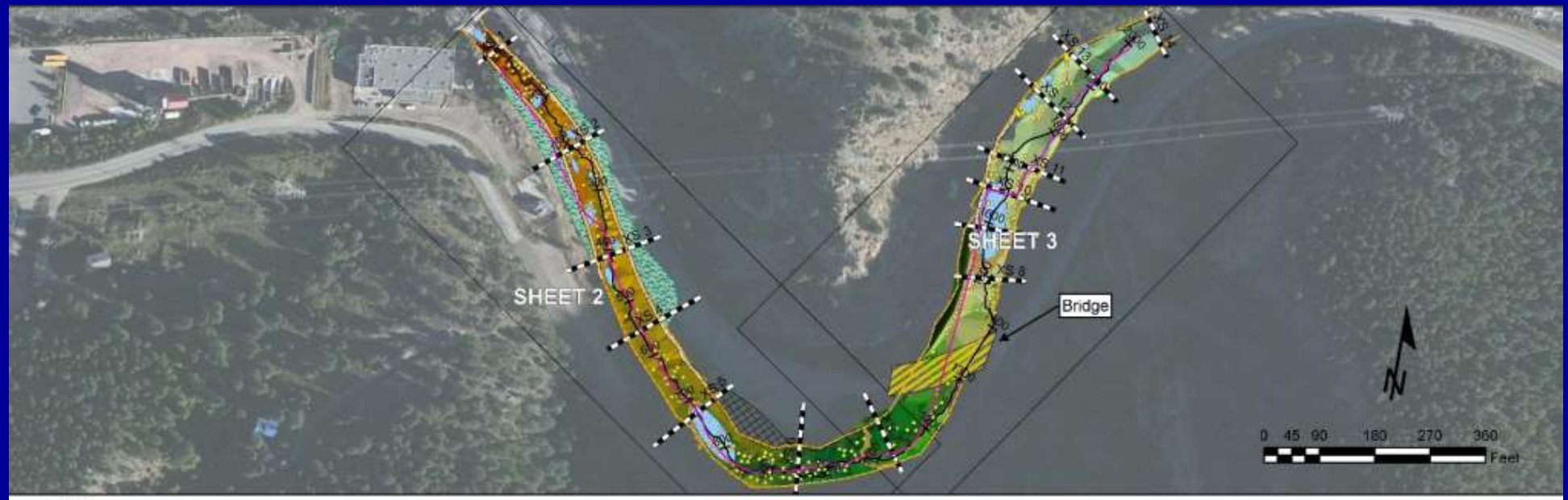
2) Improve floodplain connectivity

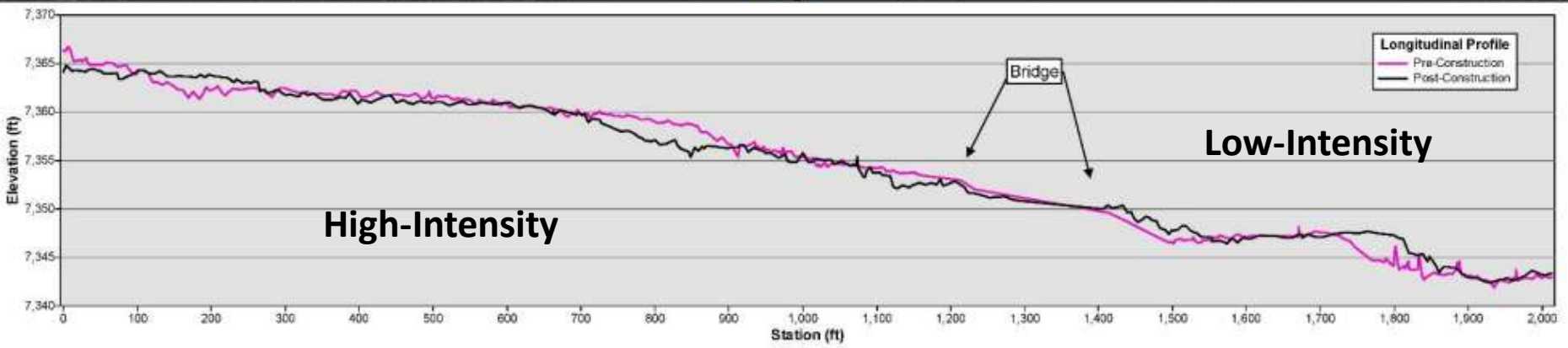
3) Convert single stage to three-stage (F → B_c)

4) Establish riparian vegetation

5) Enhance in-channel bedform features (i.e. velocity cover, depth cover and develop spawning areas)

Overview





Thalweg (Pre-Construction)
Thalweg (Post-Construction)
Channel Alignment
Cross Section
Habitat Boulder
Log Vane
Boulder Structure
Boulder Toe
Pool Development
Riparian Bench
Point Bar Development
Bridge

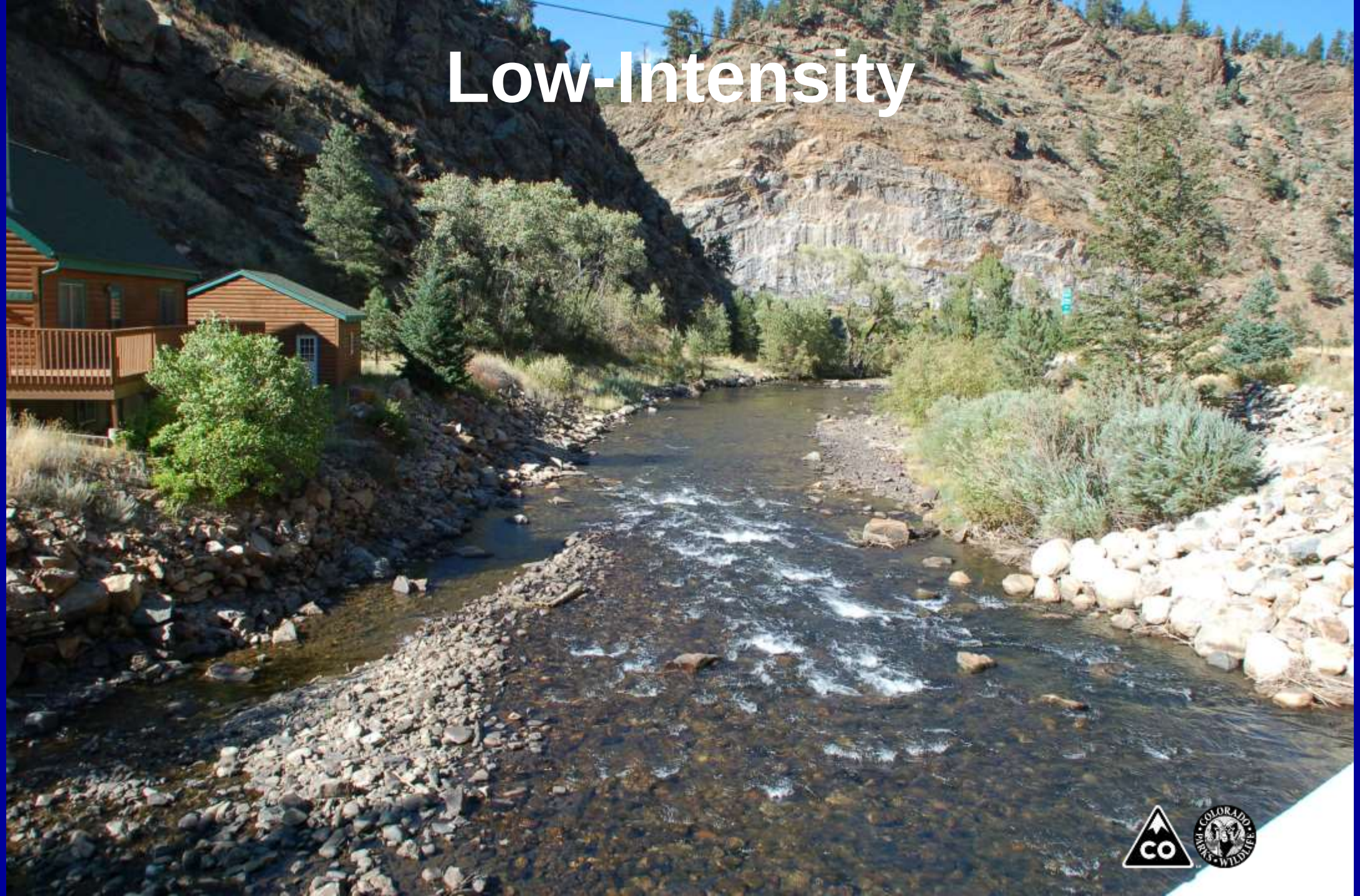
OVERVIEW

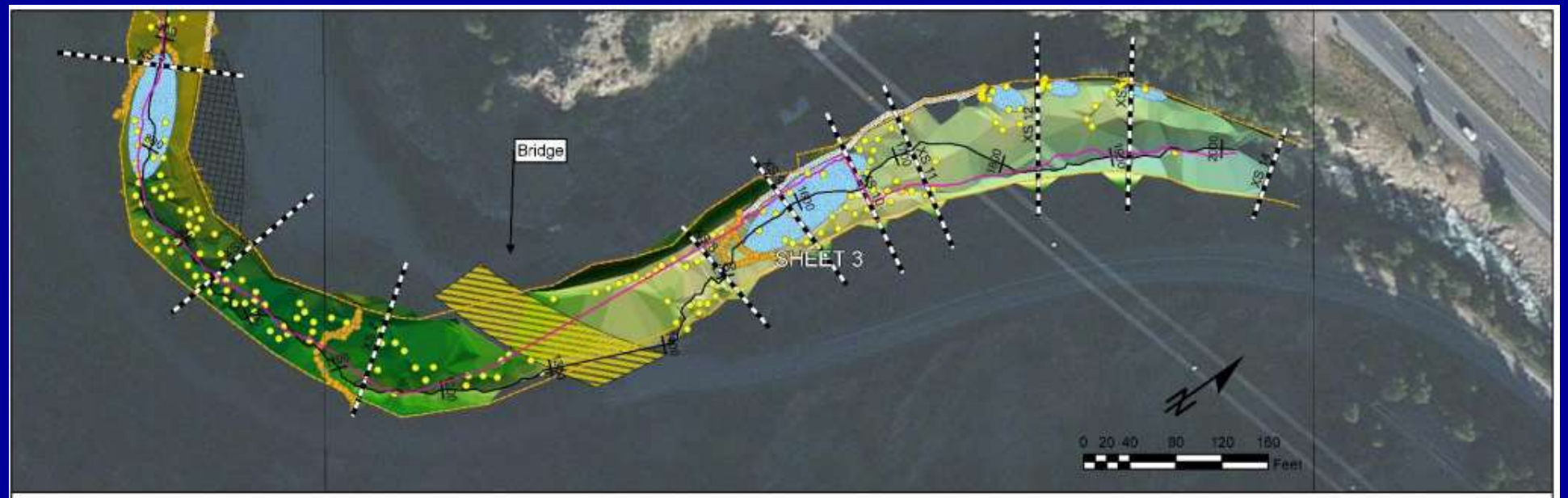
DRAWN: BSTAMPER	8/16/2017
CHECKED: ERICHER	8/23/2017
APPROVED:	
SHEET 1 OF 8	

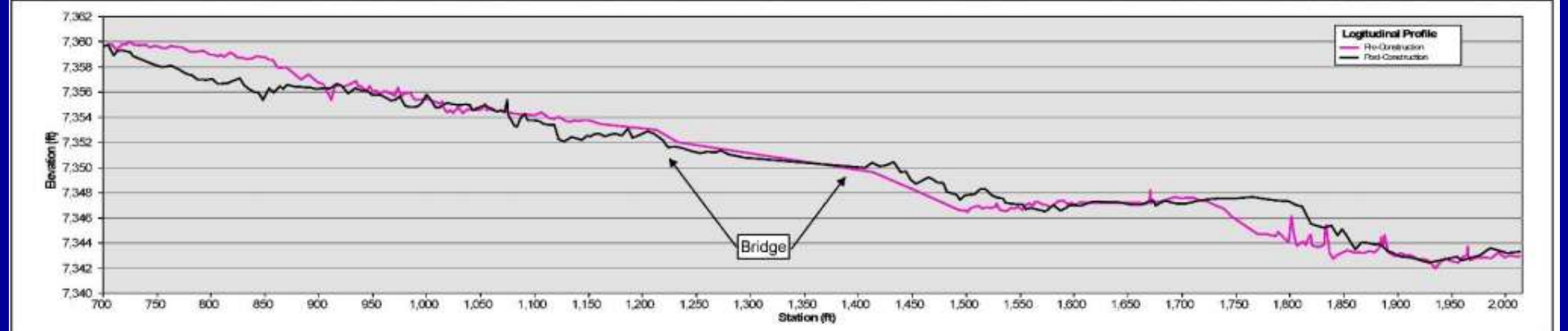
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

CLEAR CREEK
TWIN TUNNELS
AS-BUILT DRAWINGS

Low-Intensity







Thalweg (Pre-Construction)
Thalweg (Post-Construction)
Channel Alignment
Cross Section
Habitat Boulder
Log Vane
Boulder Structure
Boulder Toe
Pool Development
Riparian Bench
Point Bar Development
Bridge

LONGITUDINAL PROFILE

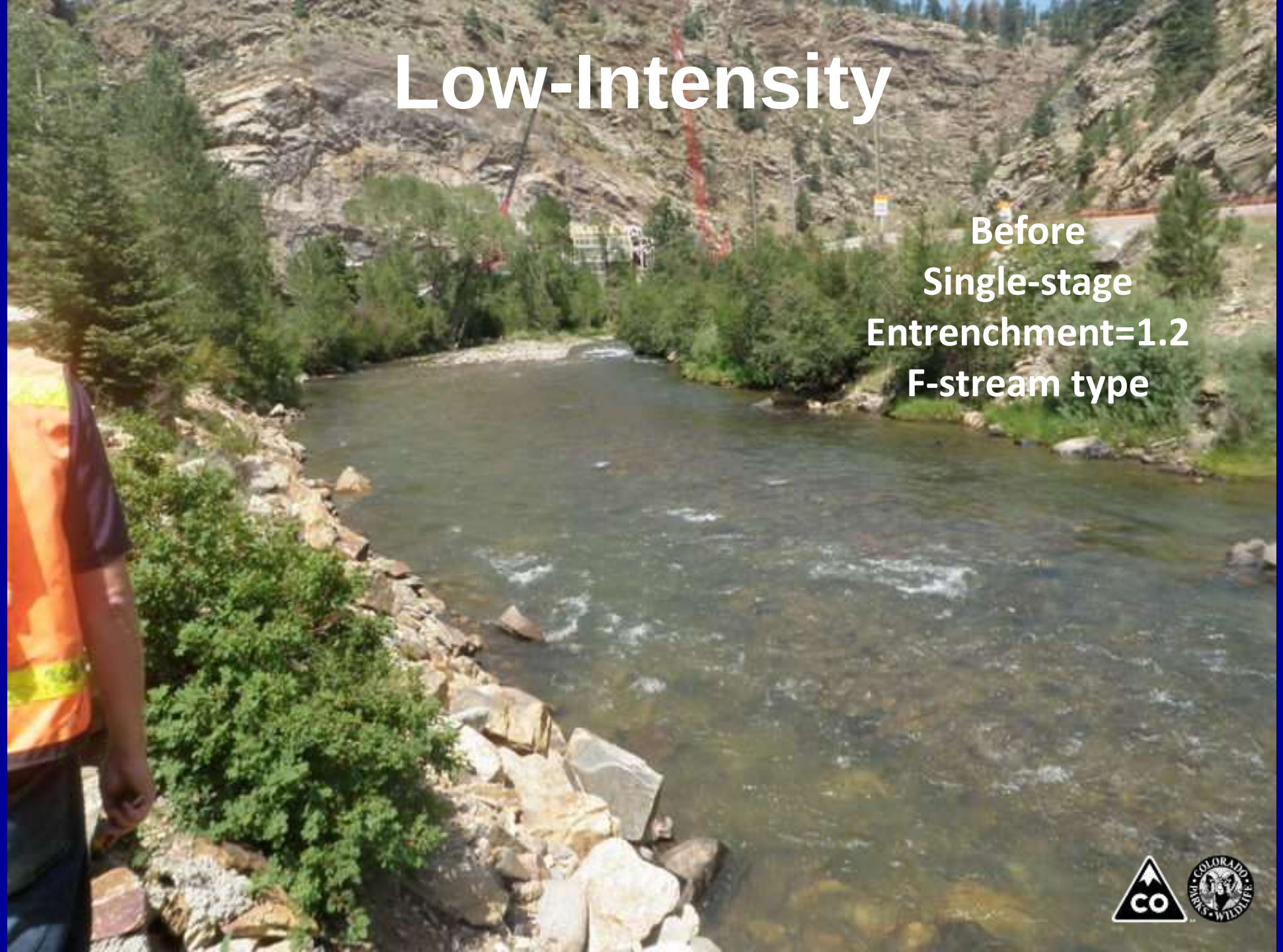
DRAWN: BSTAMPER	8/16/2017
CHECKED: ERICHER	8/23/2017
APPROVED:	

SHEET: 3 OF 8

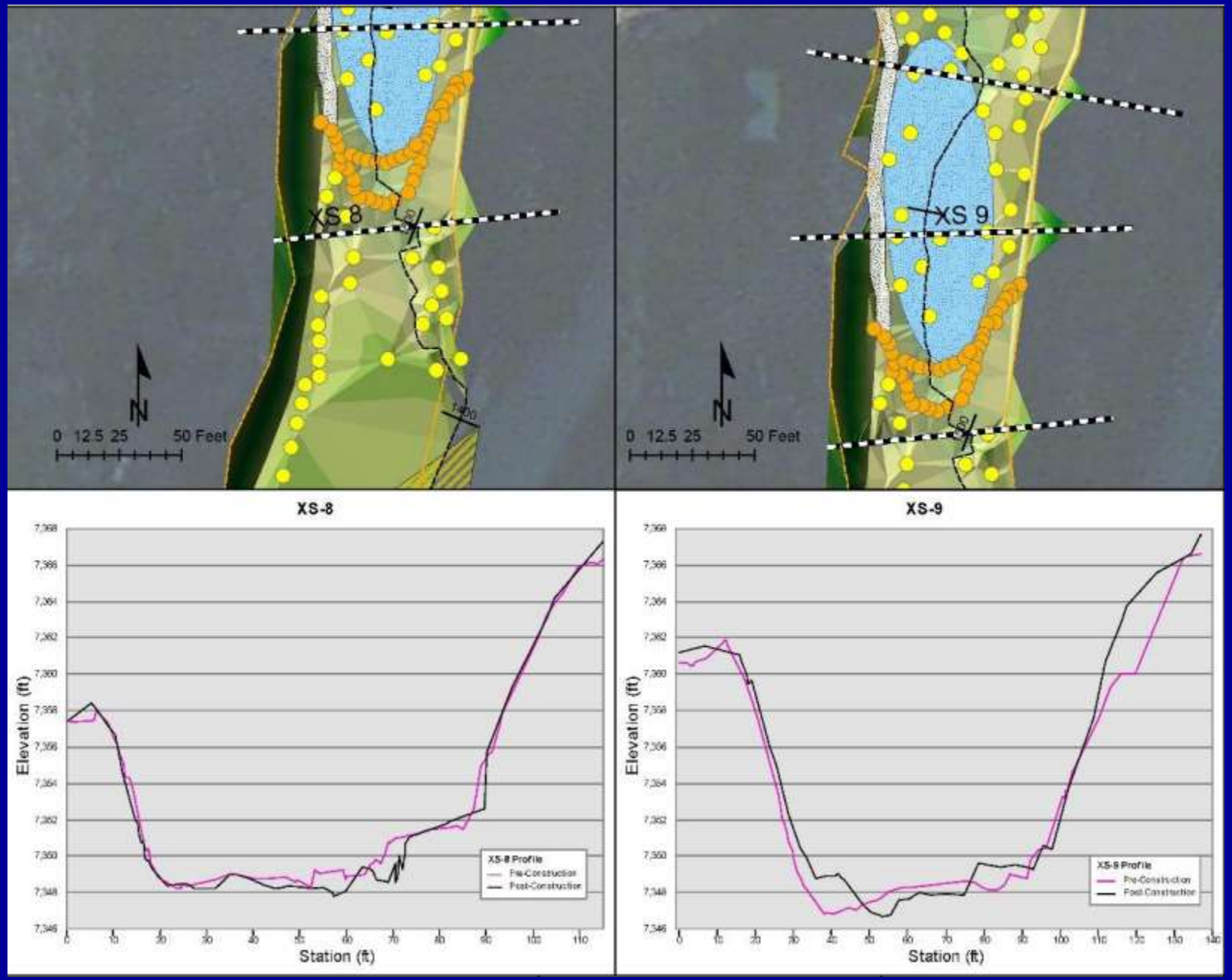
STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

CLEAR CREEK TWIN TUNNELS AS-BUILT DRAWINGS

Low-Intensity



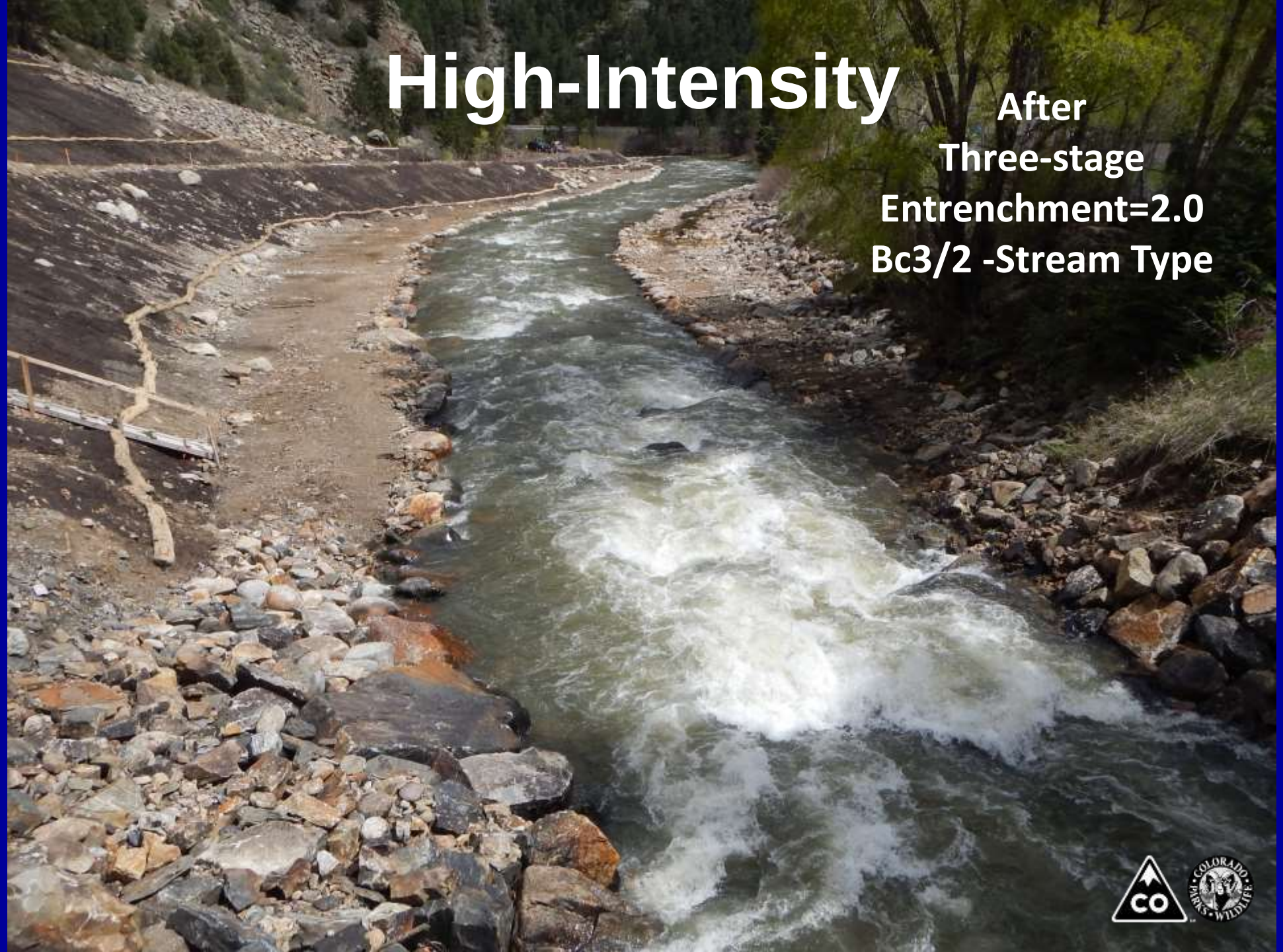
Low-Intensity

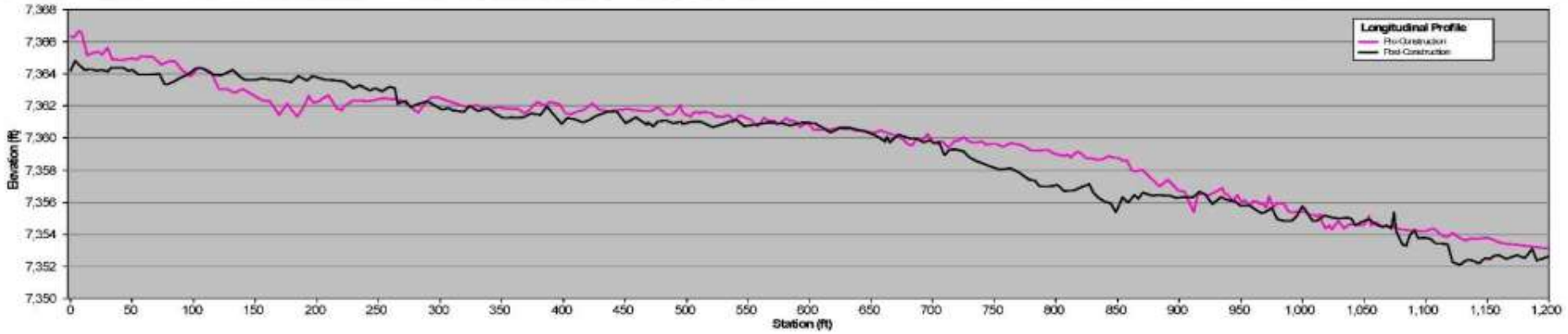

XS 8
XS 9
N
0 12.5 25 50 Feet
XS-8
XS-9
Elevation (ft)
Station (ft)
XS-8 Profile
Pre-Construction
Post-Construction

Low-Intensity

Treatment	Quantity	Units	Total	% of Total Project
Habitat Boulder	81	Each	234	35%
Boulder Structure	1	Each	9	11%
Boulder Toe	250	LF	2,708	9%
Pool Development	4	Each	14	29%
Point-Bar Development	0	SF	5,420	0%
Floodplain Development	0	SF	18,775	0%


High-Intensity
Before
Single-stage
Entrenchment=1.2
F3/2-stream type


High-Intensity
After
Three-stage
Entrenchment=2.0
Bc3/2 -Stream Type



Thalweg (Pre-Construction)
Thalweg (Post-Construction)
Channel Alignment
Cross Section
Habitat Boulder
Log Vane
Boulder Structure
Boulder Toe
Pool Development
Riparian Bench
Point Bar Development
Bridge

LONGITUDINAL PROFILE

DRAWN: BSTAMPER	8/16/2017
CHECKED: ERICHER	8/23/2017
APPROVED:	

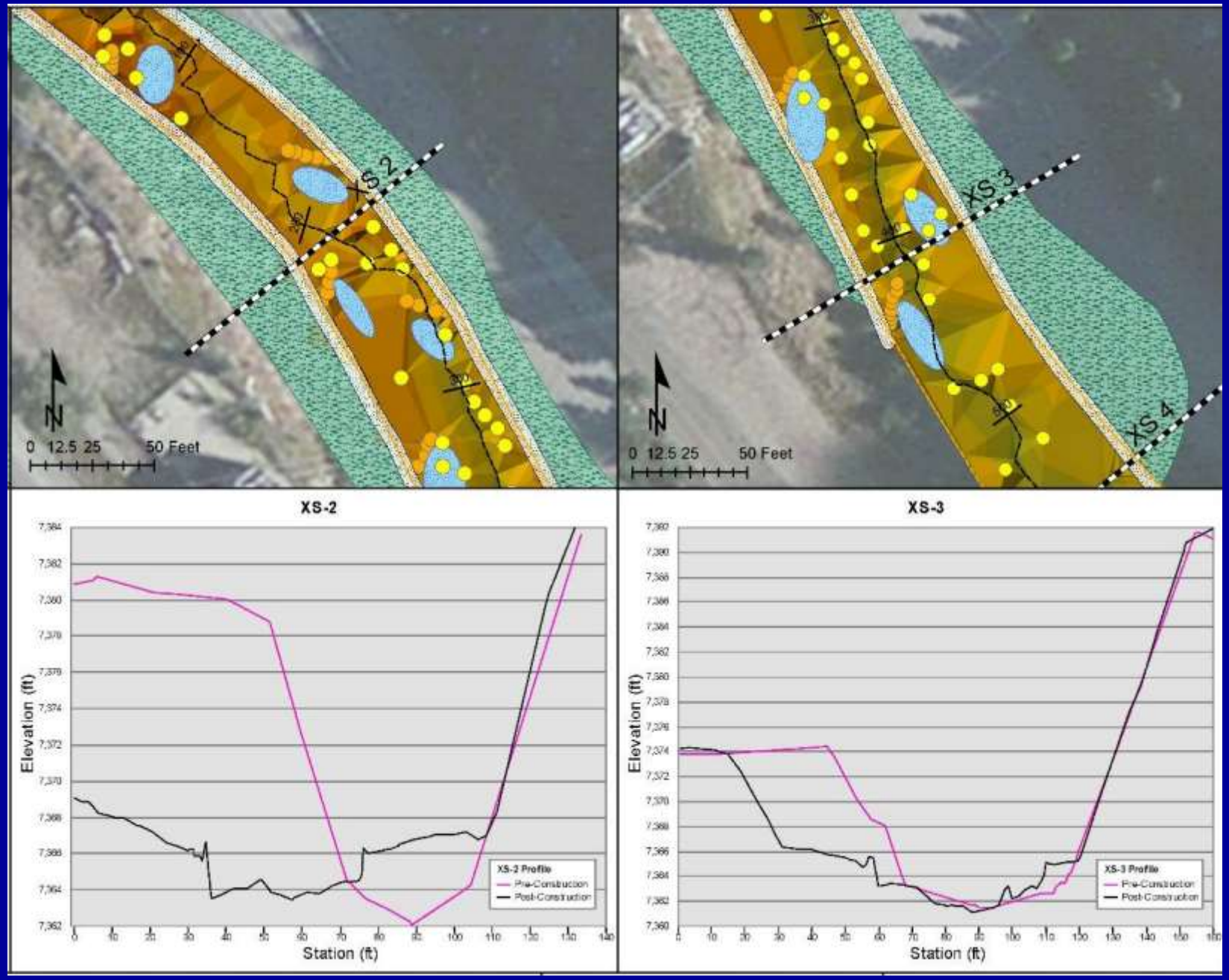
SHEET 2 OF 8

STATE OF COLORADO
DEPARTMENT OF NATURAL RESOURCES
COLORADO PARKS AND WILDLIFE
FORT COLLINS, COLORADO

CLEAR CREEK TWIN TUNNELS AS-BUILT DRAWINGS


High-Intensity
Before


High-Intensity
After

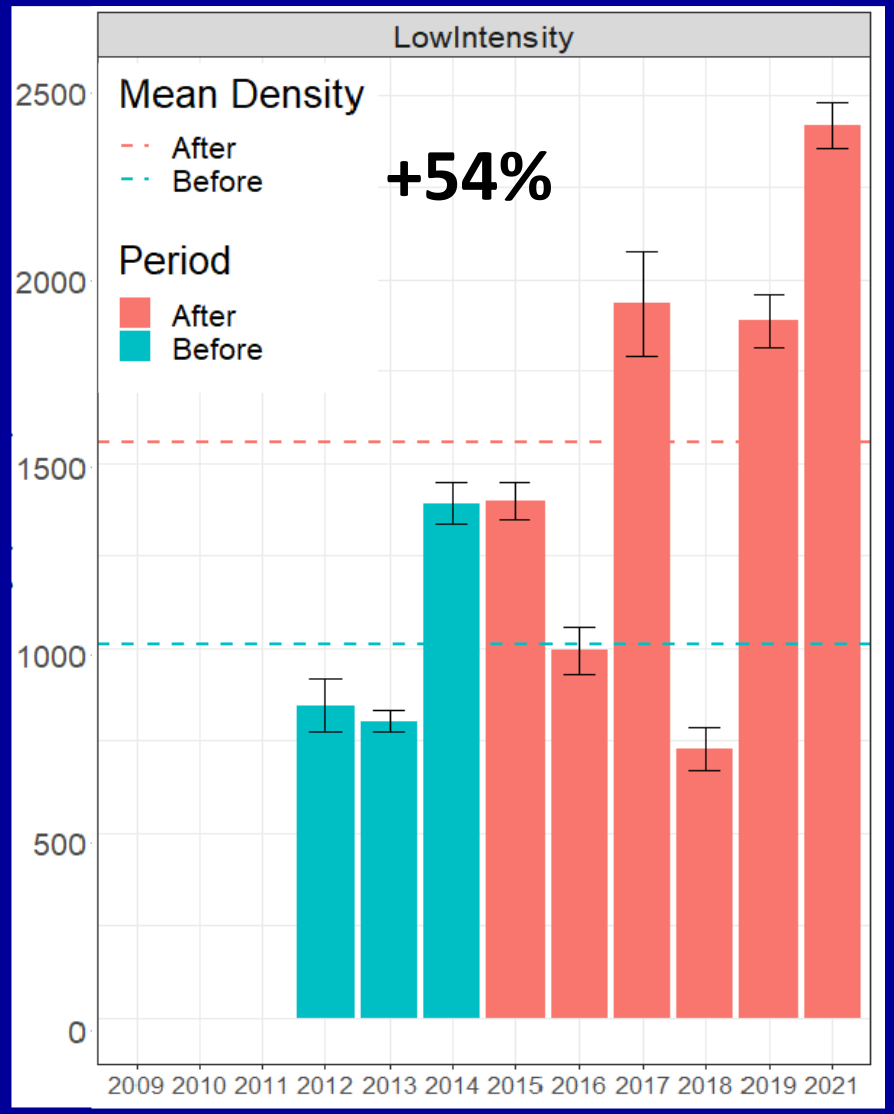

XS 2
XS 3
XS 4
N
0 12.5 25 50 Feet
XS-2
Elevation (ft)
Station (ft)
XS-2 Profile
Pre-Construction
Post-Construction
XS-3
Elevation (ft)
Station (ft)
XS-3 Profile
Pre-Construction
Post-Construction

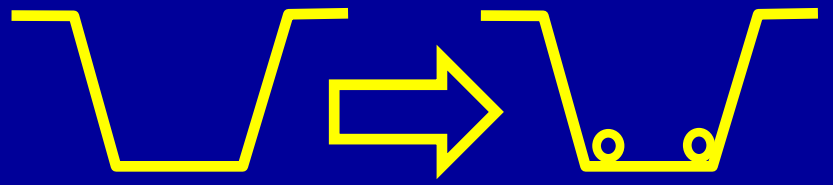
High-Intensity

Treatment	Quantity	Units	Total	% of Total Project
Habitat Boulder	153	Each	234	65%
Boulder Structure	8	Each	9	89%
Boulder Toe	2,458	LF	2,708	91%
Pool Development	10	SF	14	71%
Point-Bar Development	5,420	SF	5,420	100%
Floodplain Development	18,775	SF	18,775	100%

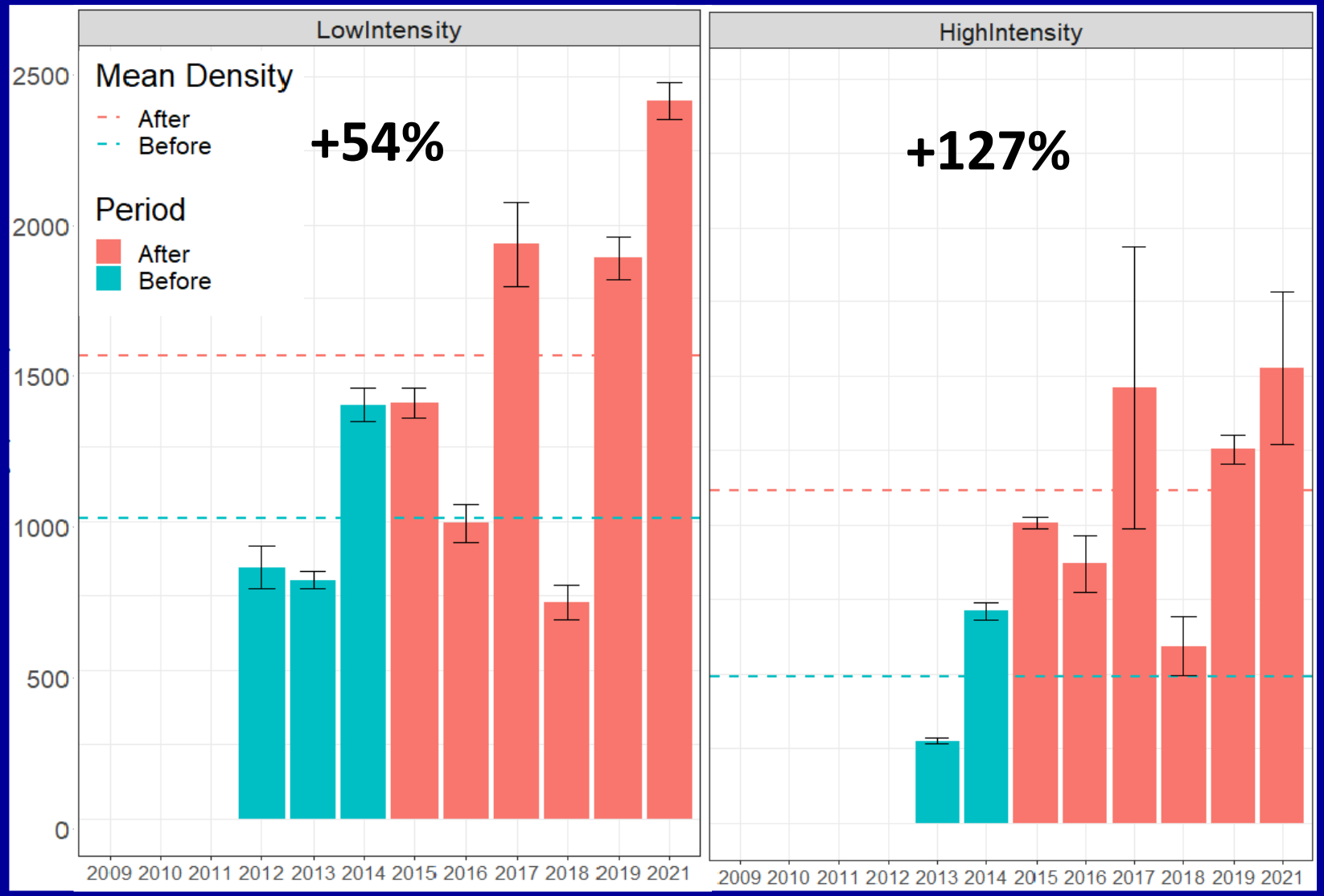
Control

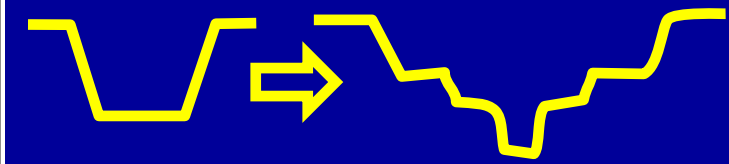
Low-Intensity Treatment



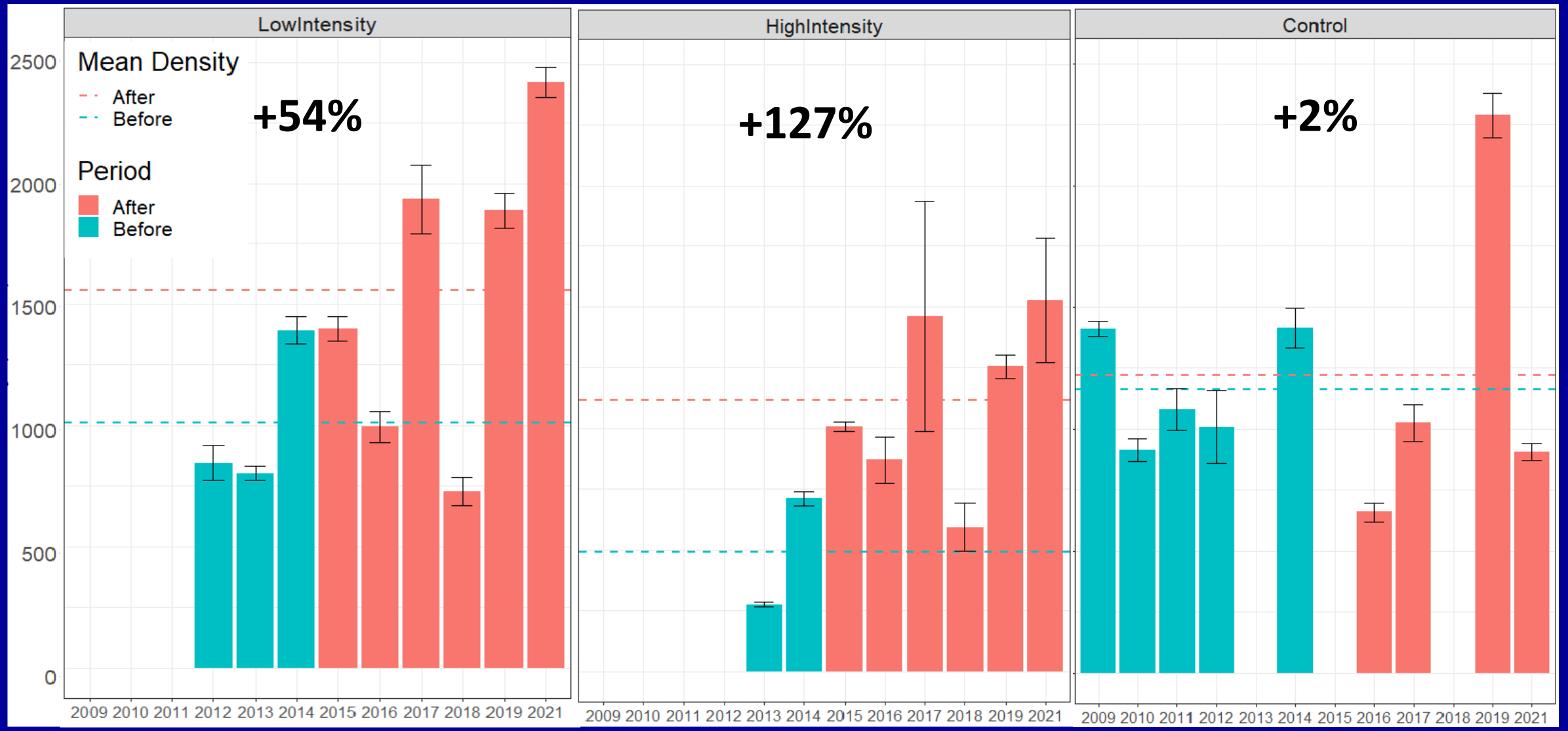


High-Intensity Treatment





Control

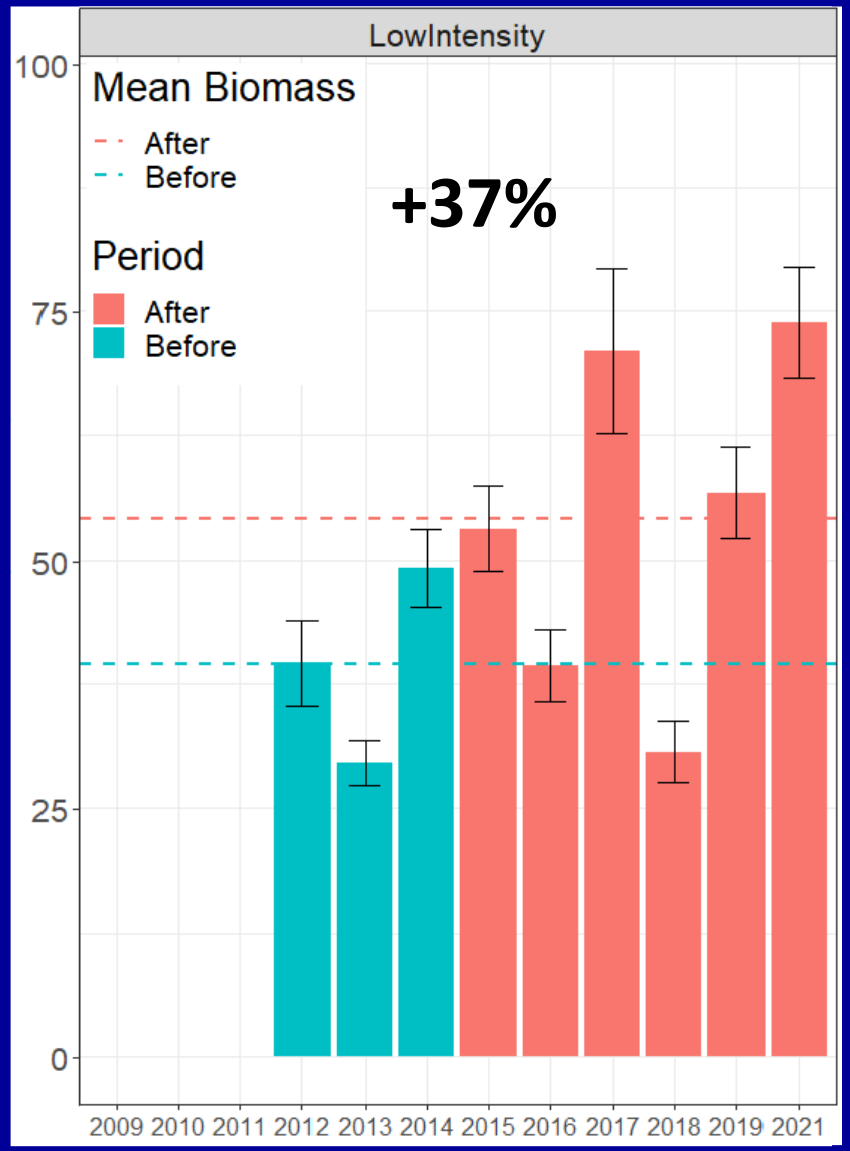

Age 1+ Brown Trout Density (#/mile
LowIntensity
HighIntensity
Control
Mean Density
After
Before
Period
After
Before
+54%
+127%
+2%
2500
2000
1500
1000
500
0
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2021
Year

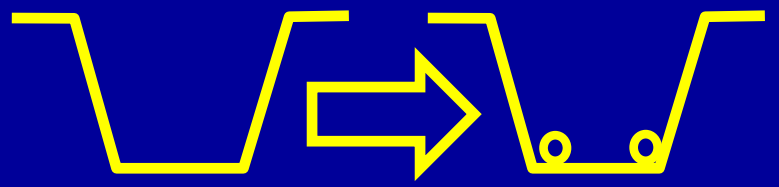
Treatment vs. Control: Age 1+ Brown Trout Density (#/mile)

Evidence of Treatment effect on Age 1+ Trout Density?

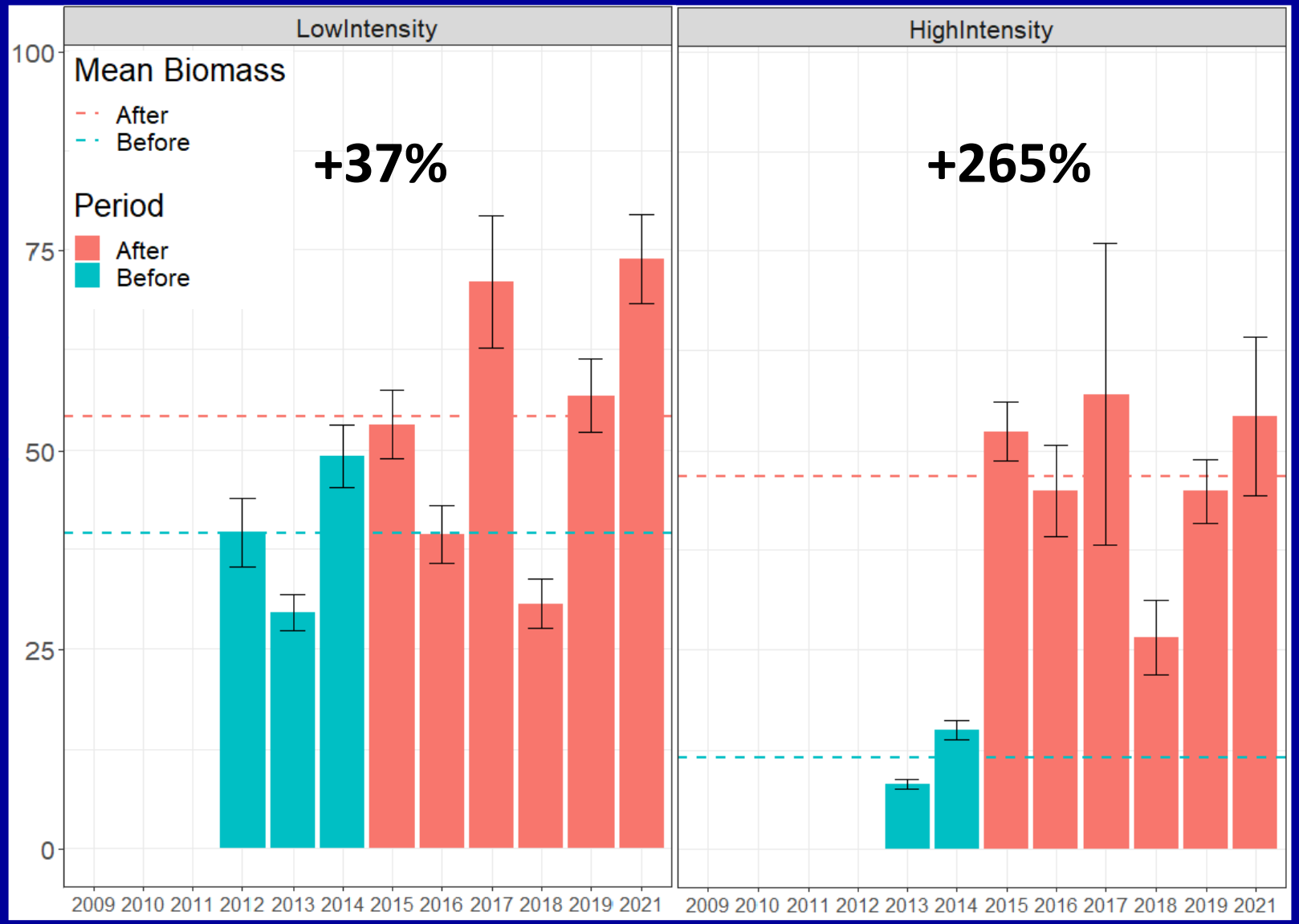
No: “period × type” interaction not significant ($p > 0.1$)

Low-Intensity Treatment



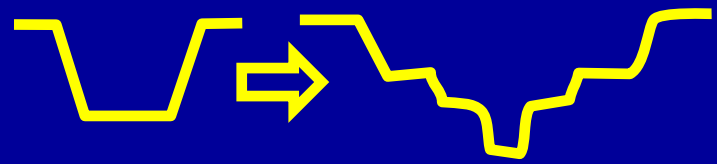


High-Intensity Treatment

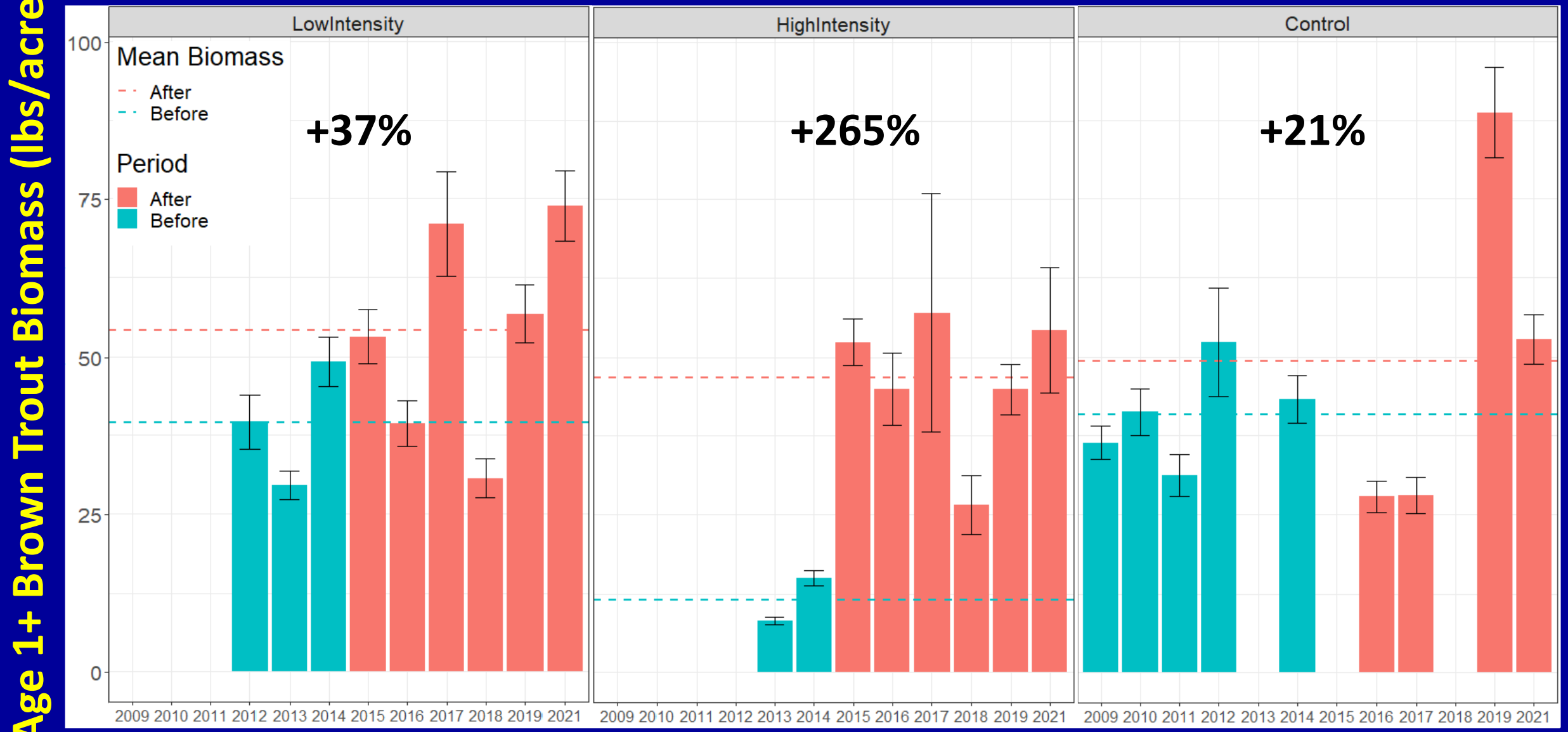


Age 1+ Brown Trout Biomass (lbs/acre)

Year



Control

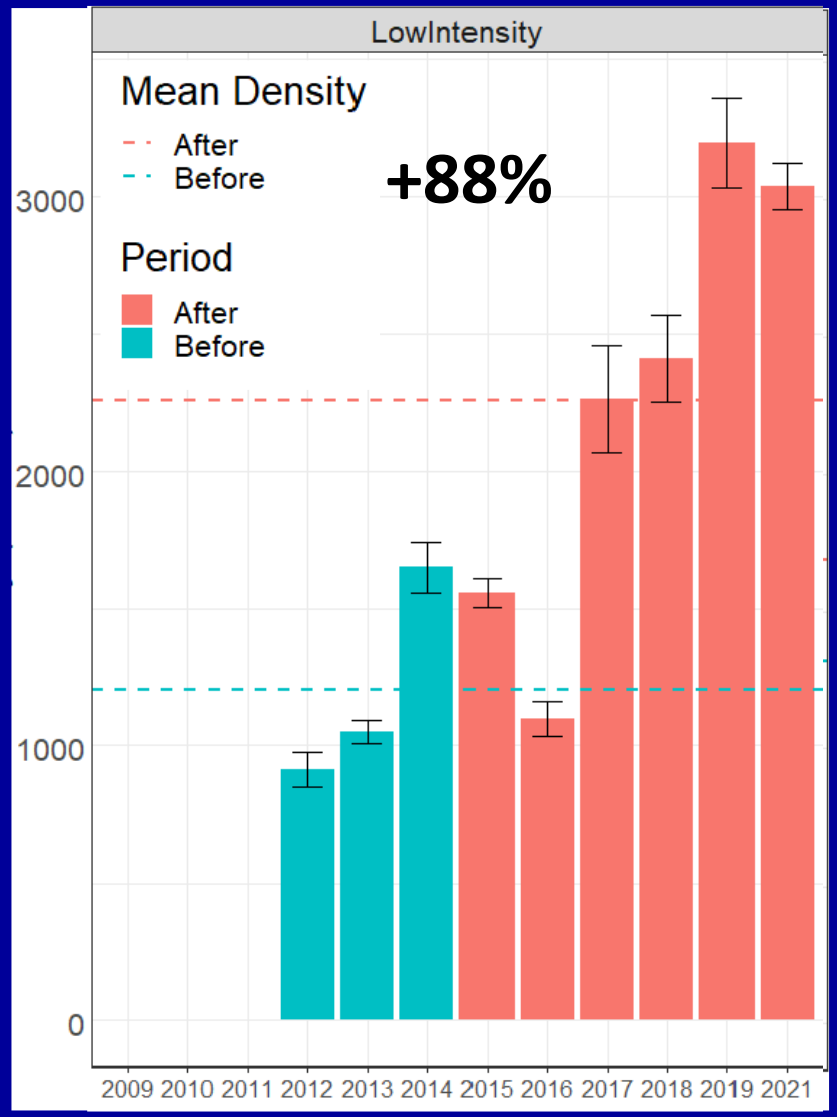

Age 1+ Brown Trout Biomass (lbs/acre)
LowIntensity
HighIntensity
Control
Mean Biomass
After
Before
Period
After
Before
+37%
+265%
+21%
100
75
50
25
0
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2021
Year

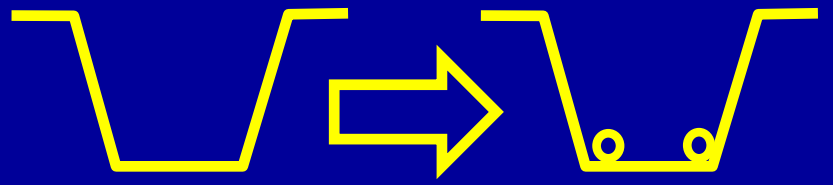
Treatment vs. Control: Age 1+ Brown Trout Biomass (lbs/acre)

Evidence of Treatment effect on Age 1+ Trout Biomass?

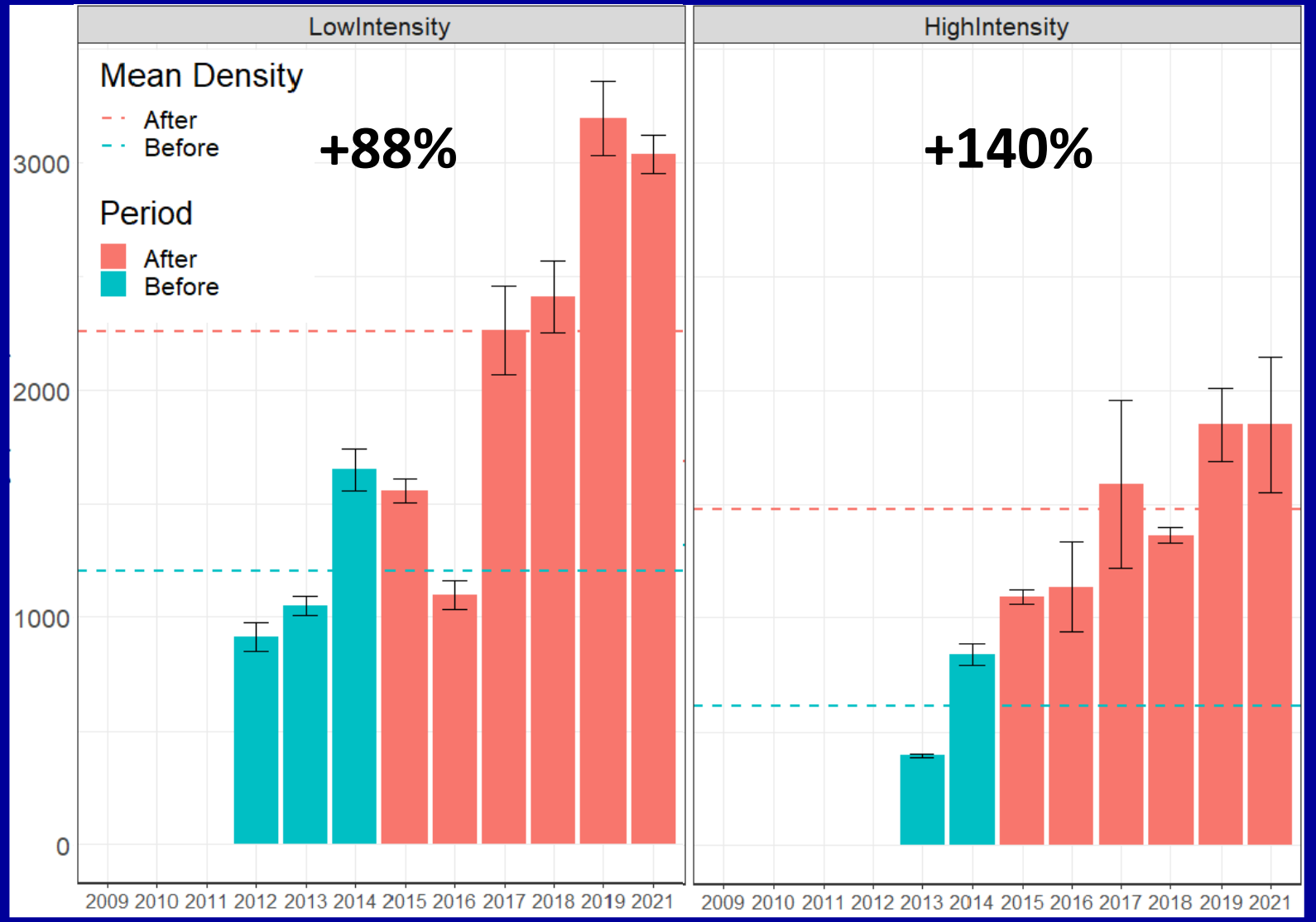
No: “period × type” interaction not significant ($p > 0.1$)

Low-Intensity Treatment



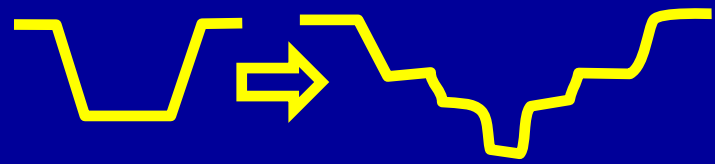


High-Intensity Treatment

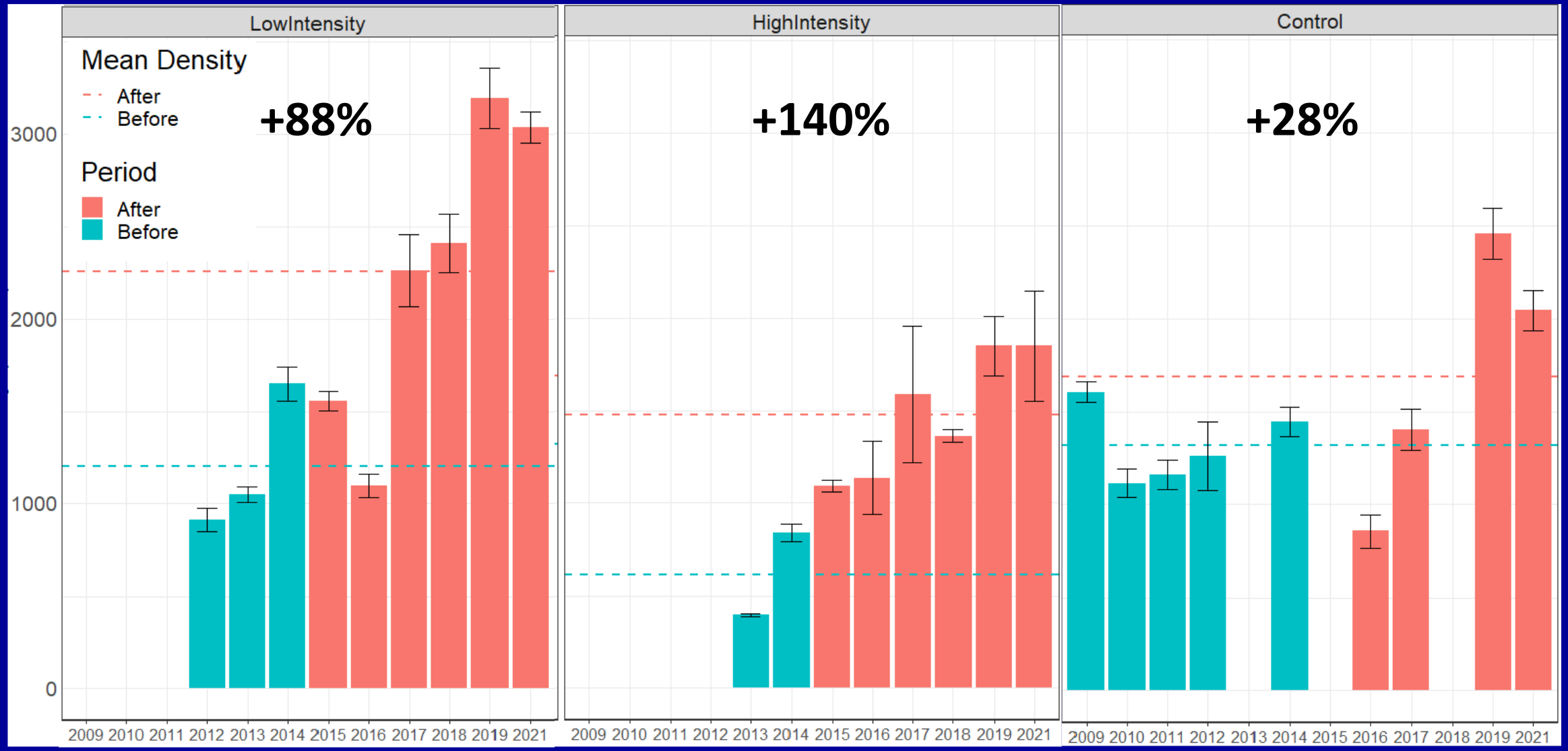


Total Brown Trout Density (#/mile

Year



Control

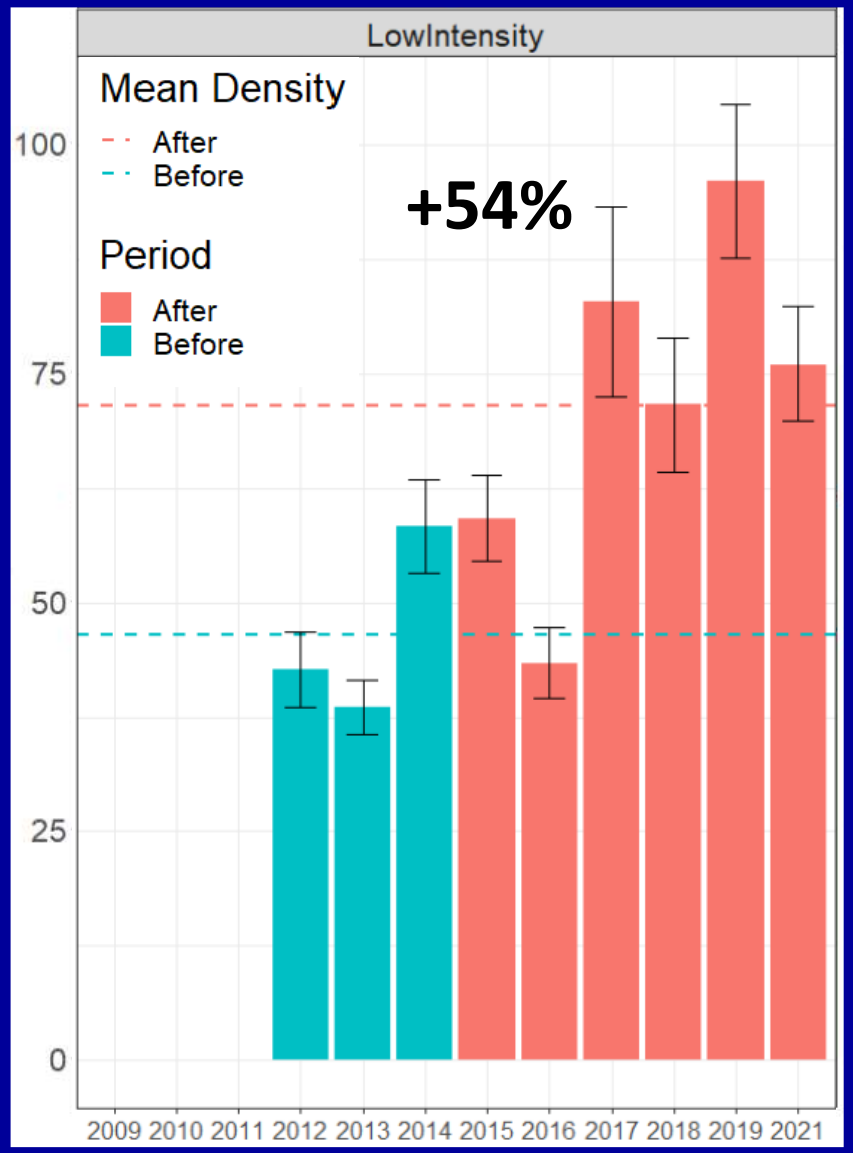

LowIntensity
HighIntensity
Control
Mean Density
After
Before
Period
After
Before
+88%
+140%
+28%
Total Brown Trout Density (#/mile
3000
2000
1000
0
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2021
Year

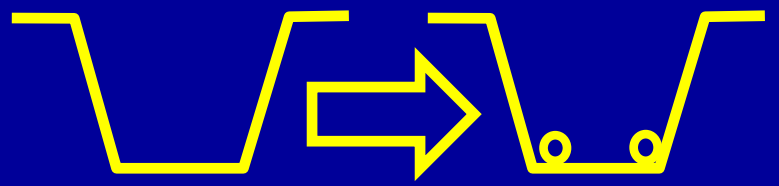
Treatment vs. Control: Total Brown Trout Density (#/mile)

Evidence of Treatment effect on Total Trout Density?

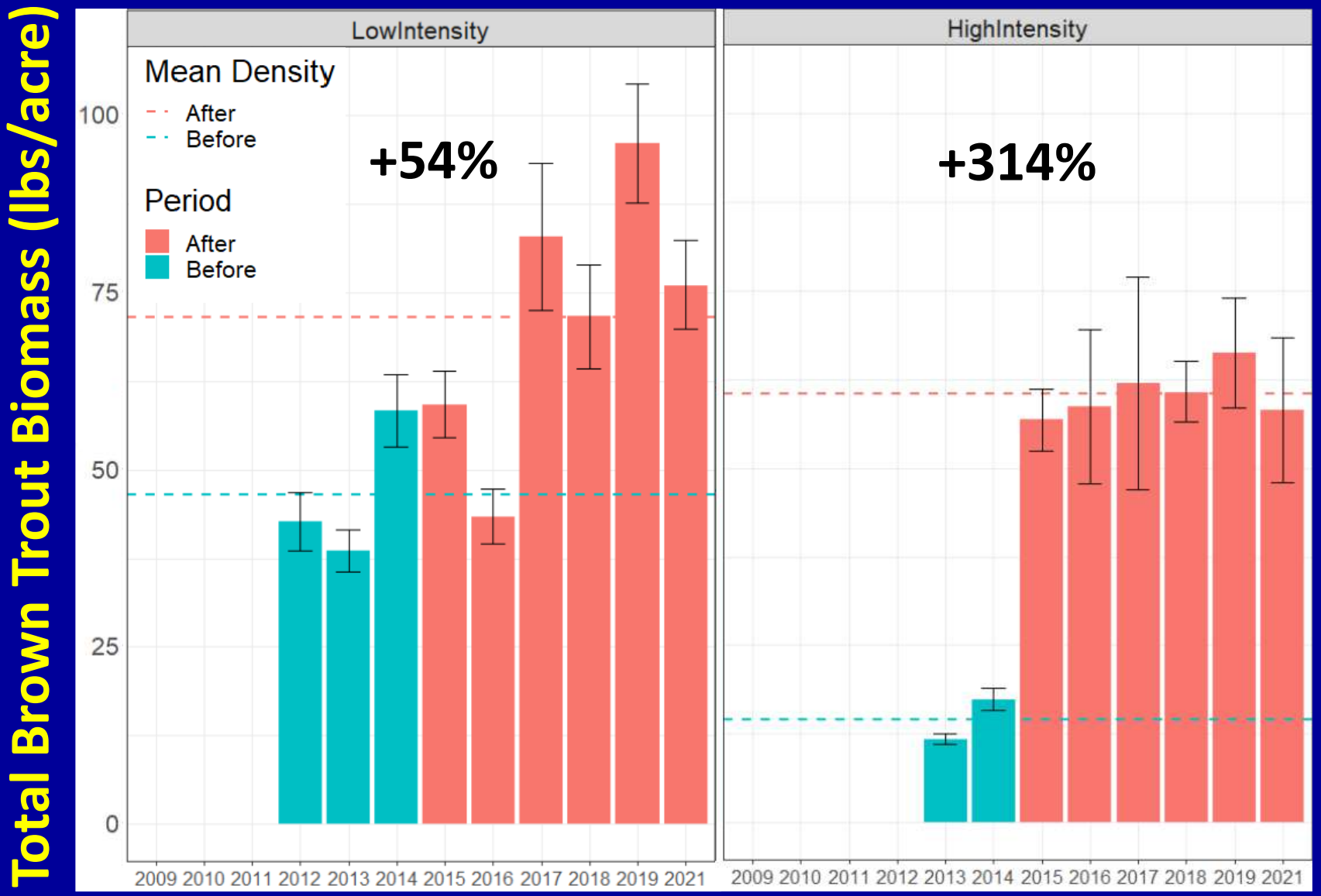
No: “period × type” interaction not significant ($p > 0.1$)

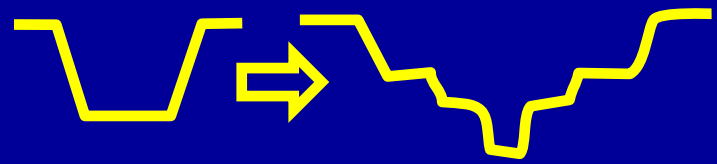
Low-Intensity Treatment



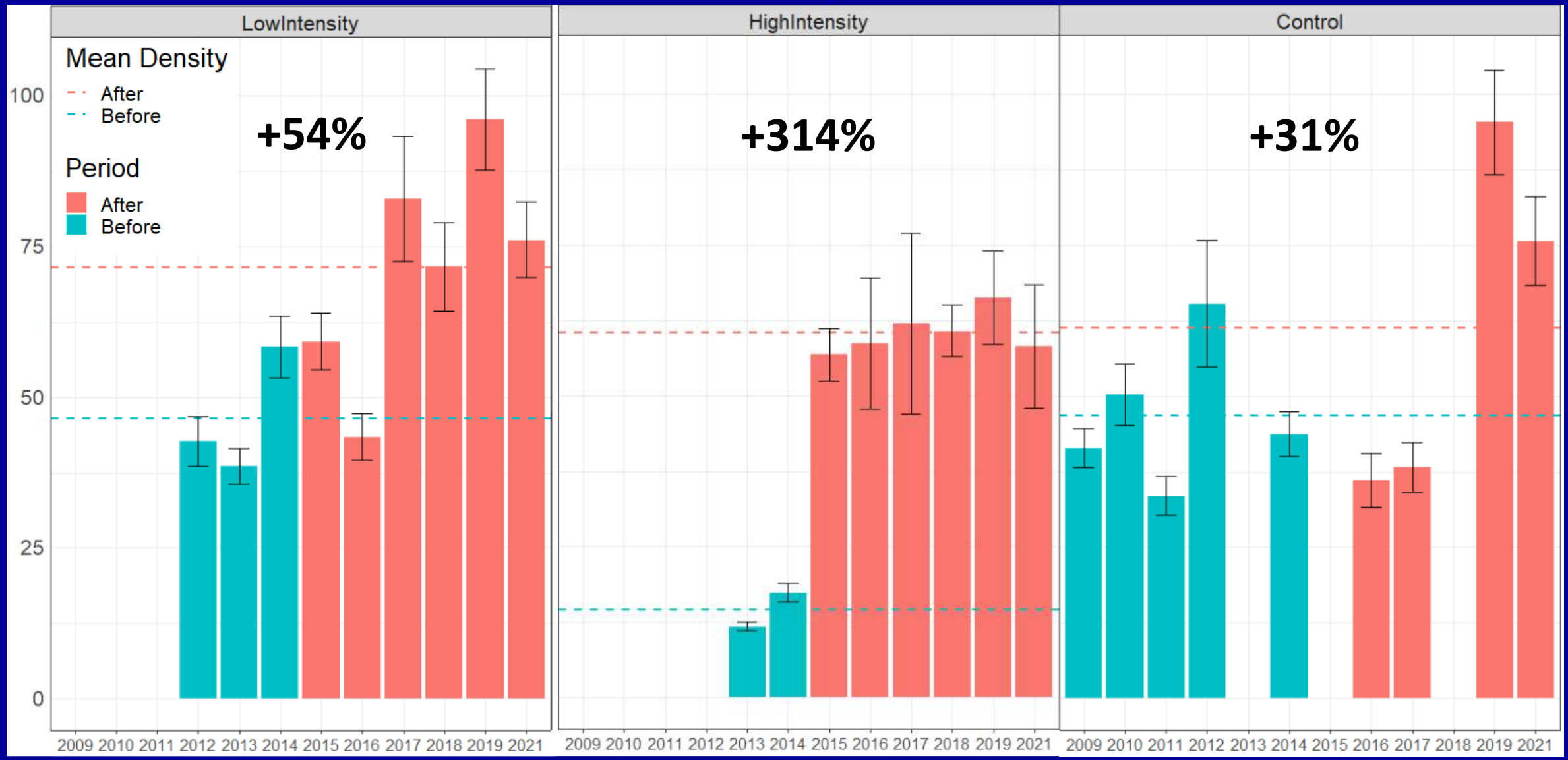


High-Intensity Treatment





Control


Total Brown Trout Biomass (lbs/acre)
LowIntensity
HighIntensity
Control
Mean Density
After
Before
Period
After
Before
+54%
+314%
+31%
100
75
50
25
0
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2021
Year

Treatment vs. Control: Total Brown Trout Biomass (lbs/acre)

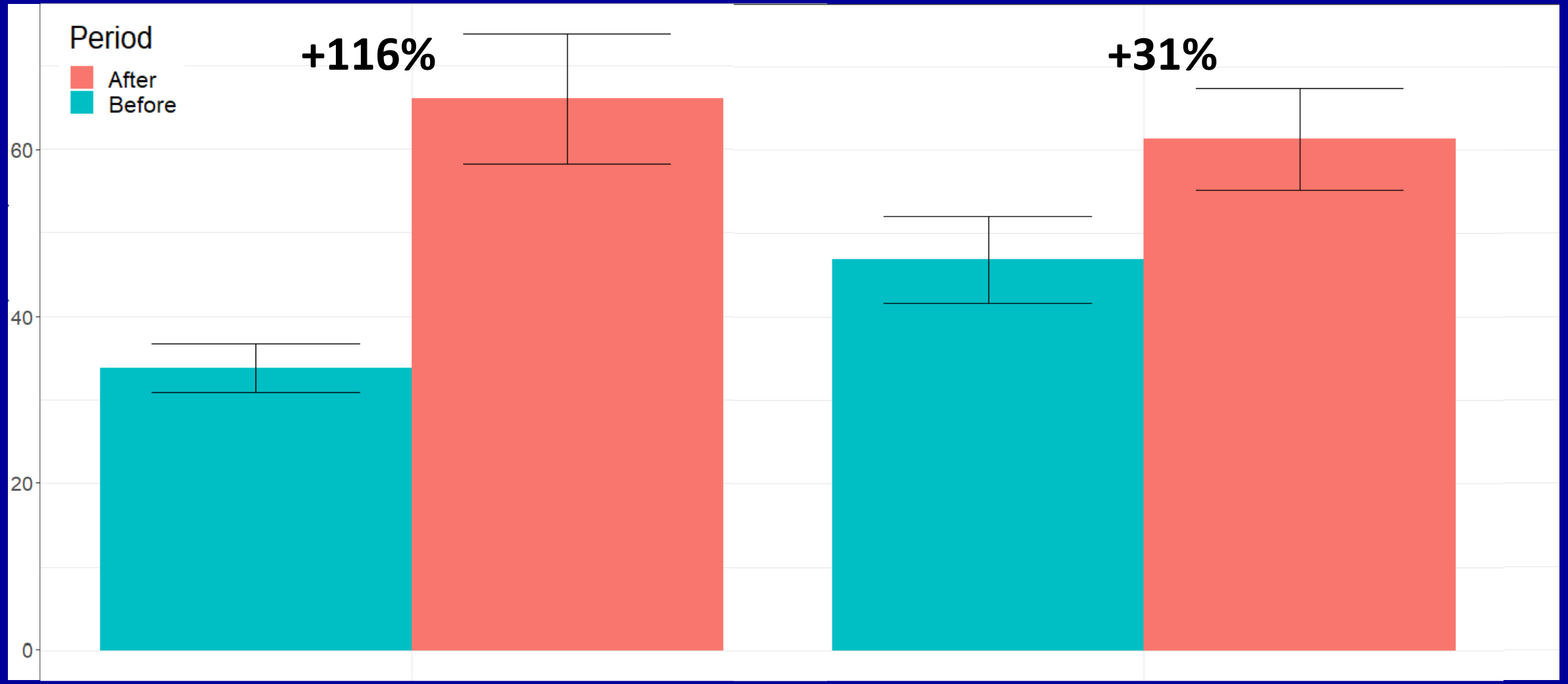
Evidence of Treatment effect on Total Trout Biomass?

Yes "period × type" interaction IS significant ($p = 0.07$; $p<0.1$)

AND

"period" IS significant ($p = 0.0009$; $p<0.1$)

Treatment vs. Control



Low vs. High vs. Control: Total Brown Trout Biomass (lbs/acre)

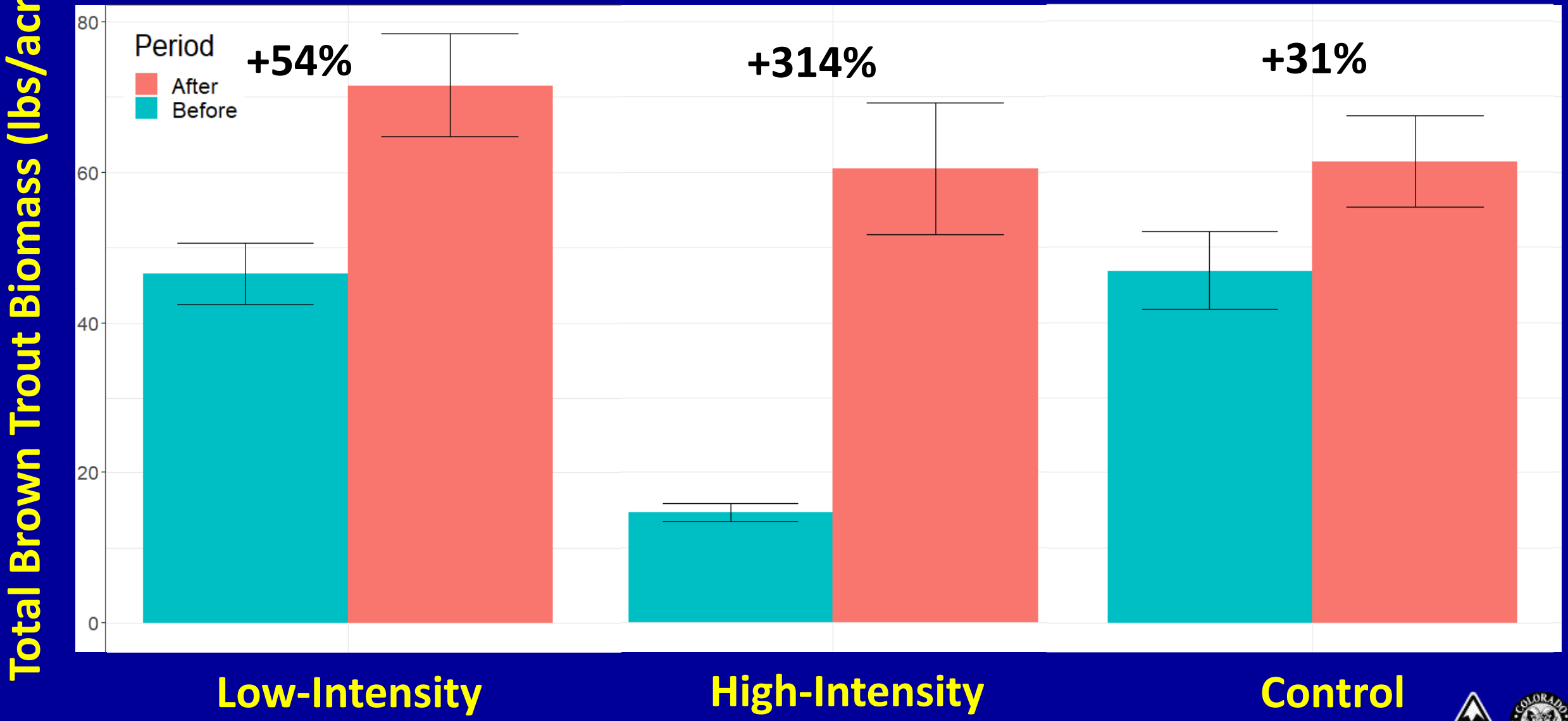
Evidence of Treatment effect on Total Trout Biomass?

Yes “period × type [High-Intensity]” interaction IS significant ($p = 0.027$; $p<0.1$)

AND

“period” IS significant ($p = 0.0009$; $p<0.1$)

Low vs. High vs. Control



Channel Bed Characteristics

Treatment Reach	D50		% change
Low-Intensity	Before	After	
	131.3 mm	77.0 mm	- 41% (finer)
High-Intensity	Before	After	
	125.5 mm	81.5 mm	- 35% (finer)

Conclusions

- Departure from natural conditions (such as channelization) has negative consequences to fish populations that may not recover without physical intervention

Conclusions

- Departure from natural conditions (such as channelization) has negative consequences to fish populations that may not recover without physical intervention
- Restoration of channelized, single-stage streams to a multi-stage channel form with a functional floodplain has greatest potential for increasing trout biomass, density and spawning habitat suitability

Conclusions

- Departure from natural conditions (such as channelization) has negative consequences to fish populations that may not recover without physical intervention
- Restoration of channelized, single-stage streams to a multi-stage channel form with a functional floodplain has greatest potential for increasing trout biomass, density and spawning habitat suitability
- Channelization and loss of floodplain connectivity have the potential for devastating impacts to wild trout populations