Effects of forest harvesting and riparian buffers on headwater stream temperatures

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Headwater Streams

- Small in size, but can be 80% of stream length
- High density on the landscape in steep terrain
- High Biodiversity – invertebrates, amphibians, fish
- Sensitive to Landscape Changes – e.g., harvesting
- Concern about headwater stream temperature and sediments that impact biota
- Impact Downstream Processes – Cumulative Effects

Objectives

1. To determine the effect of clearcut harvesting and riparian buffers on headwater stream summer temperatures (July and August) in lowland Douglas-fir forests in western Washington

2. To determine how long stream temperatures in headwater streams take to recover after clearcut harvesting

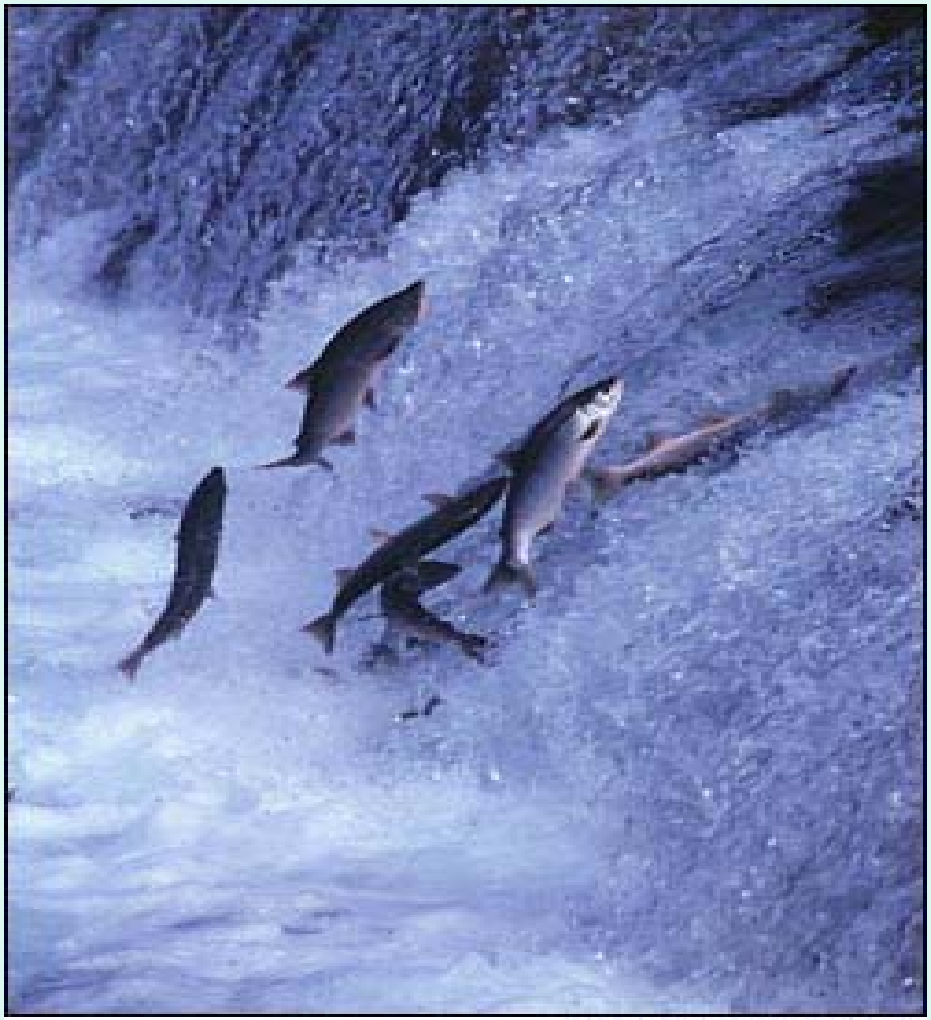
3. To determine management implications with respect to harvesting and stream temperatures

What have others found about effects of harvesting and riparian buffers on headwater stream temperatures

Studies from California, Oregon, Washington, and BC

- Summer maximum stream temperatures in clearcuts can be cooler or as much as 11 C higher compared to uncut forests
- Summer minimum temperatures are less sensitive to harvesting
- Riparian buffers can reduce elevated temperatures by as much as half
- Recovery after harvesting can be as long as 15 years

Cold-water salmon are very sensitive to temperature changes



Courtesy American Rivers

Invertebrates and salamanders are also very sensitive to temperature changes

Sensitivity of fish and amphibians to temperature

- WA DOE criteria – 7 day- average of maximum temperatures in excess of 16 C.

- Critical thermal maxima for NW salamander species larvae and adults,

  - southern torrent salamander - 26.7 and 27.9 C (Bury, 2008)

Many factors affect stream temperatures

air temperature

stream morphology

ground-water

riparian and basin vegetation condition

harvesting

shade

aspect

windthrow and sediment

stream wood

Factors controlling Stream Temperatures

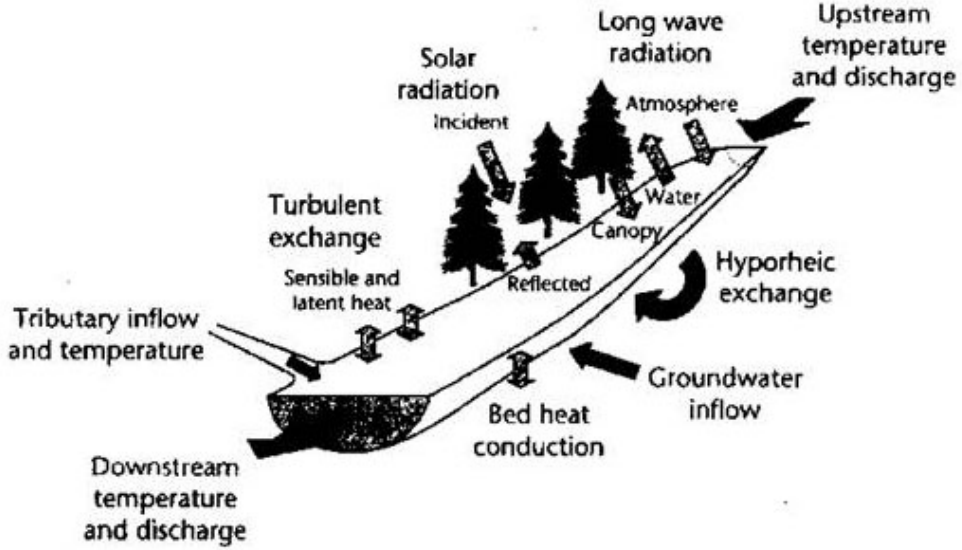
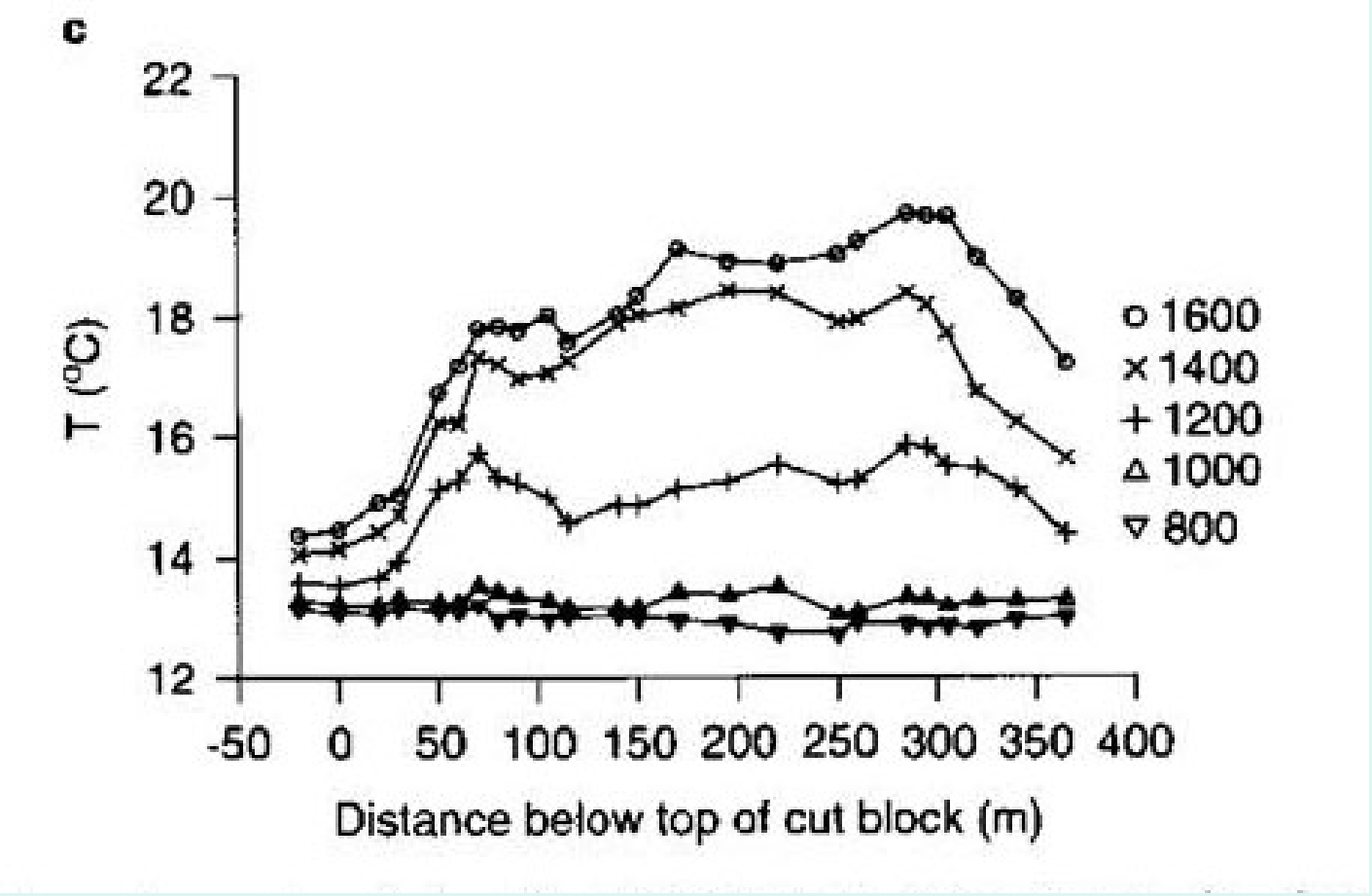


Figure 1. Factors Controlling Stream Temperature. Energy fluxes associated with water exchanges are shown as black arrows.

Lateral changes in stream temperature in a clearcut in British Columbia – August 2001 Moore et al. (2005)



Washington DNR Forest Practices Stream Classification

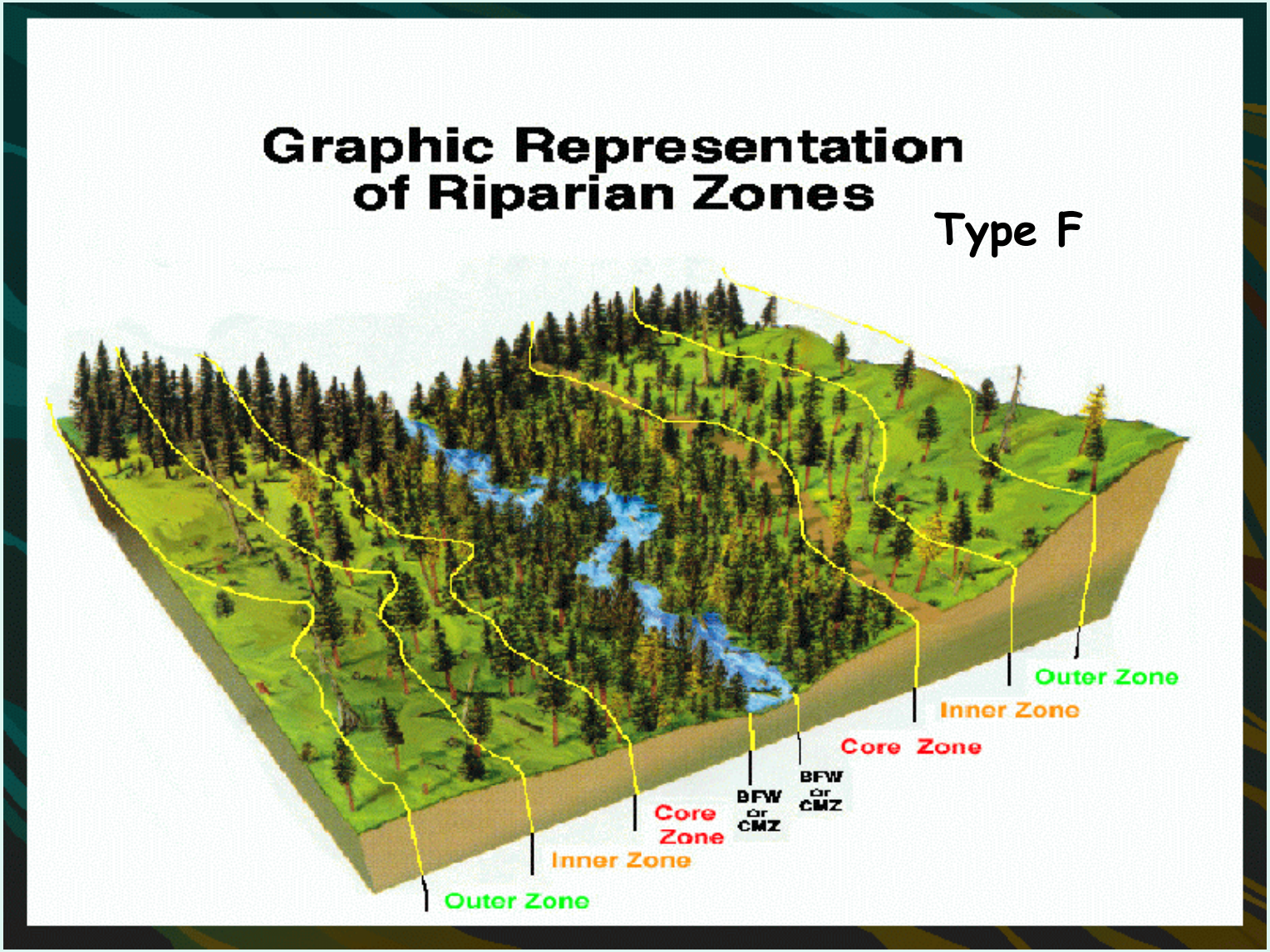
Type S - Shoreline

Type F - Fish

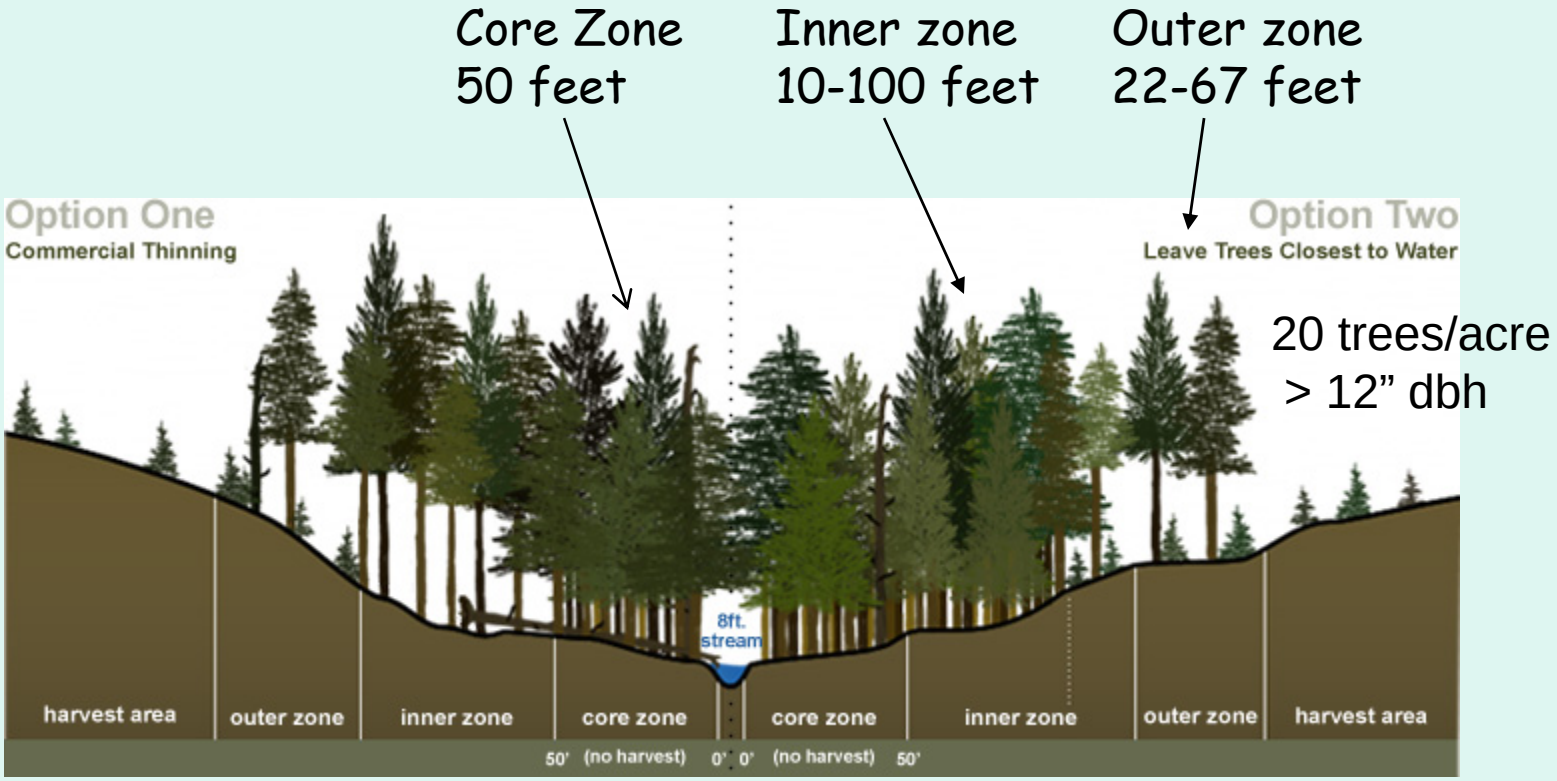
Type Np - Non-fish perennial

Type Ns - Non-fish seasonal

TYPE F STREAMS HAVE RIPARIAN PROTECTION

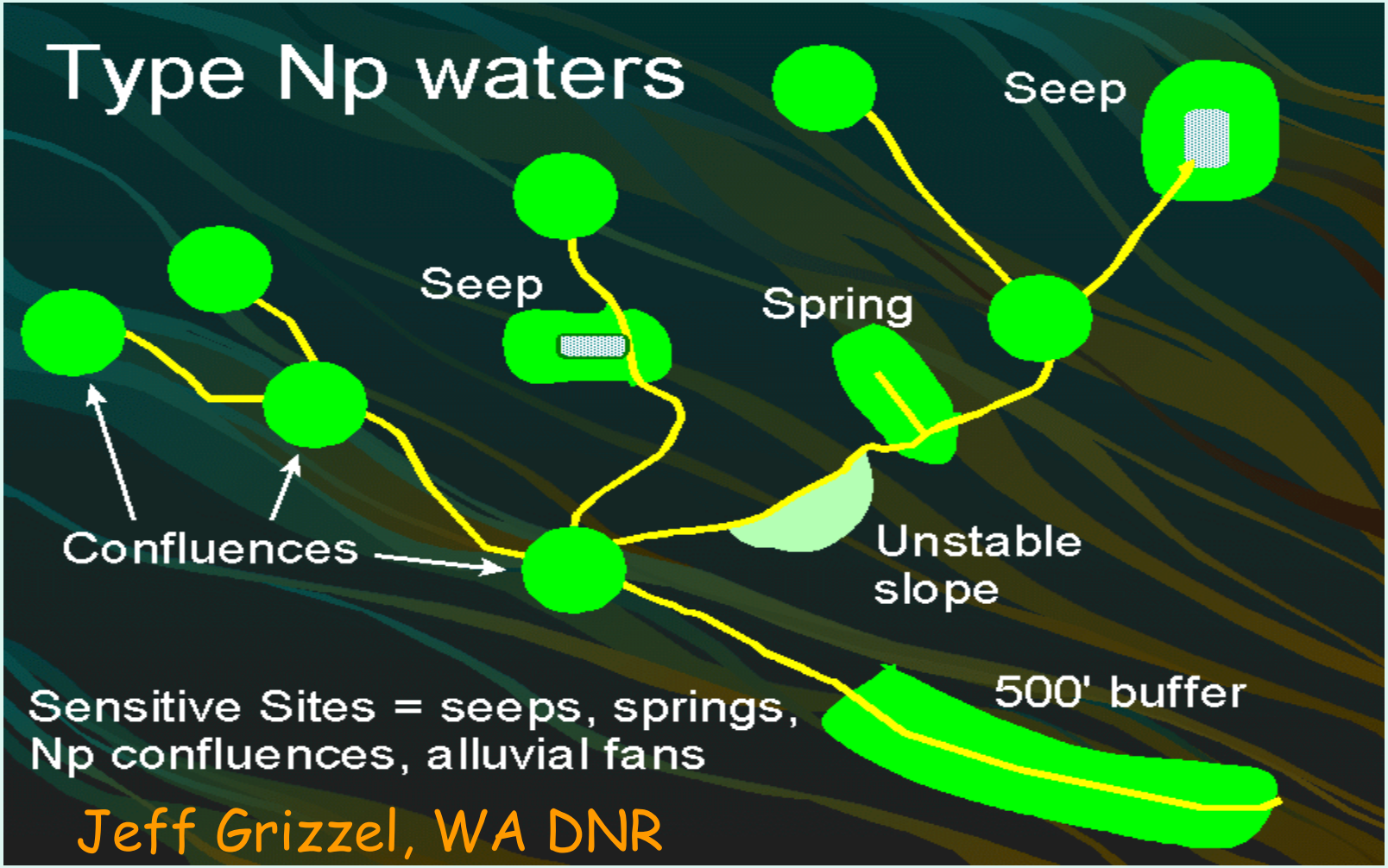


Jeff Grizzel, WA DNR



The WA Forest Practices requires leaving the riparian area in a condition today that will grow to replicate natural stands of older forest at age 140 years. A certain number of trees and canopy cover need to be left within the riparian zone to achieve this Desired Future Condition (DFC)

Under Forest Practices, headwater streams discontinue protection
10 m equipment restriction zone
Wide buffer strips make timber harvest difficult



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- Most streams are non fish headwaters in lowland Douglas-fir forests in western Washington

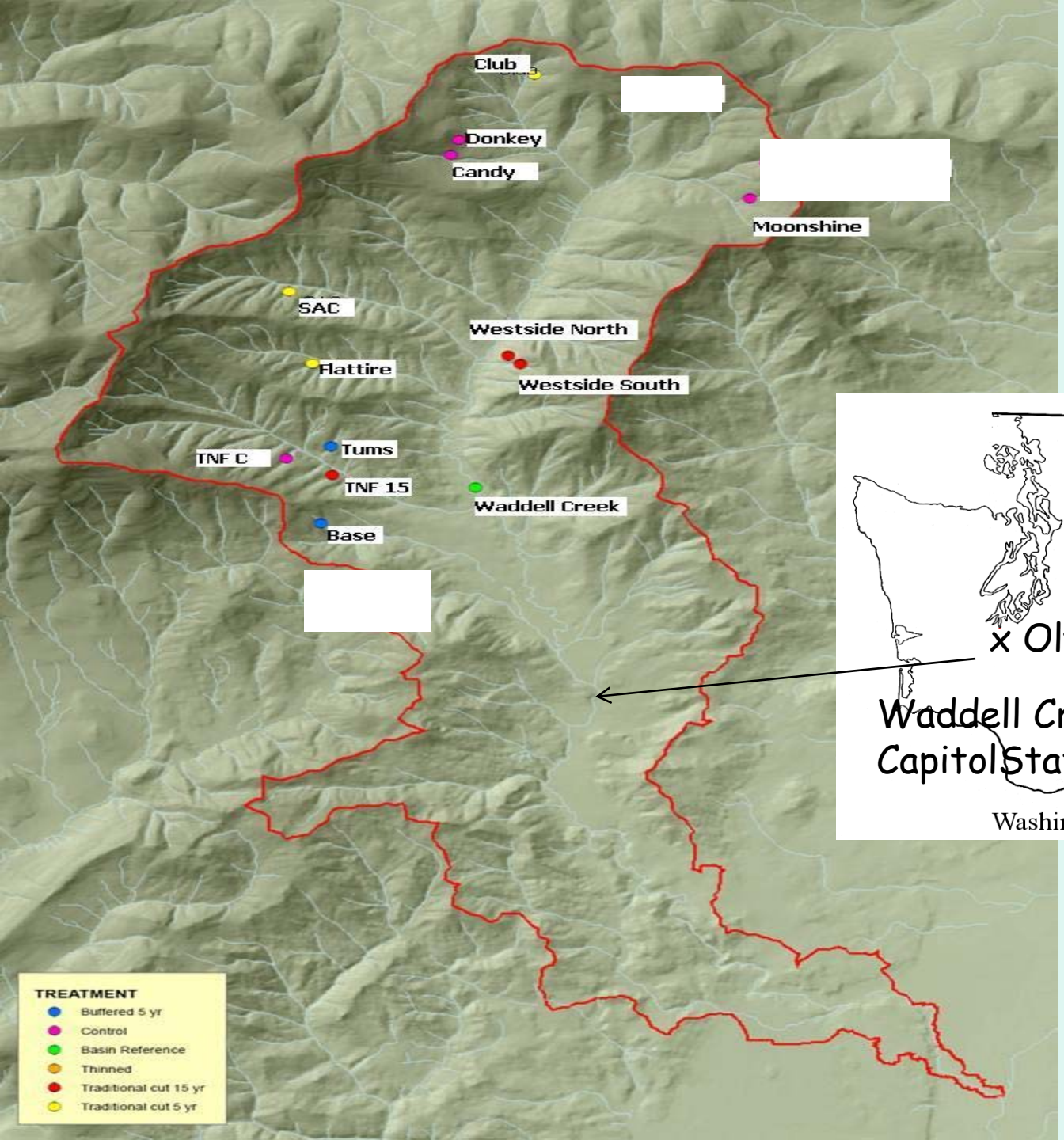
- FP rules are the default for non-federal lands owners

-DNR lands in western WA exceeded FP rules, larger headwaters receive continuous protection --added stream protection alternatives for smaller streams are being tested

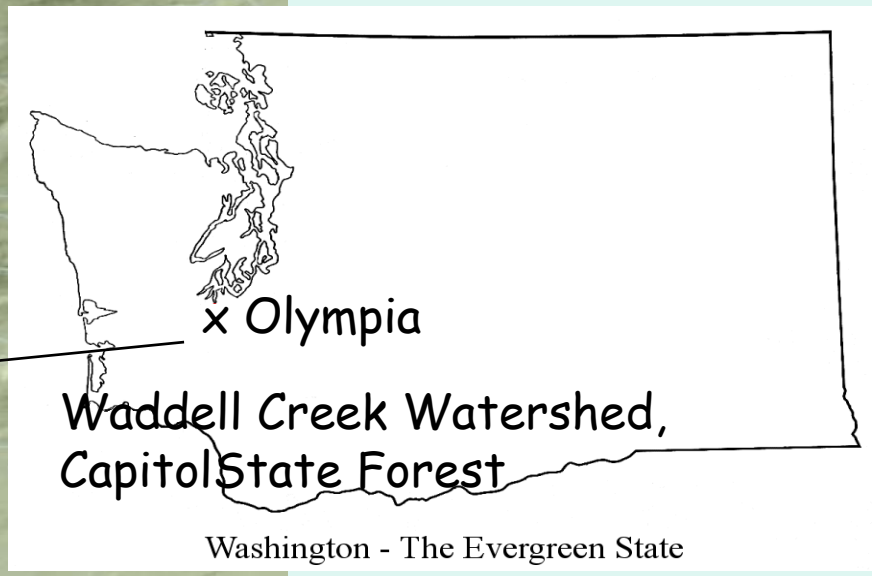
Study site

Waddell Creek Watershed, Capitol Forest,
Southwest of Olympia, Washington
Washington Department of Natural Resources

Retrospective analysis for harvest impacts to stream temperature


Club
Donkey
Candy
Moonshine
SAC
Westside North
Flattire
Westside South
TNF C
Tums
TNF 15
Waddell Creek
Base
TREATMENT
Buffered 5 yr
Control
Basin Reference
Thinned
Traditional cut 15 yr
Traditional cut 5 yr

N


x Olympia
Waddell Creek Watershed,
Capitol State Forest
Washington - The Evergreen State

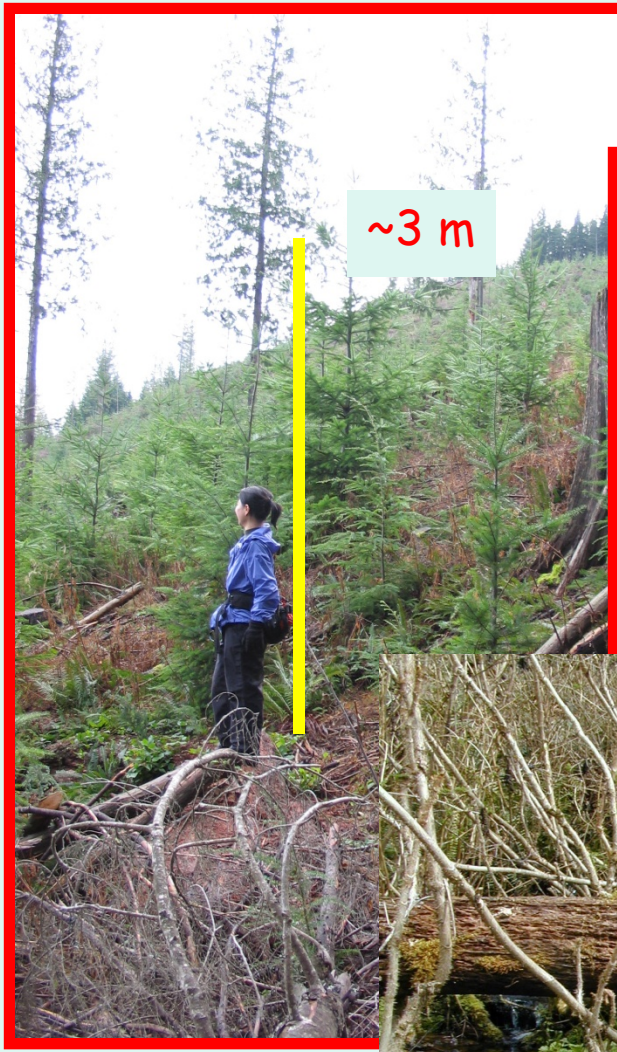
Characteristics of study streams (<1.5 m wetted width)

Treatment	Stream	Elev.(m)	Slope (º)	Aspect	Area (ha)
Unharvested 89 yrs	Moonshine	387	32.9	W	7.4
Unharvested 60 yrs	Candy	369	37.3	SE	5.0
Unharvested 60 yrs	TNFC	257	48.6	NE	9.0
Clearcut 7 years	SAC	305	30.8	NE	19.8
Clearcut 7 years	Club	345	25.3	W	6.5
Clearcut 7 years	Flattire	279	34.4	NE	7.8
Clearcut 14 years	TNF-15	211	44.0	NE	8.2
Clearcut 17 years	West-N	240	29.0	W	3.6
Clearcut 17 years	West-S	180	27.8	W	3.7
Patch Buffered 6 yrs	Tums	250	31.3	S	5.0
Patch Buffered 5 yrs	Base	271	34.5	SE	4.7
Patch Buffered 1 yr	Donkey	373	48.6	SE	2.3
	Waddell Creek (3rd order)	125	6.6	W	1962.8

WATER LEVEL SENSOR AND TEMPERATURE MEASUREMENTS AT WEIR

GLOBAL WATER WL - 15/16 WATER LEVEL LOGGER

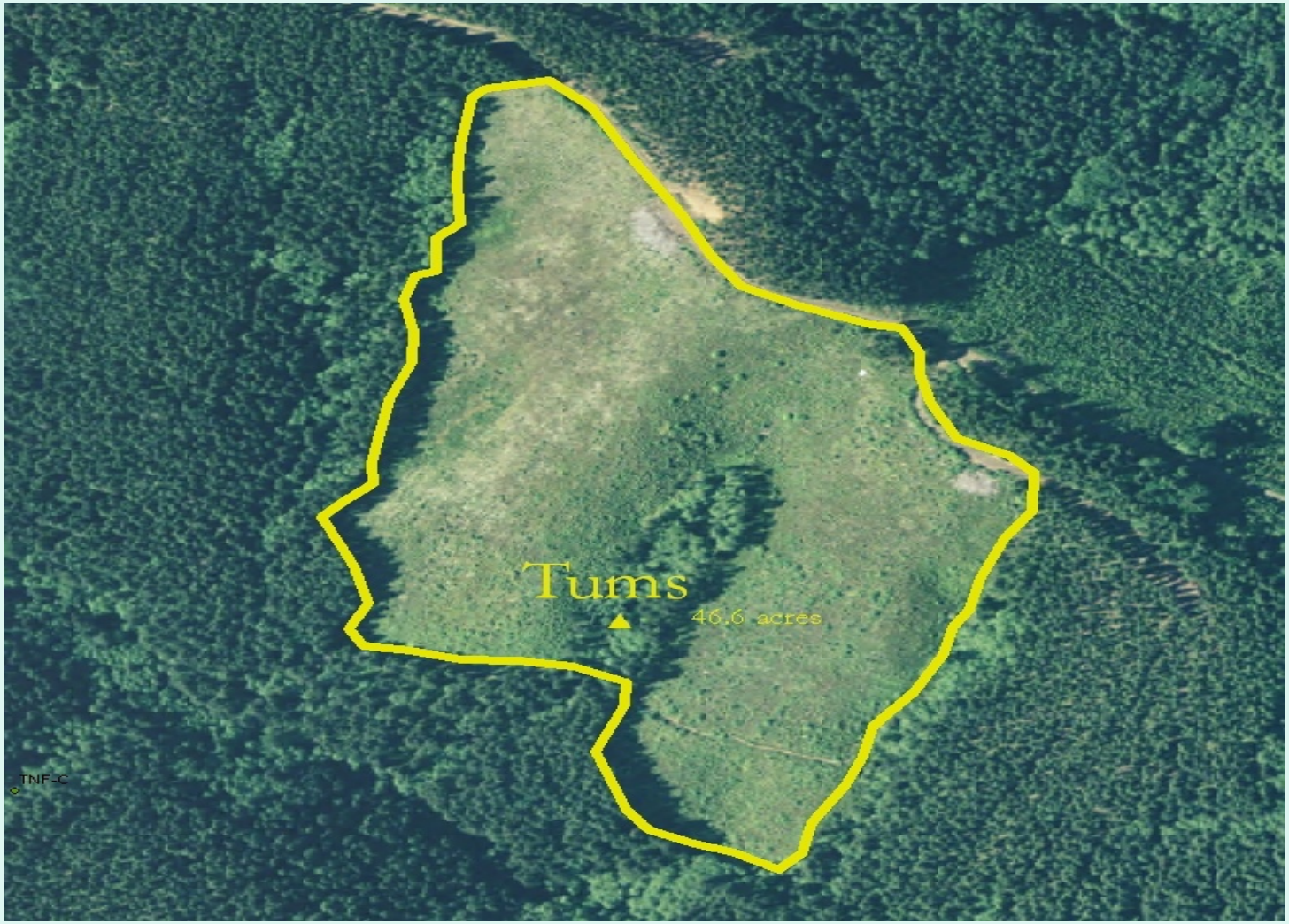
7 year Stand Conditions



14-17 year Stand Conditions

60-89 year Stand Conditions

5-6 year Buffered



Waddell Creek

Stream temperatures (°C)

Summer (July-Aug 2004-2006)

	Unharvested	7 yr CC	14-17 yr CC	5-6 yr Buff
Max.	15.2±0.7[a]	14.0±1.0[a]	14.8±1.0[a]	16.0±0.8[a]
Max-Min	3.7±1.4[a]	4.3±0.6[a]	3.3±0.6[a]	4.4±0.8[a]
Av daily Max	13.2±0.5[a]	12.4±0.7[a]	13.3±0.8[a]	14.4±1.0[a]
Winter (Jan 2005-2007)				
Min.	4.9±0.3	4.8±0.7	5.6±0.7	4.6±1.0

Temperature extremes (°C) 2004-2006

Summer maximum temperatures

Unharvested	7 yr CC	14-17 yr CC	5-6 yr Buffered
16.8	16.2	16.5	16.9

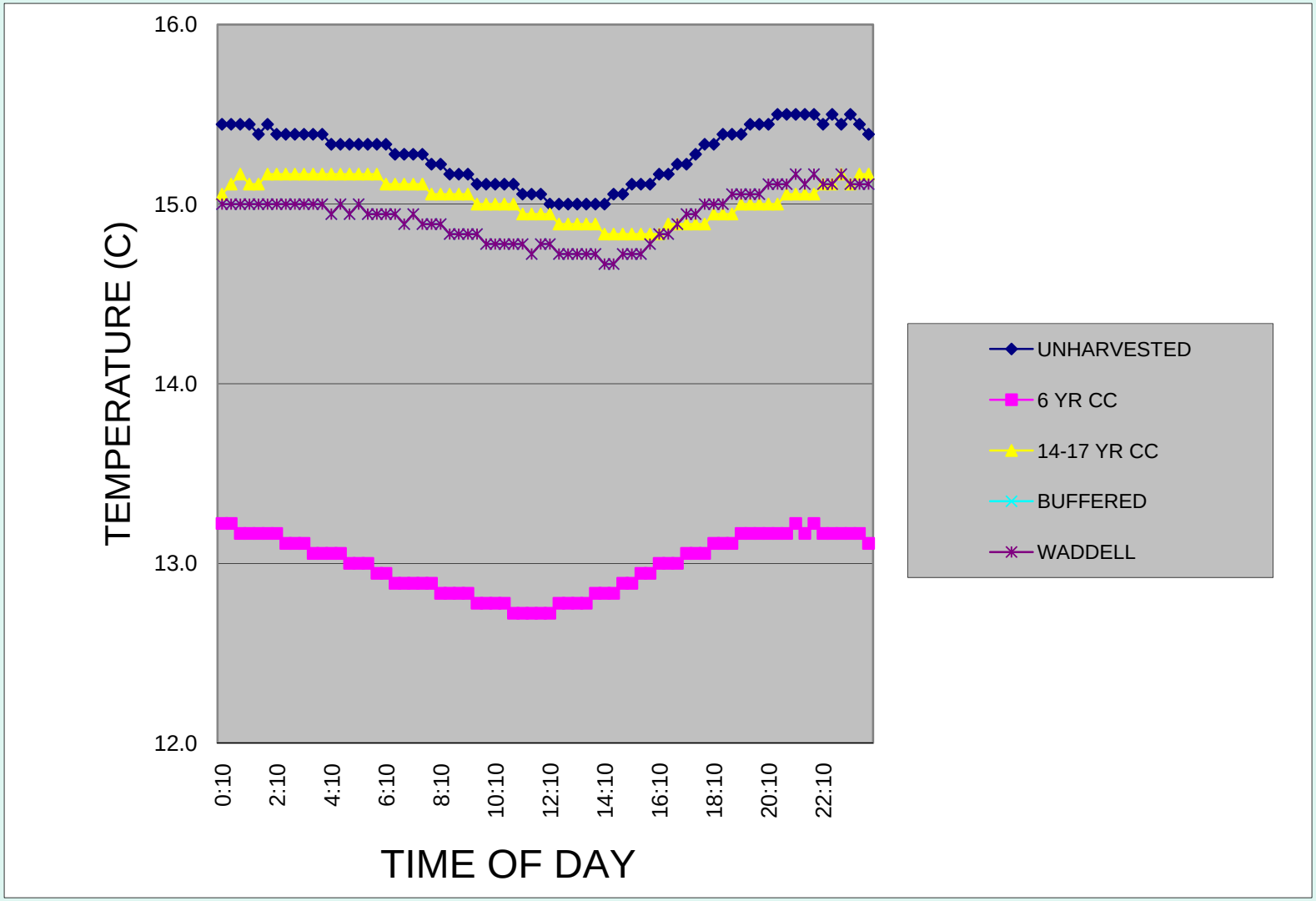
Summer maximum temperatures above average of unharvested controls

7 yr CC	14-17 yr CC	5-6 yr Buffered
0.9	1.6	2.0

Waddell Creek Stream temperatures (°C)

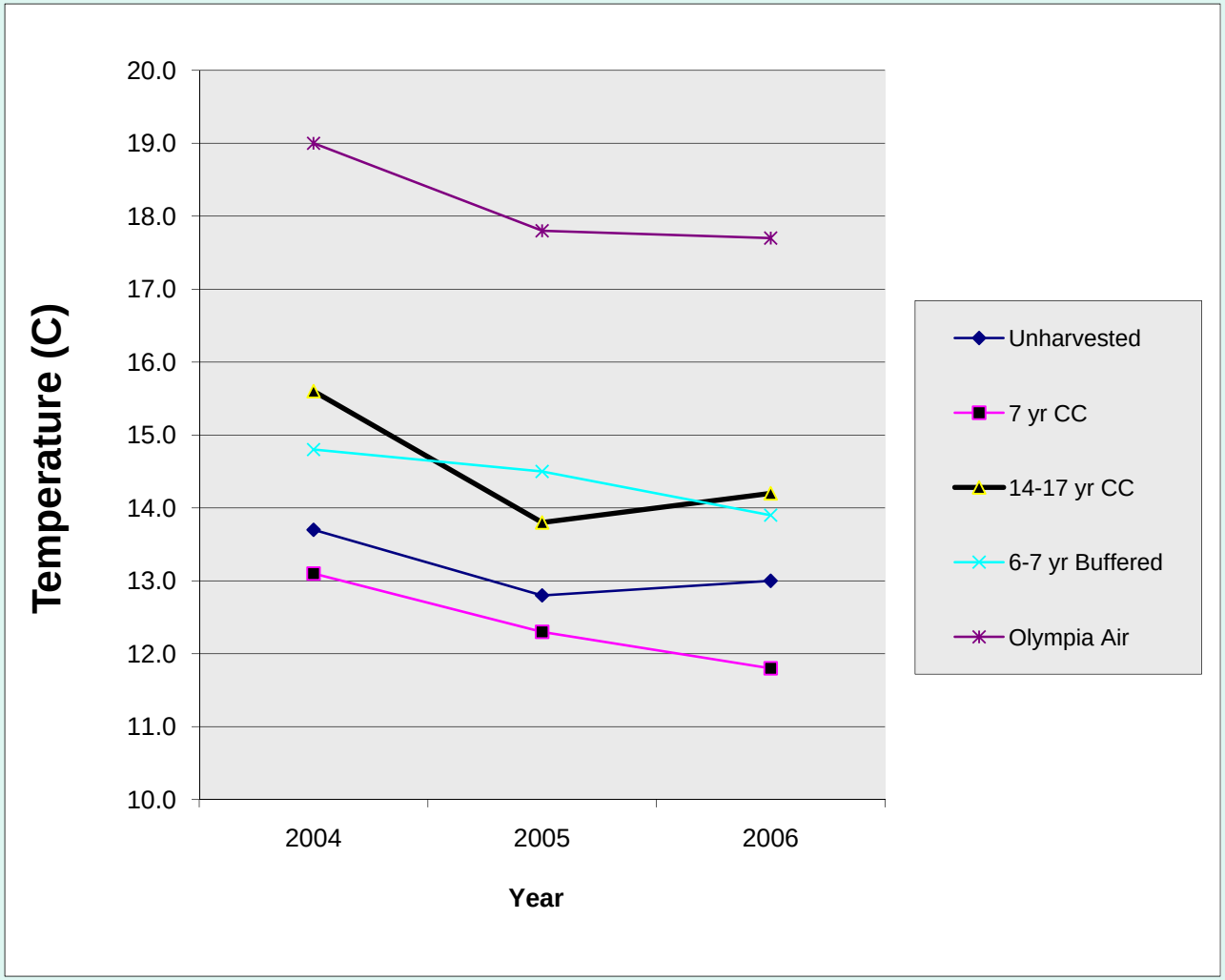
	Control	14-17 yr CC	Waddell Creek
Max.	14.3	14.5	15.6
Av daily Max	12.7	12.7	14.6

24 hour stream temperatures (ºC)
August 15, 2005

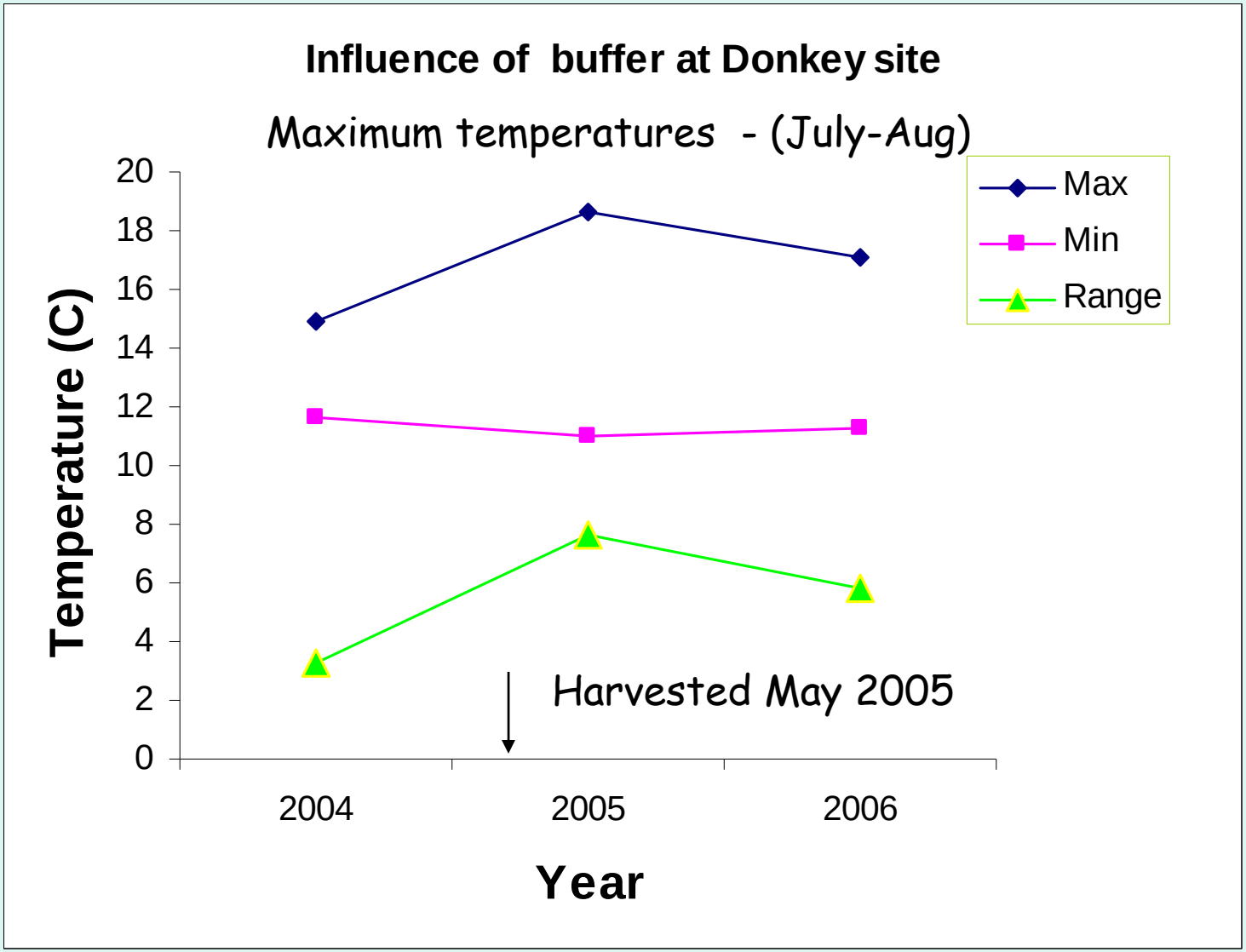


Wood volume in harvested streams in the Capitol Forest (Maxa, 2009)

Air temperature and stream temperature
Average maximum temp July and August



Variable buffer – Harvested May 2005


Influence of buffer at Donkey site
Maximum temperatures - (July-Aug)
Temperature (C)
20
18
16
14
12
10
8
6
4
2
0
Max
Min
Range
Harvested May 2005
2004
2005
2006
Year

Other stream temperature and stream biology studies at Capitol Forest (DNR, WA DOE, USFS)

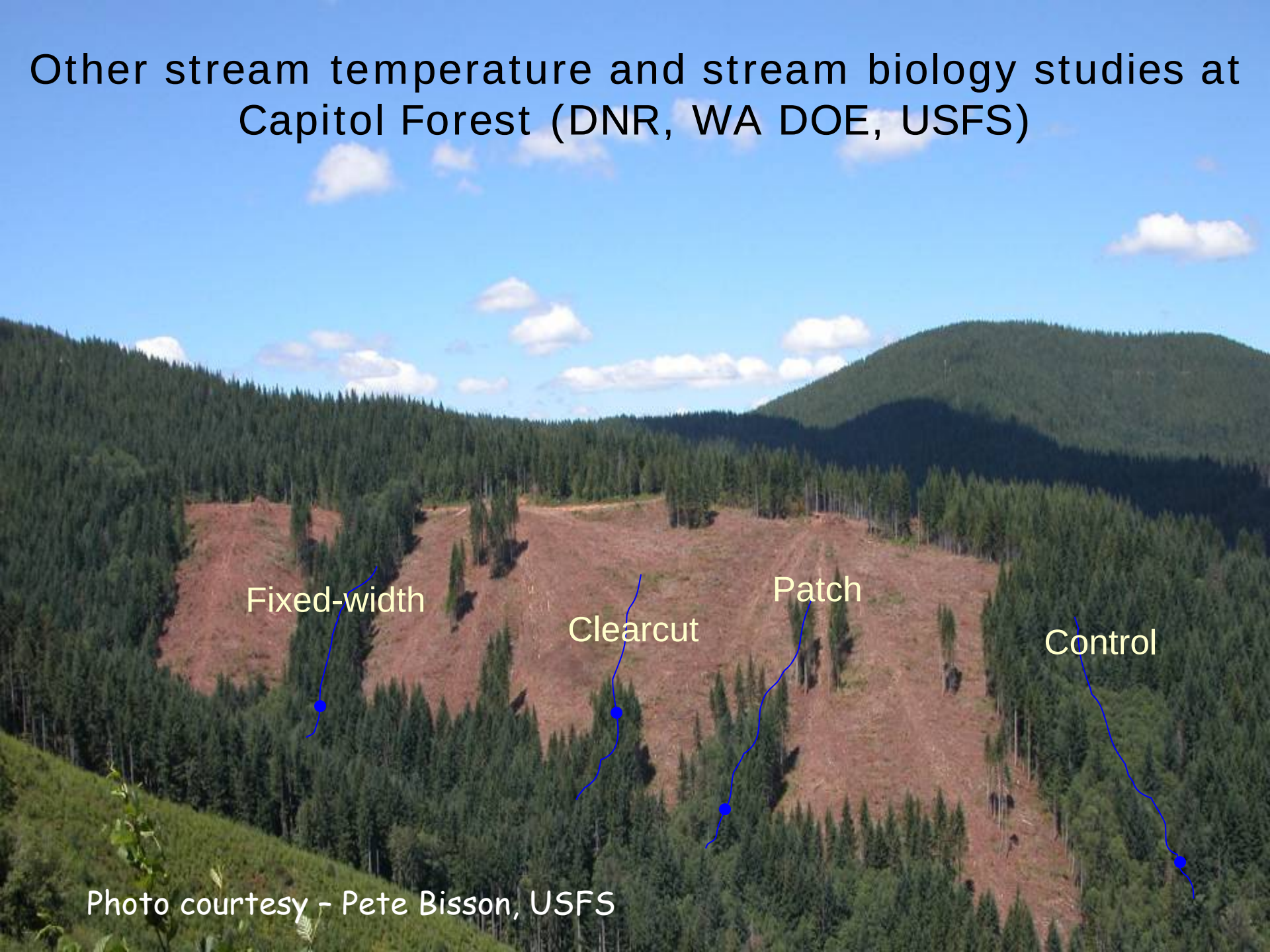


Photo courtesy – Pete Bisson, USFS

Blowdown in continuous buffer

Photo courtesy – Pete Bisson, USFS

CONCLUSIONS

- No statistical differences in maximum July-Aug stream temperatures in treatments (unharvested forest, clearcut, and buffered) from 2004-2006.

- The maximum stream temperature recorded was 18.1 C in first year after harvesting in a variably buffered stream. Not lethal for salamanders and fish, but could be disruptive to physiology. Maximum temperature in later years was 16.9 C in buffer treatment 5-6 years after harvesting. Harvesting did not greatly increase stream temperatures (max 3.3 C in first year in clearcut - WADOE)

- Stream temperatures were related to air temperatures, but not consistently among treatments which varied from year to year

- Stream temperatures in harvested streams seem to be responding to multiple factors; air temperature, shading, changing vegetation, wood in the channel, sediments and aspect, and are extremely variable from stream to stream

CONCLUSIONS

- Stream temperatures have recovered 6-7 years after clearcut harvesting. Clearcuts were slightly cooler than controls due to wood and shading

- Stream buffers in headwater streams at this site don’t have a big influence on maximum stream temperatures. Headwater buffers are very vulnerable to blowdown. Could add sediment to streams increasing temperatures.

- Wood in clearcut streams reduces stream temperatures. Wood could be placed in streams.

Acknowledgements

Funding

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