# Cutthroat trout responses to gap formation in the riparian forest canopy


***Dana R. Warren[1,2]***
***Allison Swartz[1]***

*[1]Dept. Forest Ecosystems and Society, OSU*
*[2]Dept. Fisheries and Wildlife, OSU*


OSU Oregon State University

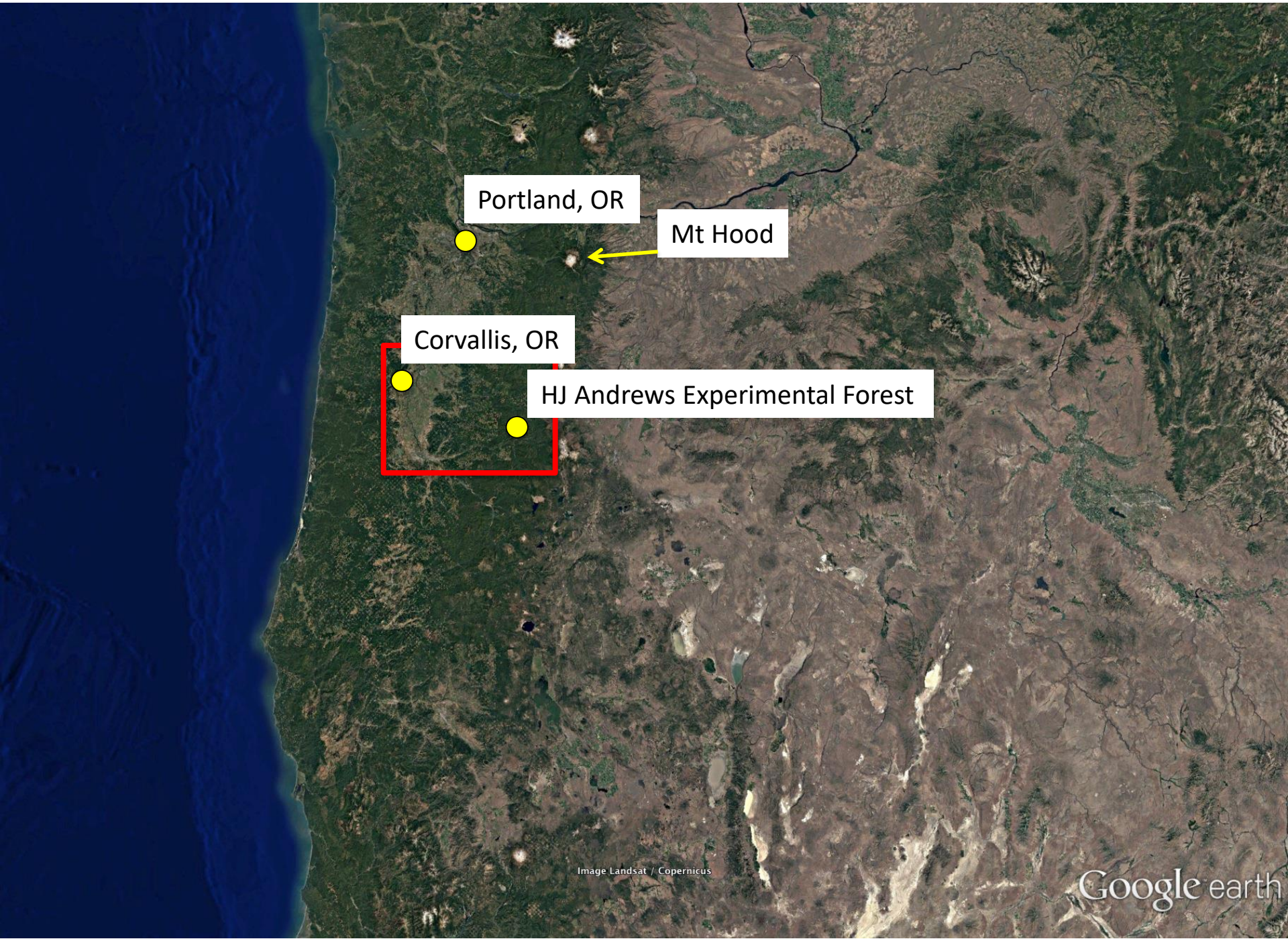
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Image Landsat / Copernicus
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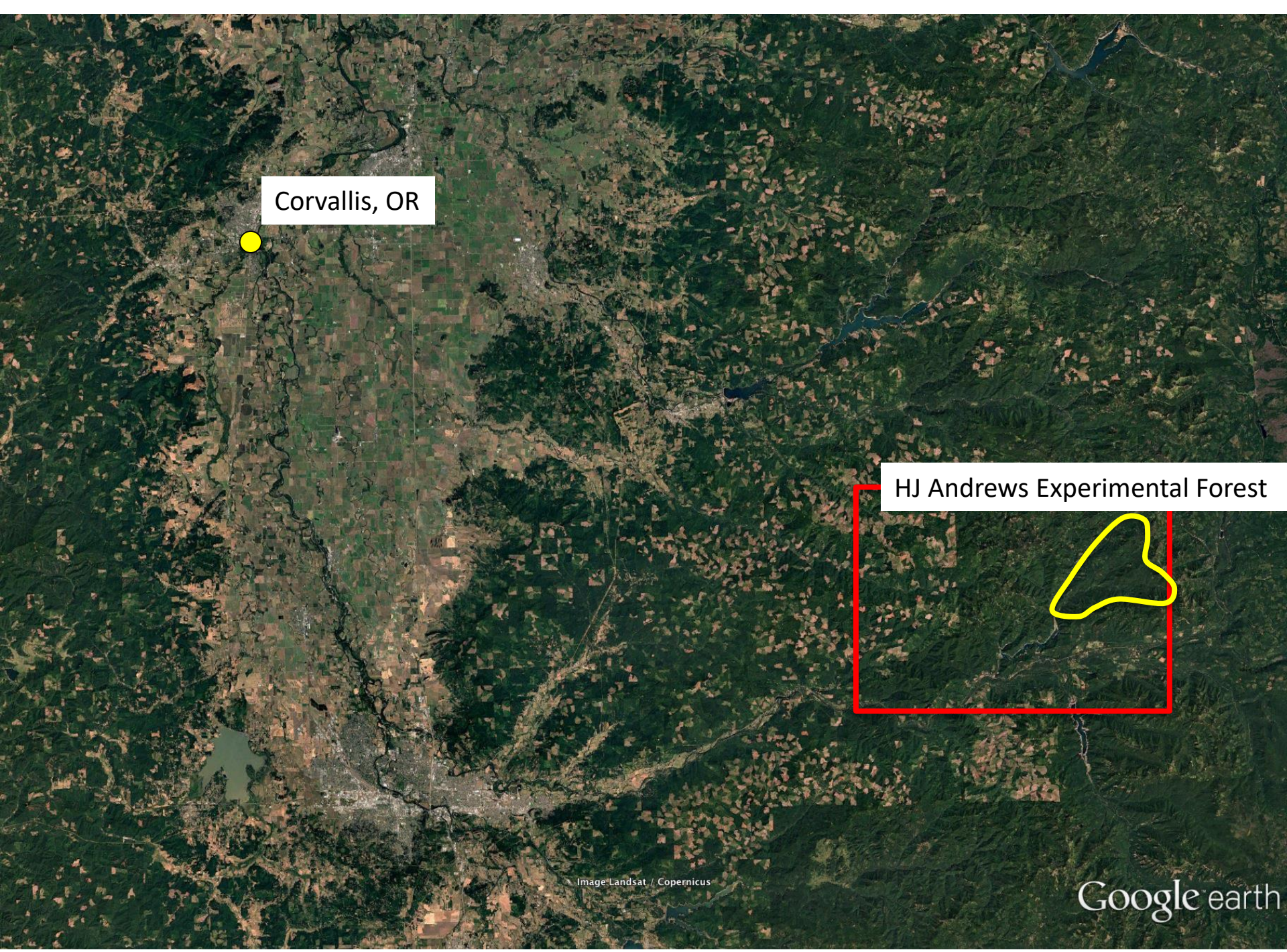
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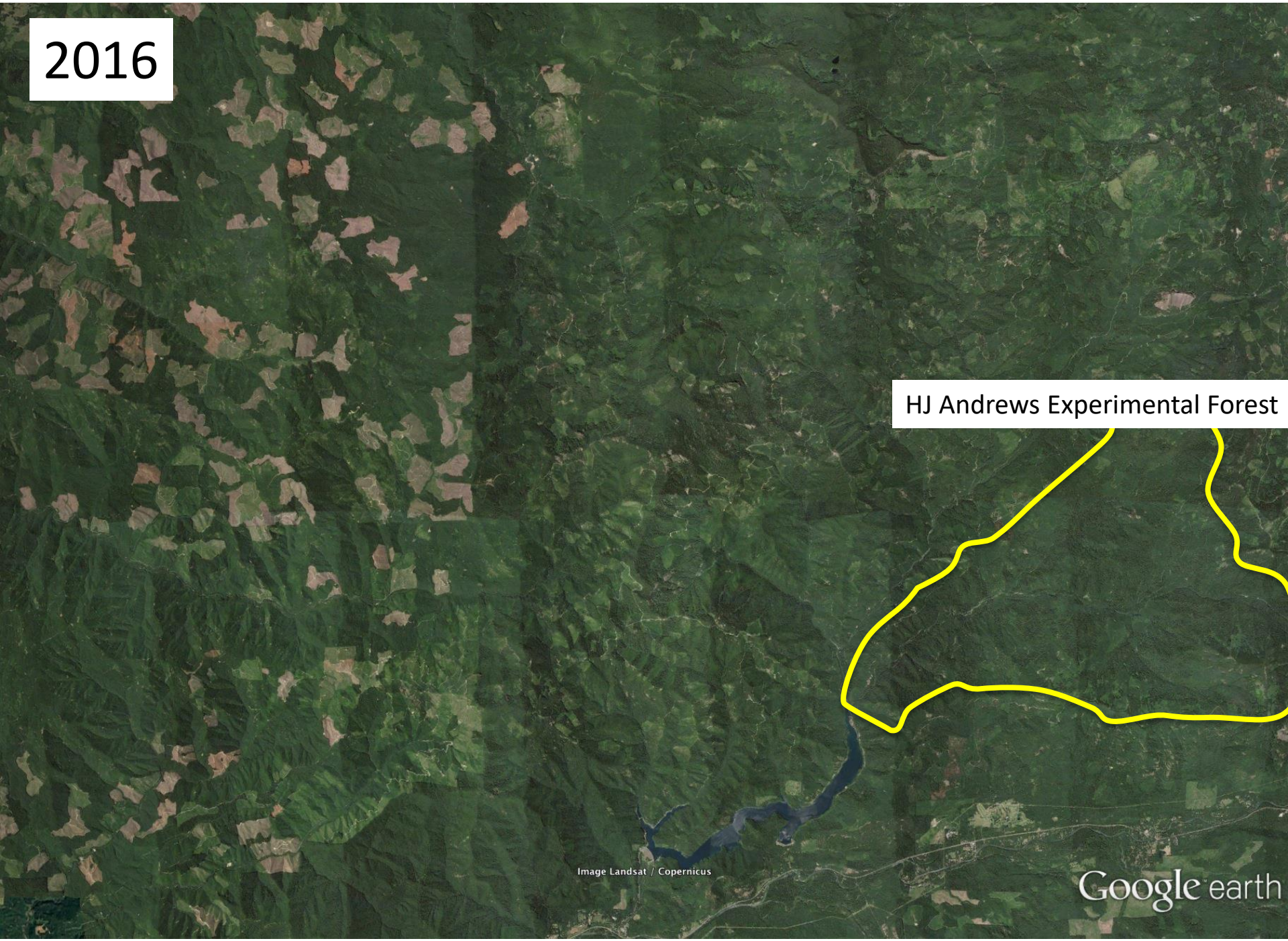
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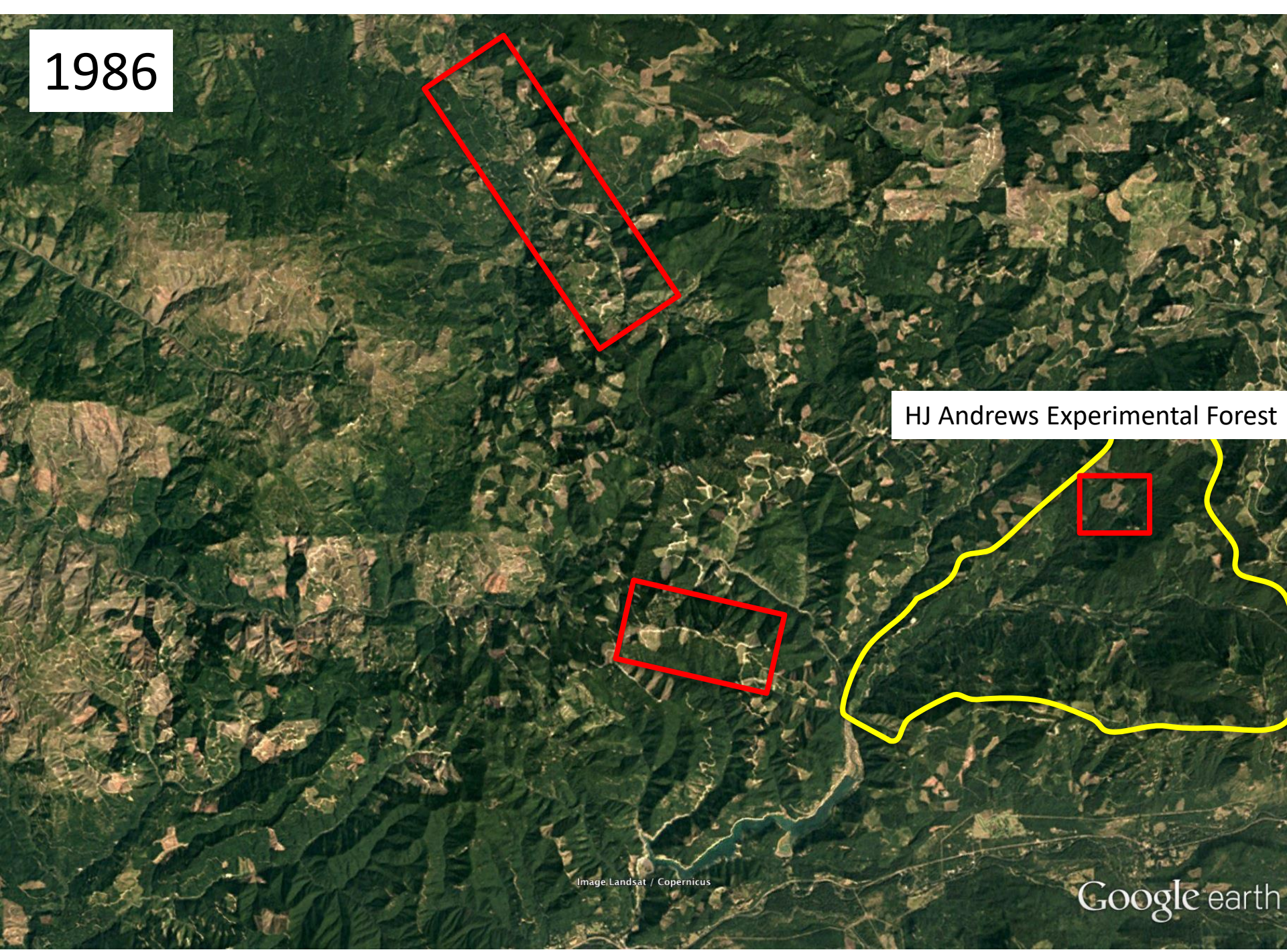
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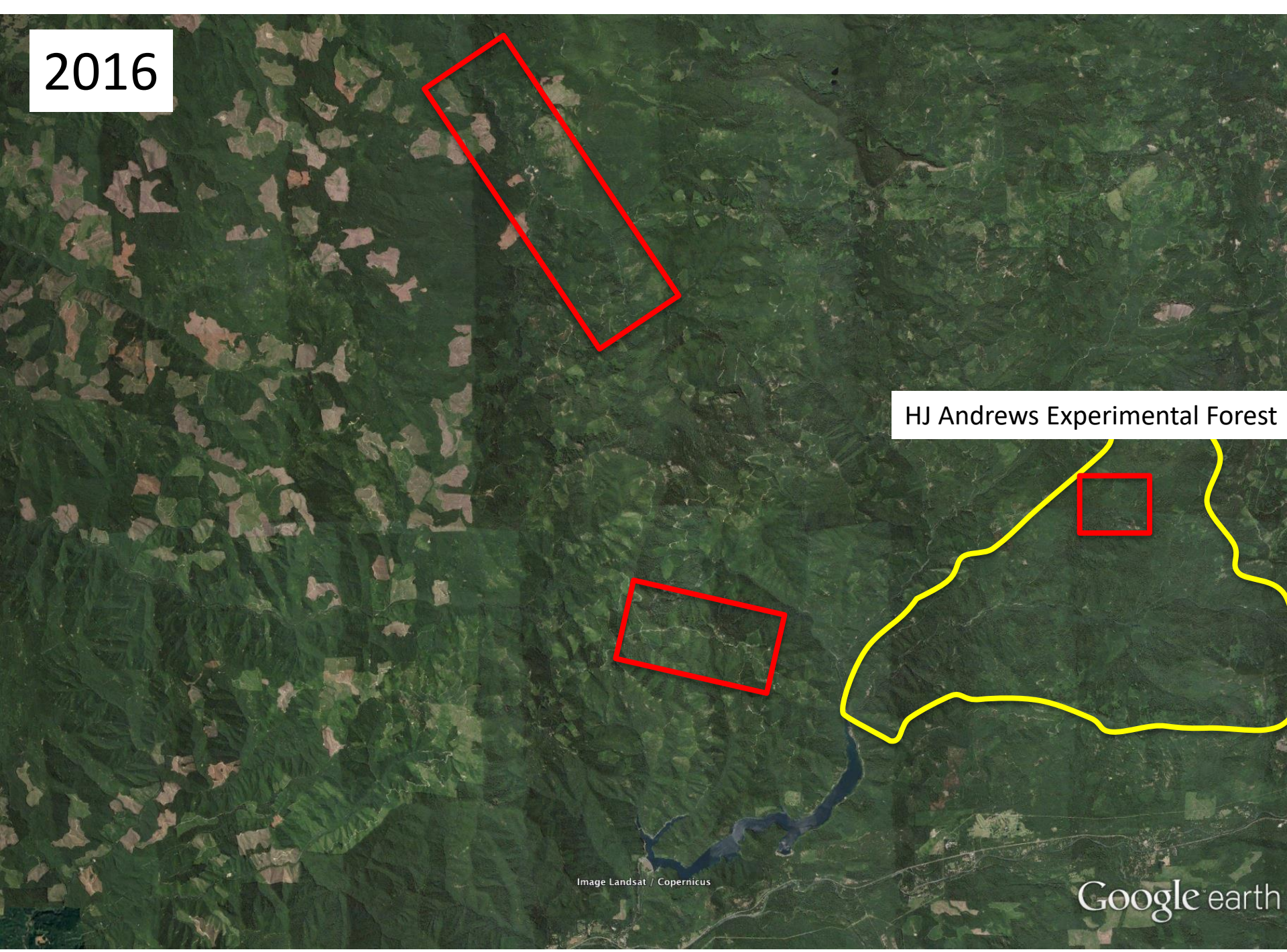
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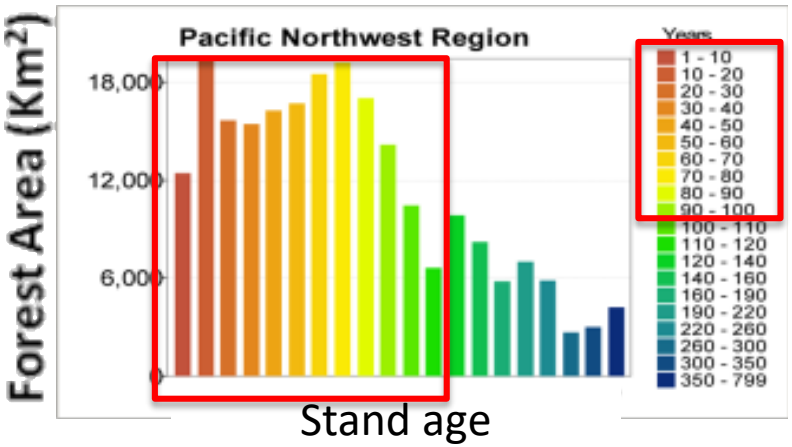
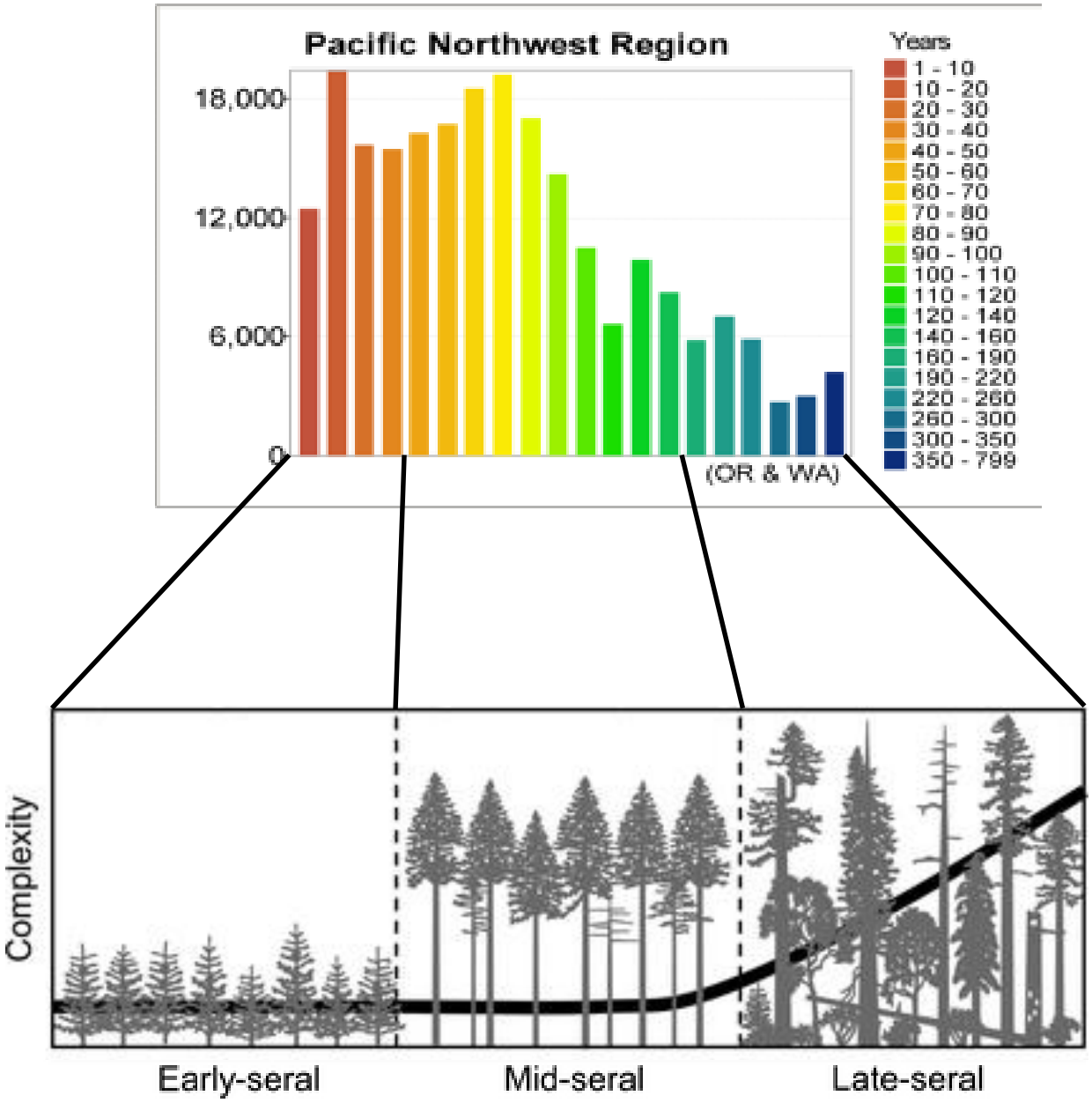
# Forests <100 yrs old dominate U.S. PNW landscapes



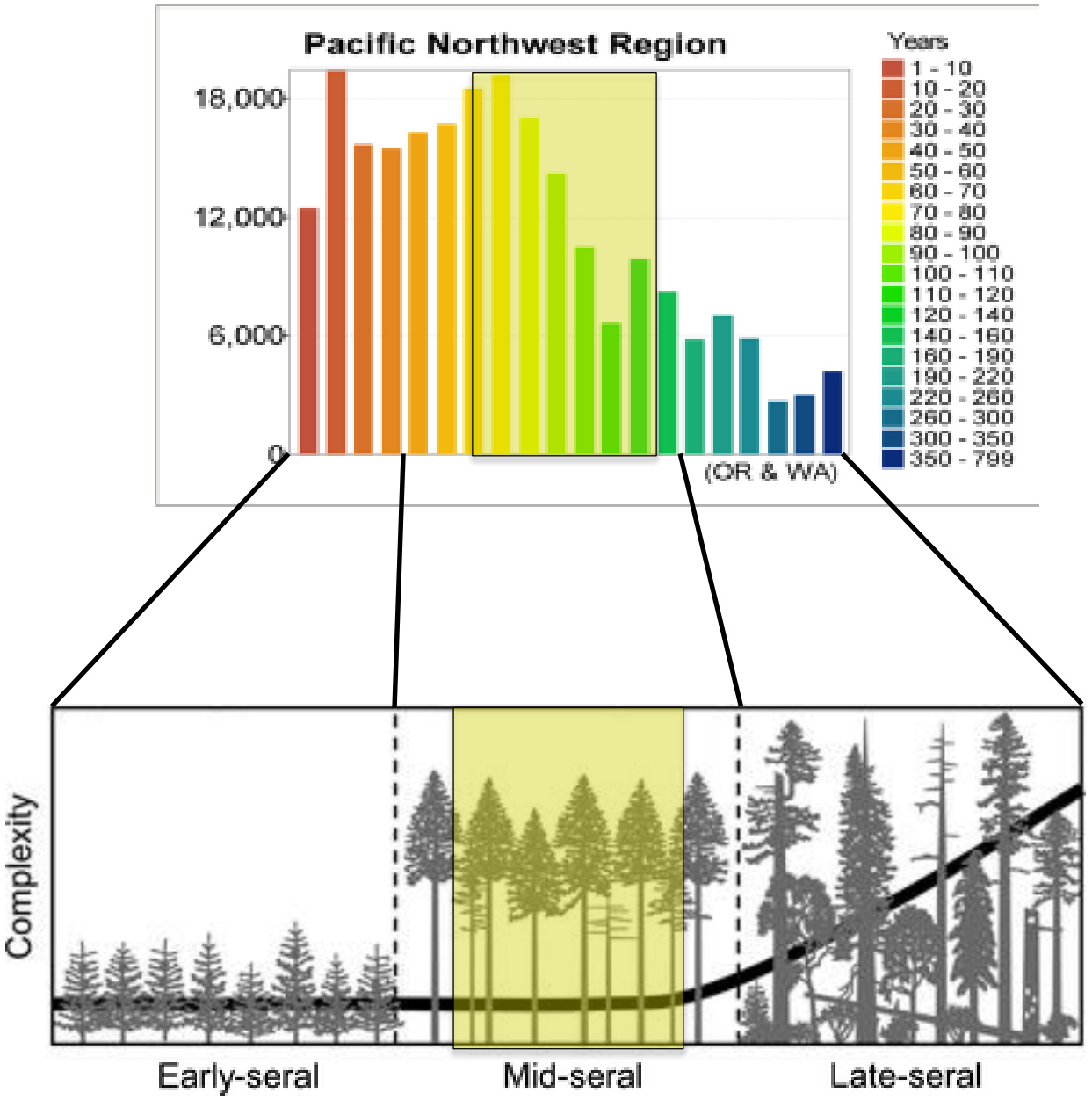

*Pan et al. 2011*

# Few stands with complex forest structure




*Pan et al. 2011*
*Donato et al. 2012*

# Forest Structure CHANGES over time


*Pan et al. 2011*
*Donato et al. 2012*

# 2. Patterns of light in streams - SPATIAL

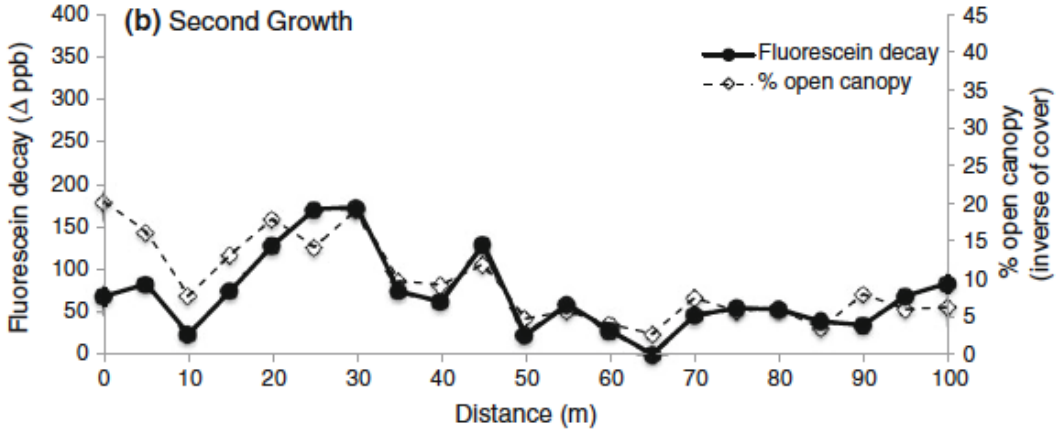
Aquat Sci (2013) 75:547–558
DOI 10.1007/s00027-013-0299-2

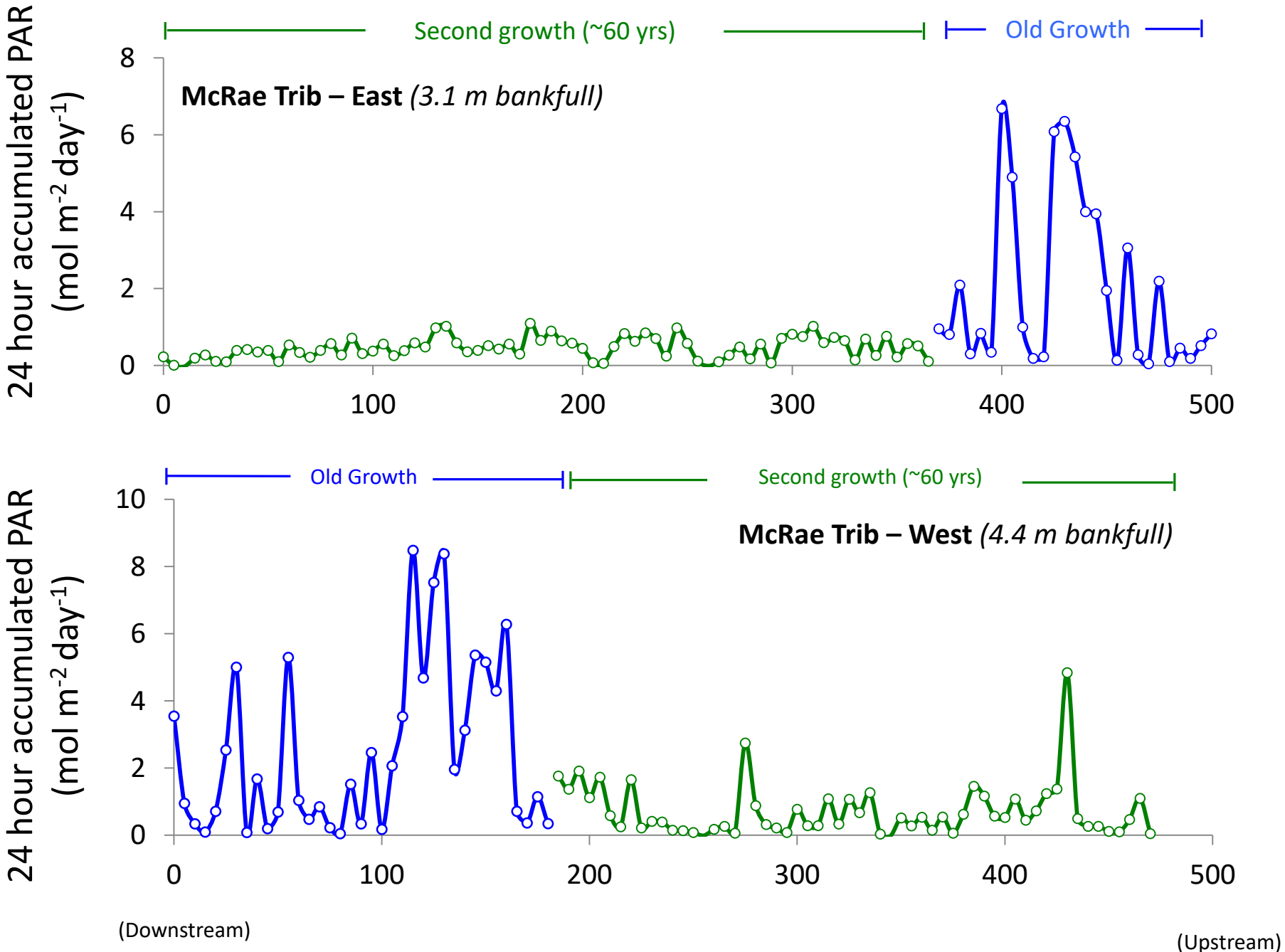
Aquatic Sciences

RESEARCH ARTICLE

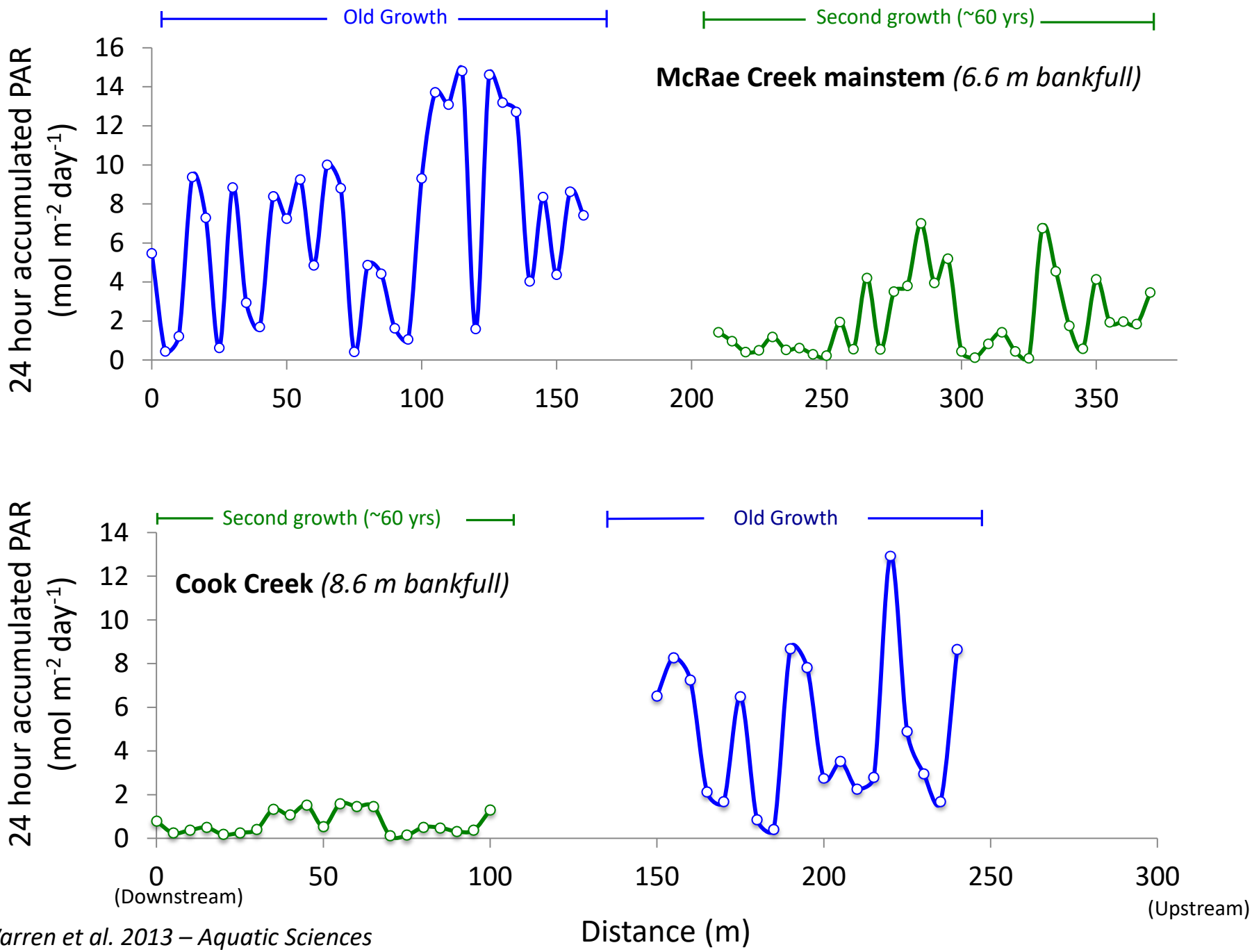
## Comparing streambed light availability and canopy cover in streams with old-growth versus early-mature riparian forests in western Oregon

Dana R. Warren · William S. Keeton · Heather A. Bechtold · Emma J. Rosi-Marshall






*Warren et al. 2013 – Aquatic Sciences*

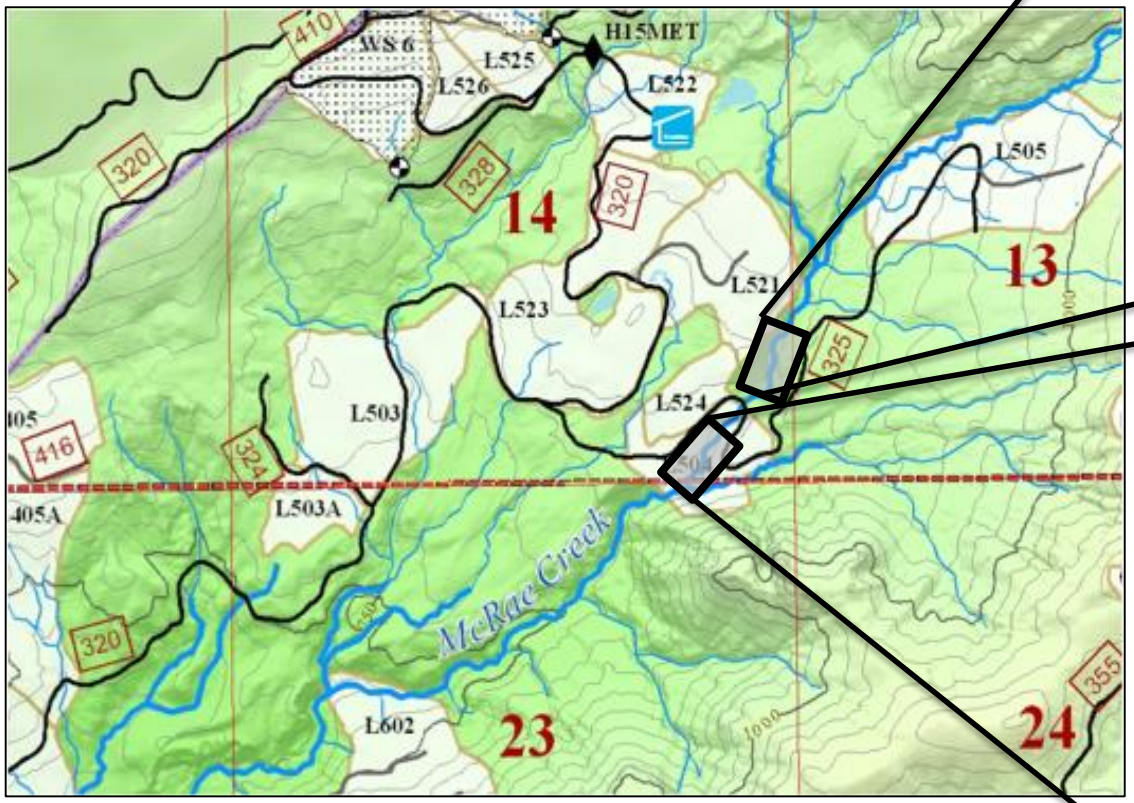



*Warren et al. 2013 – Aquatic Sciences*

# Forest age class comparison

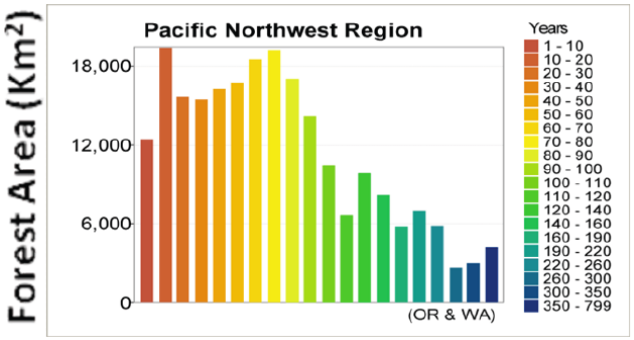
**Stream 1: upper third-order McRae Creek**

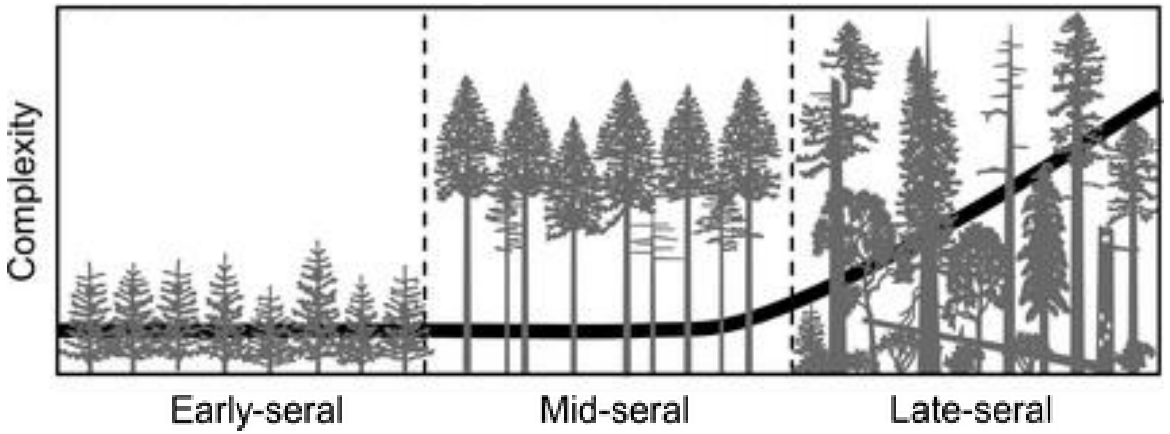
- **6.6 m bankfull width**

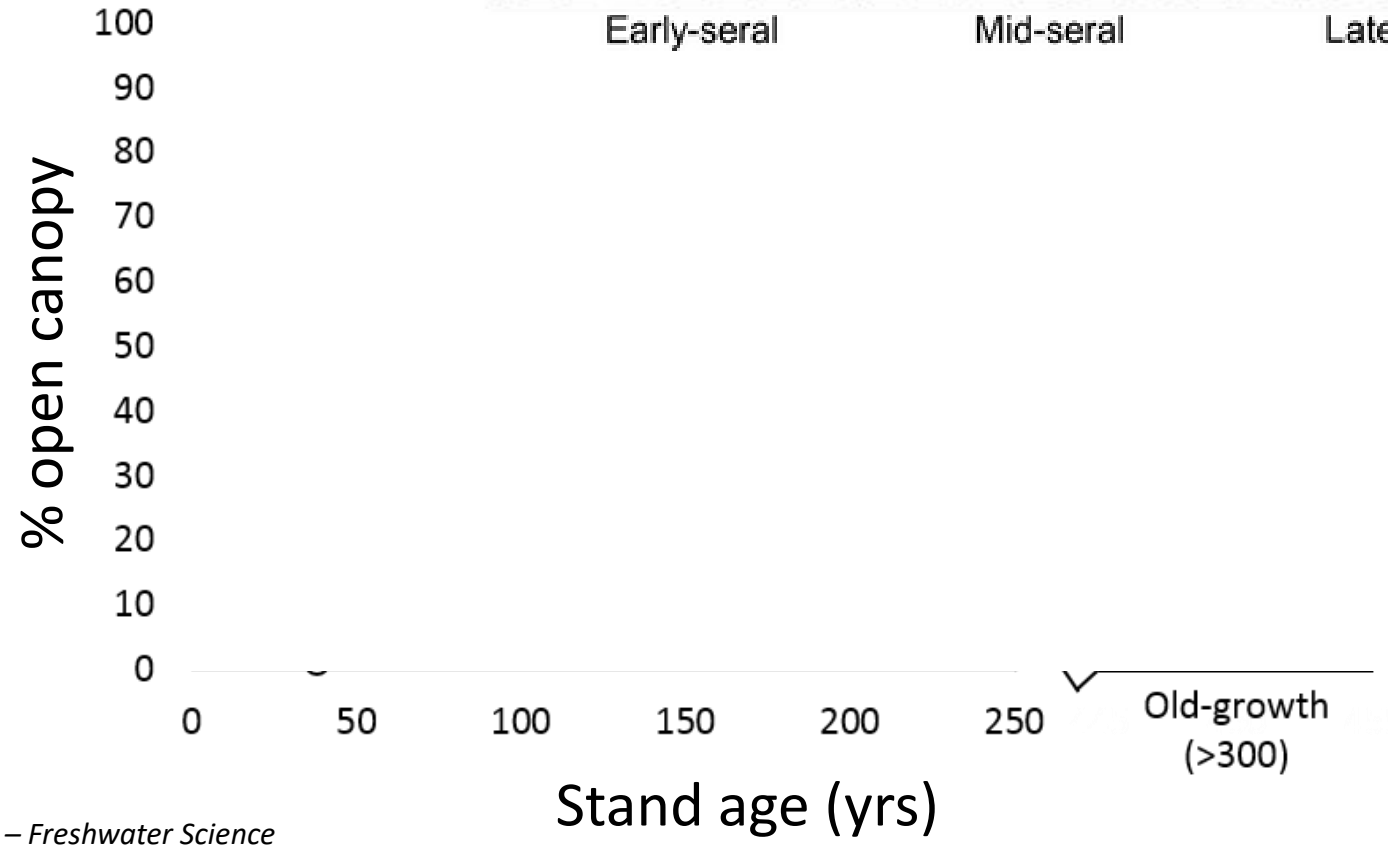



# Stand development *(simplified)*

*Donato et al. 2012*



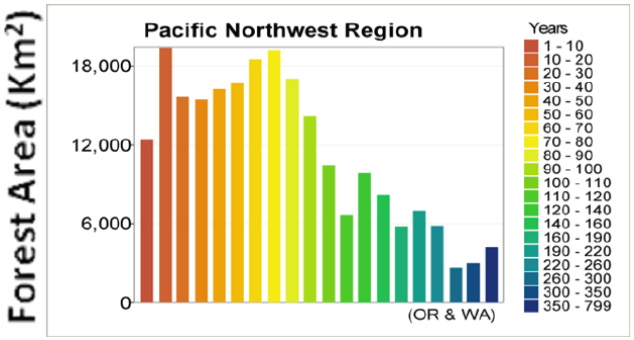



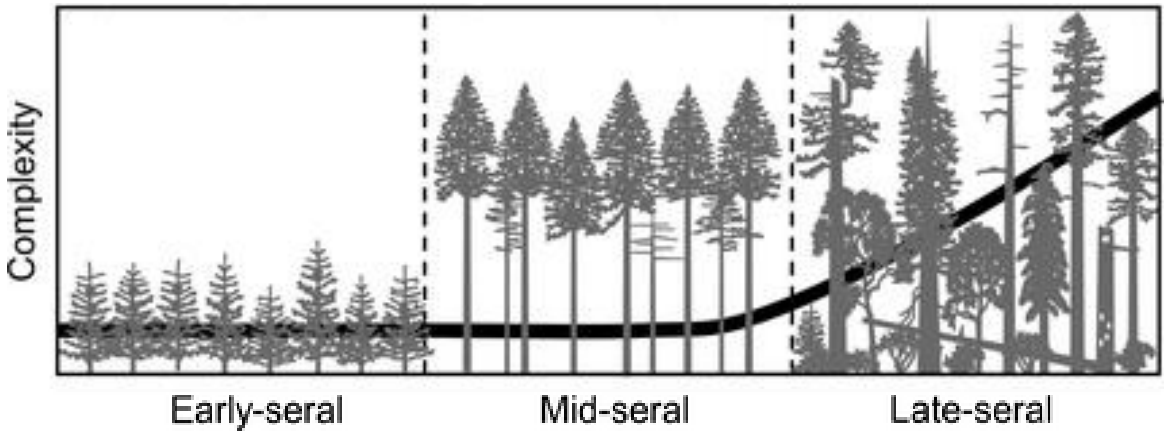



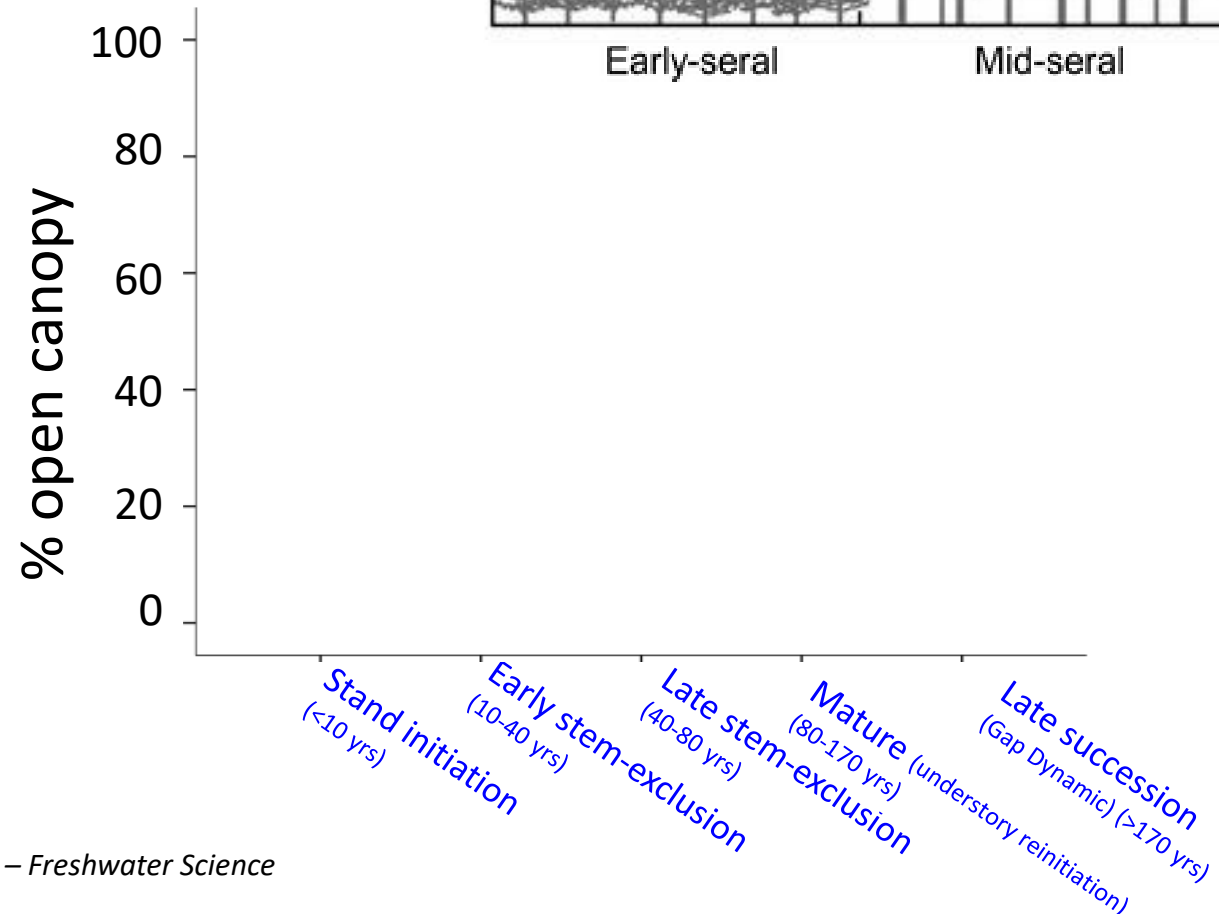

*Kaylor et al. 2017 – Freshwater Science*

# Stand development *(simplified)*

*Donato et al. 2012*




*Kaylor et al. 2017 – Freshwater Science*

# Take home messages (1)

1. Light is spatially variable in streams – and far more variable in late-succession forests

2. Late succession forests have more light on average than mid-succession forests in PNW forests

3. The greater light in late-succession forests is a result of periodic canopy gaps

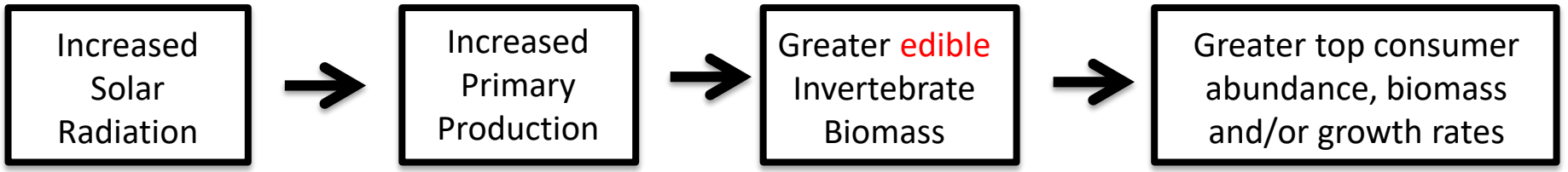
# A focus on LIGHT

## Why light?

- Stream biota (fish) are affected by more than just habitat
- Stream light can be a key control on primary production (and therefore the rest of the food web)
- Stream light influences stream temperature
- High quality food resources that respond to increasing stream light (algae) that shows up disproportionately in higher trophic levels

# Conceptual framework

Forest structure influences stream predators via
'Bottom-up" drivers in the food web

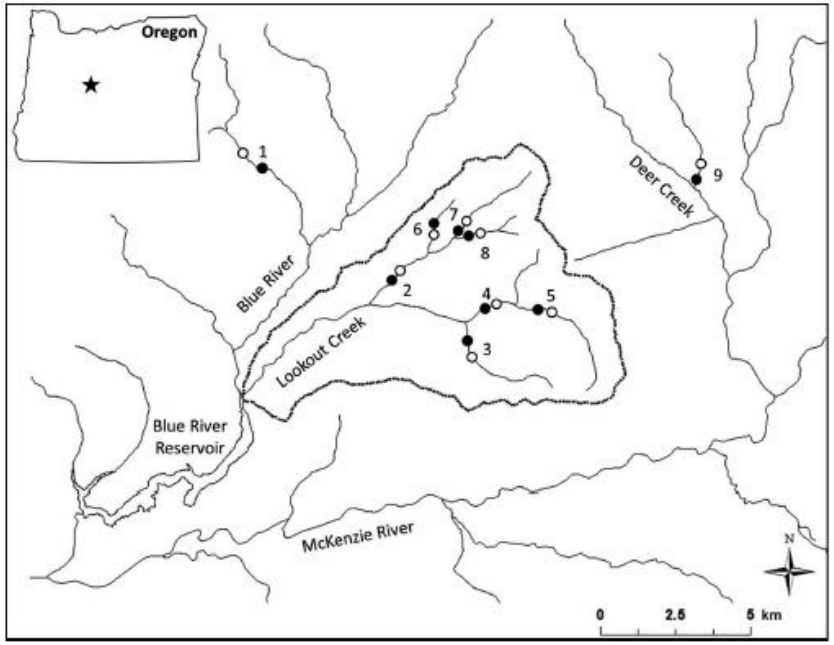


esa

ECOSPHERE

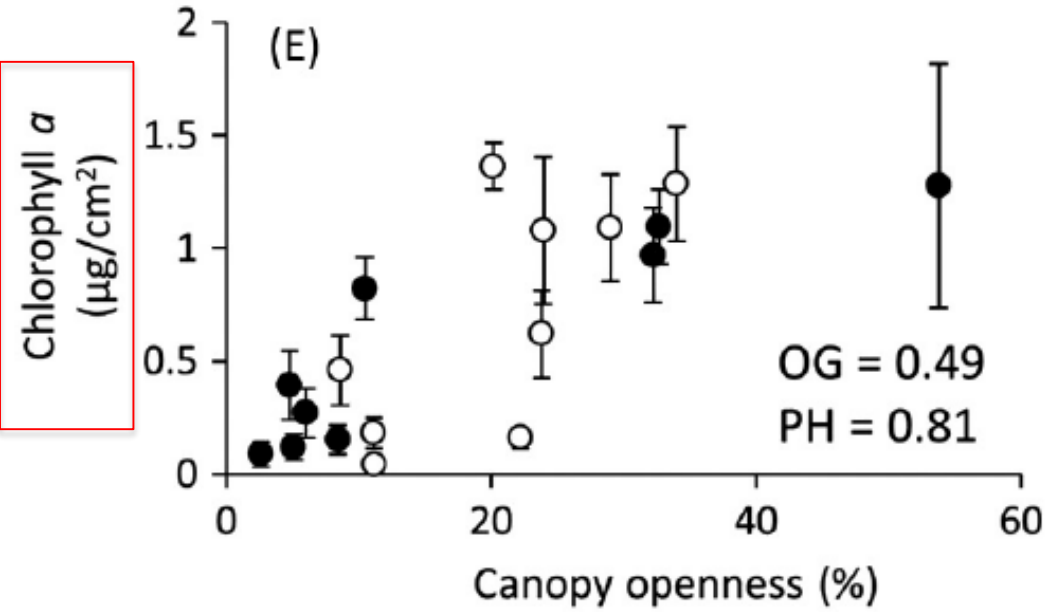
# Linking riparian shade and the legacies of forest management to fish and vertebrate biomass in forested streams

MATTHEW J. KAYLOR[1,†] AND DANA R. WARREN[1,2]

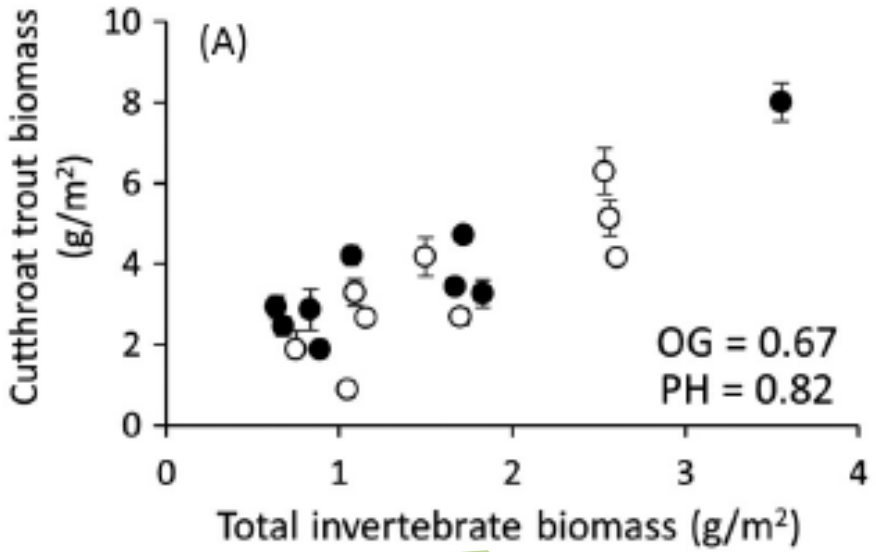


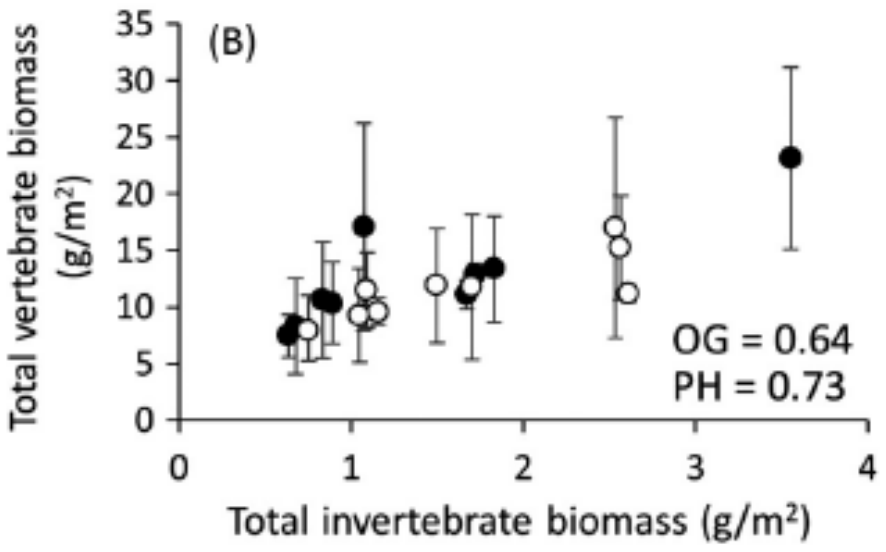

**Citation:** Kaylor, M. J., and D. R. Warren. 2017. Linking riparian shade and the legacies of forest management to fish and vertebrate biomass in forested streams. Ecosphere 8(6):e01845. 10.1002/ecs2.1845

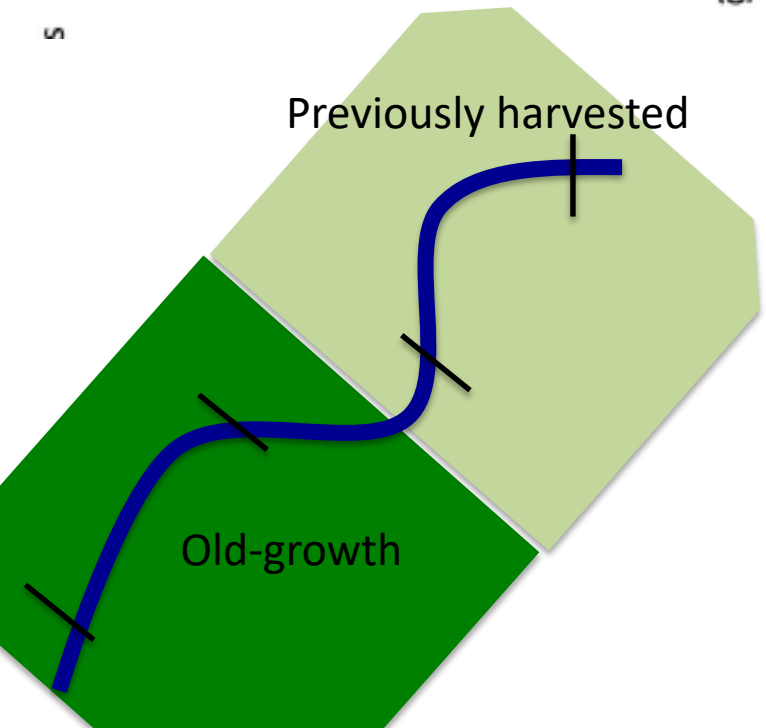
# Relationships with and among algae and stream biota

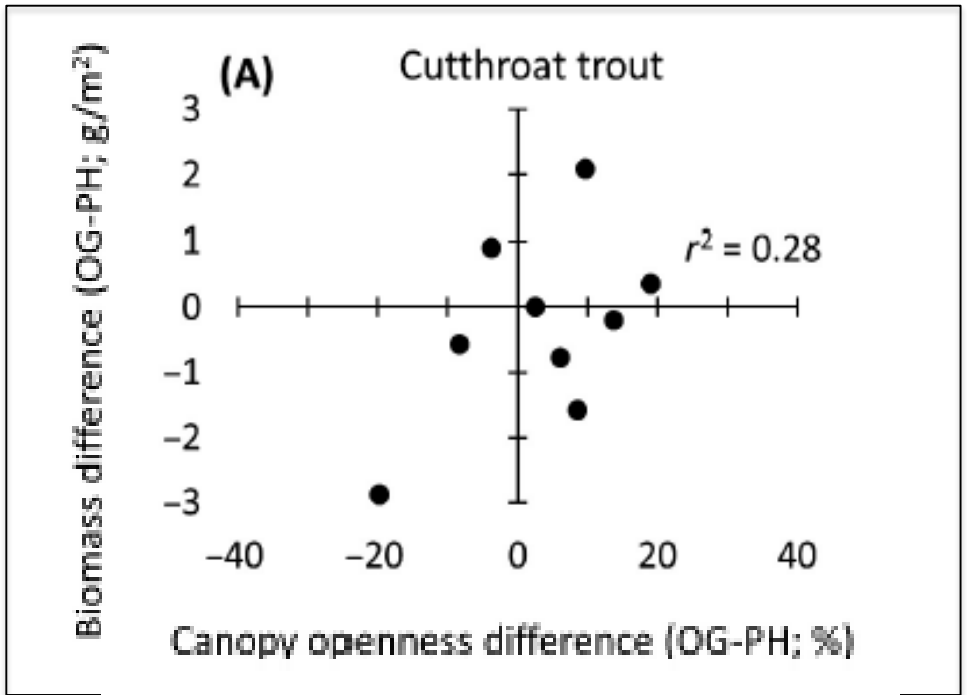


# Relationships with and among algae and stream biota

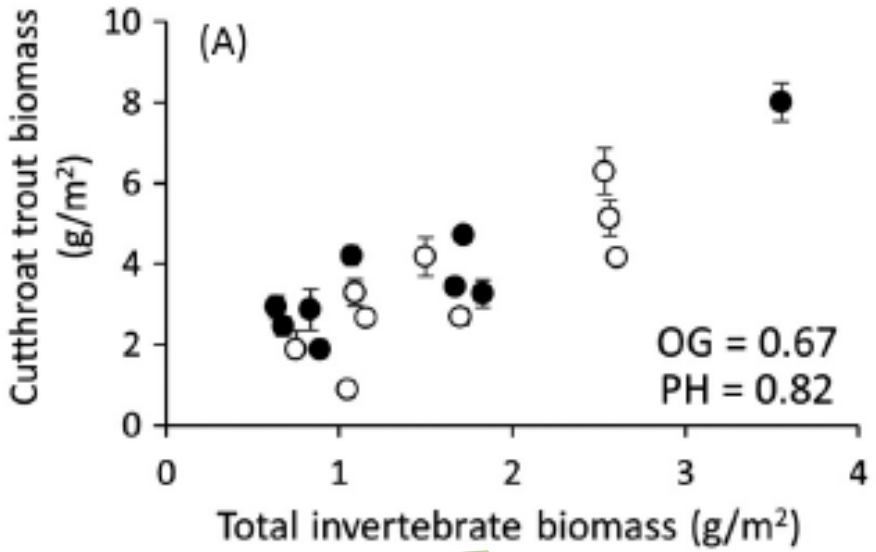


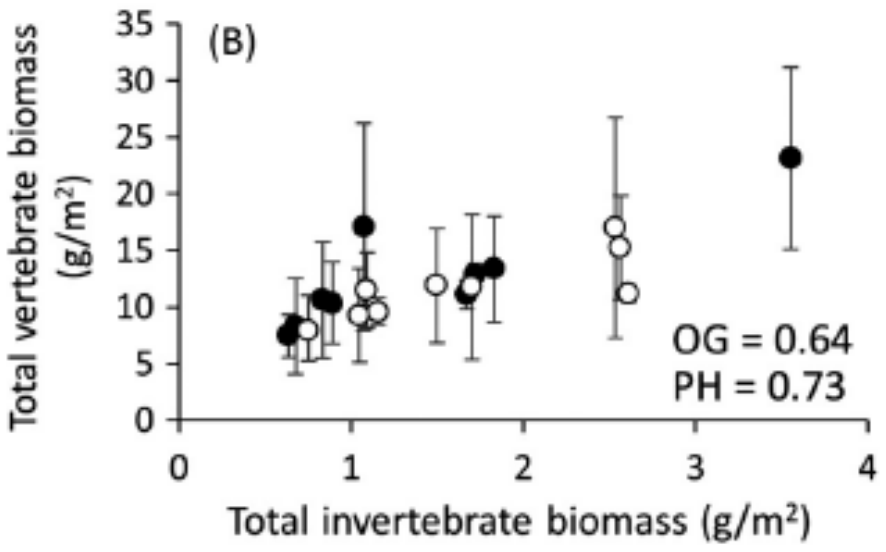



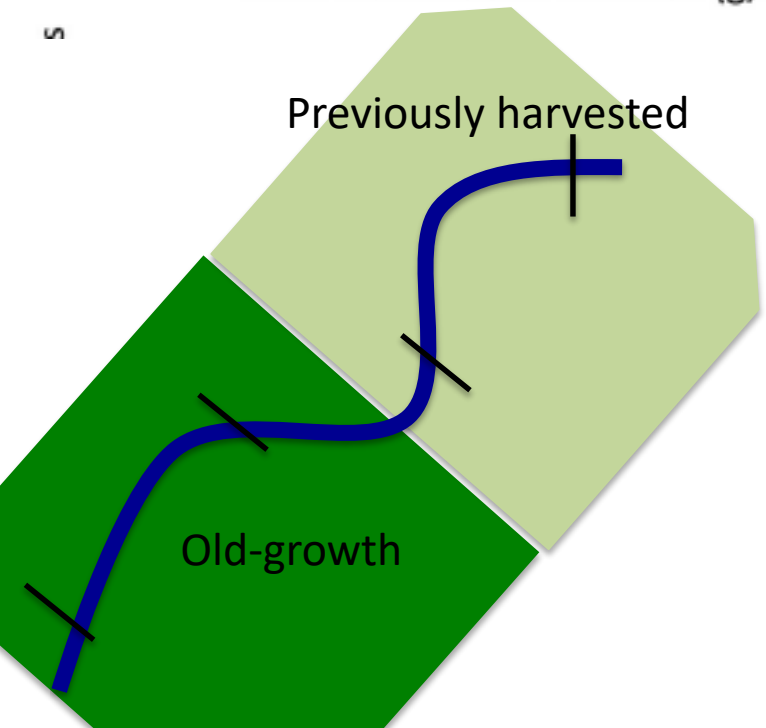



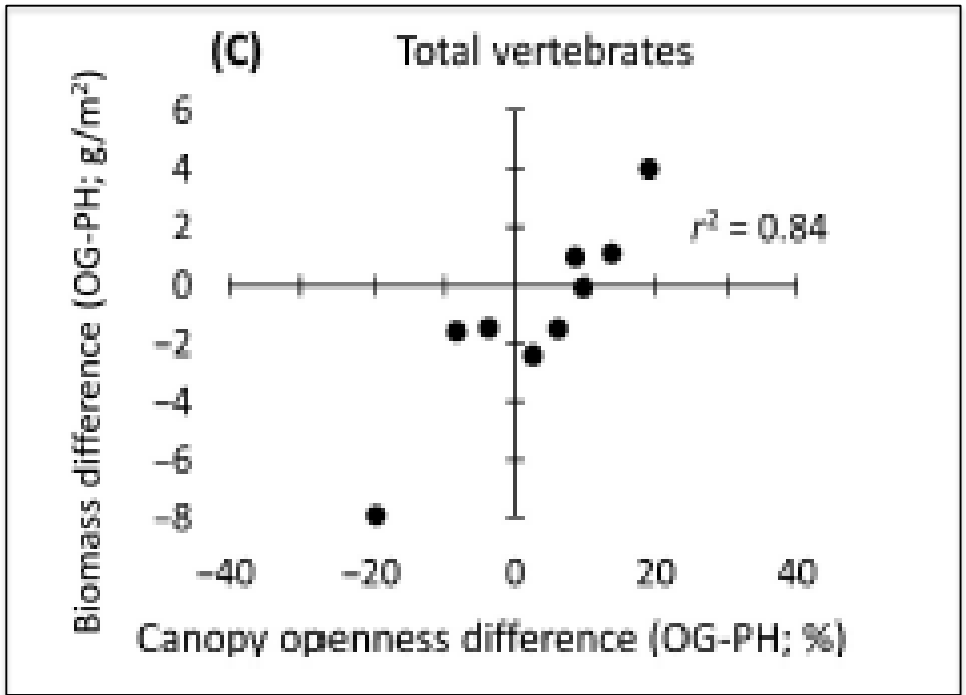



# Relationships with and among algae and stream biota



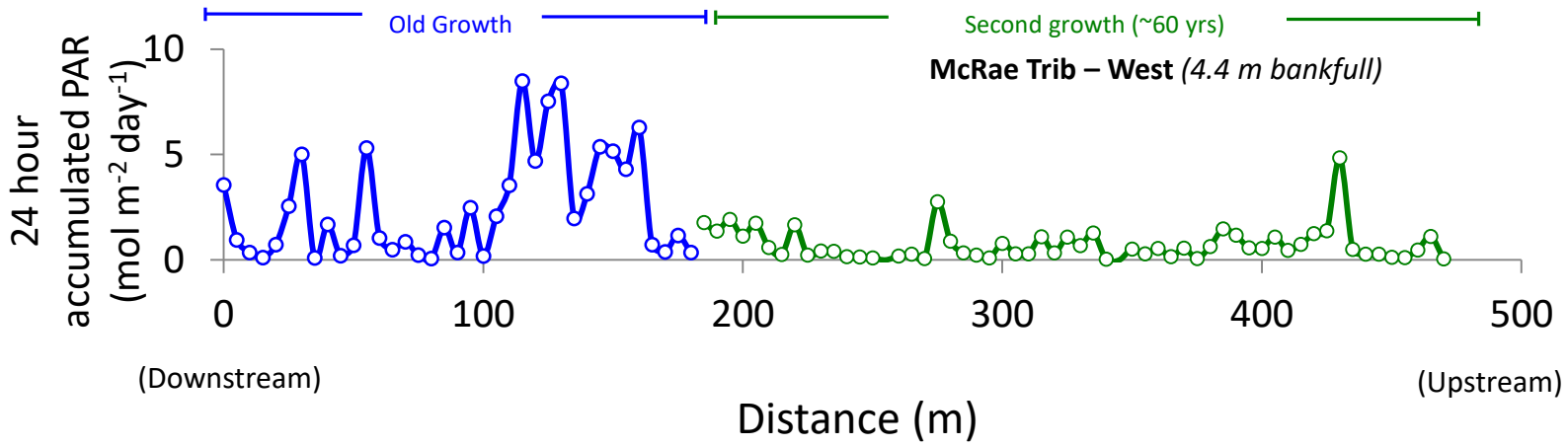
# Take home messages (2)

1. In streams with closed canopy mid-succession riparian forests algal production is often largely light limited

1. Stream reaches with complex OG riparian forests or systems where riparian regeneration by smaller trees have more light - **on average**,
   - More algae
   - More macroinvertebreates
   - More fish

# NEXT STEPS

1. Correlation does not equal Causation
2. We need an experiment. . .
3. People have clear-cut next to the stream but that is not consistent (broadly) with historic riparian conditions




1. Increases in light in older forests are due **to more gaps**

**Does creating canopy gap yield a measurable increase in fish biomass in streams?**

# NEXT STEPS

*Stream gap experiment*

- Cut gaps into a riparian zone with close-canopy second-growth forest

Study Question

*How do Coastal Cutthroat trout, and other stream biota respond to the creation of a localized area of open canopy adjacent to and over the stream?*

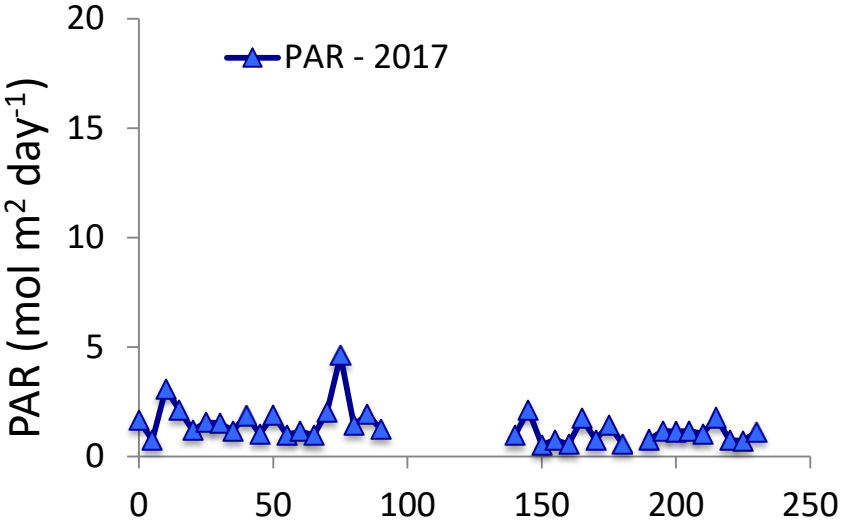
Before

After

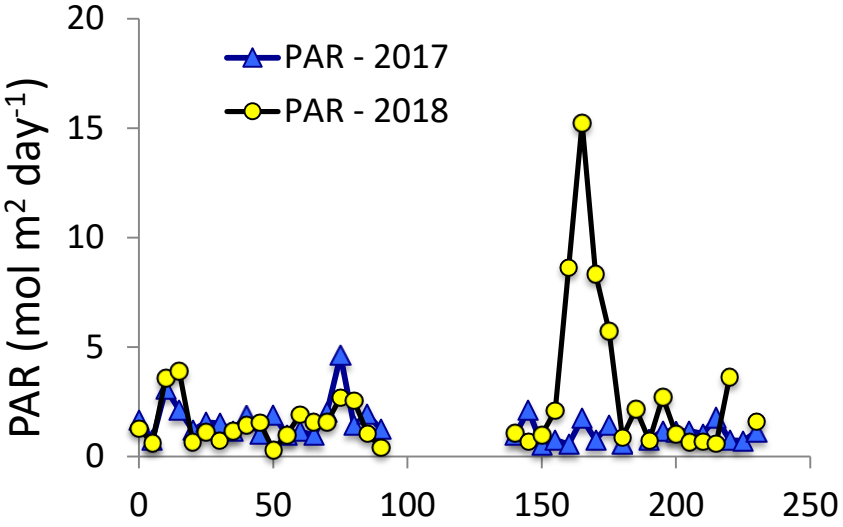
Before

After

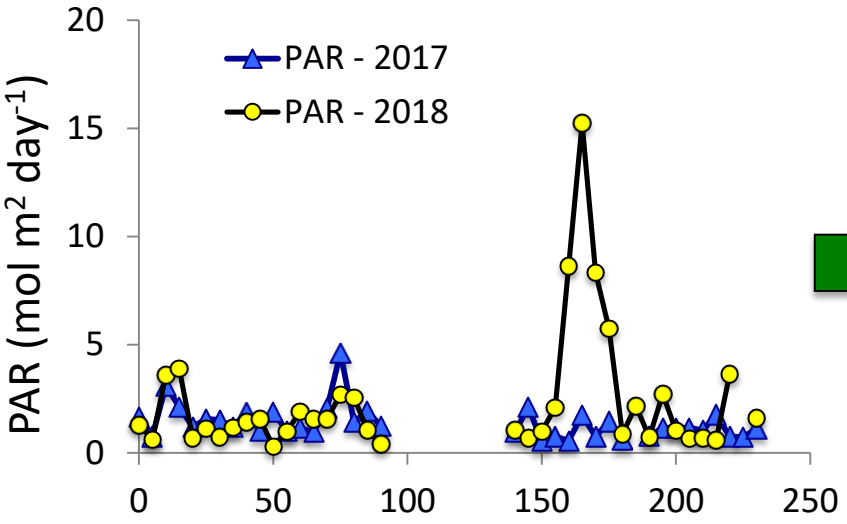
**Light** results at W100

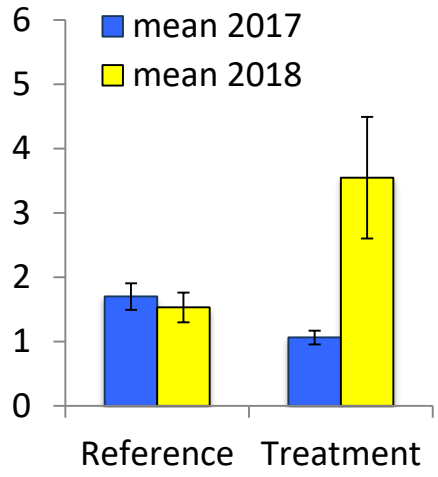


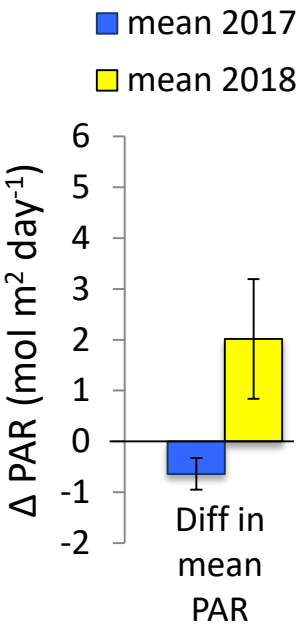
# **Light** results at W100



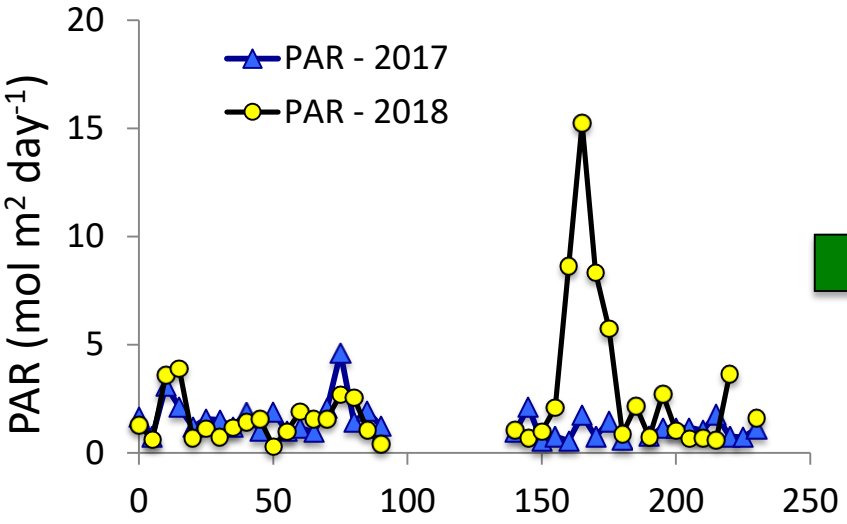
# Light results at W100

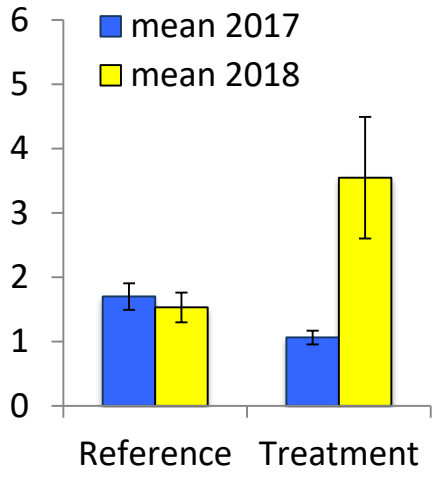


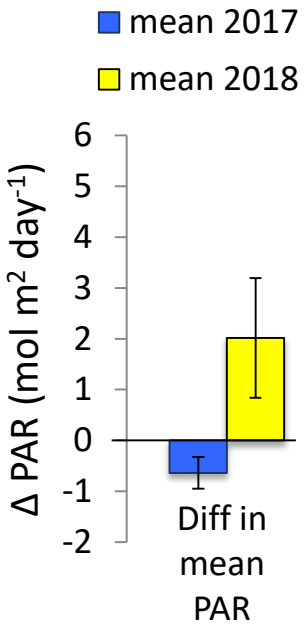



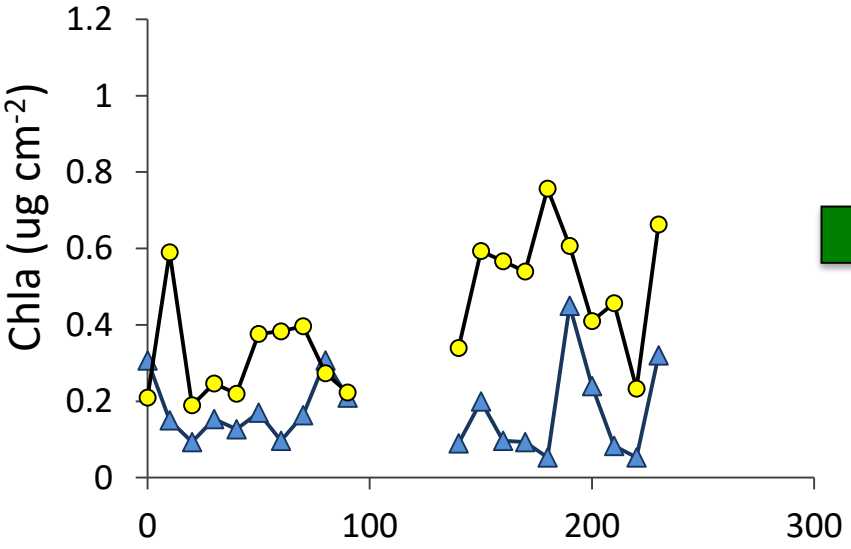
## Light results at W100

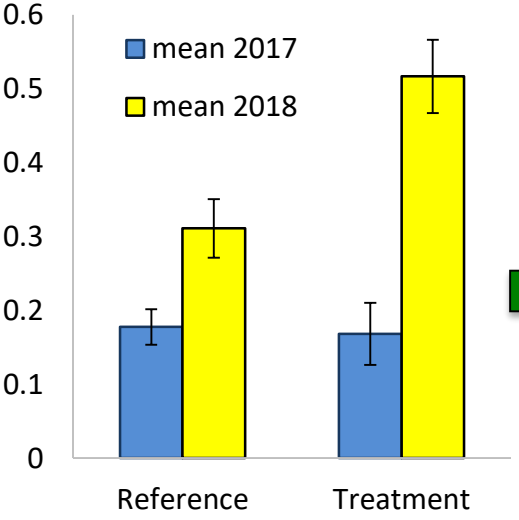


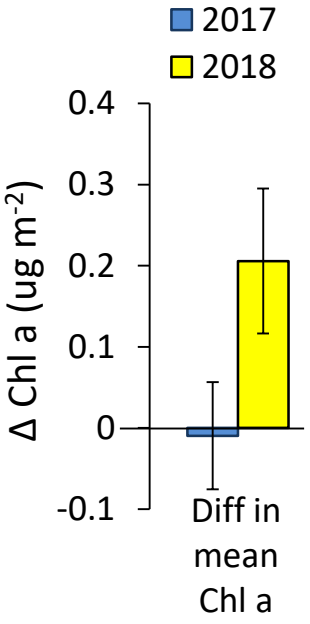



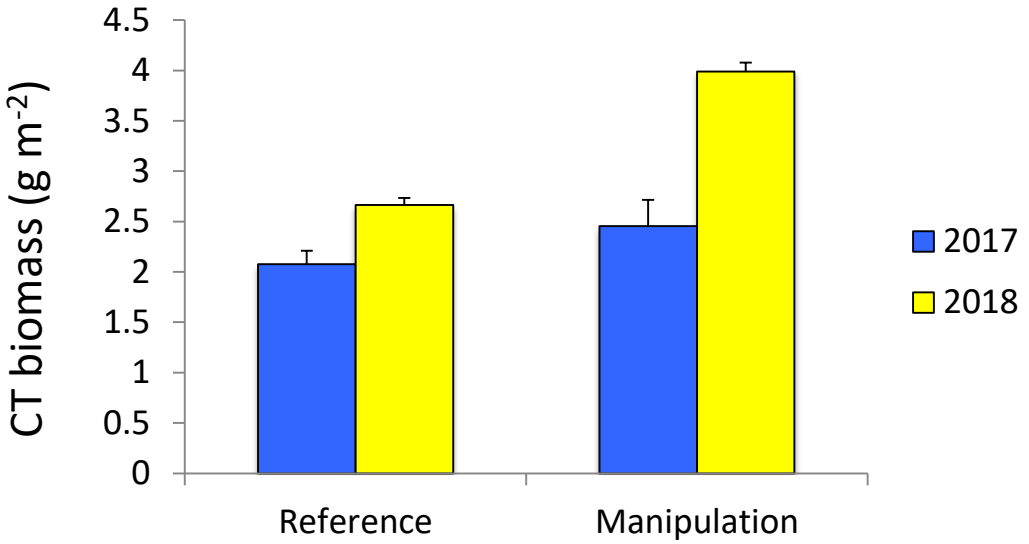

## Chlorophyll a results at W100

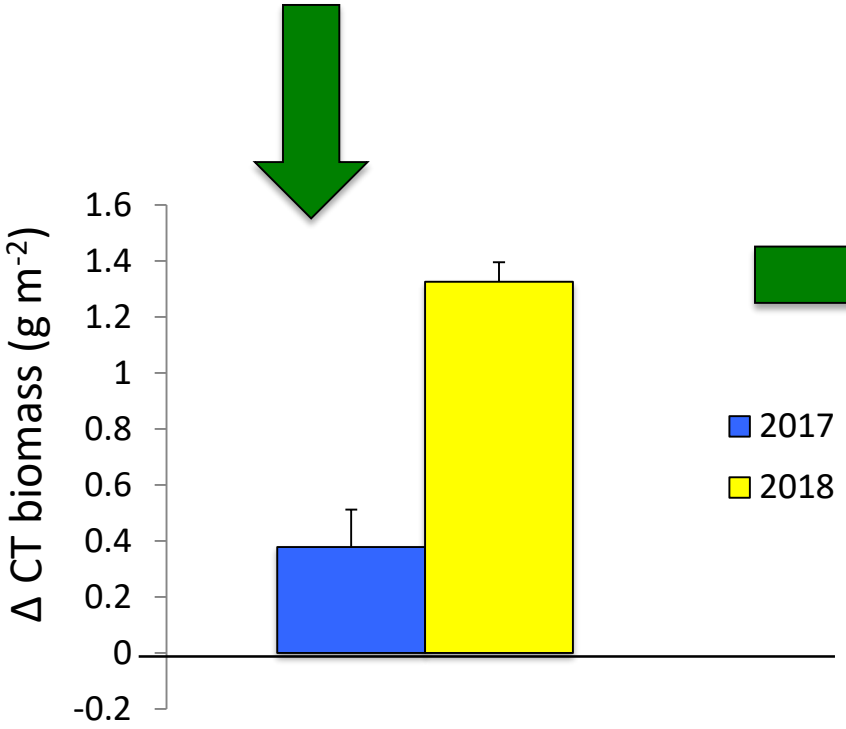


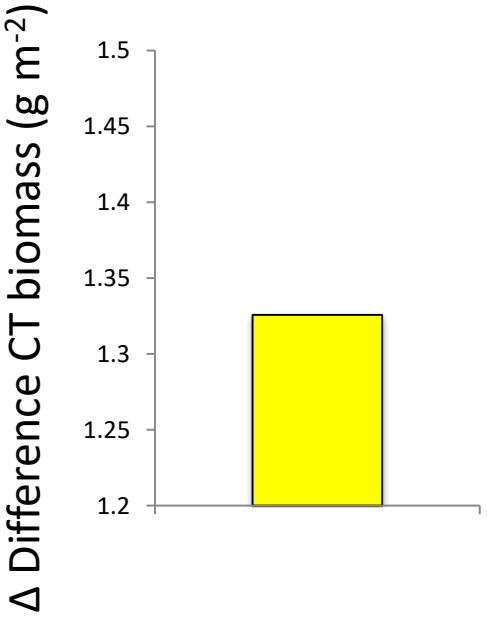



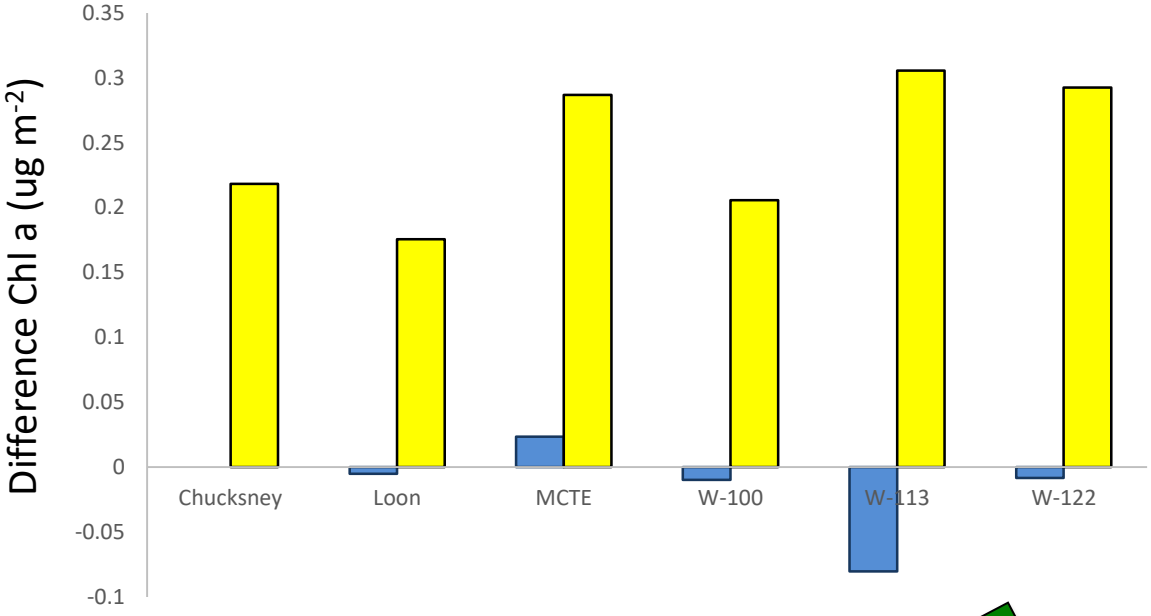



# Age 1 trout results at W100

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0.3
0.25
0.2
0.15
0.1
0.05
0
-0.05
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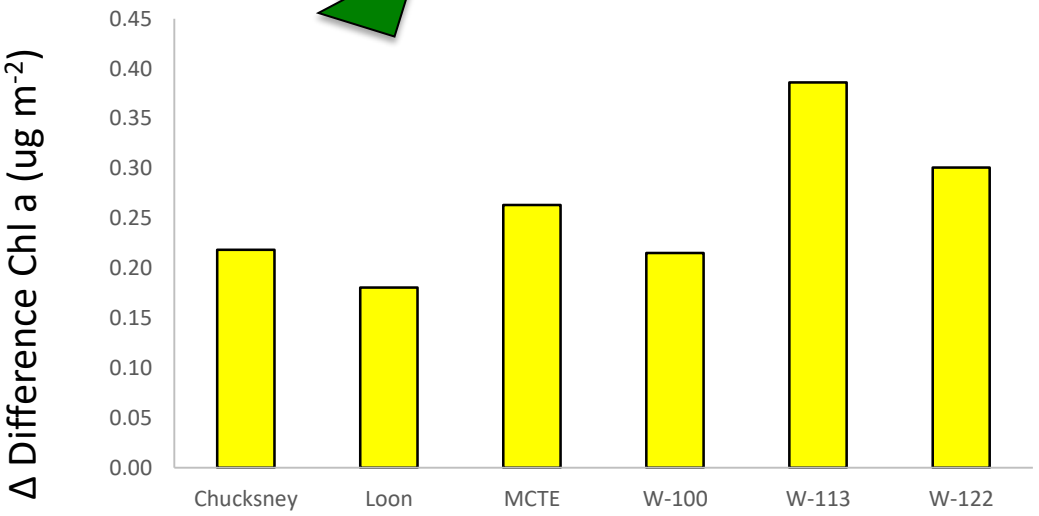
Chucksney
Loon
MCTE
W-100
W-113
W-122


Δ Difference Chl a (ug m-2)
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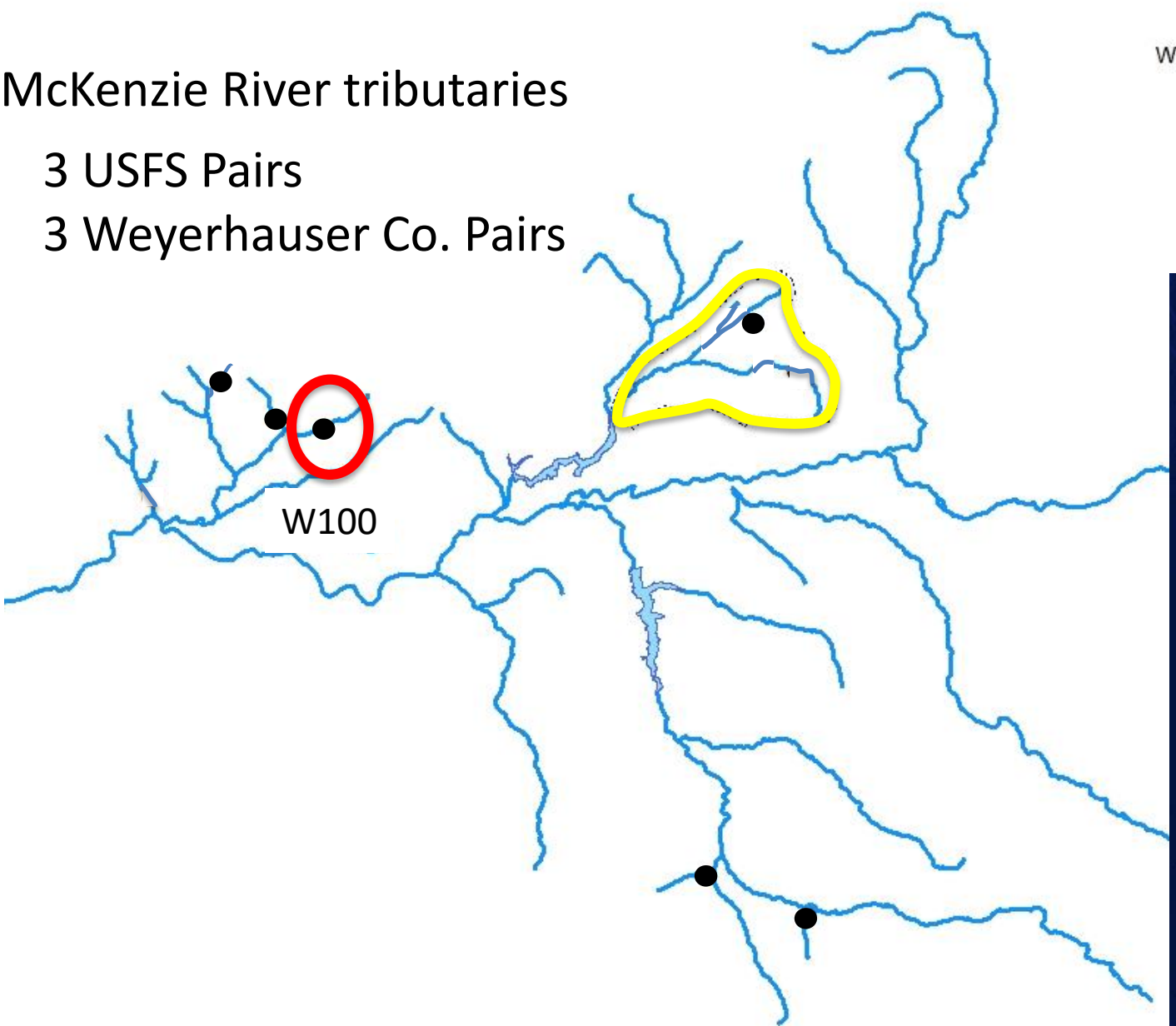
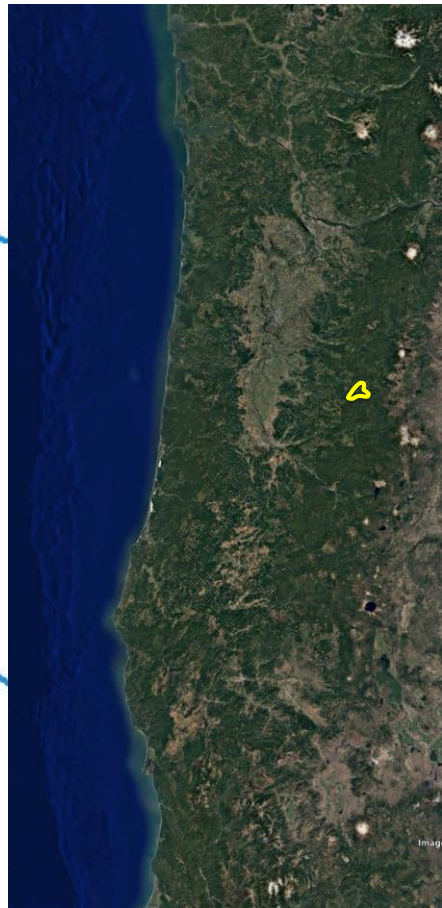
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Chucksney
Loon
MCTE
W-100
W-113
W-122

# Study sites

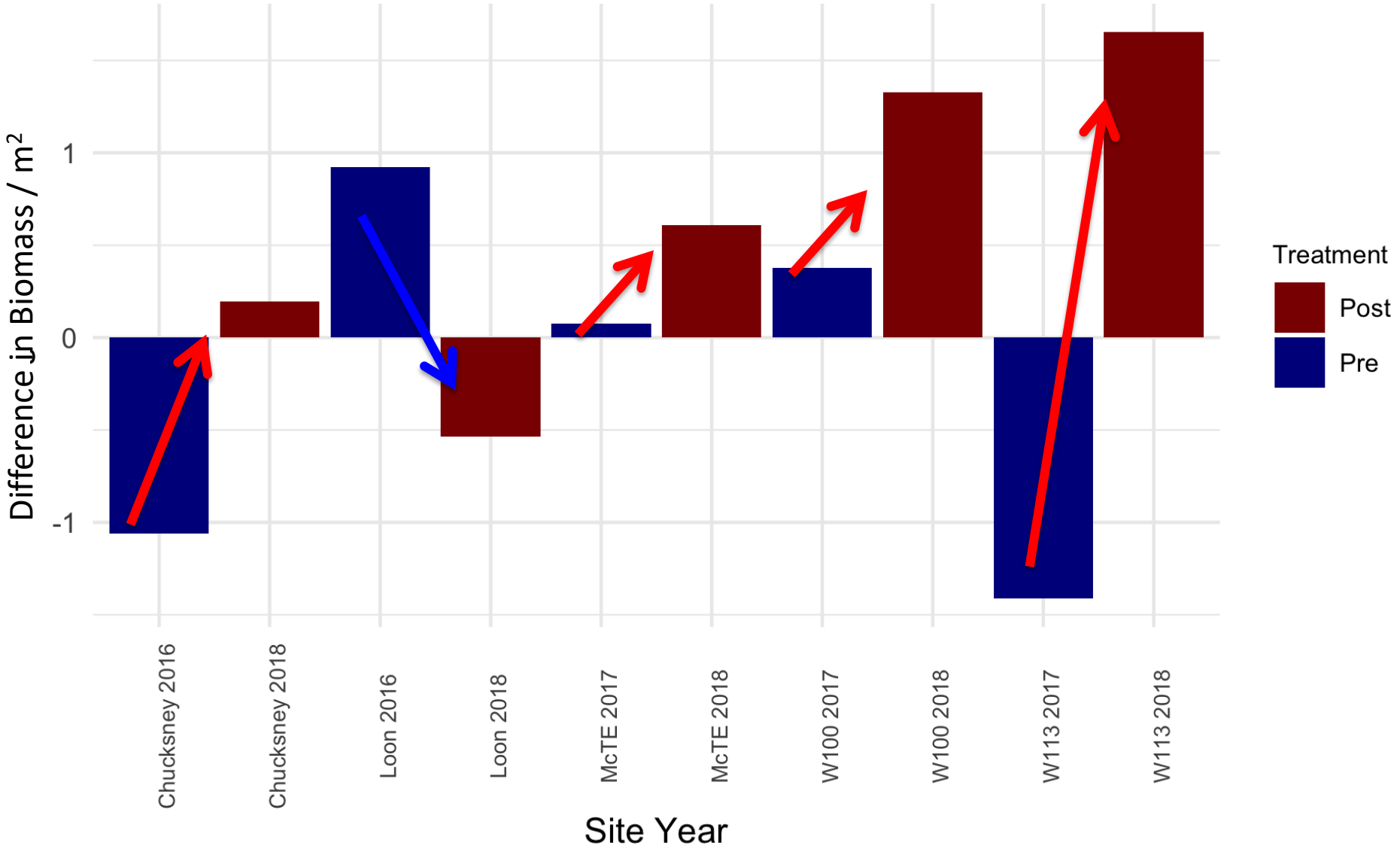
McKenzie River tributaries

- 3 USFS Pairs
- 3 Weyerhauser Co. Pairs

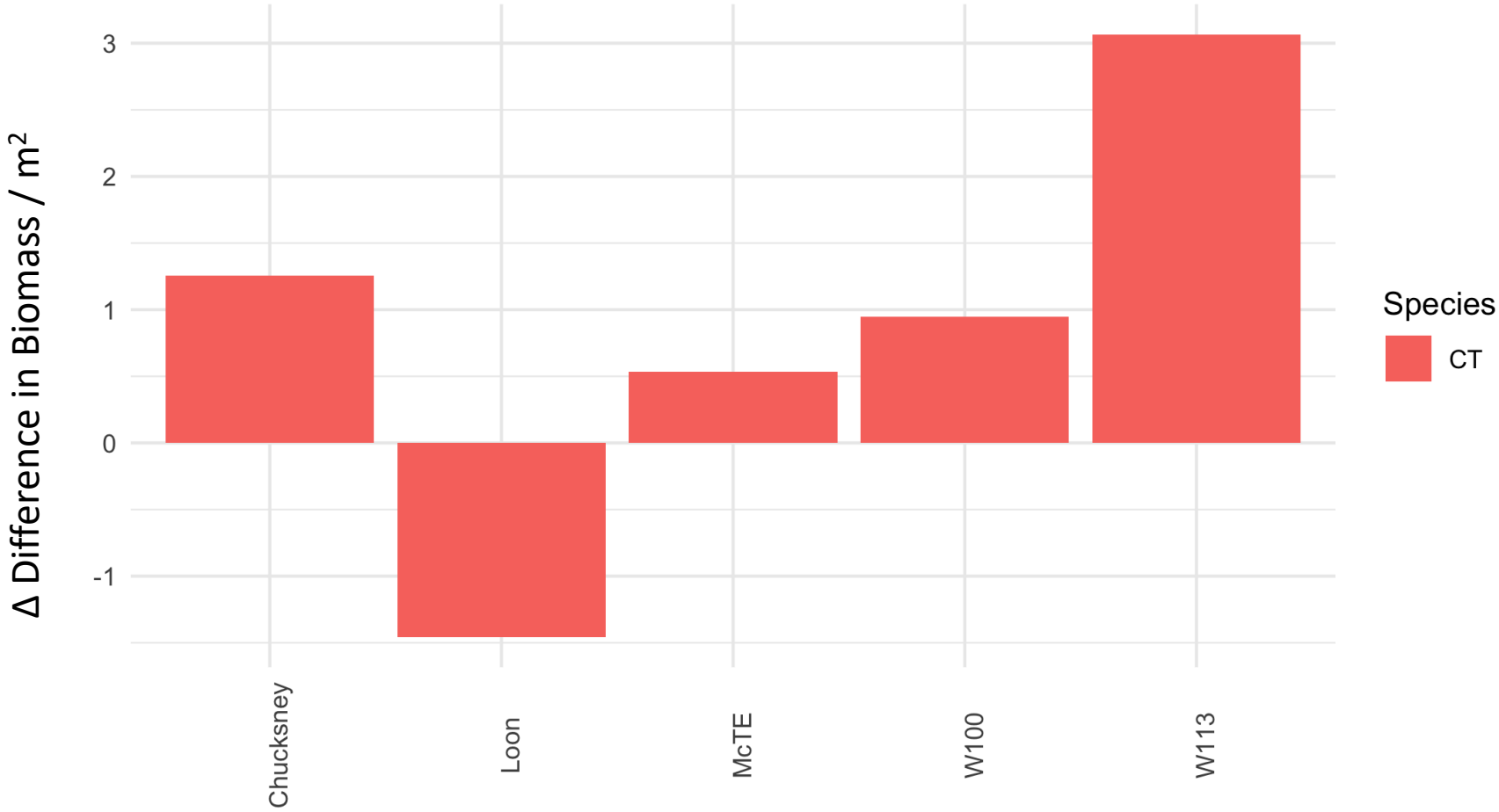


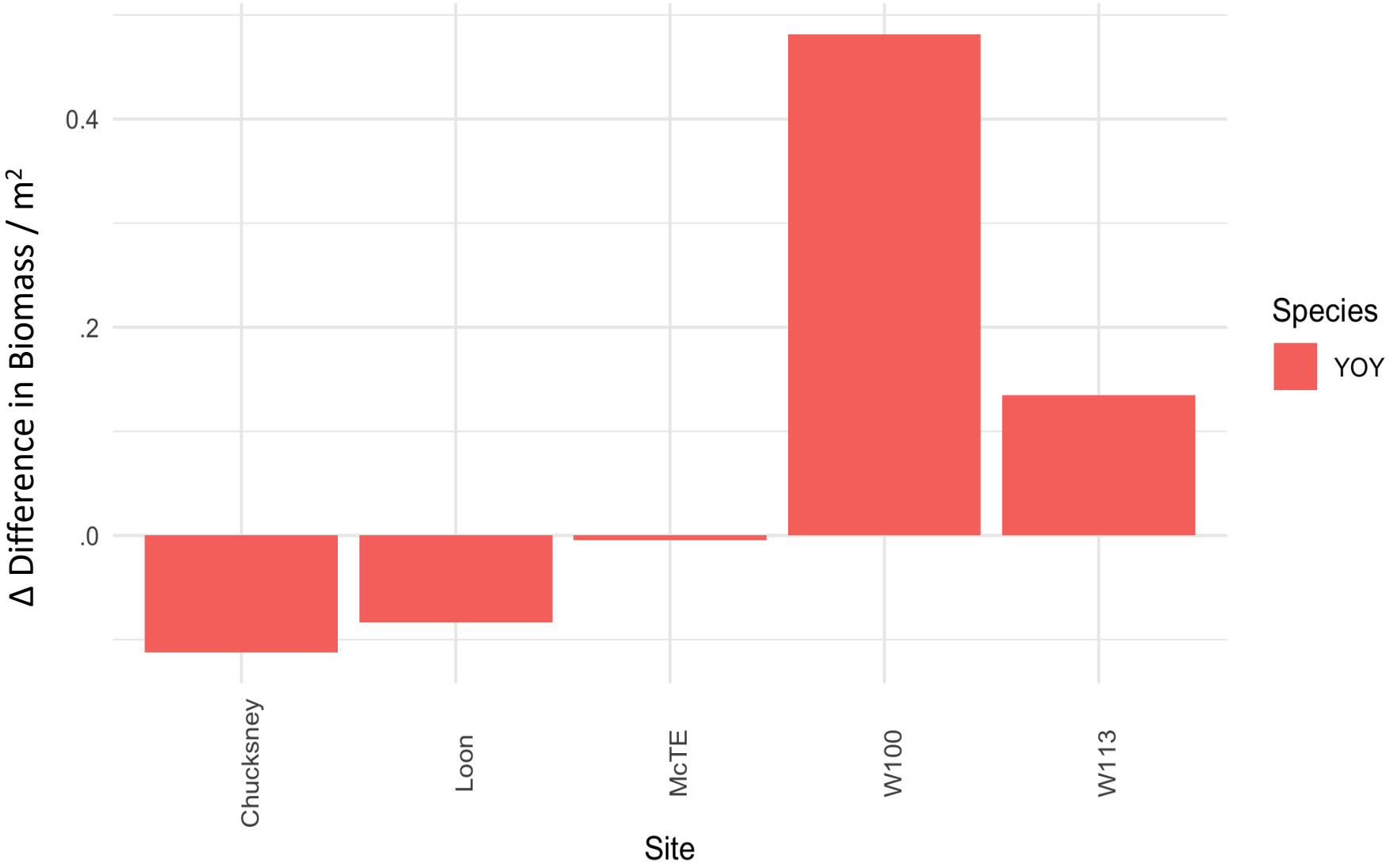
# Adult CT biomass/m$^2$ differences



# Adult CT change in biomass/$m^2$ differences



# YOY change in biomass/$m^2$ differences



# Total vertebrate change in biomass/$m^2$ differences

# Take home messages (3)

1. Creating canopy gaps can lead to increases in CT biomass (likely due to immigration into the reach

2. YOY responses are variable

3. Not all sites respond positively. . . (so extrapolation should be done with caution)

# Thank you


## Acknowledgements

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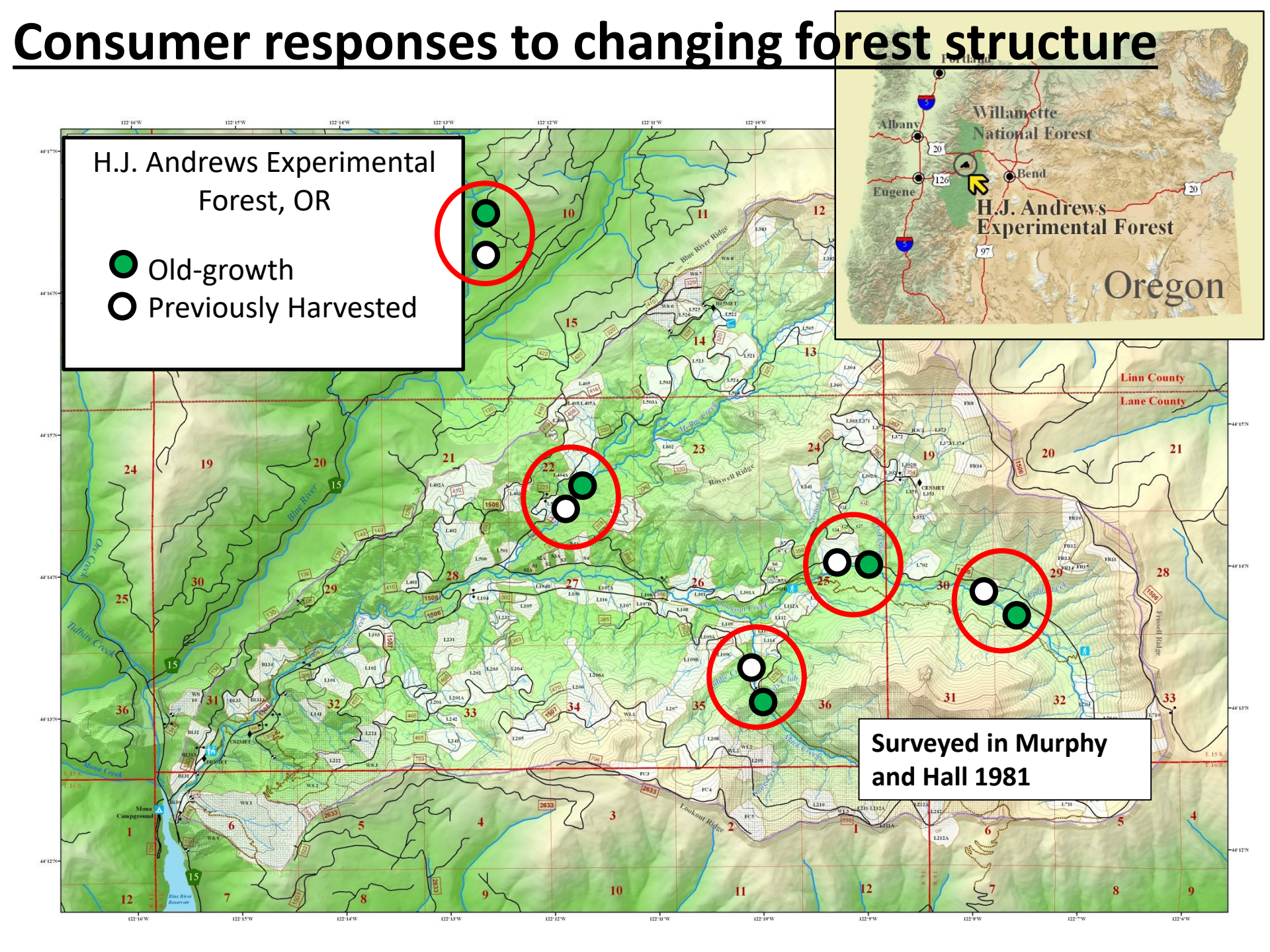
**Fieldwork and data collection:**

- Grad students: Matt Kaylor, Emily Heaston, Allison Swartz
- Field Technicians: Brian VerWey, Kate Pospisil
- Undergraduate students: Claire Hacker, Lauren Still, Gavin Jones, Chris Frisell

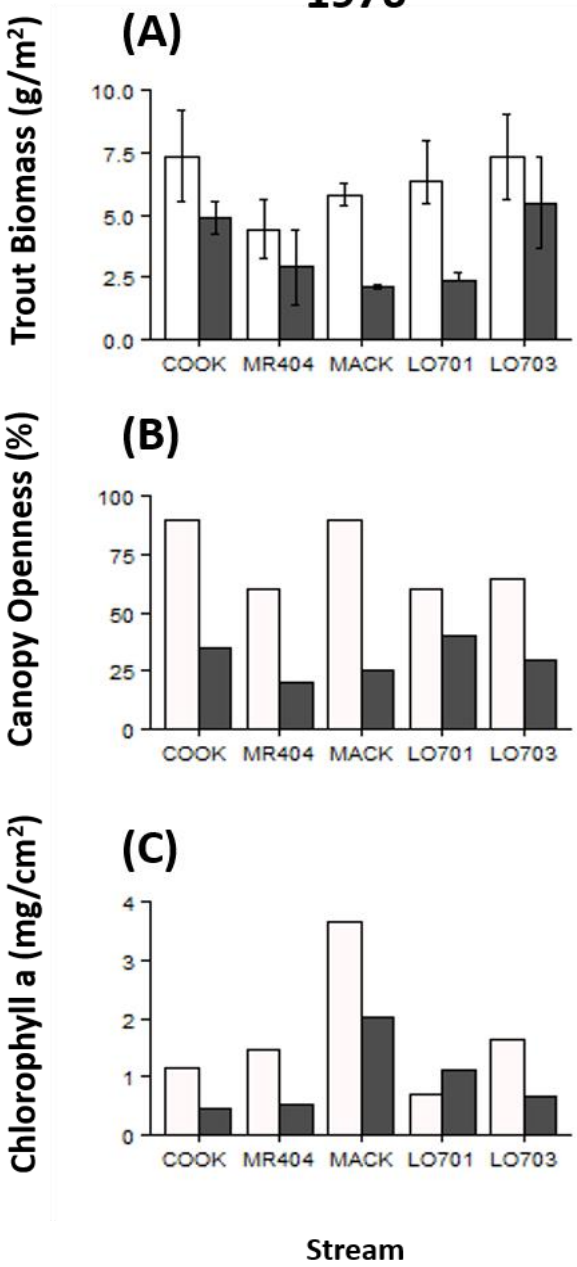
**Other intellectual contributions:**

- Lina DiGrigorio
- Cheryl Friesen
- Stan Gregory
- William Keeton
- Julie Pett-Ridge
- Mark Shultz

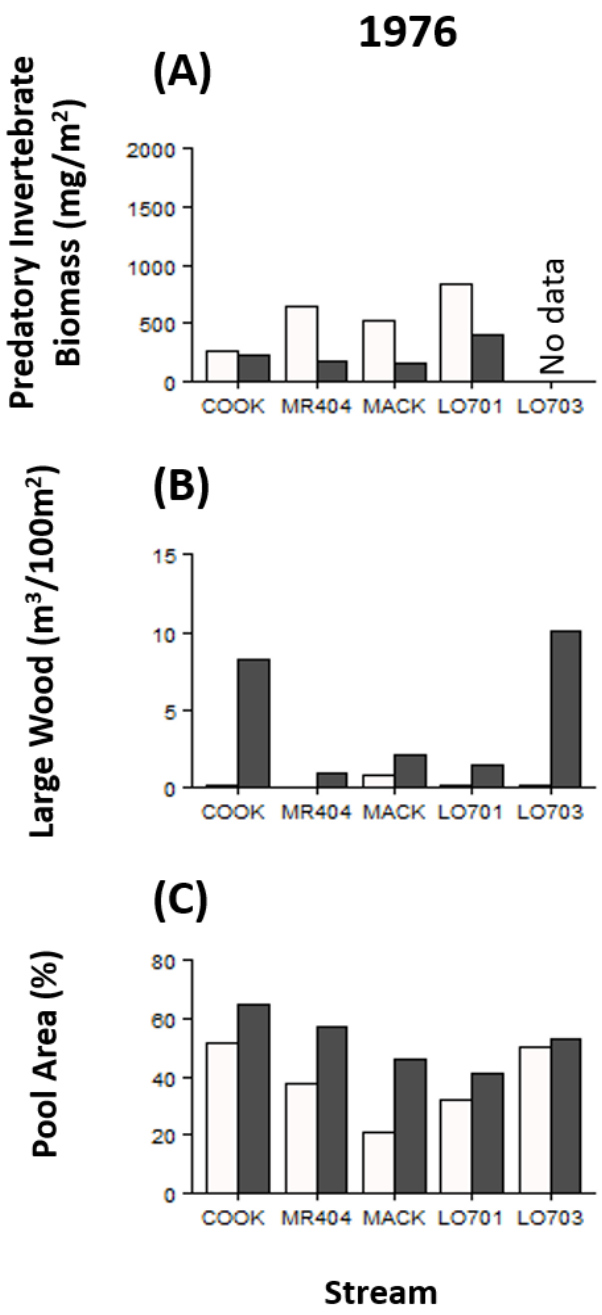
# Consumer responses to changing forest structure



1976




*Murphy and Hall 1981 - CJFAS*



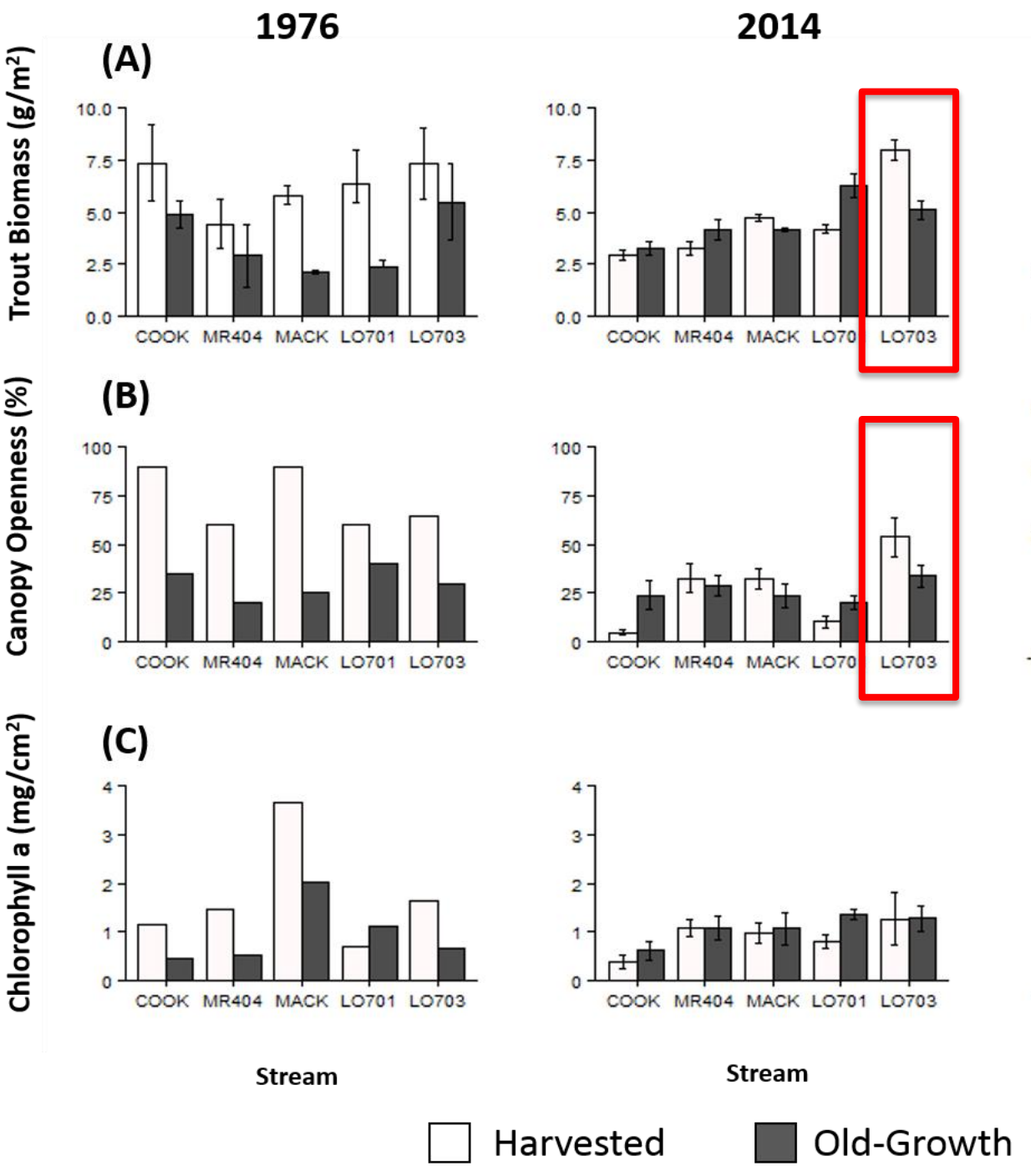

*Murphy and Hall 1981 - CJFAS*

# Consumer responses to changing forest structure

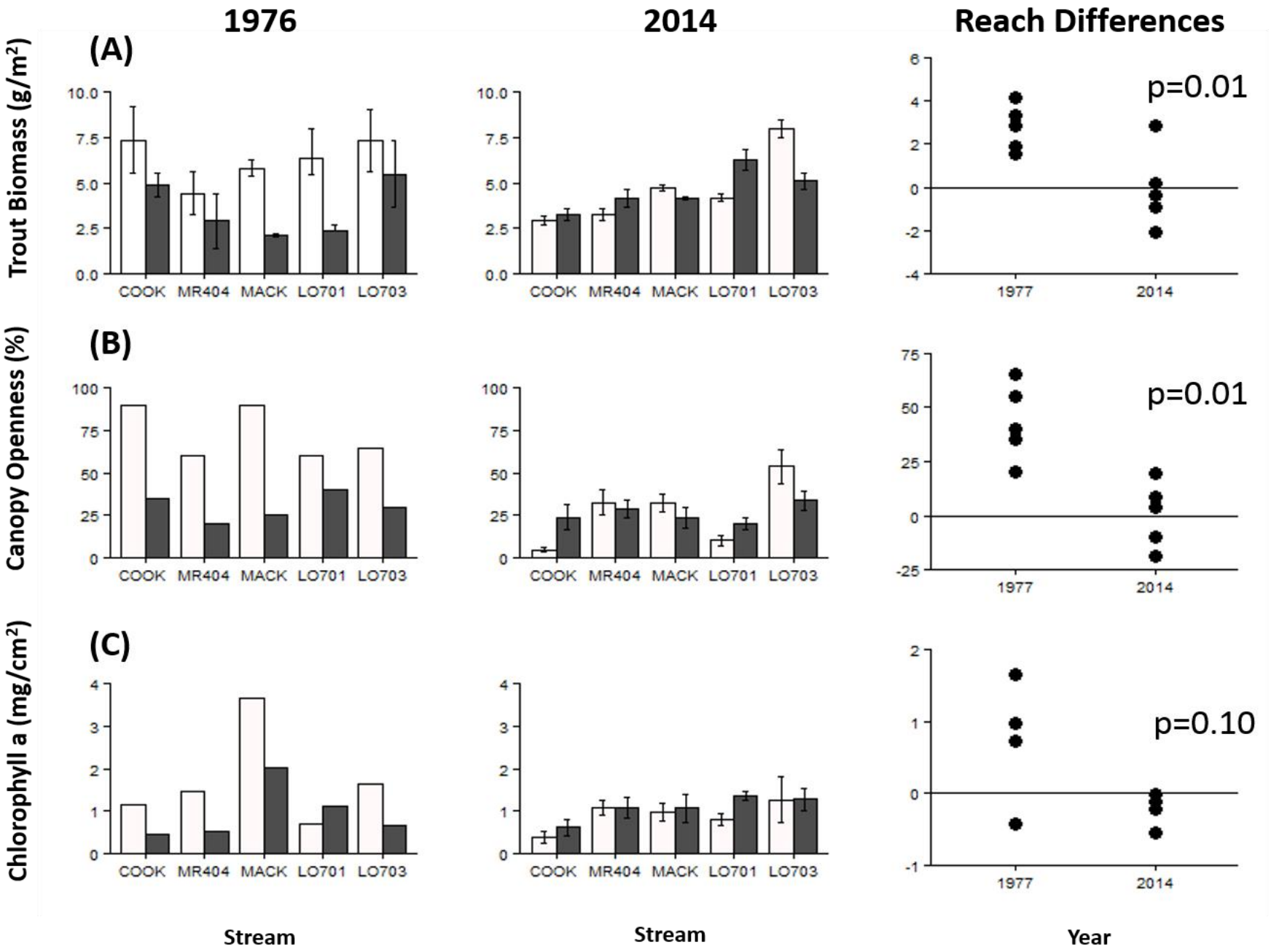
*"Stand regeneration experiment"*

- 1970's M. Murphy quantified effects of riparian forest harvest on stream food webs and stream habitat

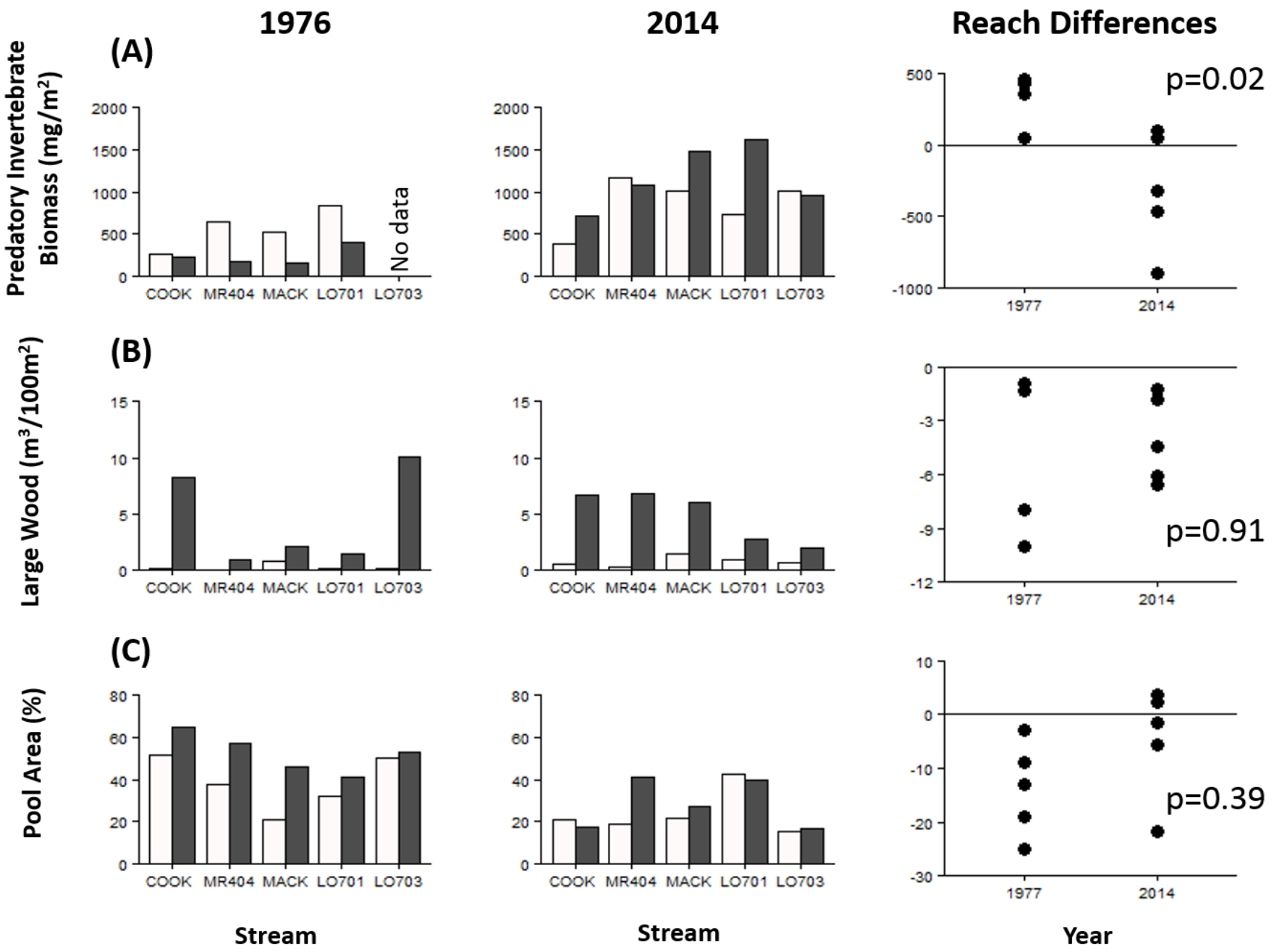
- 2014's M. Kaylor returned to these **exact** (or nearly exact) locations and re-assessed conditions in old-grown and regenerating forests after 38 yrs. of stand regeneration




Kaylor and Warren *2017- CJFAS*

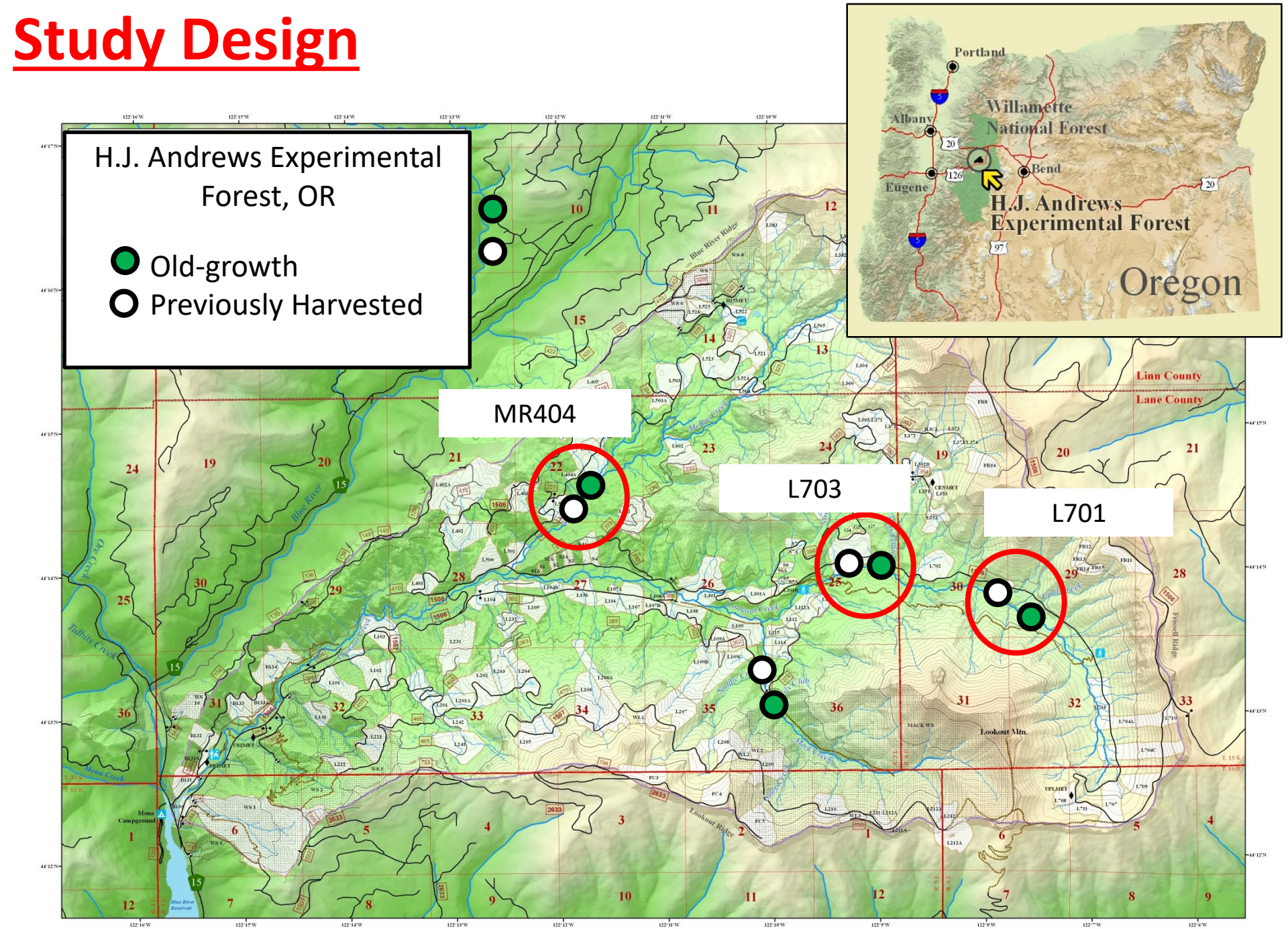


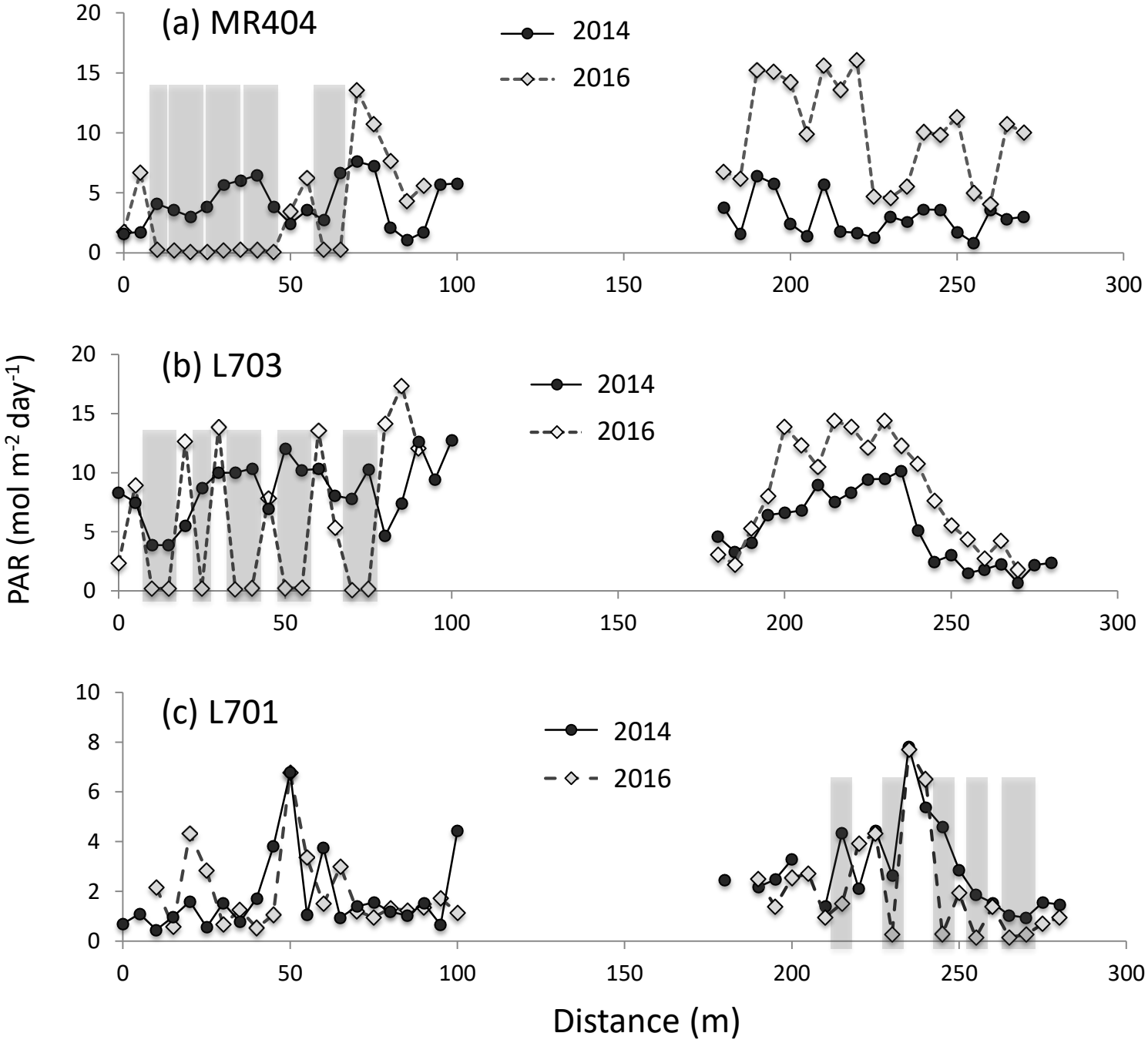

Kaylor and Warren *2017- CJFAS*

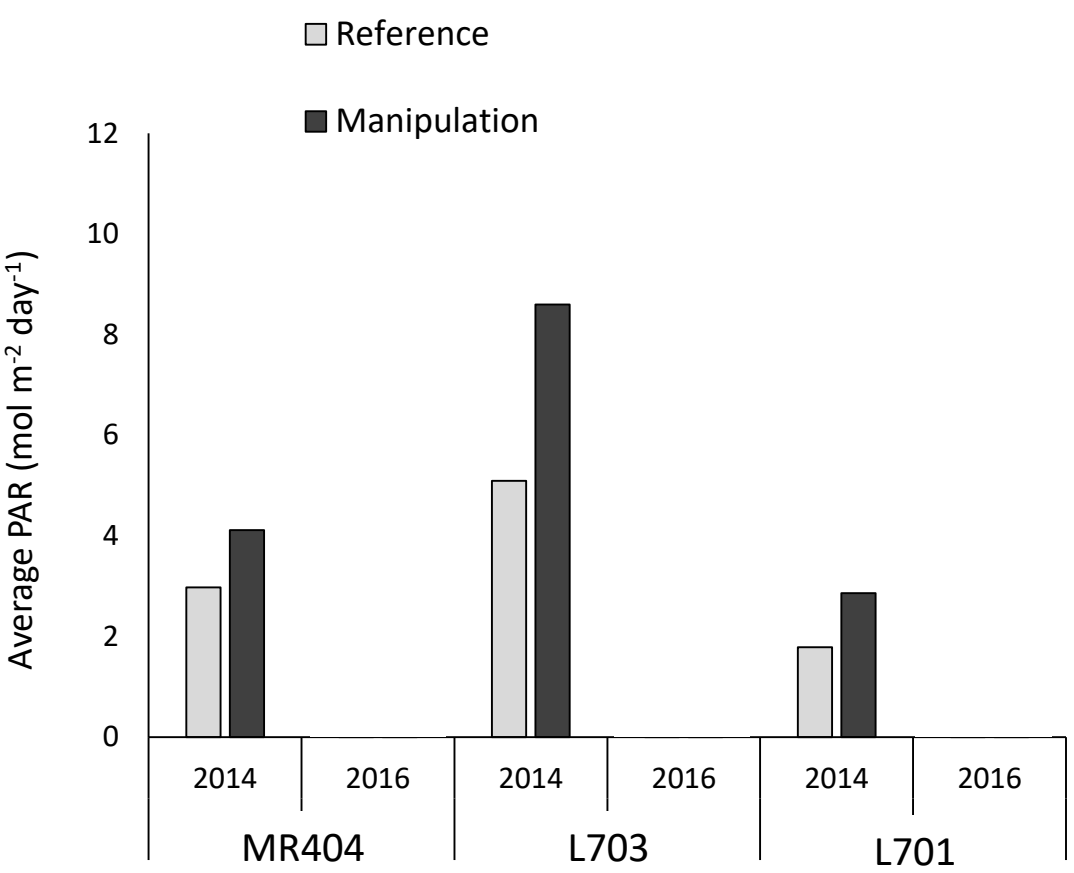


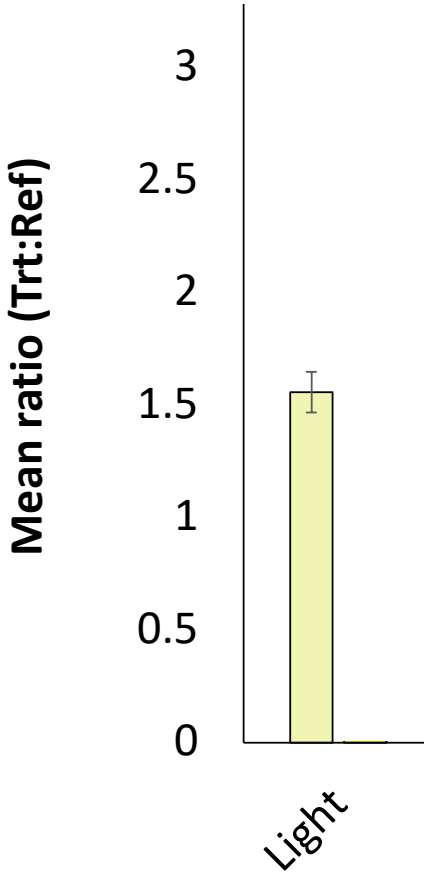

Kaylor and Warren *2017- CJFAS*

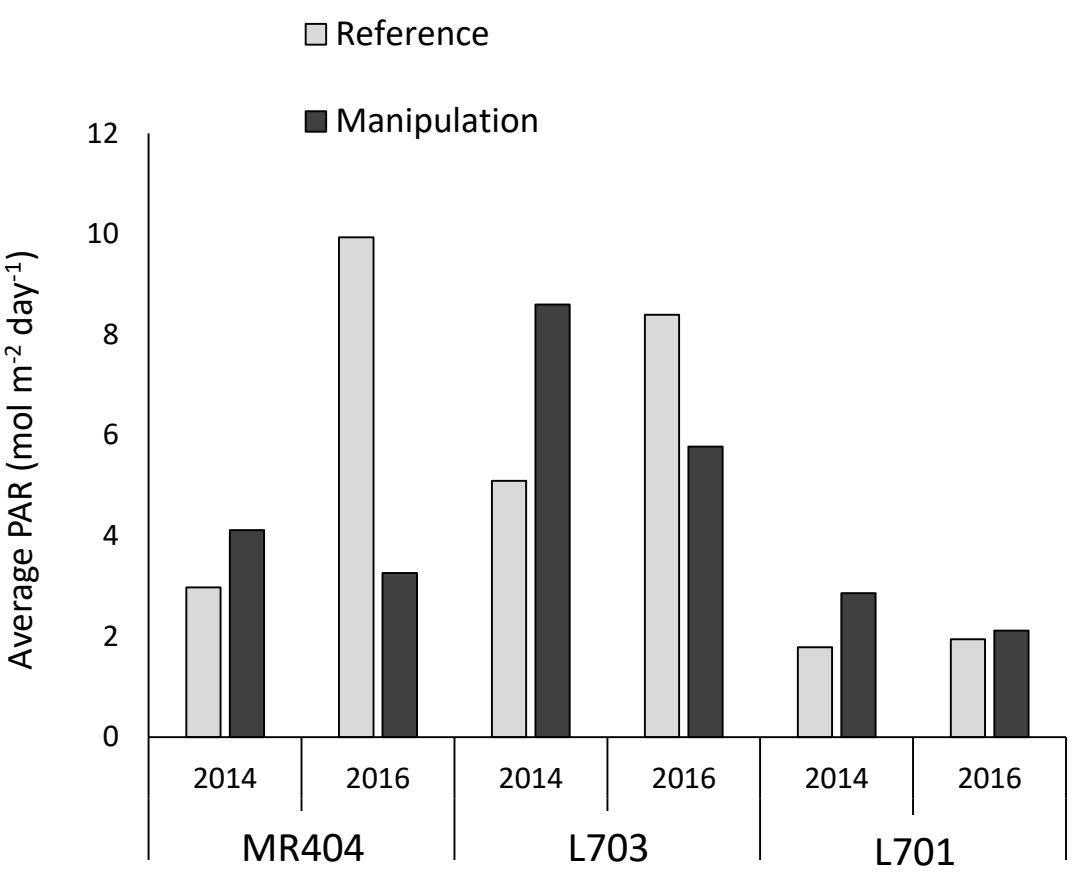
# Study Design

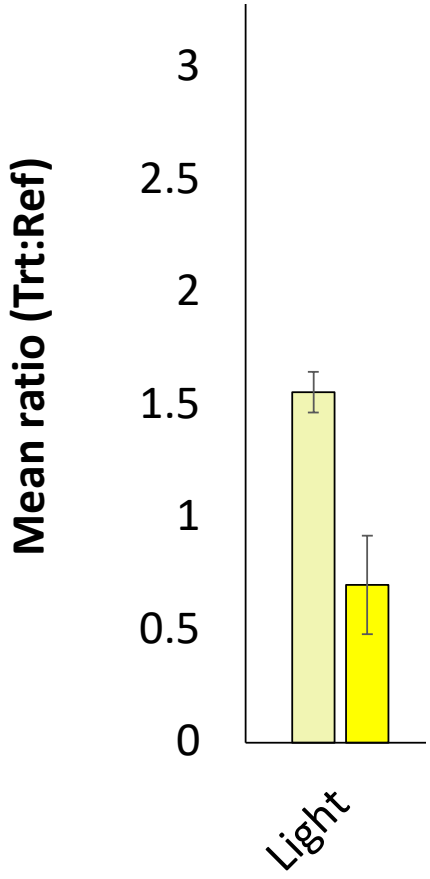


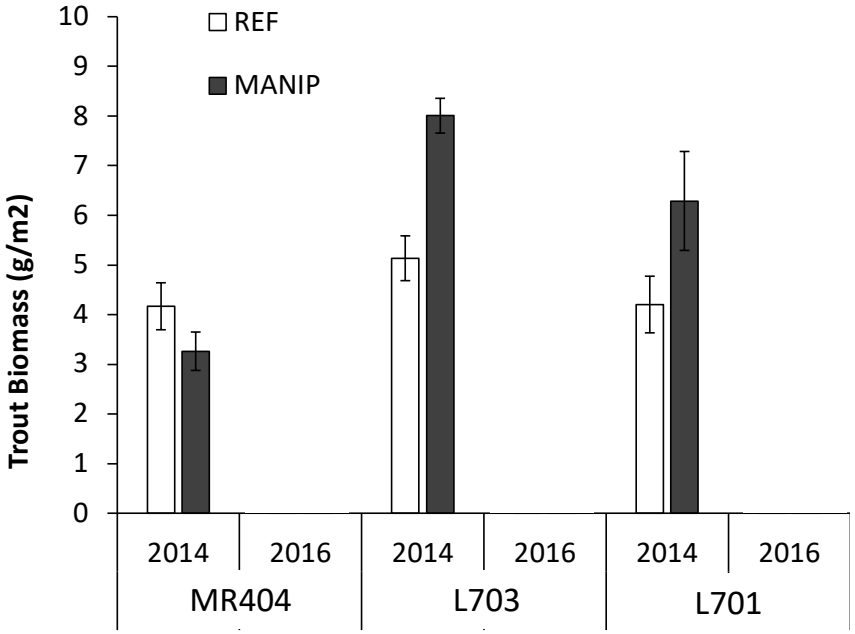

(a) MR404
2014
2016
(b) L703
2014
2016
(c) L701
2014
2016
PAR (mol m-2 day-1)
Distance (m)

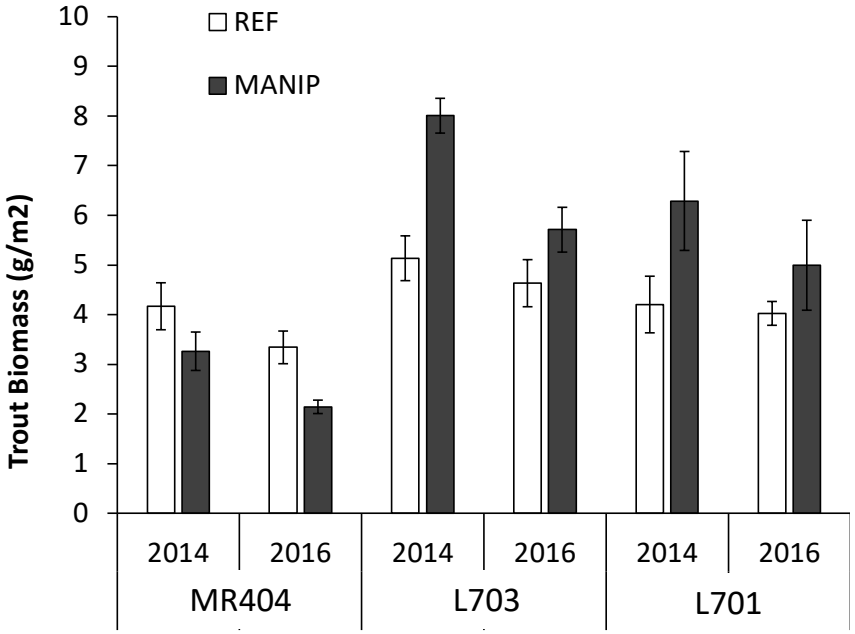

Reference
Manipulation
Average PAR (mol m-2 day-1)
12
10
8
6
4
2
0
2014
2016
2014
2016
2014
2016
MR404
L703
L701

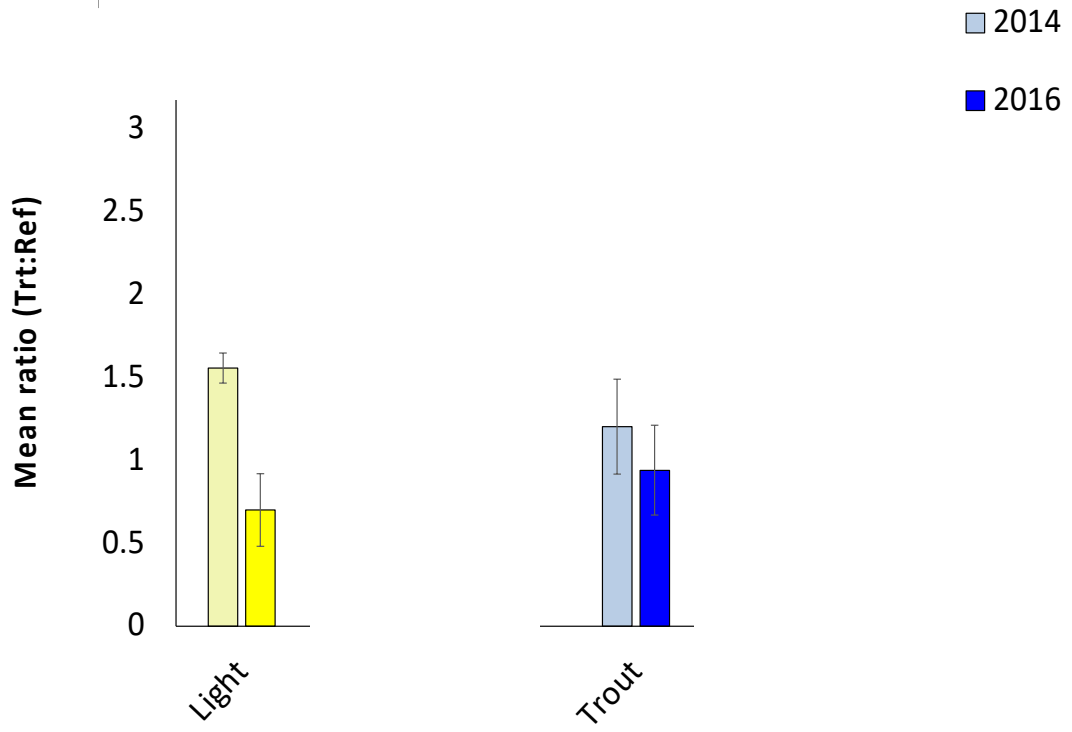

Mean ratio (Trt:Ref)
3
2.5
2
1.5
1
0.5
0
Light

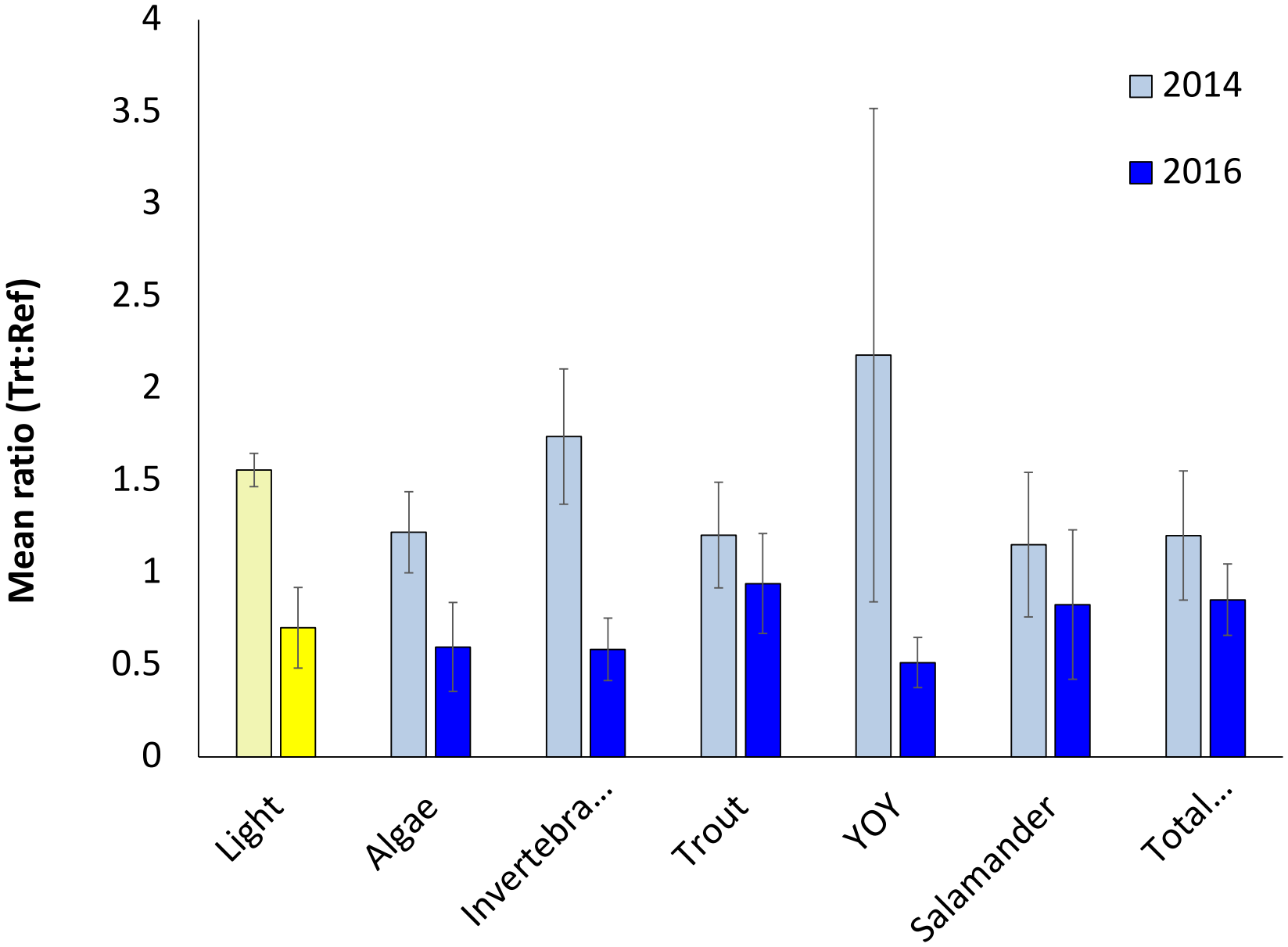

Reference
Manipulation
Average PAR (mol m-2 day-1)
12
10
8
6
4
2
0
2014
2016
2014
2016
2014
2016
MR404
L703
L701


Mean ratio (Trt:Ref)
3
2.5
2
1.5
1
0.5
0
Light

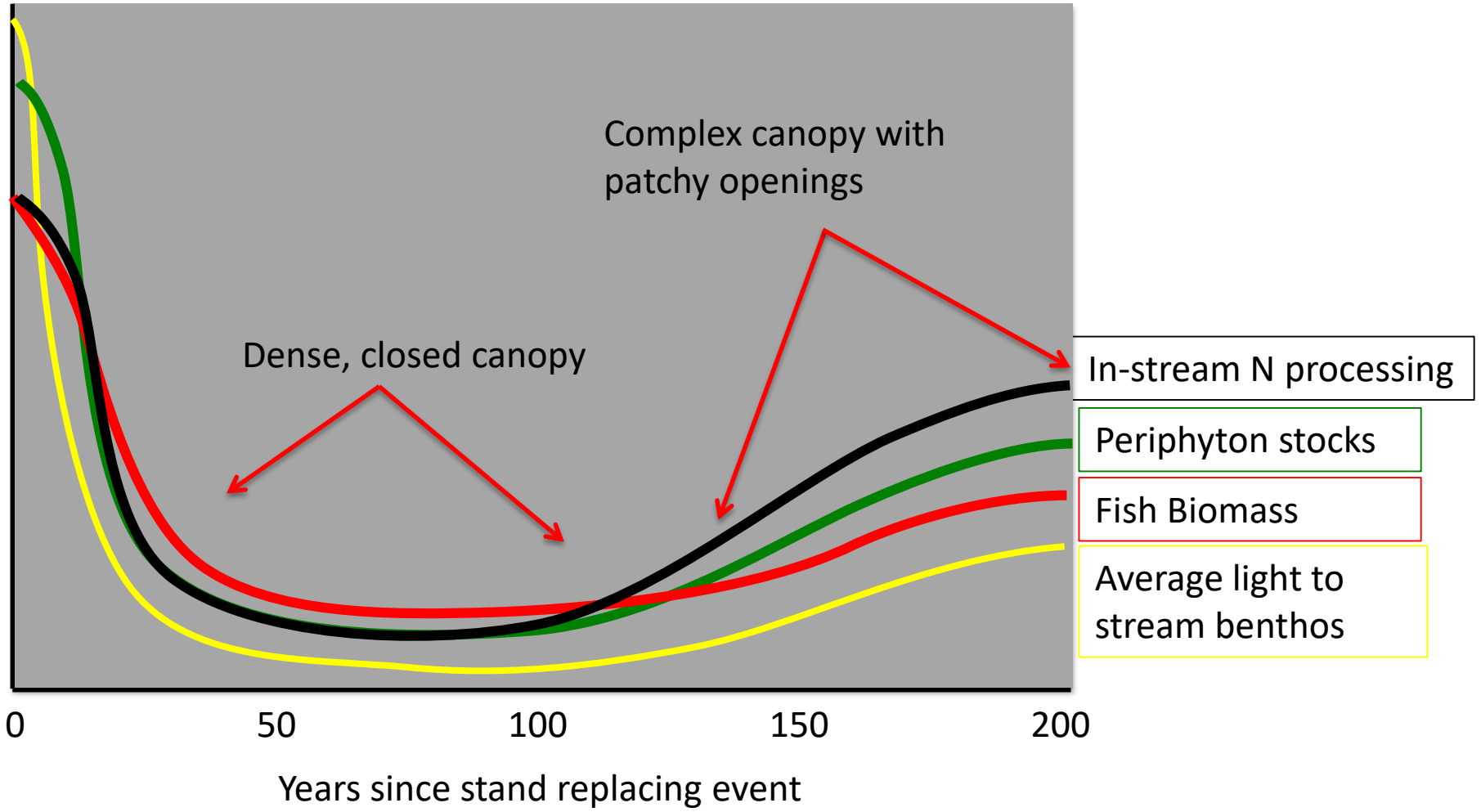

Trout Biomass (g/m2)
10
9
8
7
6
5
4
3
2
1
0
REF
MANIP
2014
2016
2014
2016
2014
2016
MR404
L703
L701


Trout Biomass (g/m2)
10
9
8
7
6
5
4
3
2
1
0
REF
MANIP
2014
2016
2014
2016
2014
2016
MR404
L703
L701

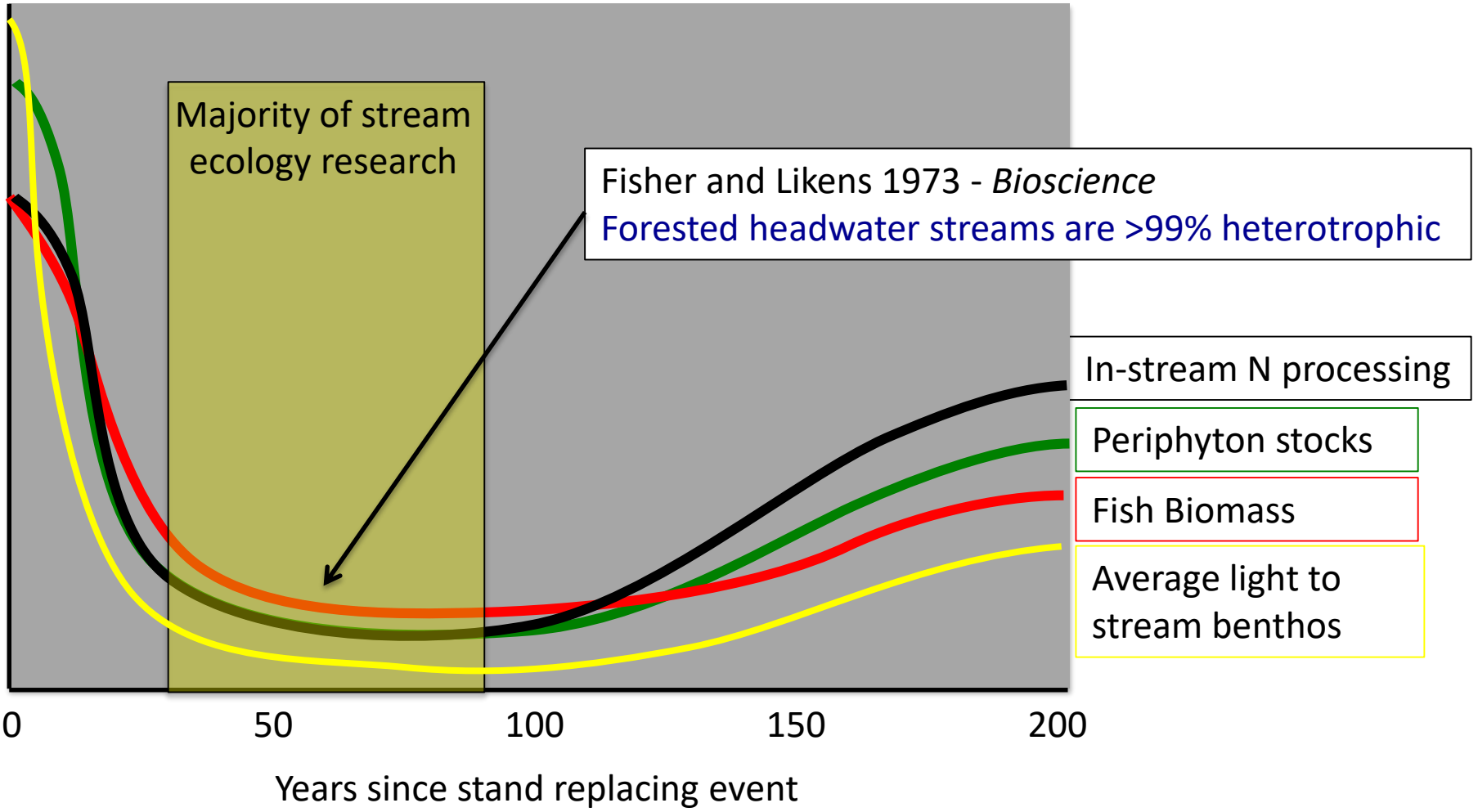

2014
2016
Mean ratio (Trt:Ref)
3
2.5
2
1.5
1
0.5
0
Light
Trout


Mean ratio (Trt:Ref)
4
3.5
3
2.5
2
1.5
1
0.5
0
2014
2016
Light
Algae
Invertebra...
Trout
YOY
Salamander
Total...

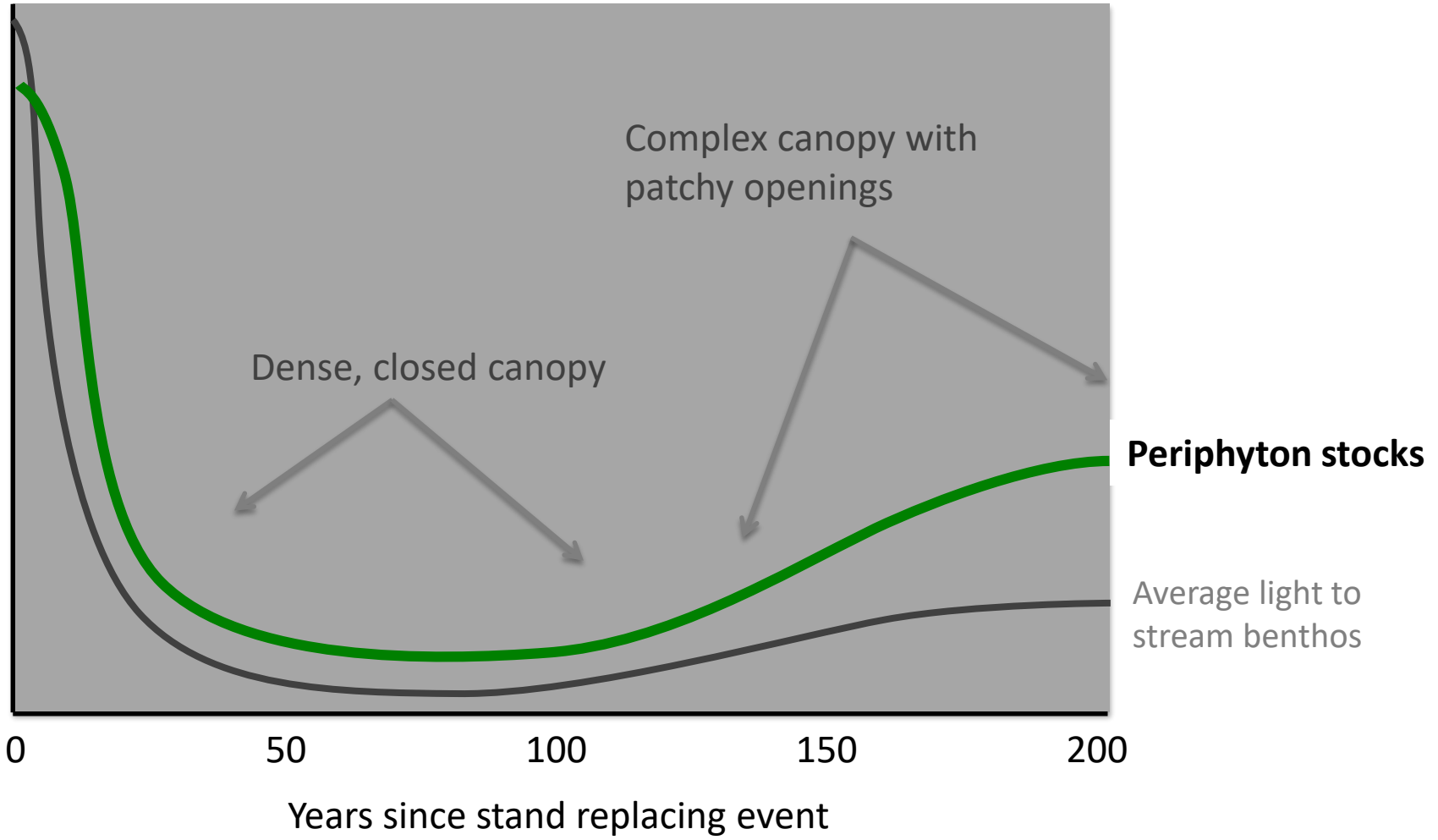
# Conceptual model for changing **Stream Ecosystem Function** over time in forested headwaters



# Do we need to change our understanding of stream function and stream processes?

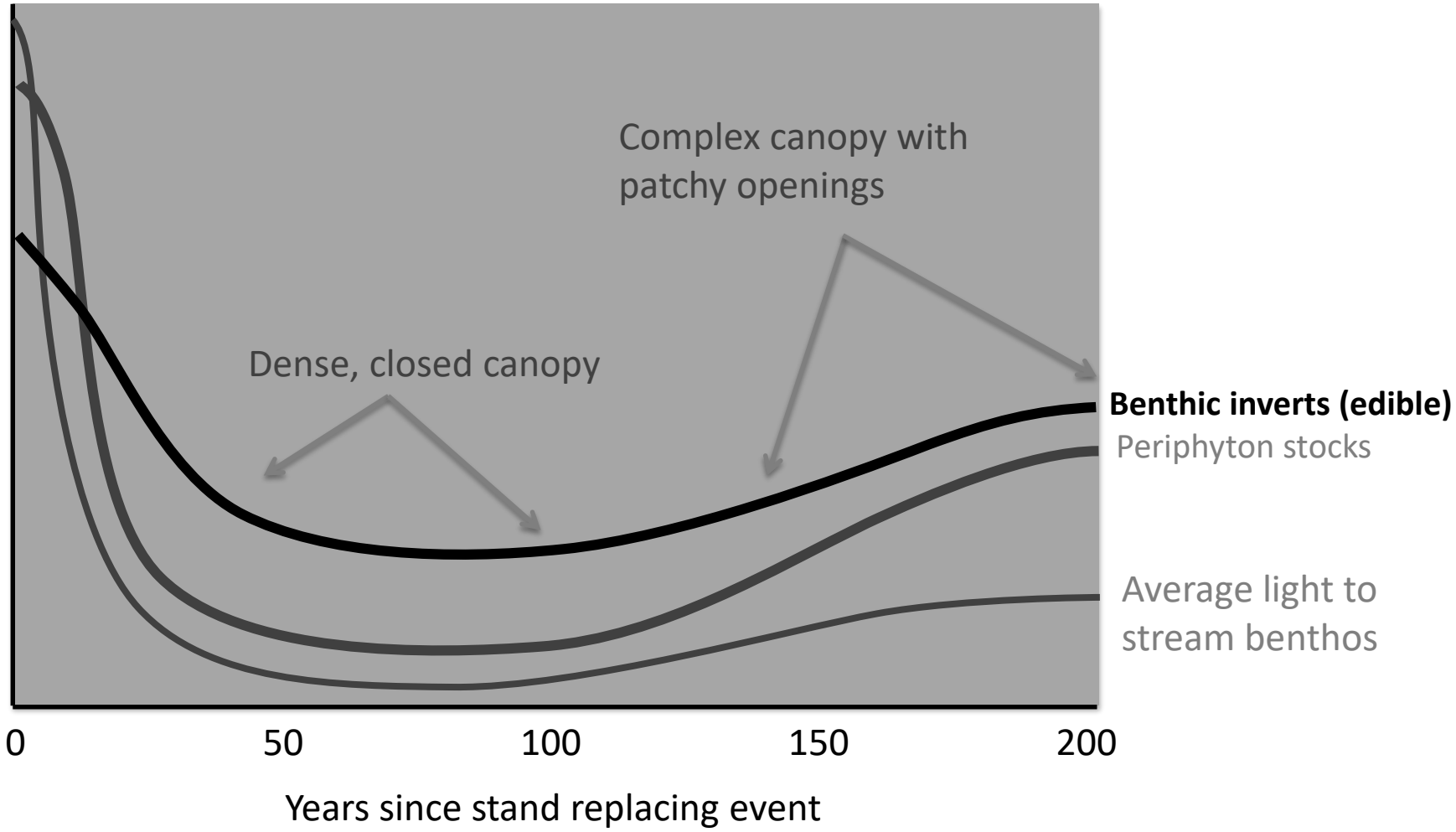


# Conceptual model for changing **periphytion** over time in a forested headwater stream



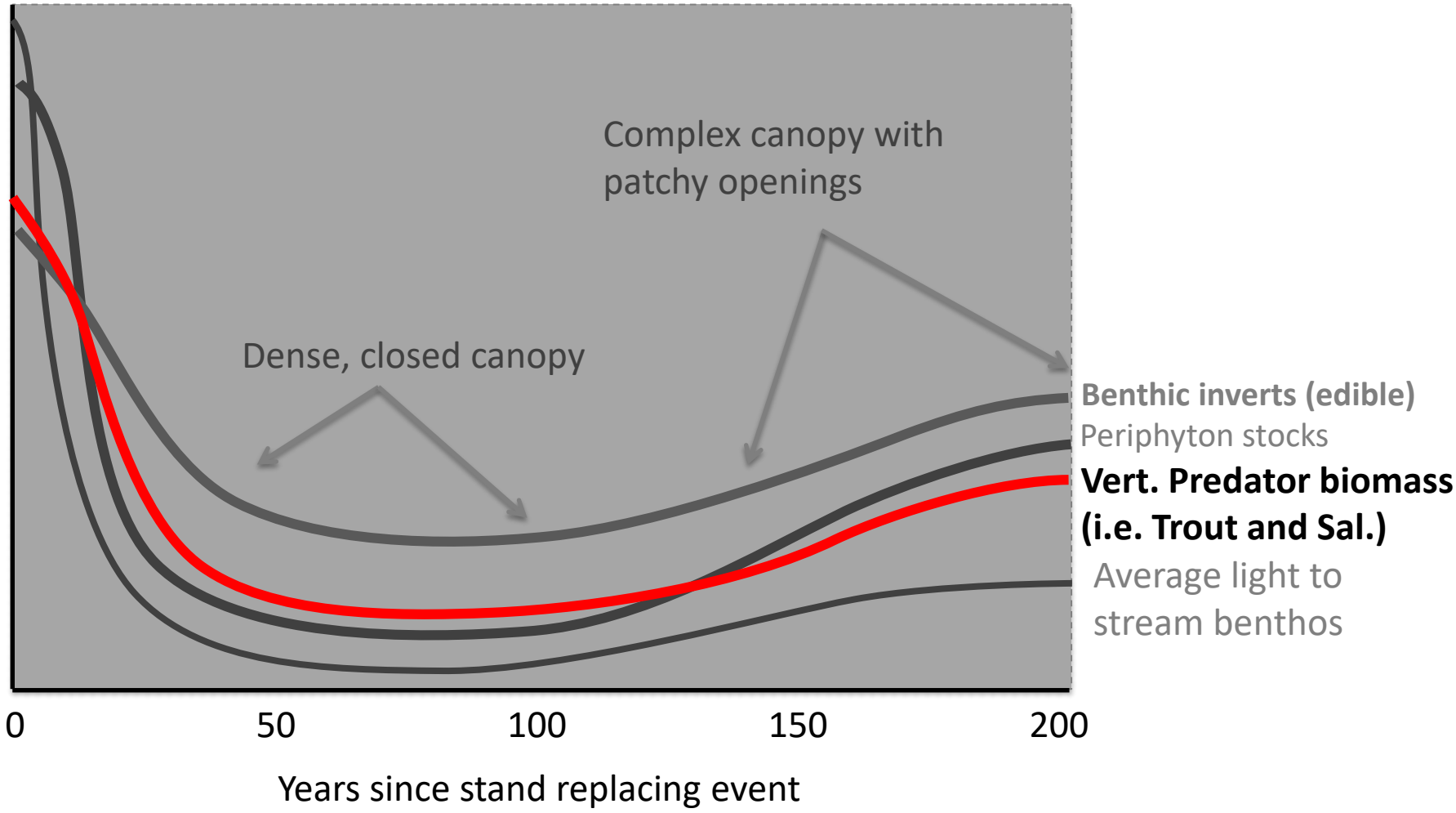

*Warren et al. 2016 - Ecosphere*

# Conceptual model for changing **invertebrates** over time in a forested headwater stream



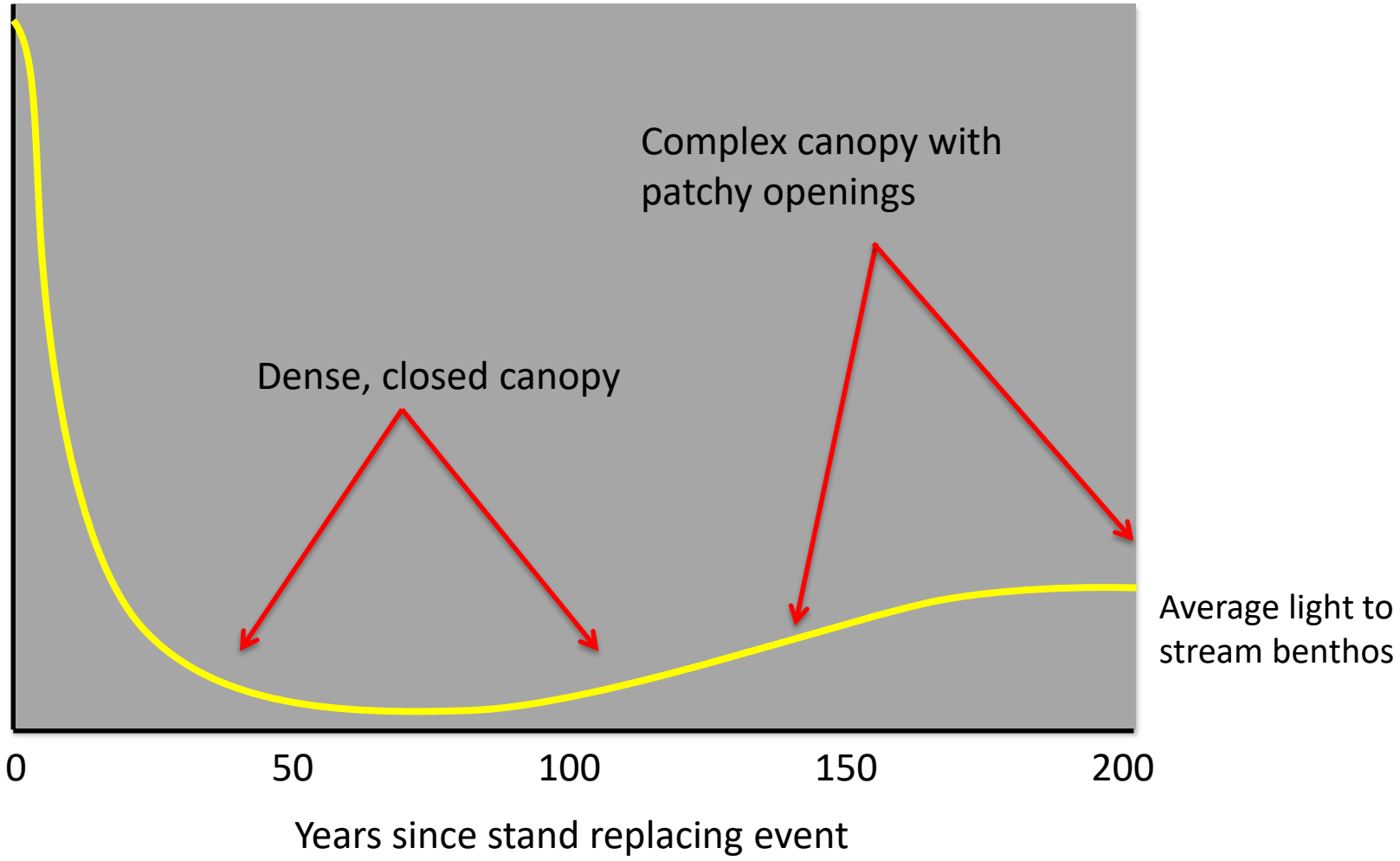

*Warren et al. 2016 - Ecosphere*

# Conceptual model for changing **predator biomass** over time in a forested headwater stream




*Warren et al. 2016 - Ecosphere*

# Conceptual model for changing light over time in a forested headwater stream

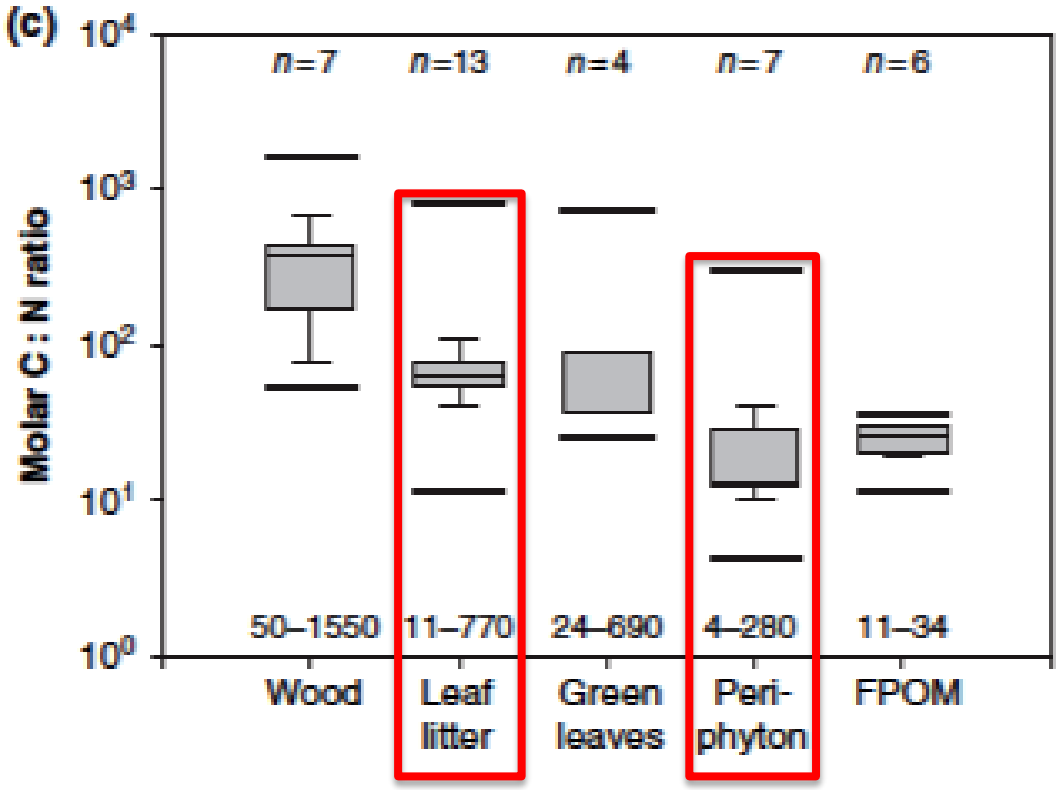



*Warren et al. 2016 - Ecosphere*

# 1. Study Questions and Conceptual Framework

- Algal material is “higher quality” food that most allochthonous material that enters streams (i.e. leaves)

- Therefore relatively small increases in primary production have the potential to disproportionately impact secondary production




Cross et al. 2005 *Freshwater Biology*