Stream Conditions in Western Olympic Peninsula's Second-Growth Forests after 25 Years of Passive Restoration

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Habitat Conservation Plan (HCP)

State lands HCP (est. 1997)

- Northern spotted owl
- Marbled murrelet
- Riparian habitat/salmonids

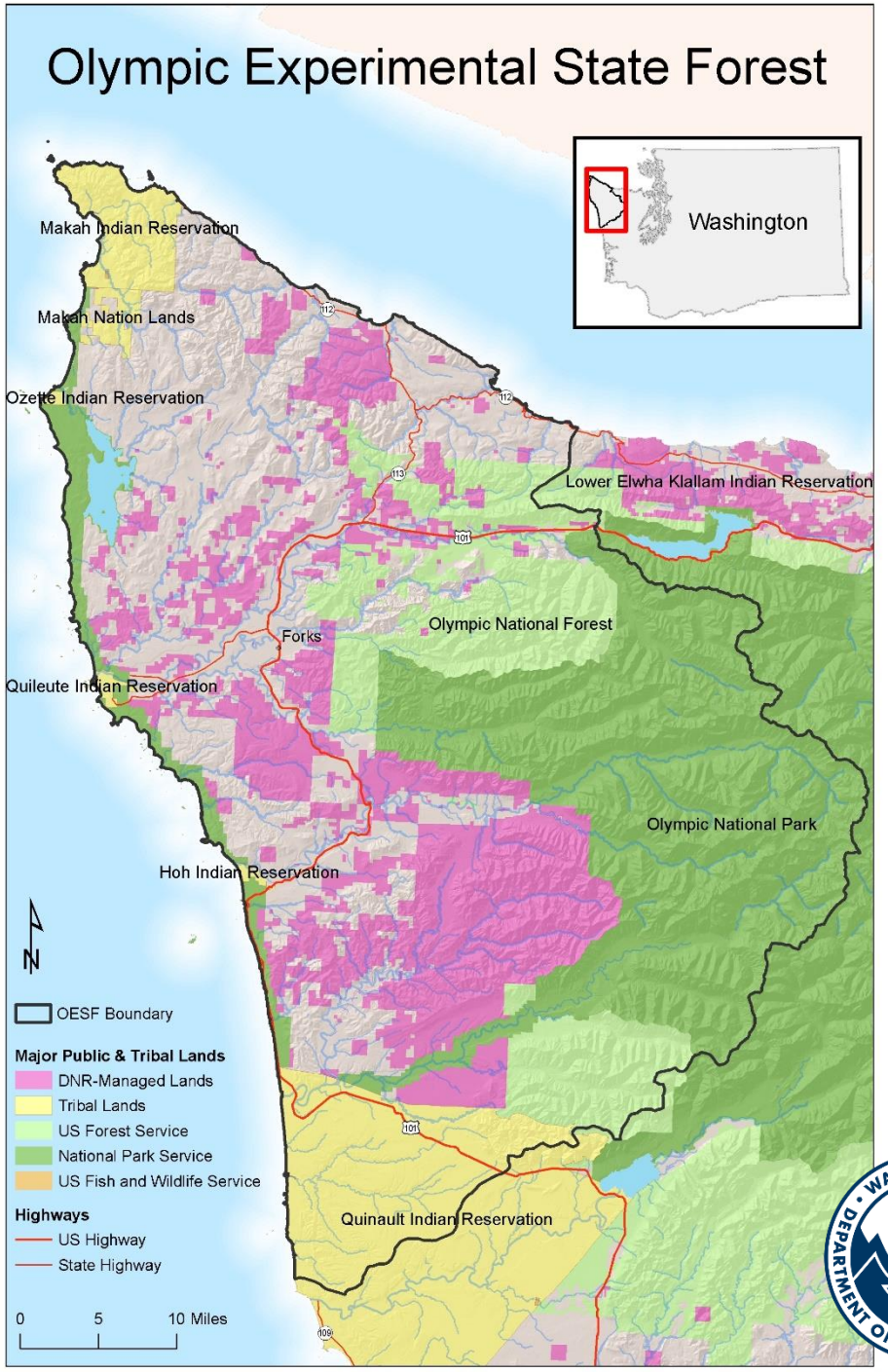
Olympic Experimental State Forest (OESF)

Est. 1992

270,000 acres of DNR-managed lands

>2,500 miles of stream
Major river systems (n=13):
Queets, Clearwater, Hoh, Bogachiel, Calawah, Sol Duc, Quillayute, Dickey, and Hoko

The OESF is both a working forest (current harvest level of 576 mmbf/decade) and a place designated for experimentation



DNR Monitoring

Status and Trends (Habitat Monitoring)

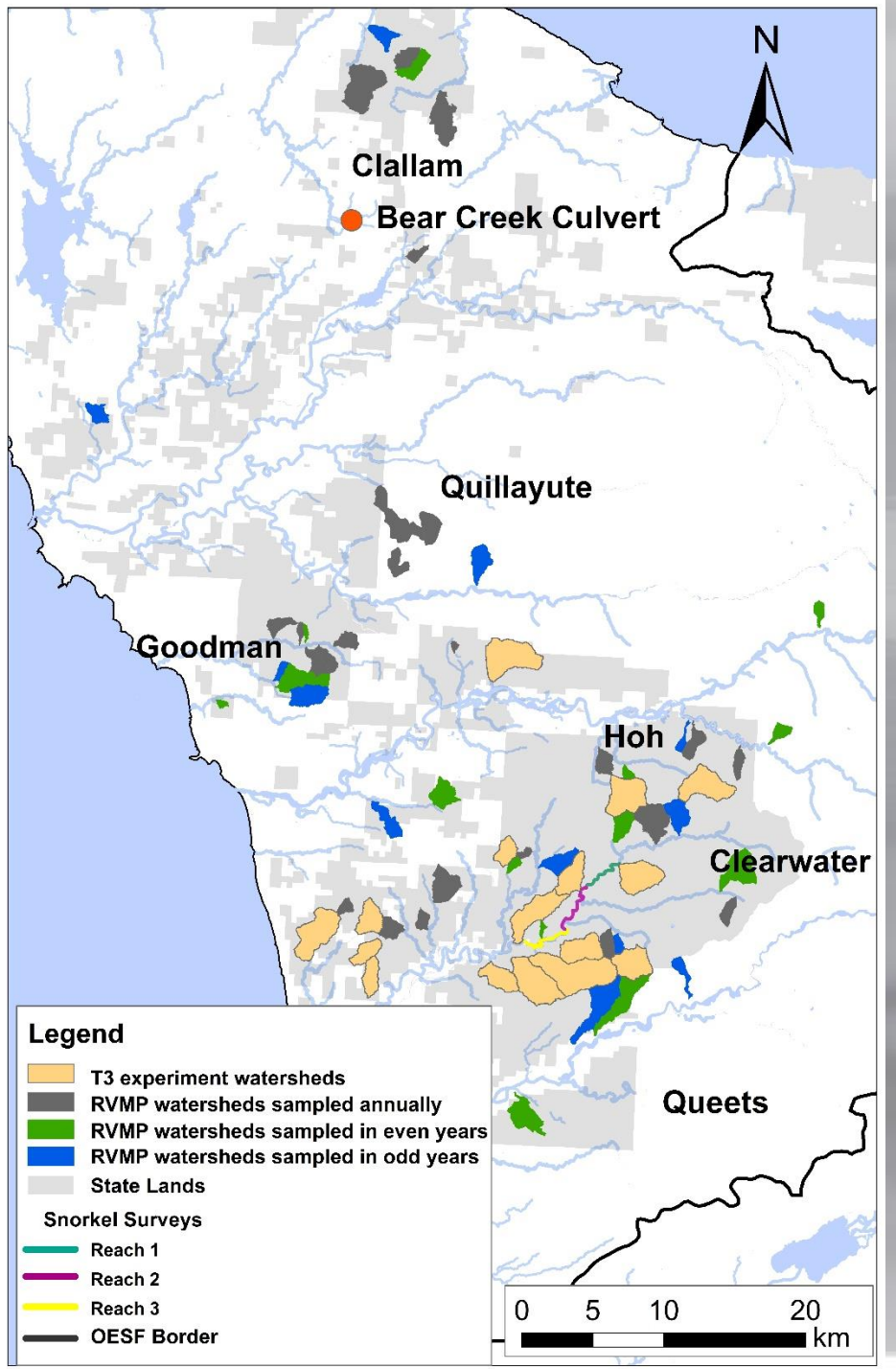
- 62 Type-3 watersheds (15-669 ha); 50 state and 12 unharvested; 2013
- 12 annual sites and 50 on a 5-year rotation
- Substrate, instream wood, habitat units, stream shade, water temperature, stream discharge (n=14) and riparian forest vegetation

Validation Monitoring (Fish Monitoring)

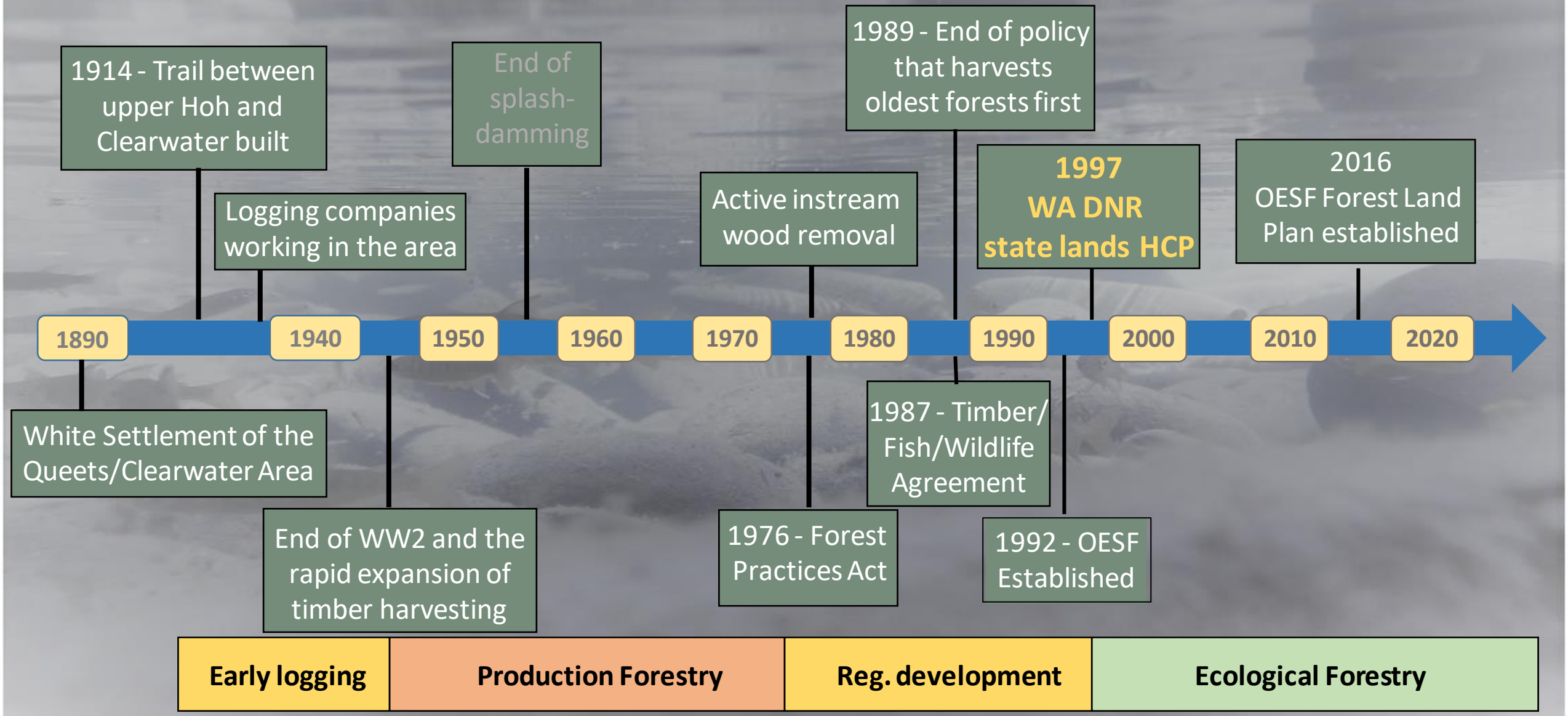
- 50 Type-3 watersheds - 20 annually + 30 2-year rotation; 2016
- Snorkeling – Annual survey of a 13 km section of the Clearwater River (last week of August)

T3 Watershed Experiment (Fish and Habitat)

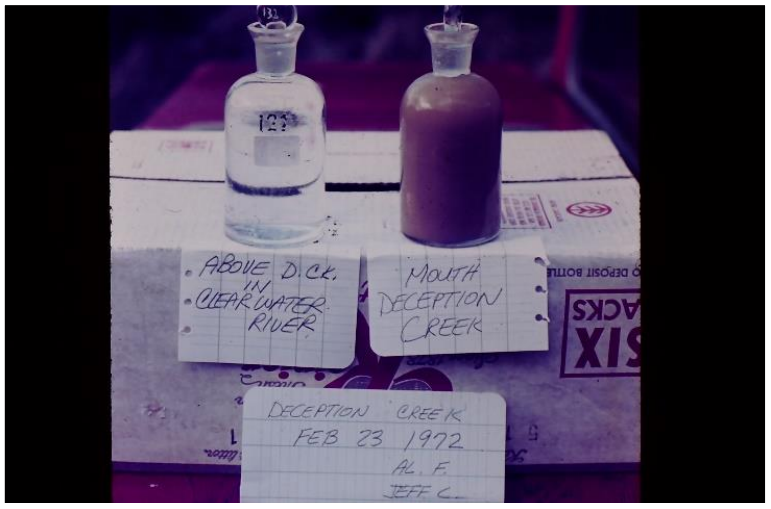
- 16 watersheds (4 blocks) with 2 sites per watershed; 2020
- 5 riparian prescriptions (active habitat, heavy thinning with alder, variable-width buffer, standard buffer, and control)



History of Riparian Management on the OESF

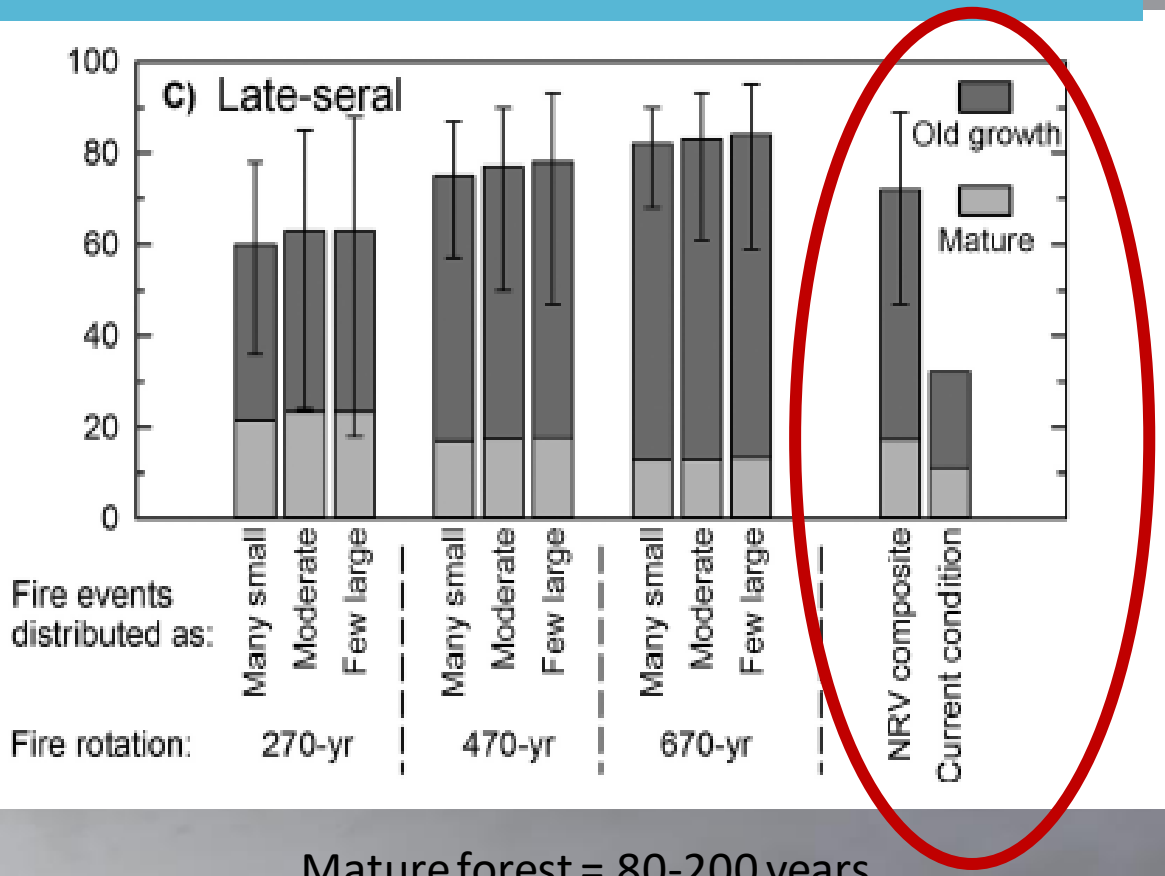


Pictures of forest management on the Olympic Peninsula (1960-70's)

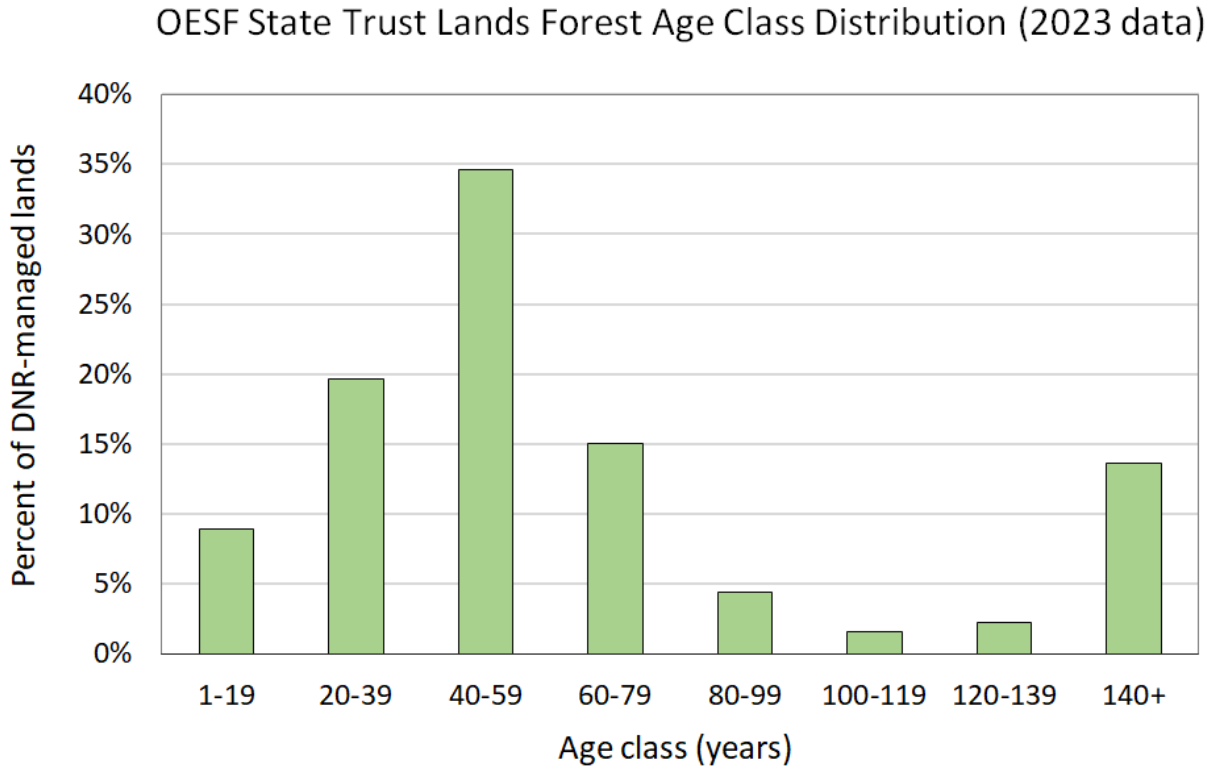


Forest Conditions

Natural Range of Variation

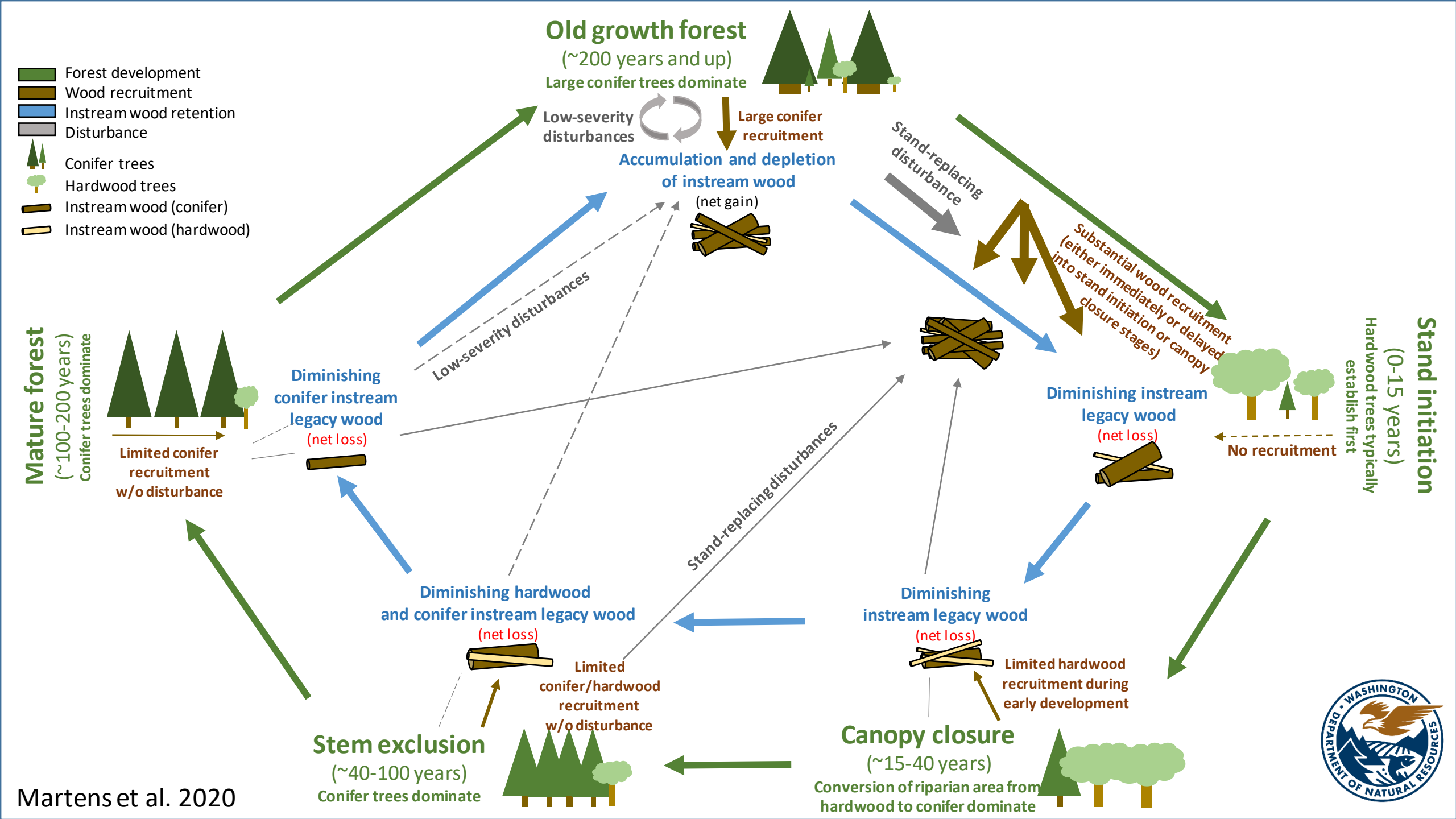


Western Olympic Peninsula



Mature forest = 80-200 years
Old-Growth = >200 Years old

Donato et al. 2020



Martens et al. 2020

Forest development
Wood recruitment
Instream wood retention
Disturbance
Conifer trees
Hardwood trees
Instream wood (conifer)
Instream wood (hardwood)

Old growth forest

(~200 years and up)

Large conifer trees dominate

Low-severity disturbances

Large conifer recruitment

Accumulation and depletion of instream wood

(net gain)

Stand-replacing disturbance

Substantial wood recruitment (either immediately or delayed into stand initiation or canopy closure stages)

Stand initiation

(0-15 years)

Hardwood trees typically establish first

Martens et al. 2020

Forest development
Wood recruitment
Instream wood retention
Disturbance
Conifer trees
Hardwood trees
Instream wood (conifer)
Instream wood (hardwood)

Stand initiation
(0-15 years)
Hardwood trees typically establish first

No recruitment

Diminishing instream legacy wood
(net loss)

Canopy closure
(~15-40 years)
Conversion of riparian area from hardwood to conifer dominate

Martens et al. 2020

Forest development
Wood recruitment
Instream wood retention
Disturbance
Conifer trees
Hardwood trees
Instream wood (conifer)
Instream wood (hardwood)

Diminishing instream legacy wood
(net loss)

Limited hardwood recruitment during early development

Canopy closure
(~15-40 years)
Conversion of riparian area from hardwood to conifer dominate

Stem exclusion
(~40-100 years)
Conifer trees dominate

Martens et al. 2020

Forest development
Wood recruitment
Instream wood retention
Disturbance
Conifer trees
Hardwood trees
Instream wood (conifer)
Instream wood (hardwood)

Mature forest
(~100-200 years)
Conifer trees dominate

Diminishing hardwood and conifer instream legacy wood
(net loss)

Limited conifer/hardwood recruitment w/o disturbance

Stem exclusion
(~40-100 years)
Conifer trees dominate

Martens et al. 2020

Forest development
Wood recruitment
Instream wood retention
Disturbance

Conifer trees
Hardwood trees
Instream wood (conifer)
Instream wood (hardwood)

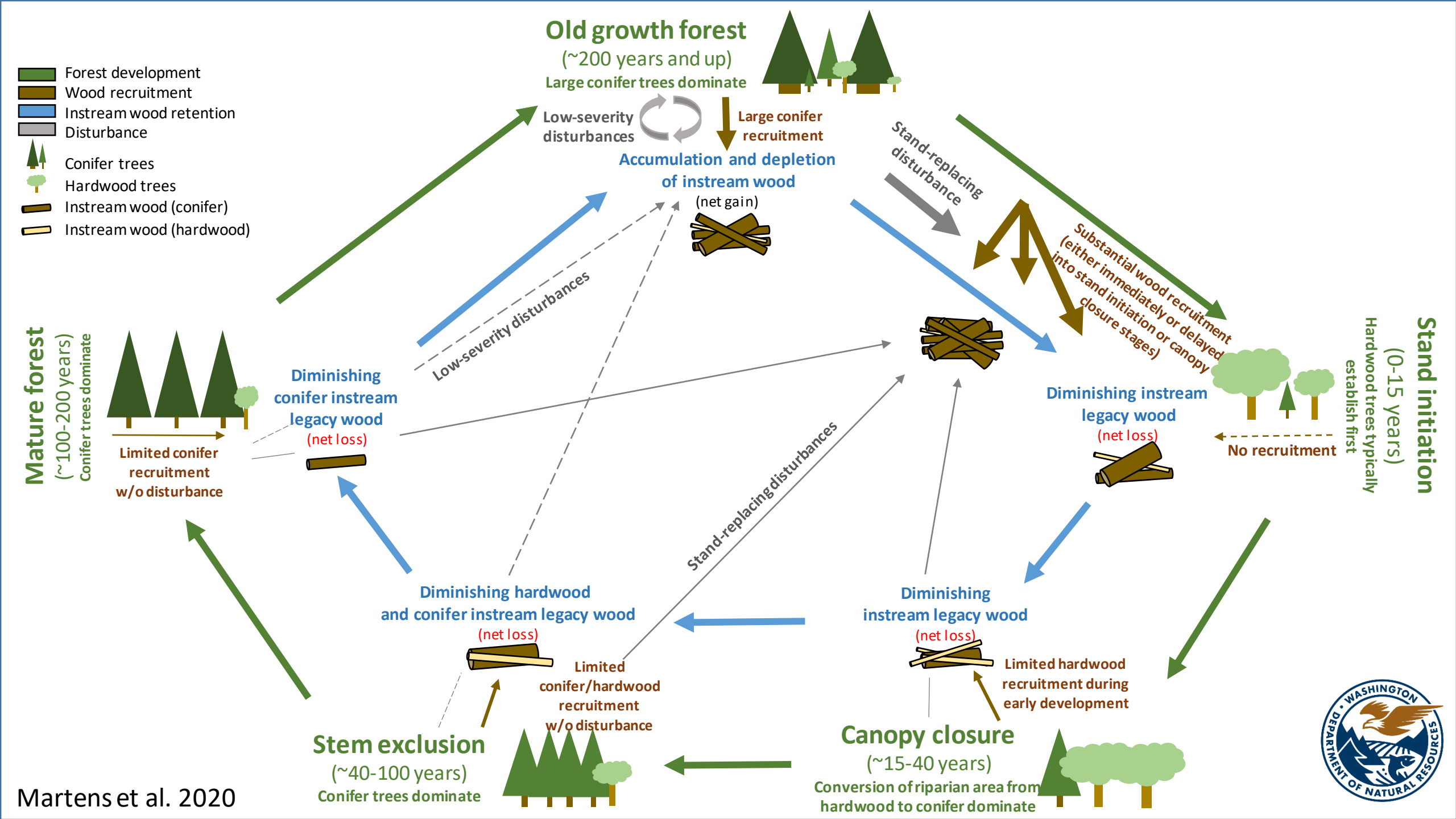
Old growth forest
(~200 years and up)
Large conifer trees dominate

Mature forest
(~100-200 years)
Conifer trees dominate

Limited conifer recruitment w/o disturbance

Diminishing conifer instream legacy wood
(net loss)

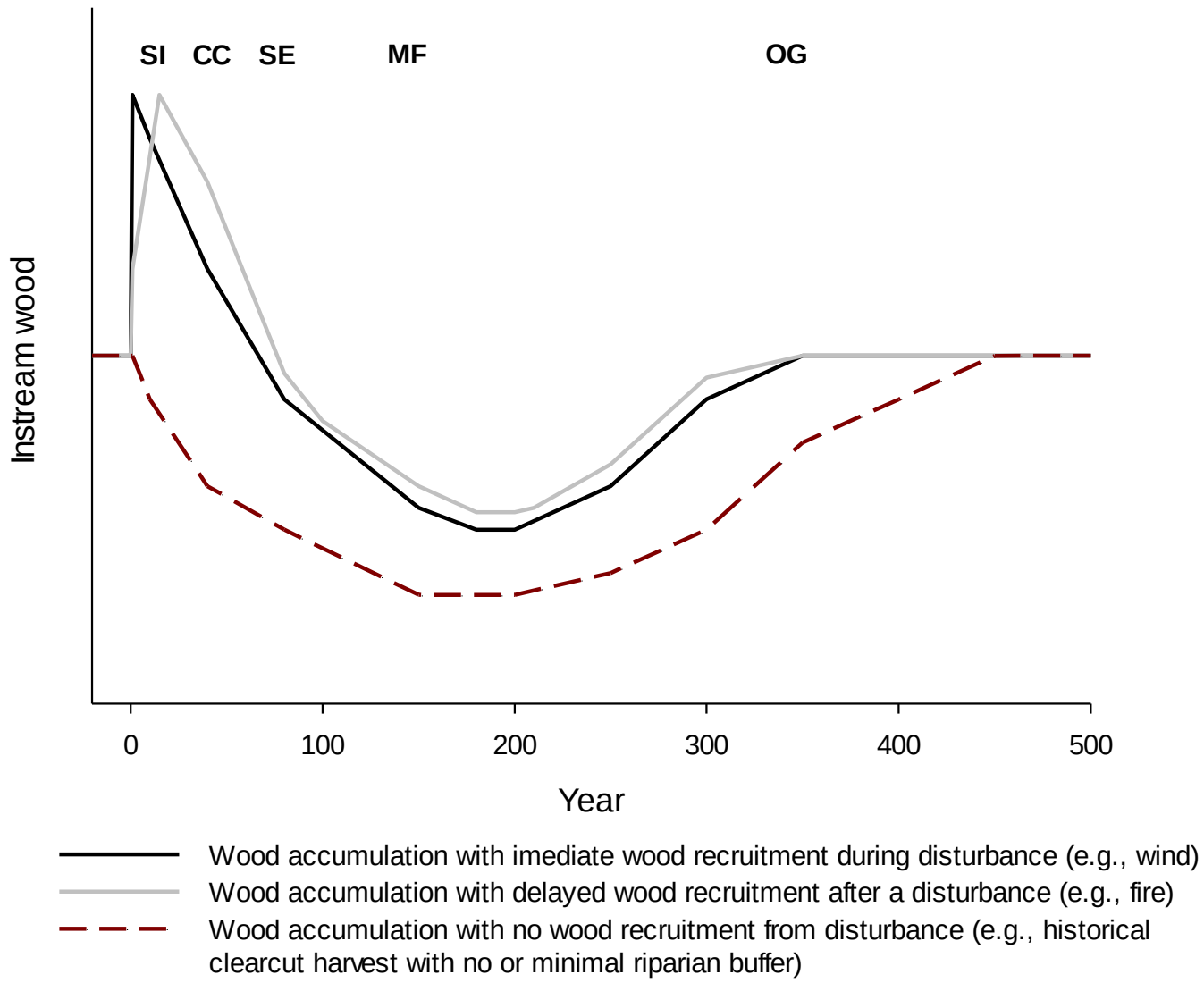
Martens et al. 2020



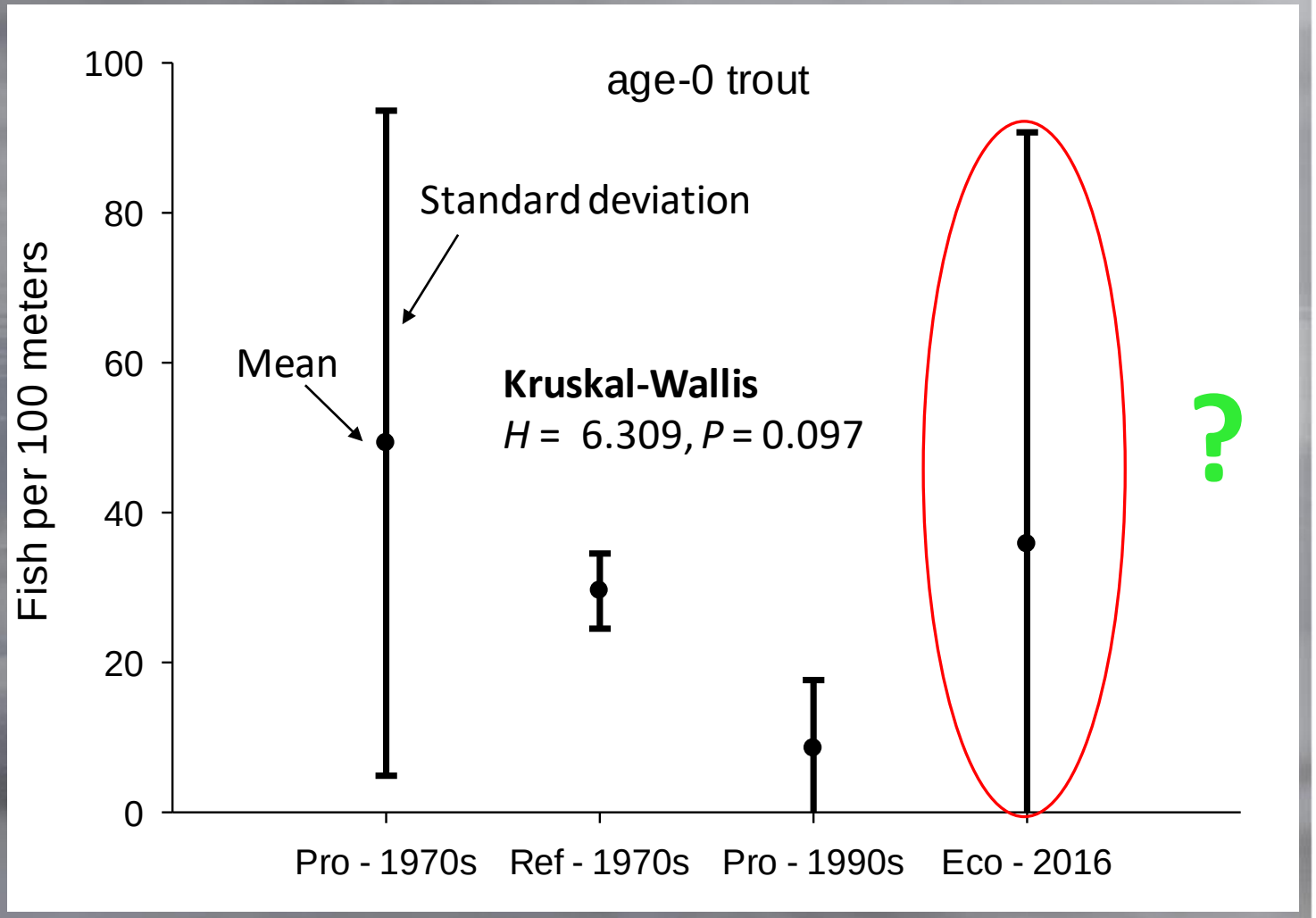
Martens et al. 2020

Wood recruitment

- Stand Initiation
- Closed Canopy
- Stem Exclusion
- Mature Forest
- Old Growth



Age-0 Trout



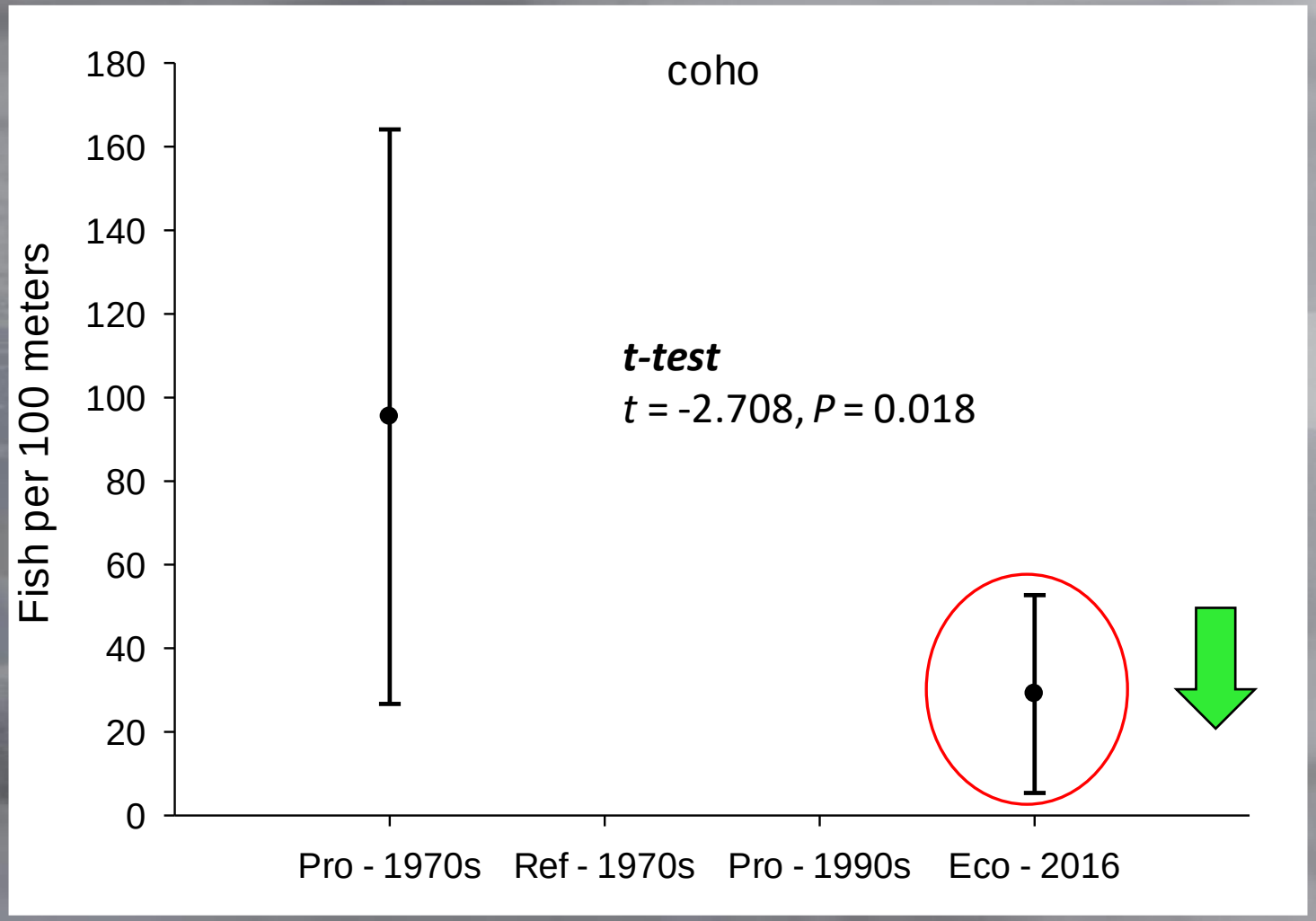
Data from: Edie 1975, Lestelle 1978, Osborn 1980, Martin 1985, Bisson et al. 2002

Production forestry (Pro); Reference (Ref); Ecological forestry (Eco)

Martens et al. 2019

Coho salmon

Data from: Edie 1975, Lestelle 1978, Osborn 1980, Martin 1985, Bisson et al. 2002

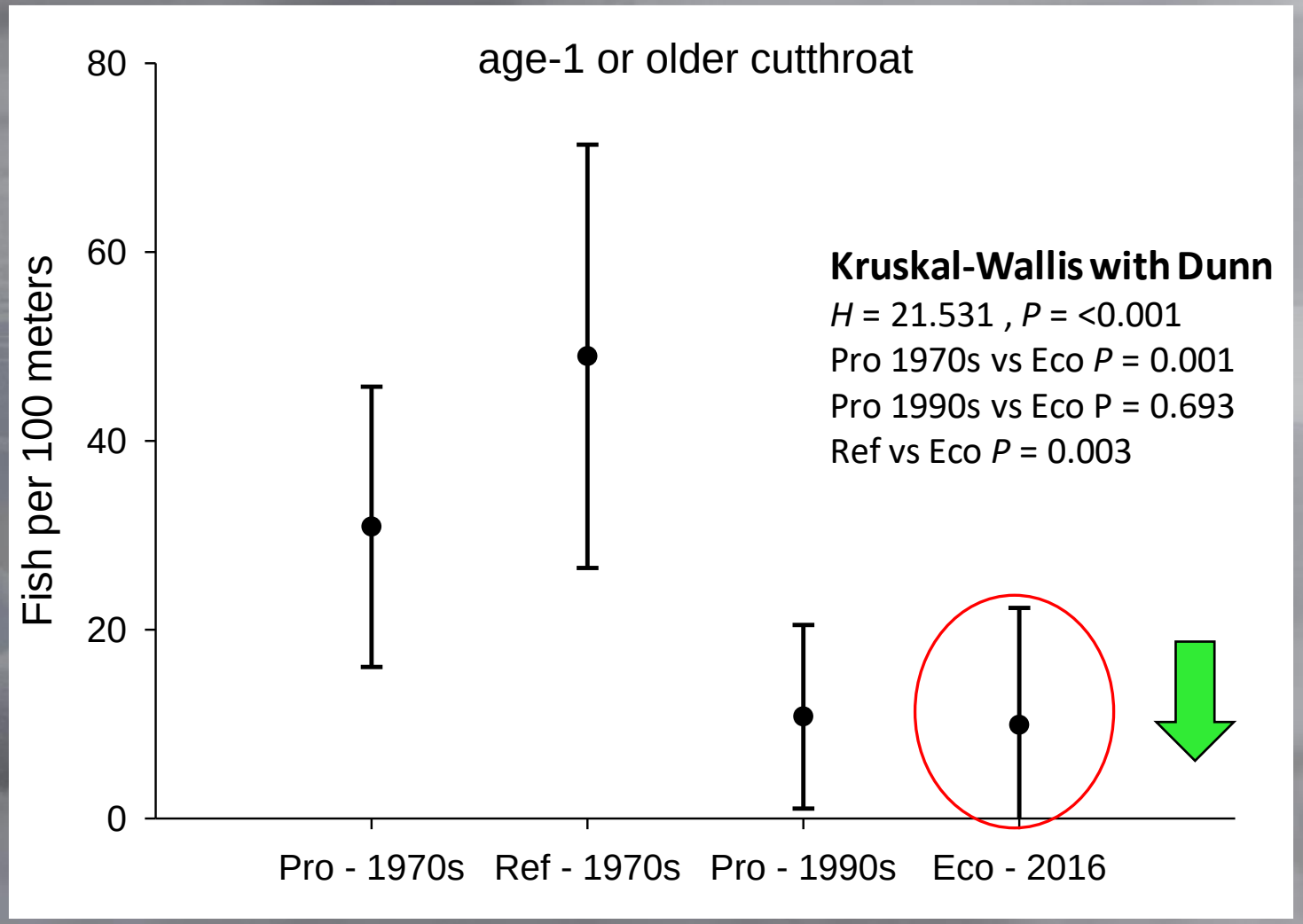


Production forestry (Pro); Reference (Ref); Ecological forestry (Eco)

Martens et al. 2019

Age-1 or older cutthroat trout

Data from: Edie 1975, Lestelle 1978, Osborn 1980, Martin 1985, Bisson et al. 2002

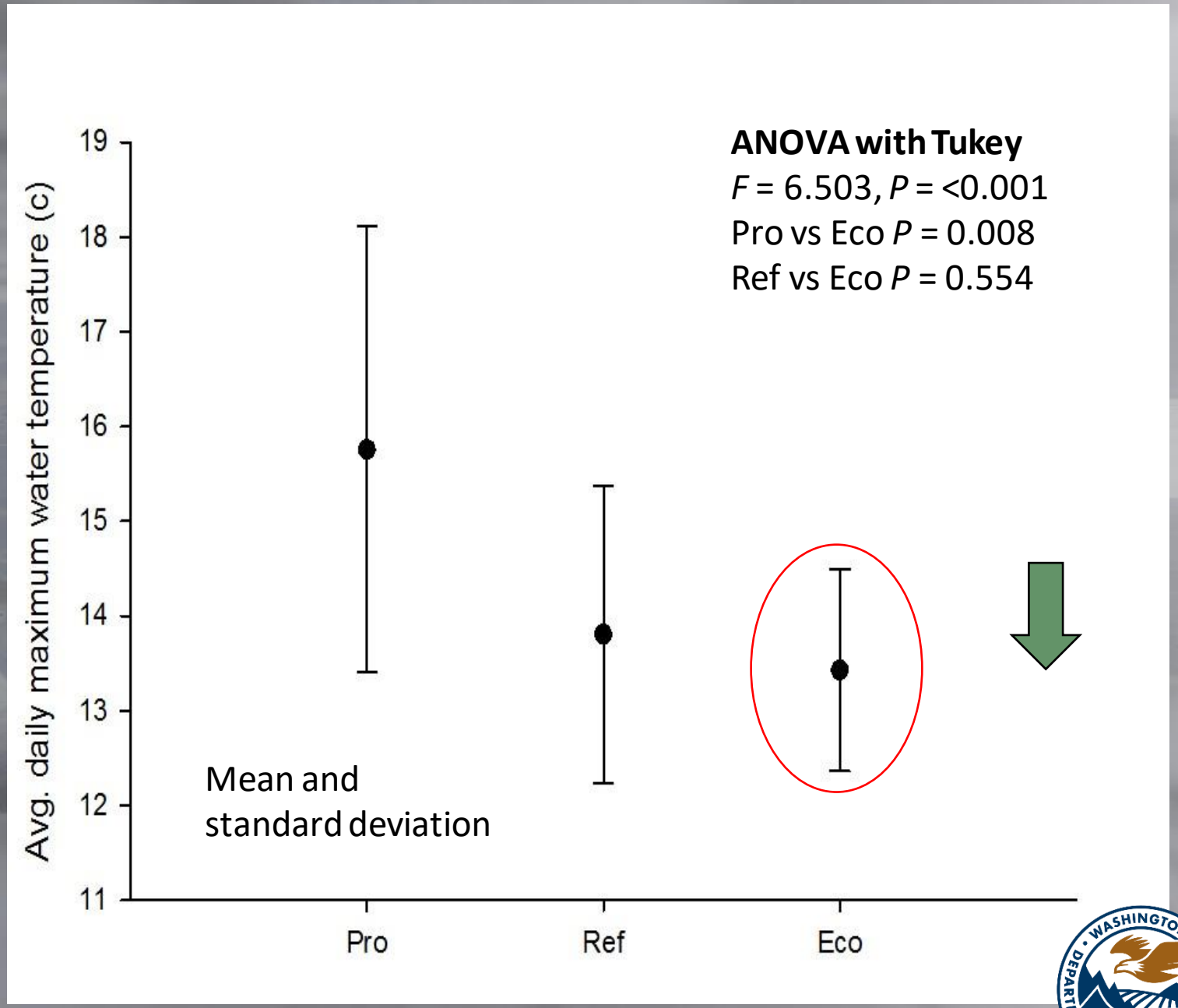


Production forestry (Pro); Reference (Ref); Ecological forestry (Eco)

Martens et al. 2019

Stream Temperature

Martens et al. 2019



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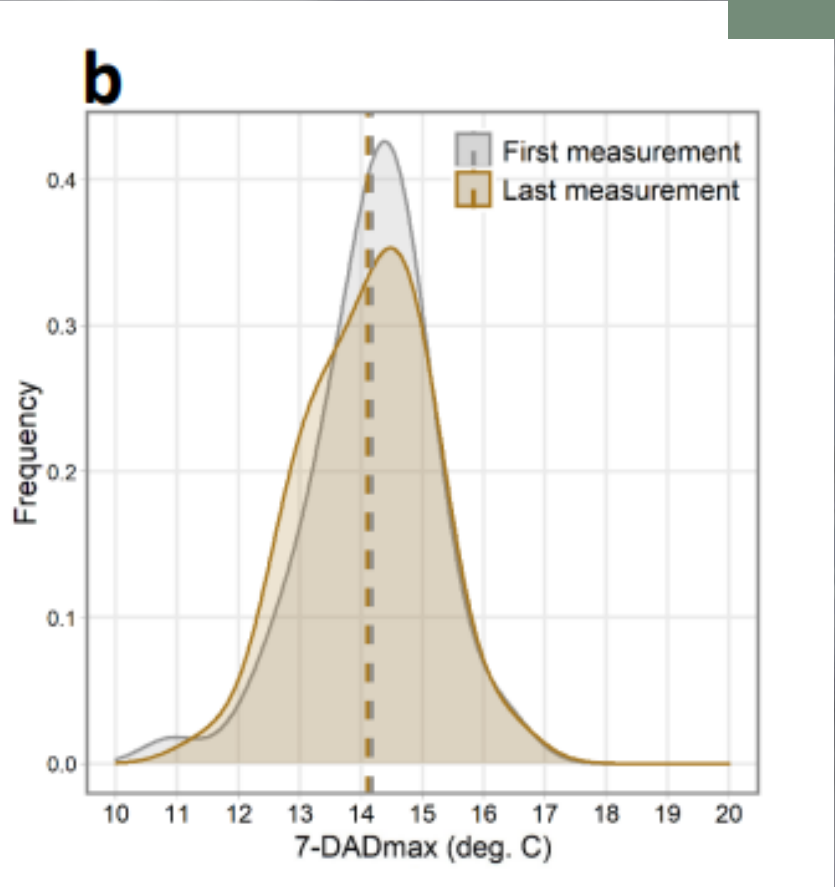
Stream Temperature



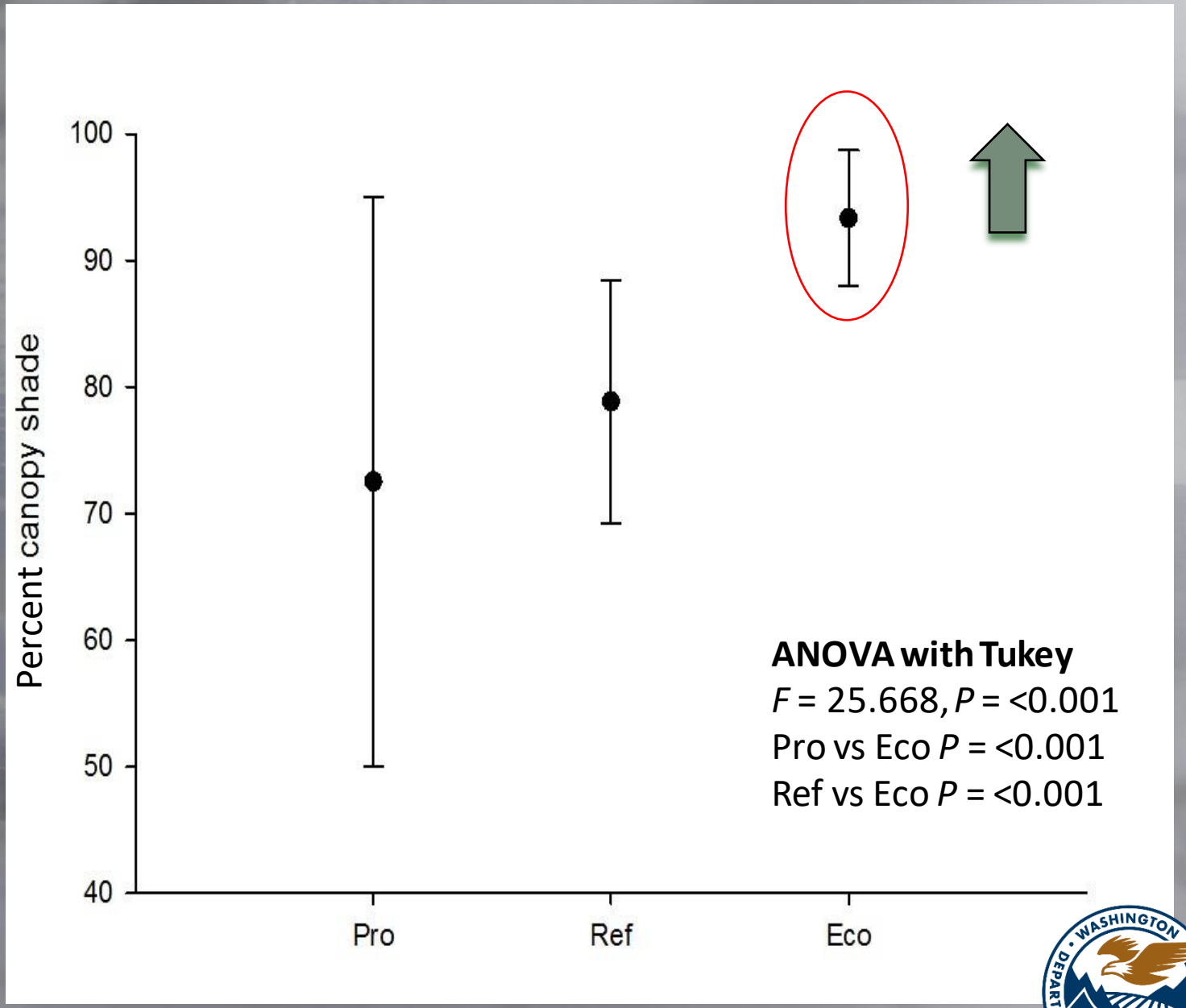
2013-2020

Table 19b. Analysis of maximum 7-day average daily maximum water temperature (°C) in 50 Type 3 streams on DNR-managed land in the OESF.

Effect	F value	*p*-value	Interpretation
Channel type	0.3	0.71	No effect
Year	23.9	<0.01	Significant
Bankfull width (covariate)	2.2	0.15	No effect
Elevation of sample reach (covariate)	4.0	0.05	Marginally significant (negative)
Stream shade (covariate)	3.1	0.09	No effect
Watershed solar exposure (covariate)	10.2	<0.01	Significant (positive)
Bedrock substrate (covariate)	11.6	<0.01	Significant (positive)
Percent unharvested forest (covariate)	1.0	0.32	No effect

Devine et al. 2022

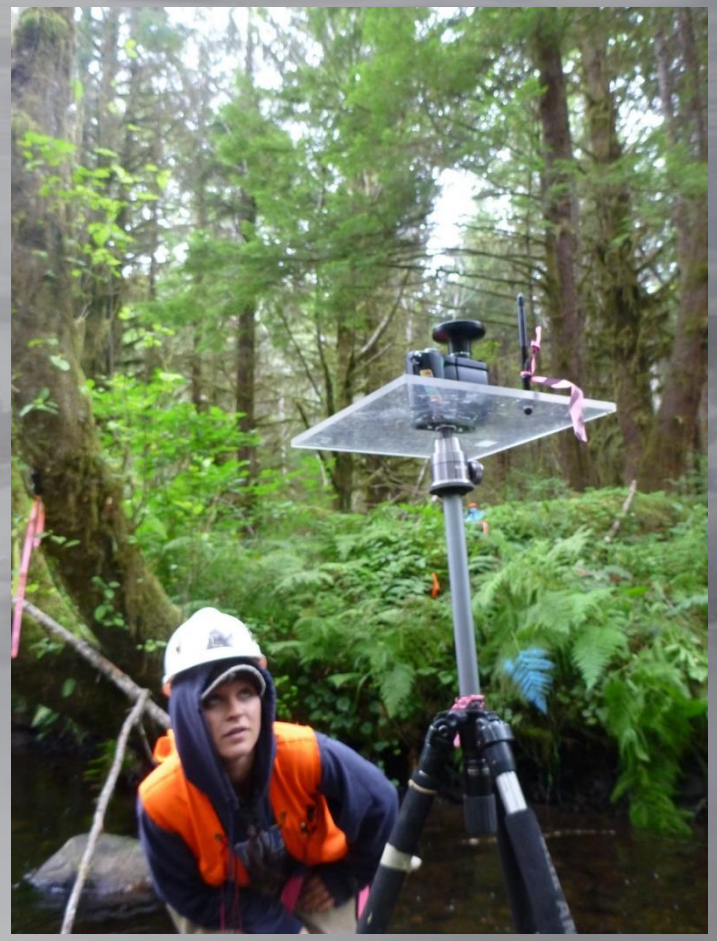
Canopy Cover

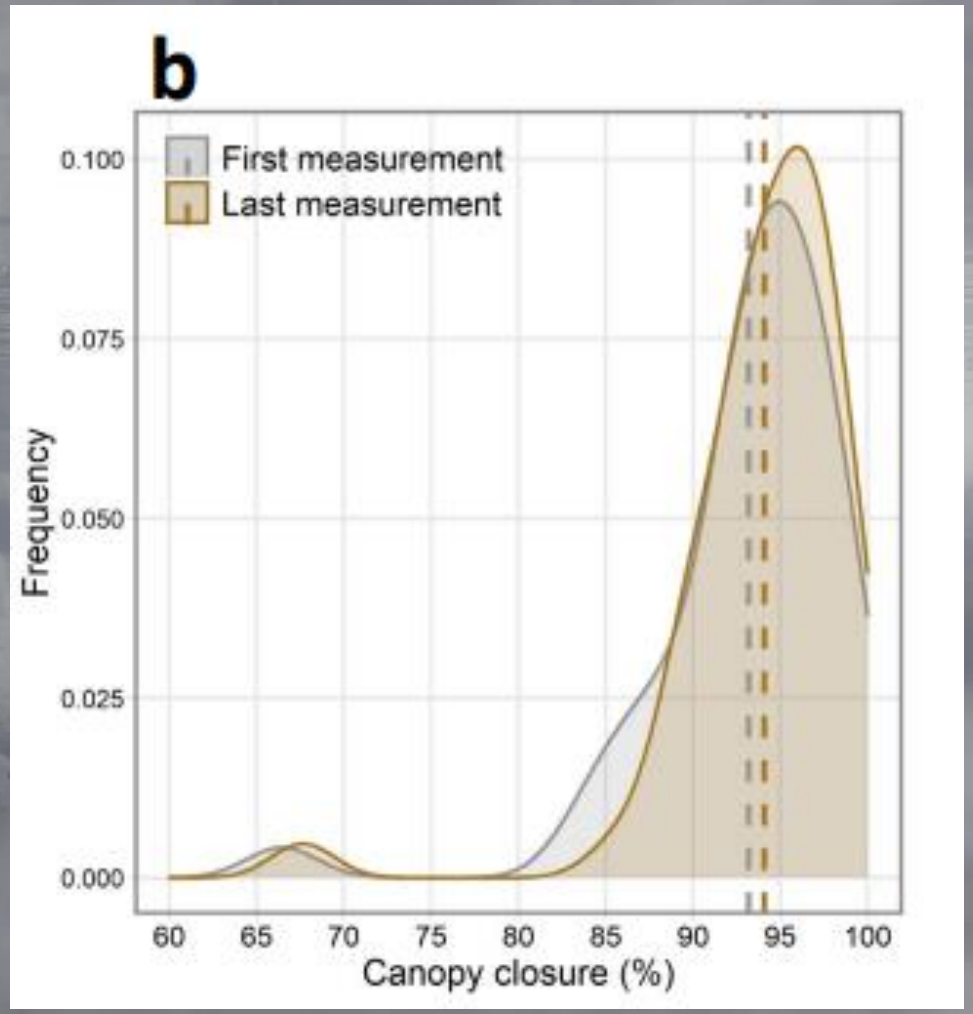


Martens et al. 2019

Production forestry (Pro); Reference (Ref); Ecological forestry (Eco

Canopy Cover



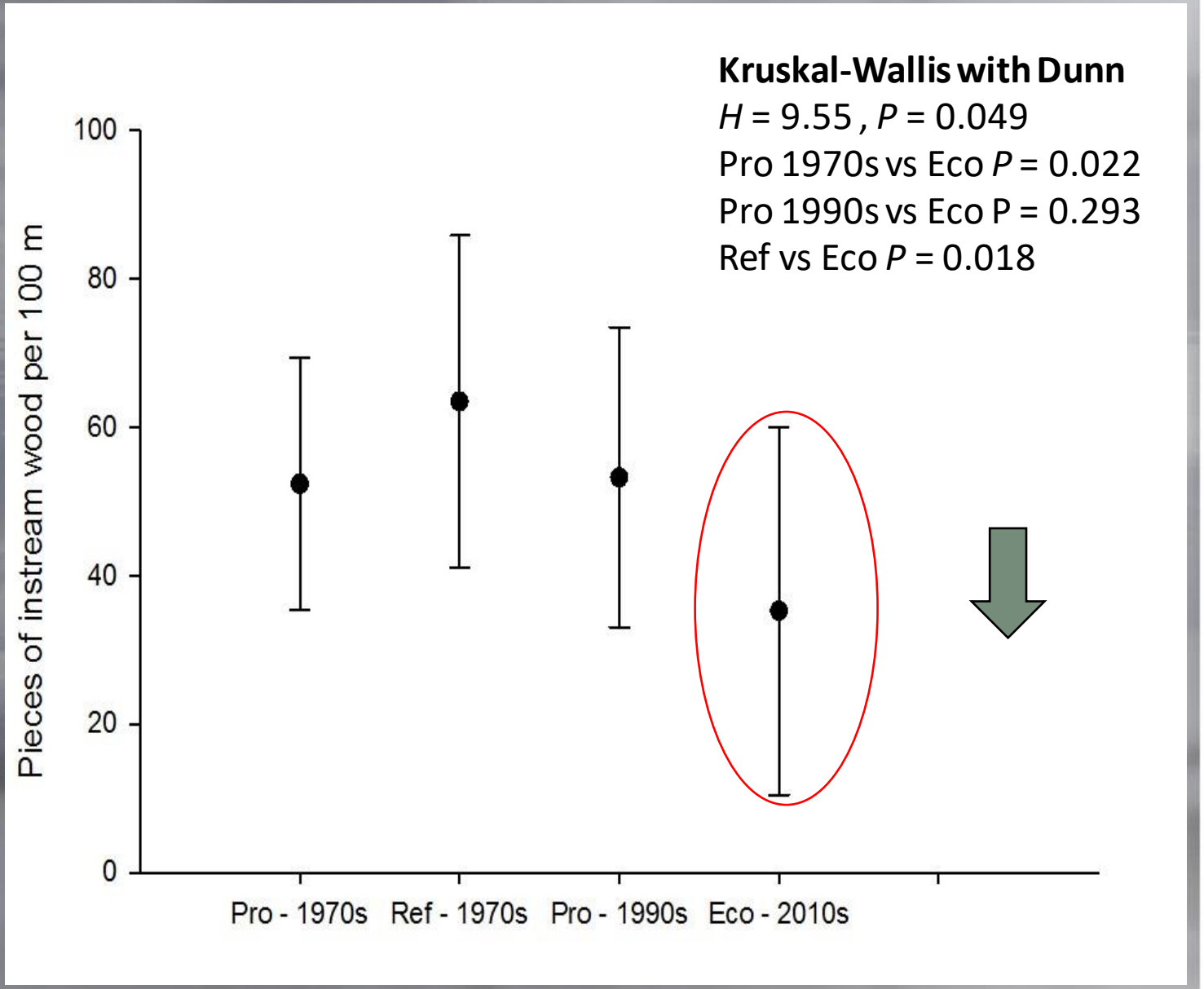


2013-2020

Devine et al. 2022

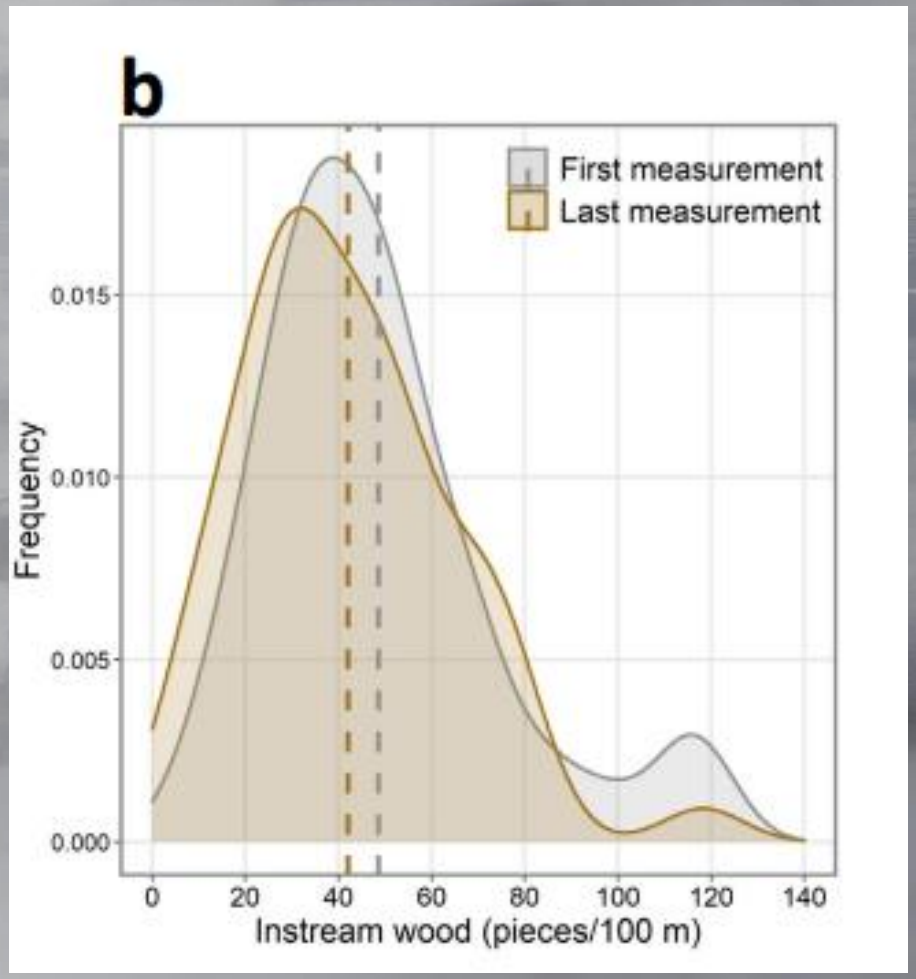
Instream Wood

Martens et al. 2019

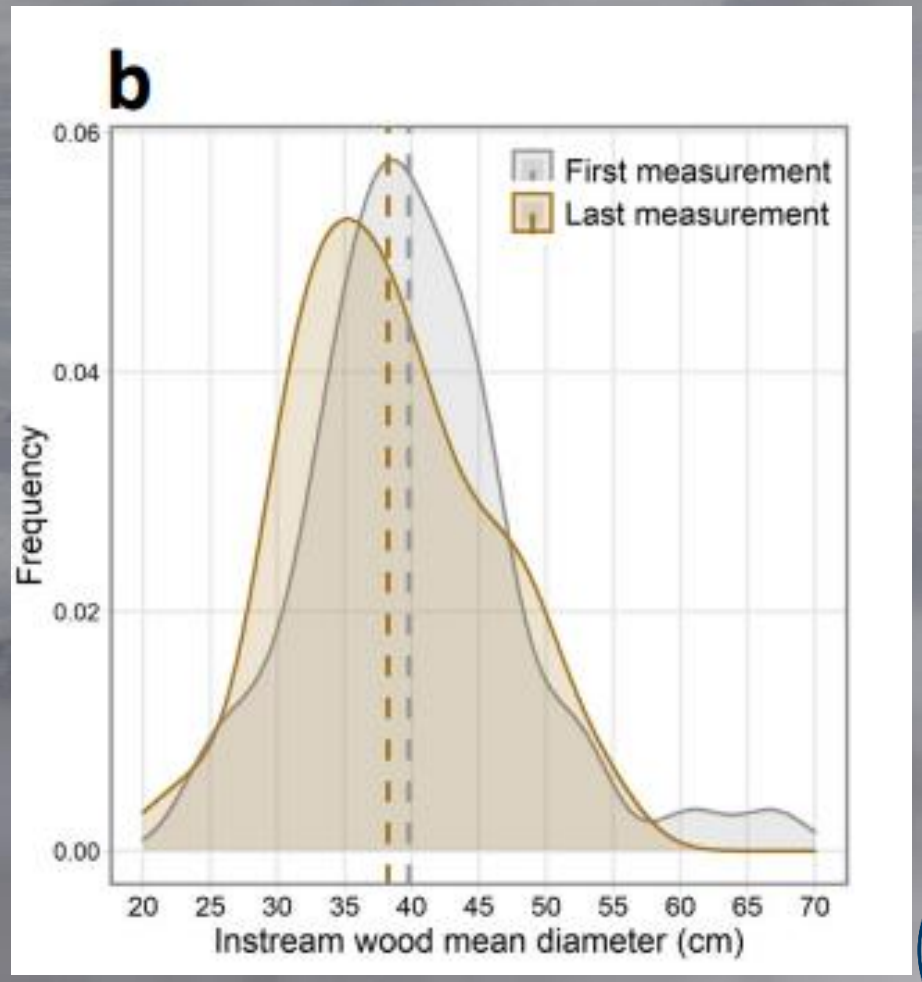


Production forestry (Pro); Reference (Ref); Ecological forestry (Eco)

Instream Wood



2013-2020



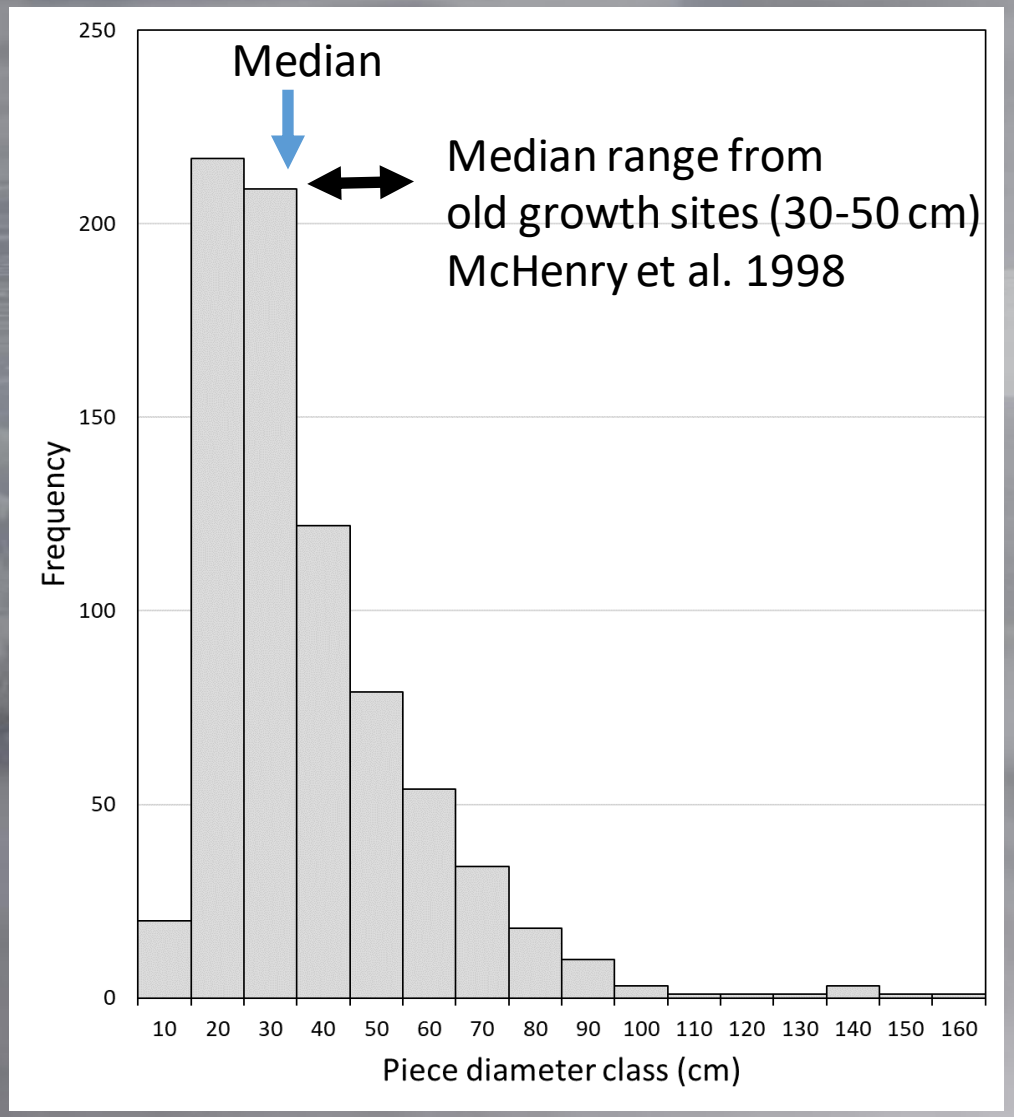
2013-2020

Devine et al. 2022

Diameter of Instream wood

The median diameter of instream wood was 28 cm with a 90th percentile of 63 cm

Martens and Devine 2022



Instream Wood's Influence on Pool Formation

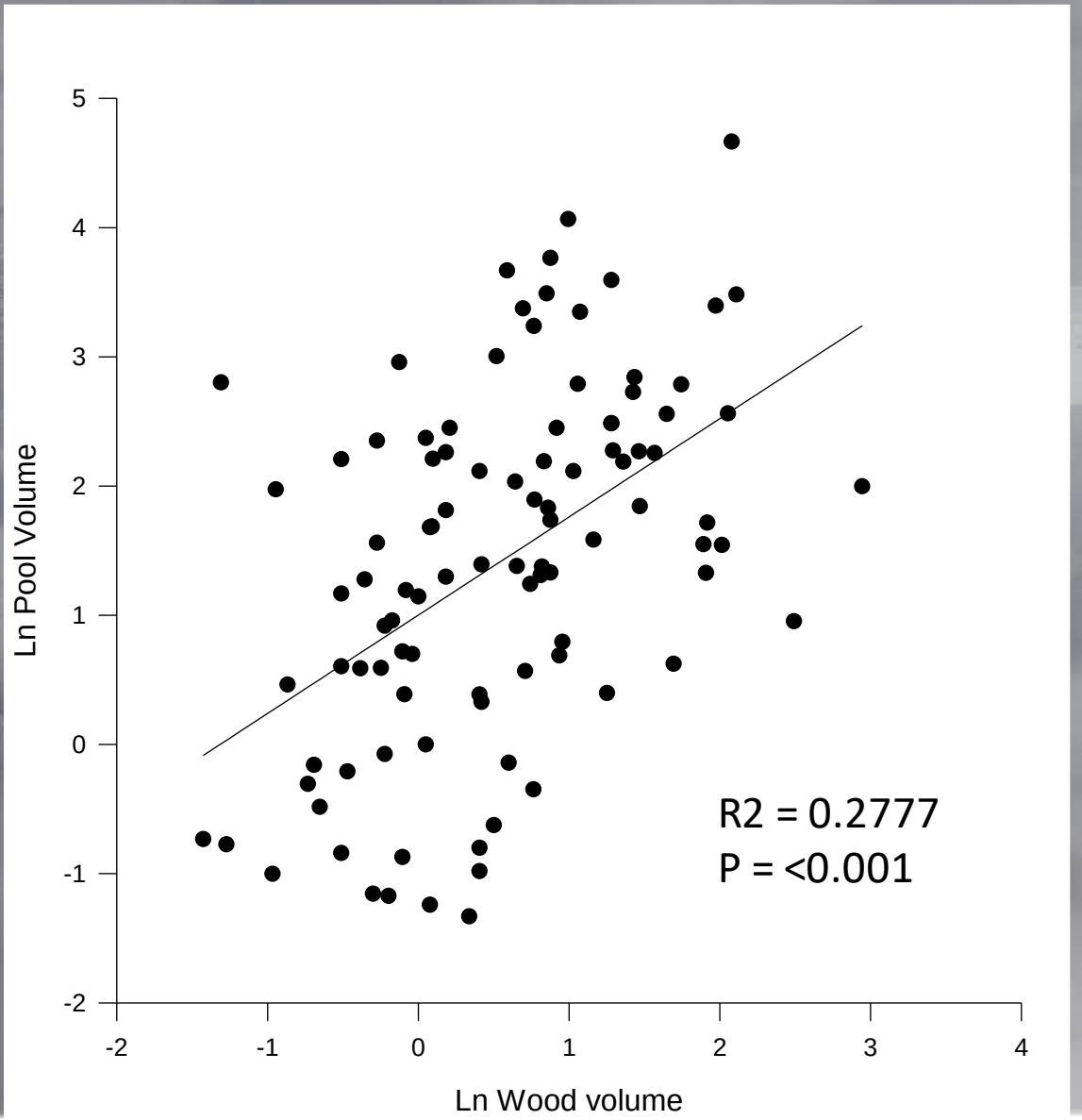
- 16% of instream wood is creating pools (20-60% Montgomery et al. (1995))
- For every additional 1 meter of length of instream wood in the bankfull width (LENBF), the probability of a pool being formed increased by 26%
- For every additional centimeter of wood piece diameter (DIAM) the likelihood of pool formation increased by 2%

Logistic Model	K	AICc	Delta AICc	AICc weight	Cumulative weight	Log likelihood
BFW + DIAM + LENBF	4	632.52	0.00	0.205	0.205	-312.23
BFW + DIAM + LENBF + LEN	5	632.94	0.42	0.166	0.371	-311.43
BFW + DIAM + GRAD + LENBF	5	632.94	0.42	0.166	0.537	-311.43
DIAM + LENBF	3	633.49	0.98	0.126	0.663	-313.73
BFW + DIAM + GRAD + LENBF + LEN	6	633.56	1.04	0.122	0.785	-310.72
DIAM + LENBF + LEN	4	633.80	1.29	0.108	0.893	-312.88
DIAM + GRAD + LENBF	4	635.02	2.50	0.059	0.952	-313.48
DIAM + GRAD + LENBF + LEN	5	635.41	2.90	0.048	1.000	-312.67

Martens and Devine 2022

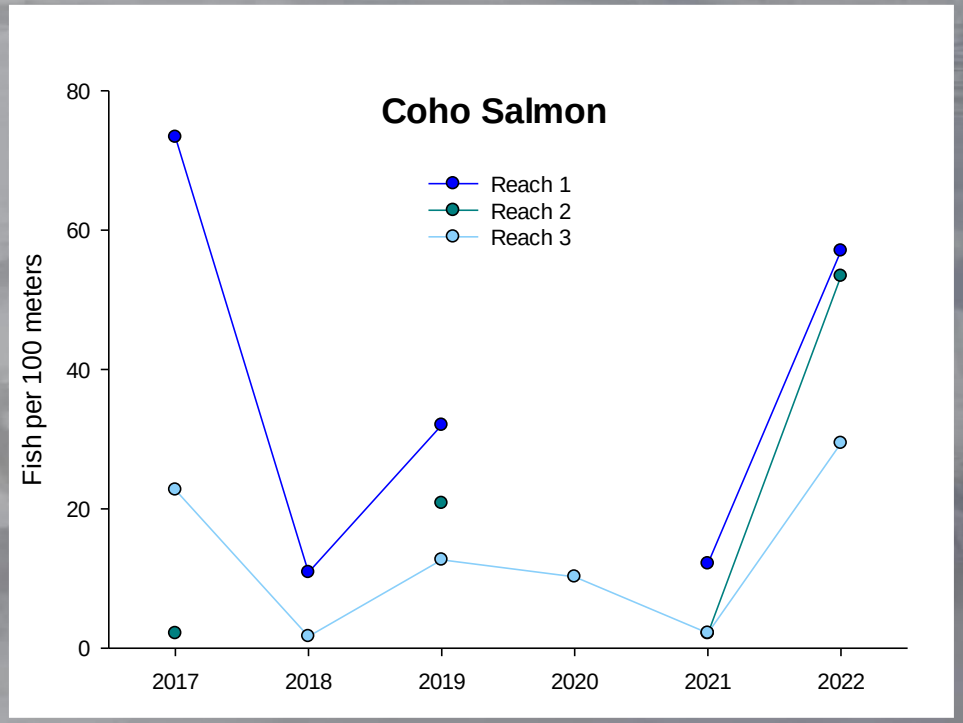
Relationship between Pools and Instream Wood Size

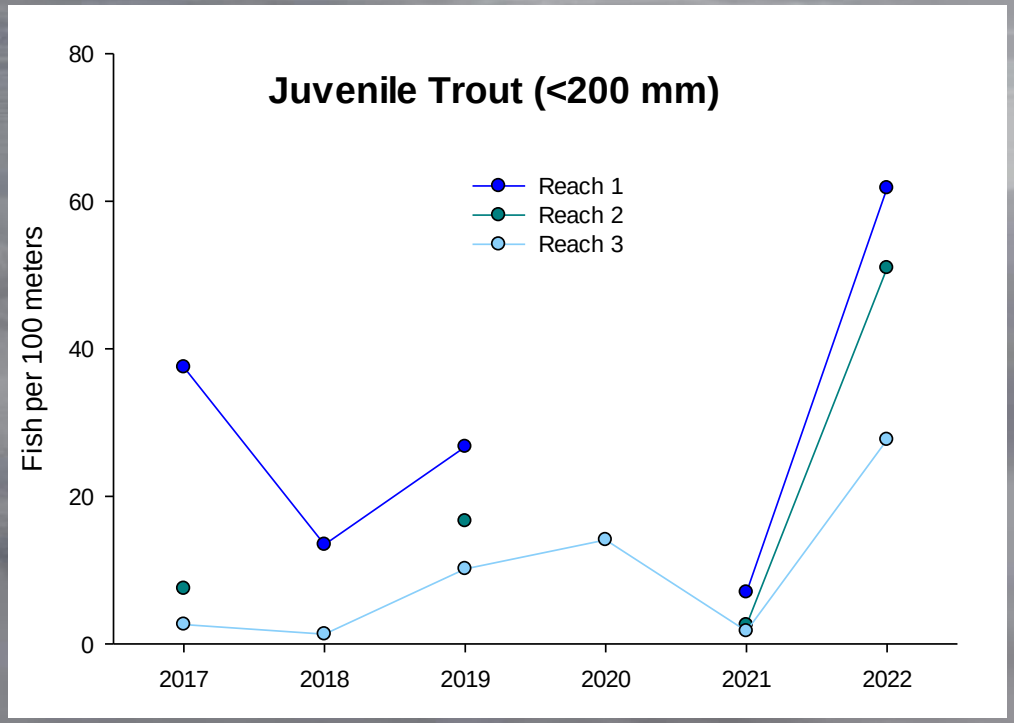
Martens and Devine 2022



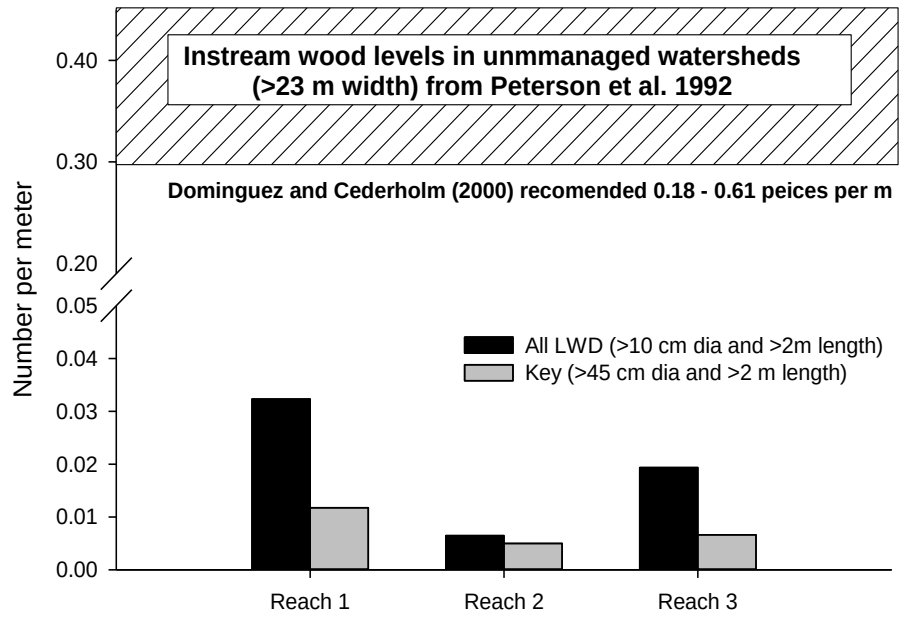
Upper Clearwater River

Kunamakst Creek (rkm 46) to Bull Creek (rkm 33)



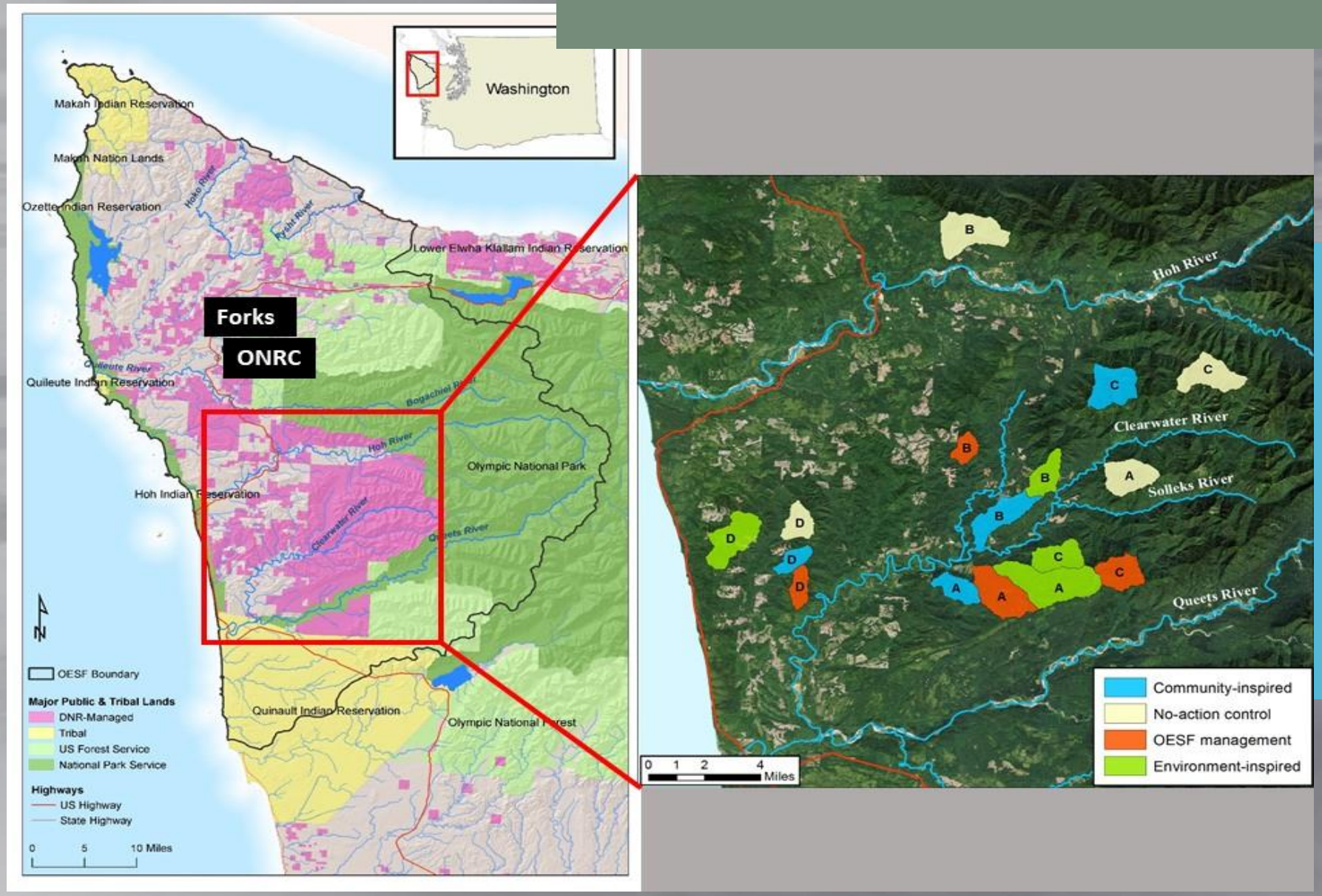


Instream wood - Clearwater River



Martens 2018

T3 Watershed Experiment



Pre-sampling 2020-2023
Treatments fall 2023-2024
Post-sampling 2024-2028

16 watersheds
4 blocks
5 prescriptions

Riparian Forest Management

Riparian Forest Management:

1) Restore functions lost from past riparian harvests.

2) Protect against current upland management impacts.

Passive Restoration:

- Will take >100 years
- Cheap
- Uses natural processes

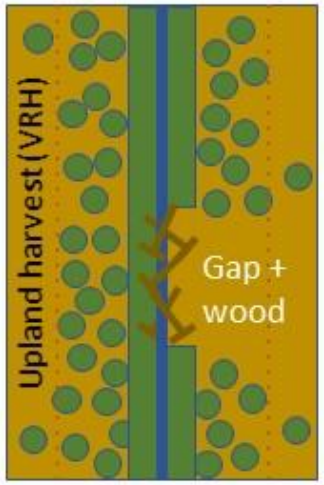
Active Restoration:

- Works quickly
- Expensive
- Risk creating conditions outside of natural range
- May help one species while hurting others

Riparian Prescriptions

Alternative 1

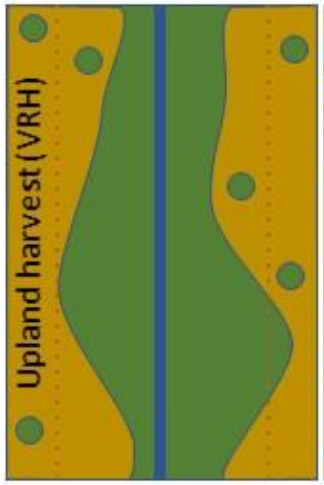
Active habitat restoration



Light thin w/gaps, wood

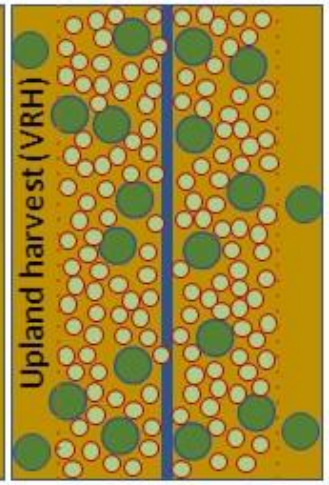
Alternative 2

Variable-width buffers



Conditions-dependent widths

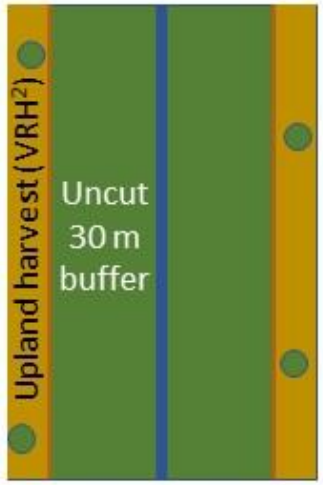
Alder rotations under heavily thinned conifers



Alder rotations, large conifers

Standard

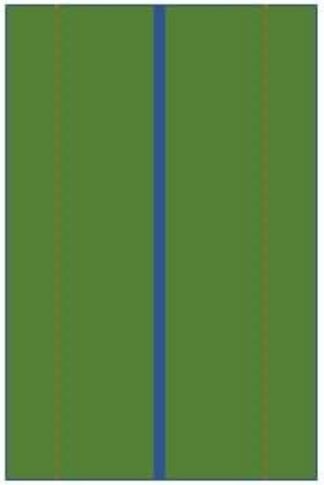
No-entry OESF buffers



Fixed OESF buffers

Control

No Action



OESF – Olympic Experimental State Forest
VRH – Variable-retention harvest

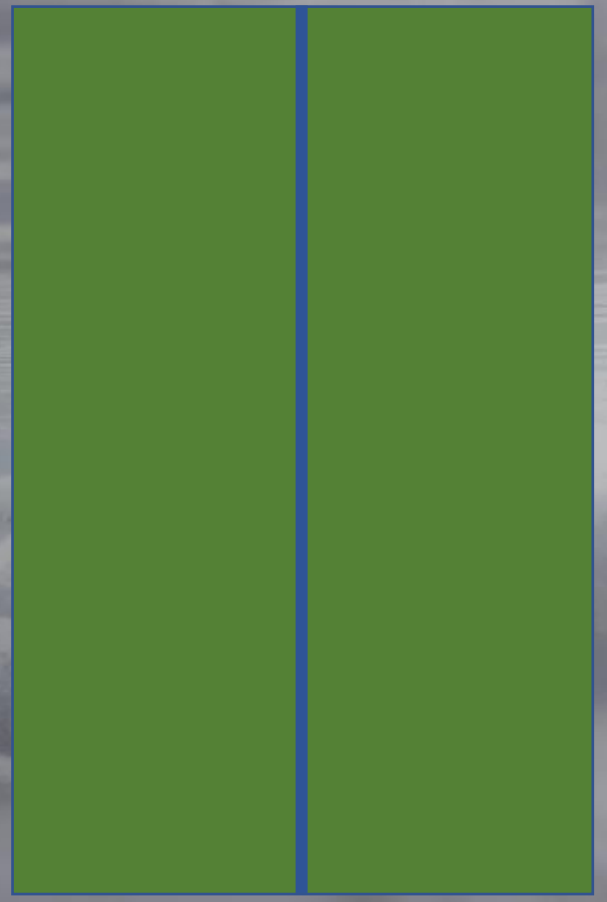
Control – No Action

Management action:

- Leave alone

Expected Results:

- Provides contrast with other prescriptions
- Passive restoration
- >100 years for stream recovery
- Not currently a viable management strategy



Standard – No-entry OESF buffers

Management action:

- 30m (100 ft) no-touch buffer

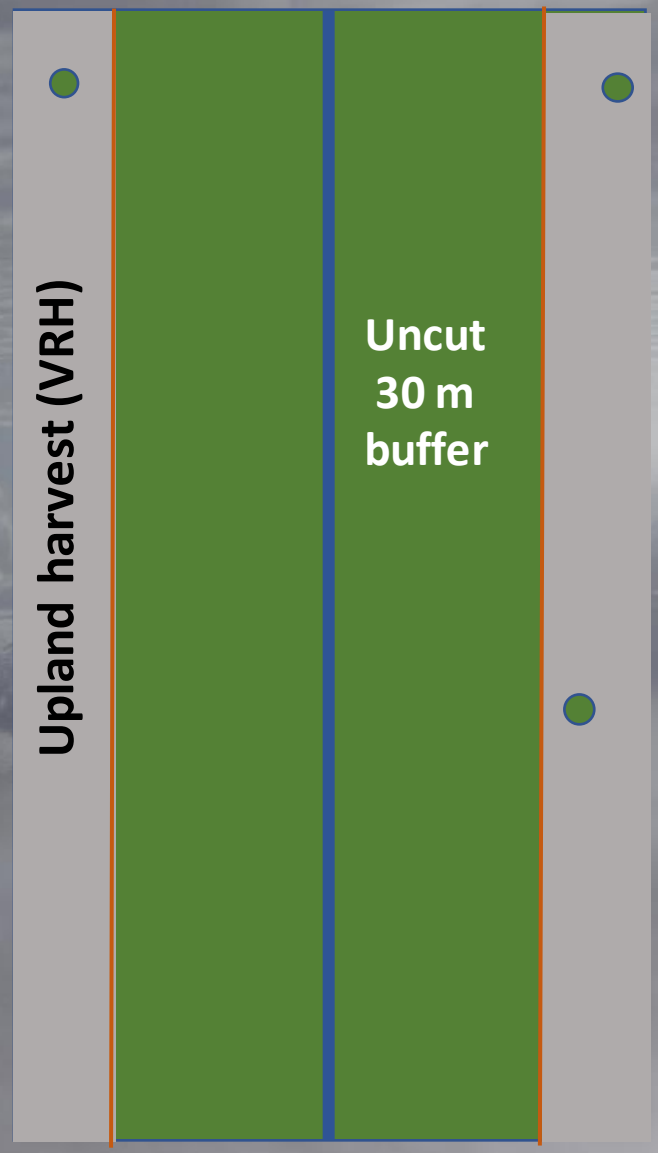
- Expanded widths for unstable slopes and when there is a high chance of wind-throw

Expected Results:

- Passive Restoration

- >100 years for stream recovery

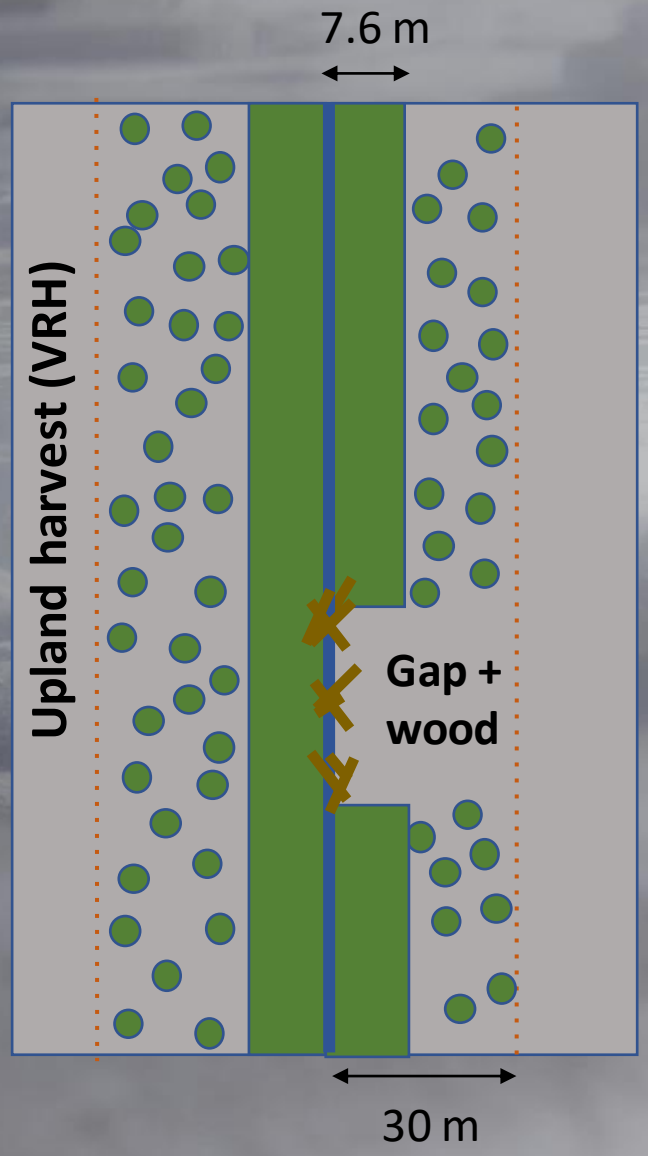
- Evaluates current management



Alternative 1 – Active habitat restoration

Management action:

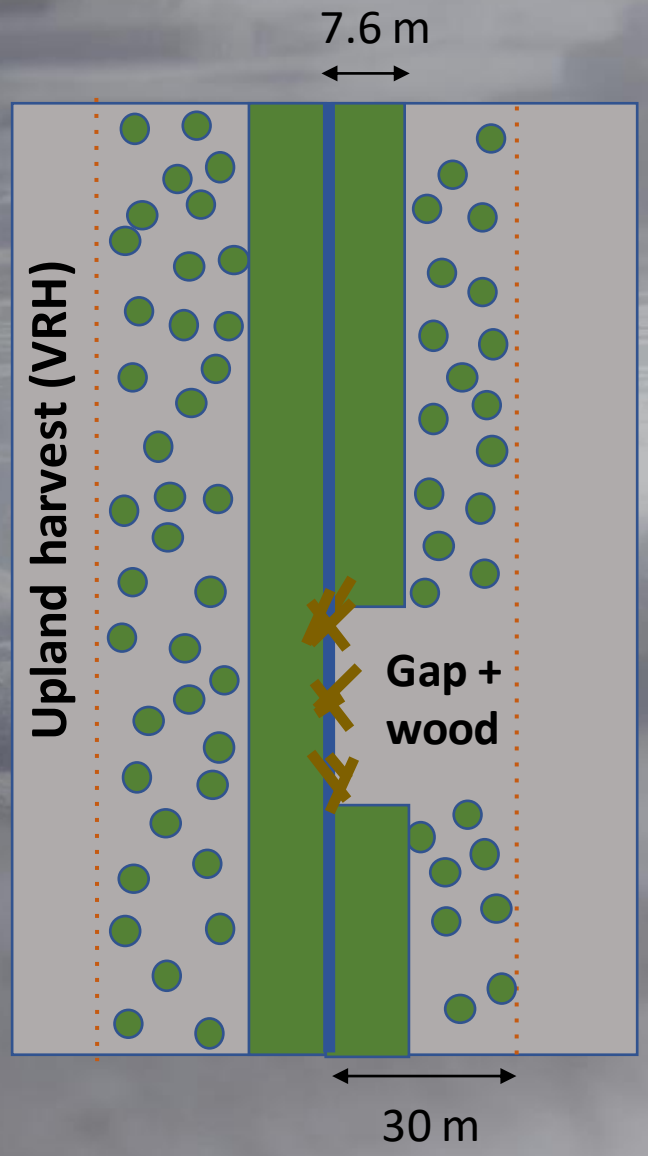
- Only applied on fish-bearing streams with mid-successional forests
- One gap (30m by 30 m [100 ft] ; 0.22 acre) per every 100 m (328 ft) of stream
- Three wood jams per gap
- 7.6 m (25 ft) no entry stream side buffer outside of gaps
- Light thinning in outer portion of the buffer



Alternative 1 – Active habitat restoration

Expected Results:

- Active Restoration
- Increases wood in stream now and in the future
- Increases light but hopefully not stream temperatures
- Thinning and gaps to create more structural diversity
- Additional work to be funded by riparian harvests (potential for additional revenue)



Alternative 2 – Variable-width buffer

Buffer width = 58.662+(0.532*Bank Full width)

Bank Full width = Buffer size

<0.6 m = 18.3 m buffer
1.8 m = 18.9 m buffer
3.0 m = 19.5 m buffer
4.3 m = 20.1 m buffer
5.5 m = 20.7 m buffer
6.7 m = 21.3 m buffer
7.9 m = 21.9 m buffer
9.1 m = 22.6 m buffer
10.4 m = 23.8 m buffer
11.6 m = 24.4 m buffer
12.8 m = 25.0 m buffer
14.0 m = 25.6 m buffer
15.2 m = 26.2 m buffer
16.5 m = 26.8 m buffer
17.7 m = 27.4 m buffer
18.9 m = 28.0 m buffer
20.1 m = 28.7 m buffer
21.3 m = 29.3 m buffer
22.6 m = 29.9 m buffer
>23.8 m = 30.5 m buffer

Loosened protections

Fish habitat -Stream gradient is >6% and <5.5 m bf width (Type-3 or less; typically highly abundant cutthroat-only streams)

or

No fish present (field identified)

Subtract 7.6 m (25 ft)

Added protections

Other hazards – unstable slopes (field identified) or Wind throw probability

As typically applied

Watershed - if over 20% of the watershed has been harvested over the last 10 years

or

Stream temp concerns – Stream gradient < 2%

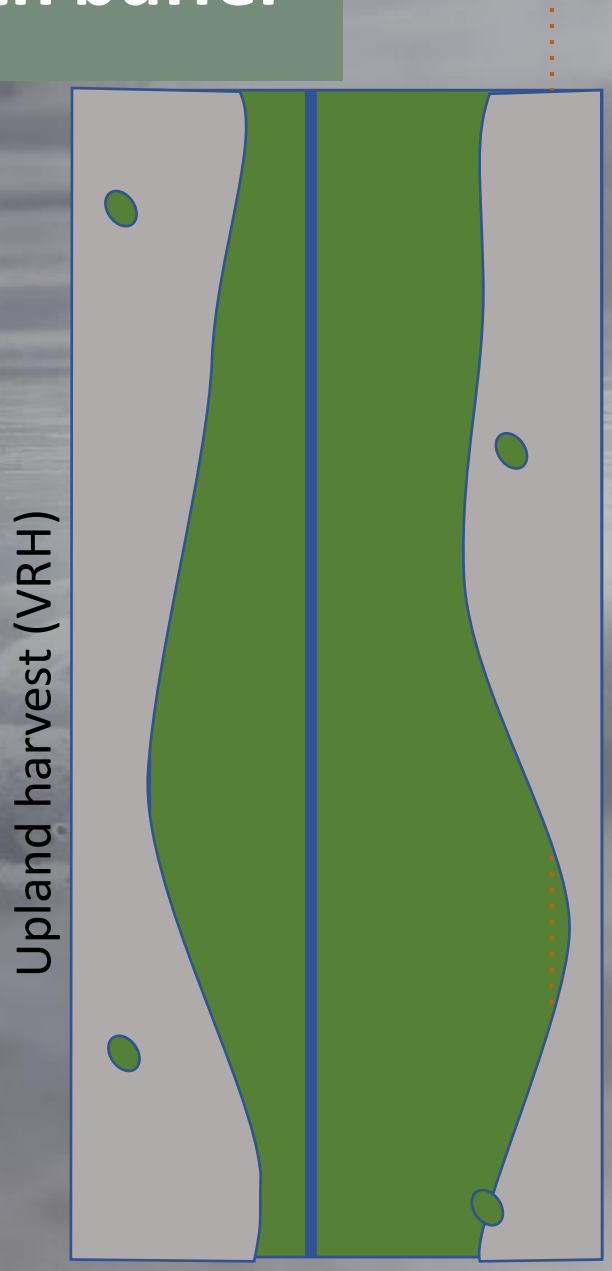
Add 7.6 m (25 ft)

60-100 ft buffers

Alternative 2 – Variable-width buffer

Expected results:

- Passive restoration
- Site specific riparian buffers
- More targeted buffer (harvest more with similar environmental response)



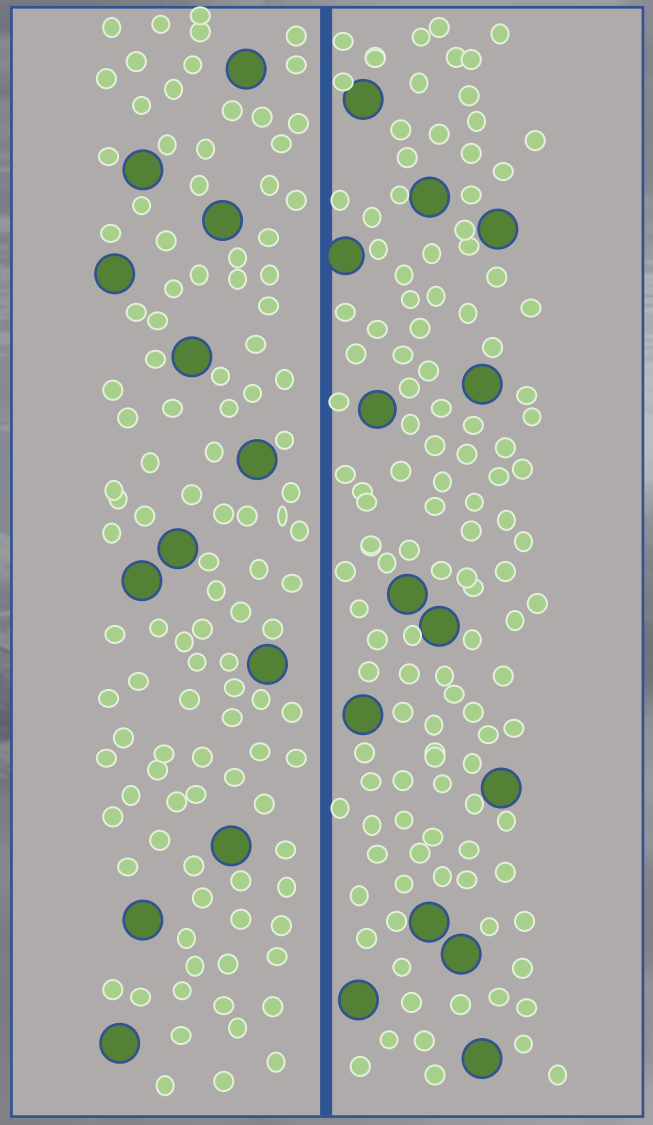
Alternative 2 – Riparian alder under-rotations

Management action:

- Applied to all streams
- Heavy thinning (74 trees ha-1; 30 tpa) throughout riparian area
- Under planting alder

Expected results:

- Active restoration
- Increases existing tree growth
- Increases nutrients, leaf litter, and terrestrial insects to stream
- Provides a short rotation crop of alder for increased revenue



Questions?

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https://www.dnr.wa.gov/oesf

OESF website

https://www.dnr.wa.gov/oesf

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