# Effectiveness of Class II Watercourse and Lake Protection Zone (WLPZ) Prescriptions

**Kevin D. Bladon, Catalina Segura, Austin D. Wissler, Jonah Nicholas, Matt House, and Drew Coe**

Board of Forestry and Fire Protection
Effectiveness Monitoring Committee
EMC-2018-006 Project Update
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Oregon State University
Watershed Processes Catalina Segura Lab
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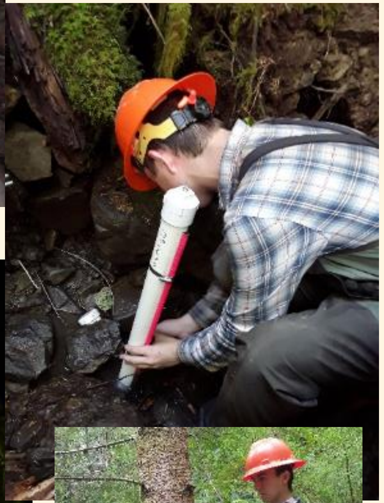
# Objectives

- How do the current ASP FPRs, and GDRCs AHCP, and pre-ASP Class II riparian requirements influence important controls on water quality and stream metabolism, including canopy closure, solar radiation, near-stream air temperature, and streamflow?

- What is the relative importance of the different drivers in influencing the variability in stream temperature dynamics (e.g., maximum, minimum, diurnal variations), dissolved oxygen, limiting nutrients (N, P, C), and primary productivity across different Class II riparian prescriptions?

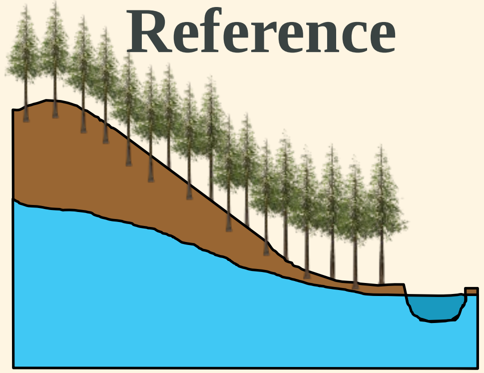






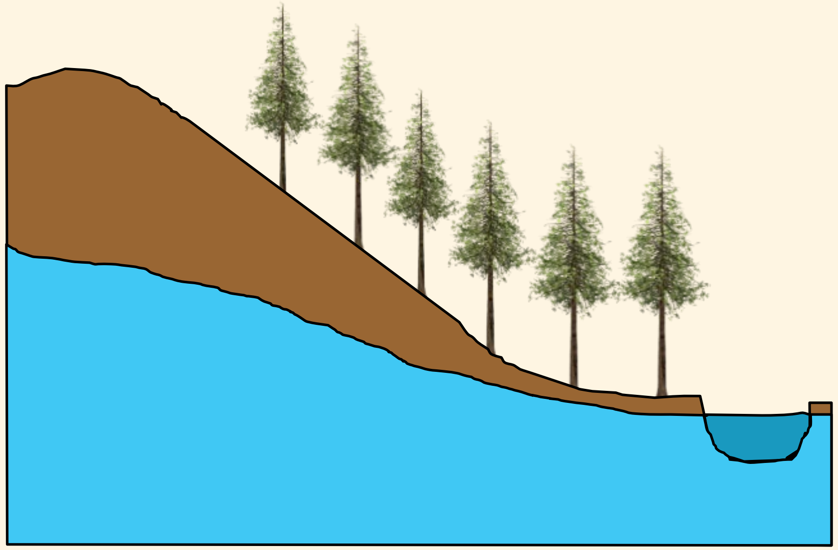
# Class II-L (II-2) Riparian Prescriptions

## Reference



## Pre-ASP

- 100 ft
- 50 % overstory

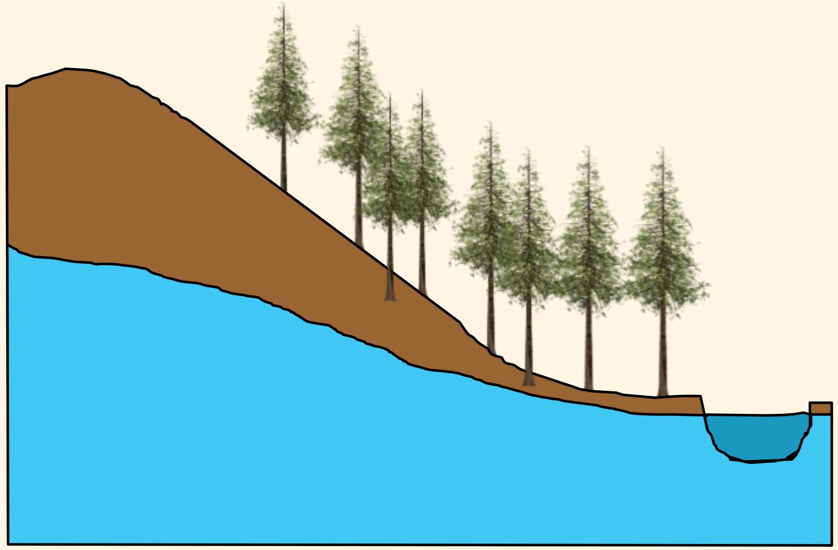


## GDRC AHCP

- 100 ft

- 70 ft outer
- 70 % overstory

- 30 ft inner
- 85 % overstory

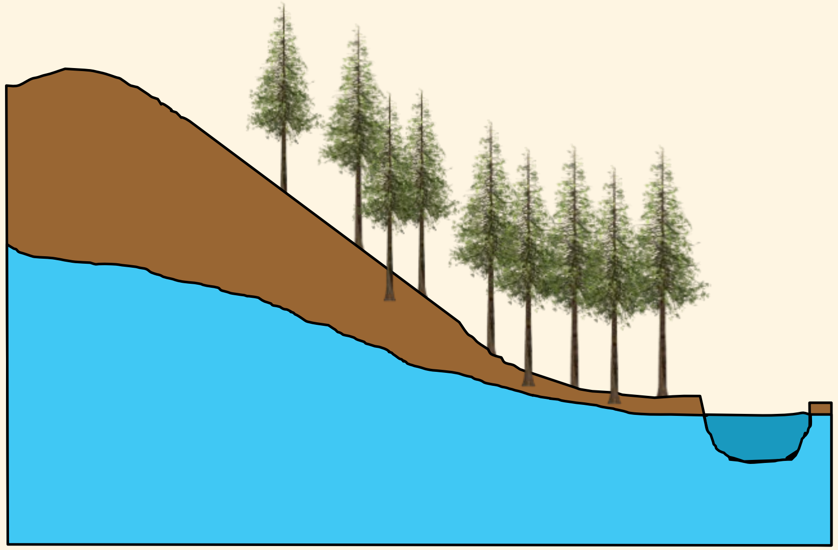


## ASP

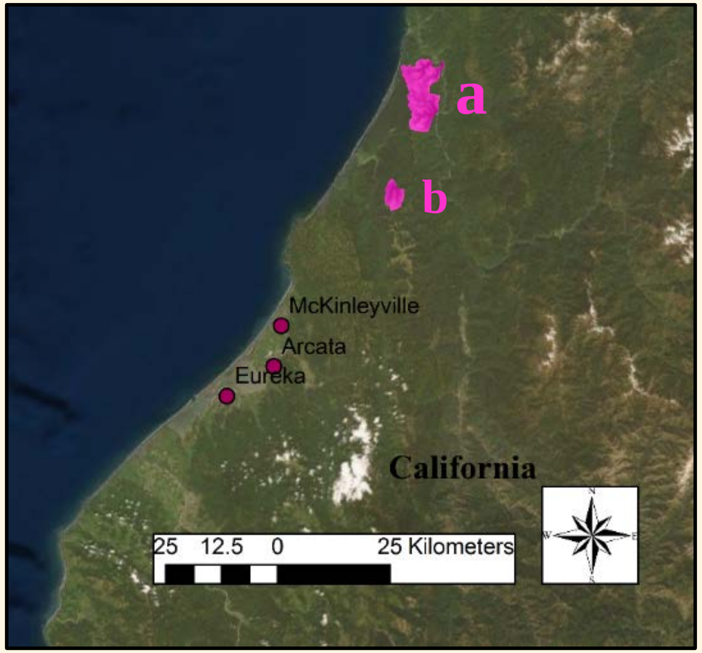
- 100 ft

- 70 ft outer
- 80 % overstory

- 30 ft inner
- No harvest

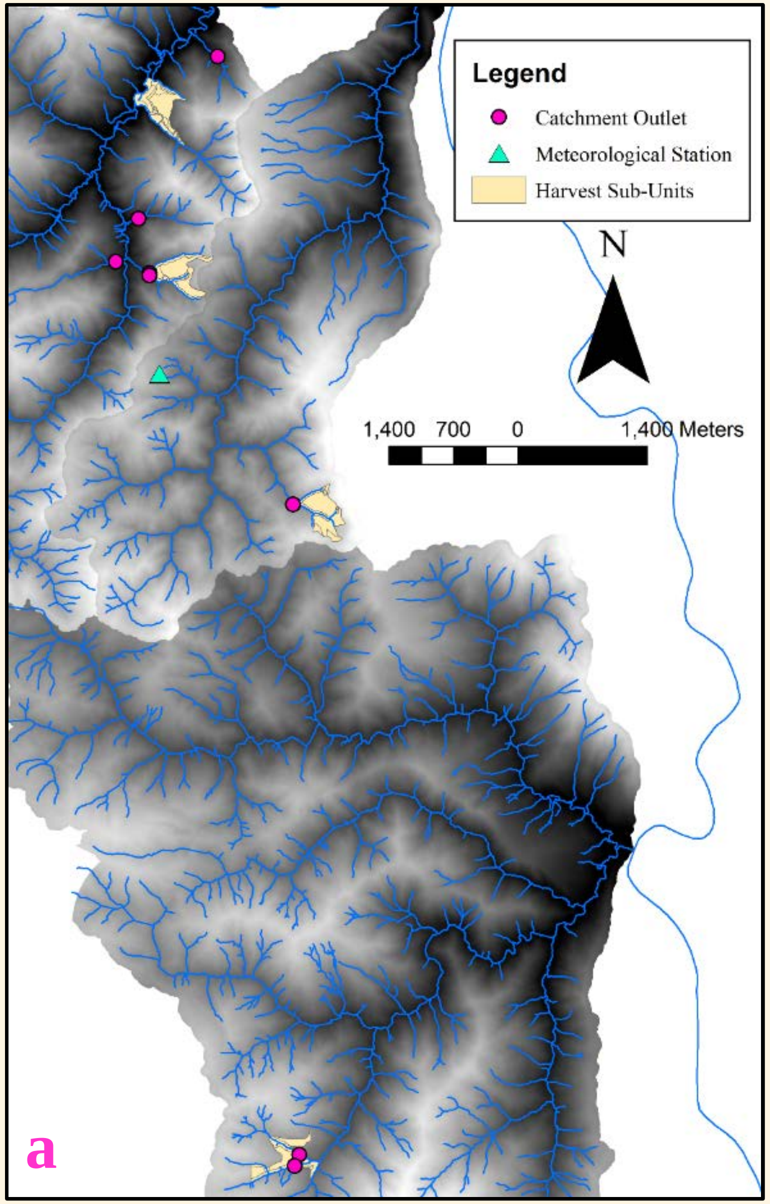


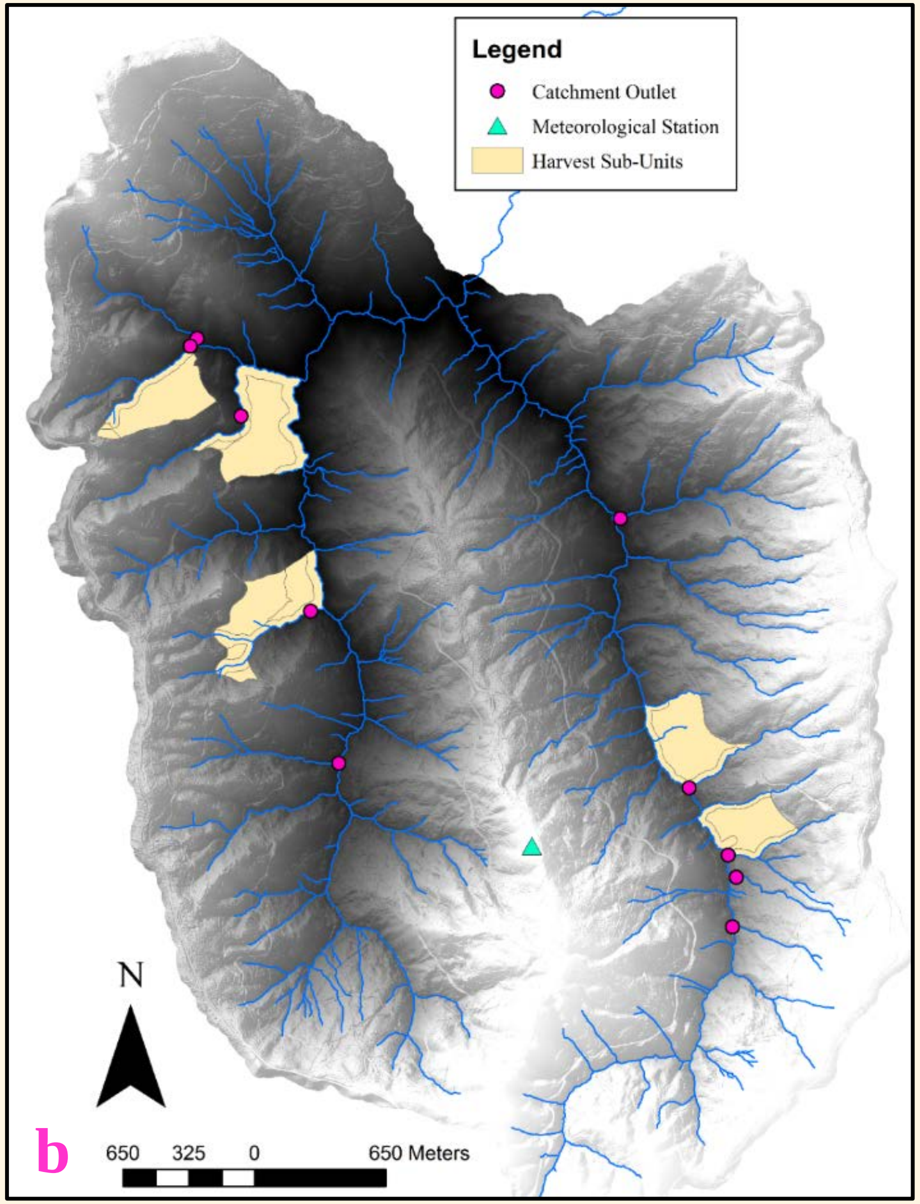
# Study Catchments




- 18 watersheds
  - 6 Reference
  - 4 ASP
  - 4 GDRC AHCP
  - 4 Pre-ASP

- Pre- and post-harvest



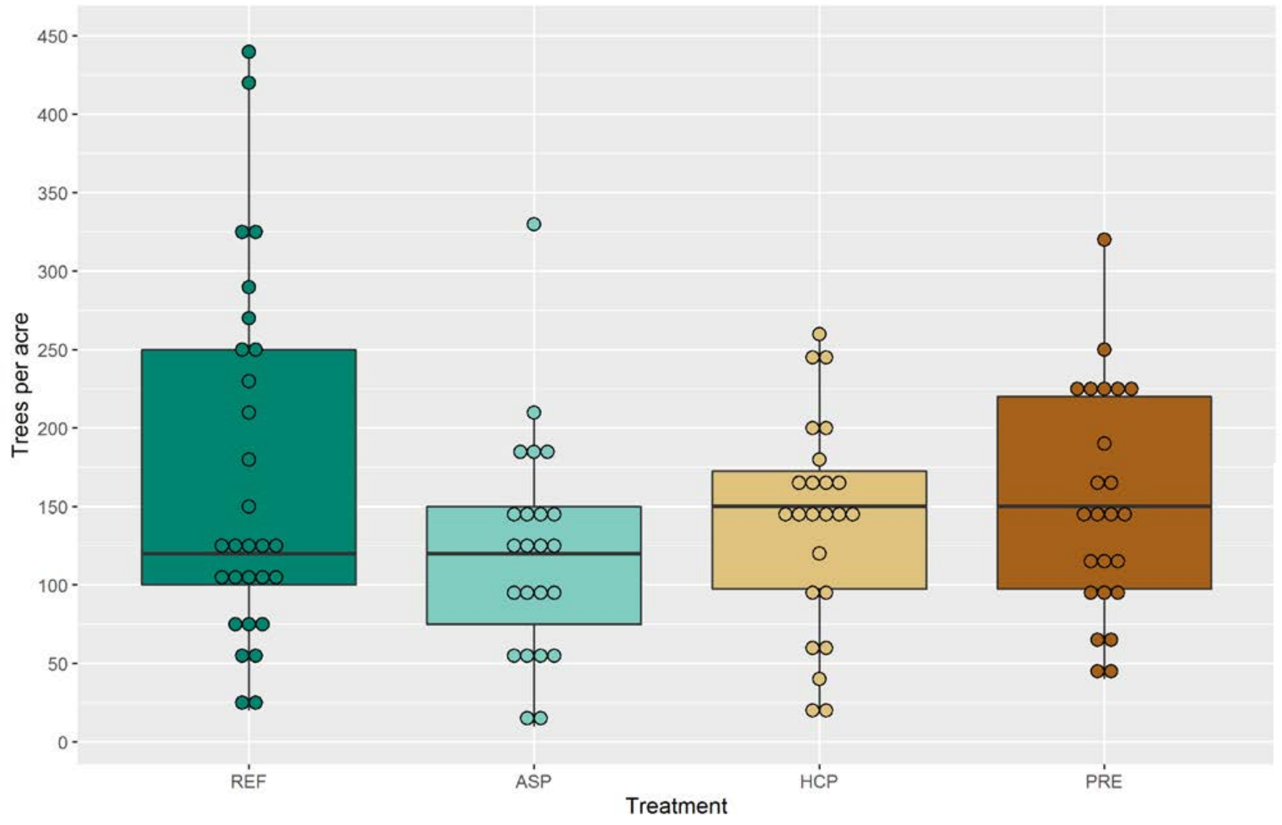
# *Riparian mensuration*

- 6 x 1/10 acre (~37.2 ft radius) fixed area plots per stream reach

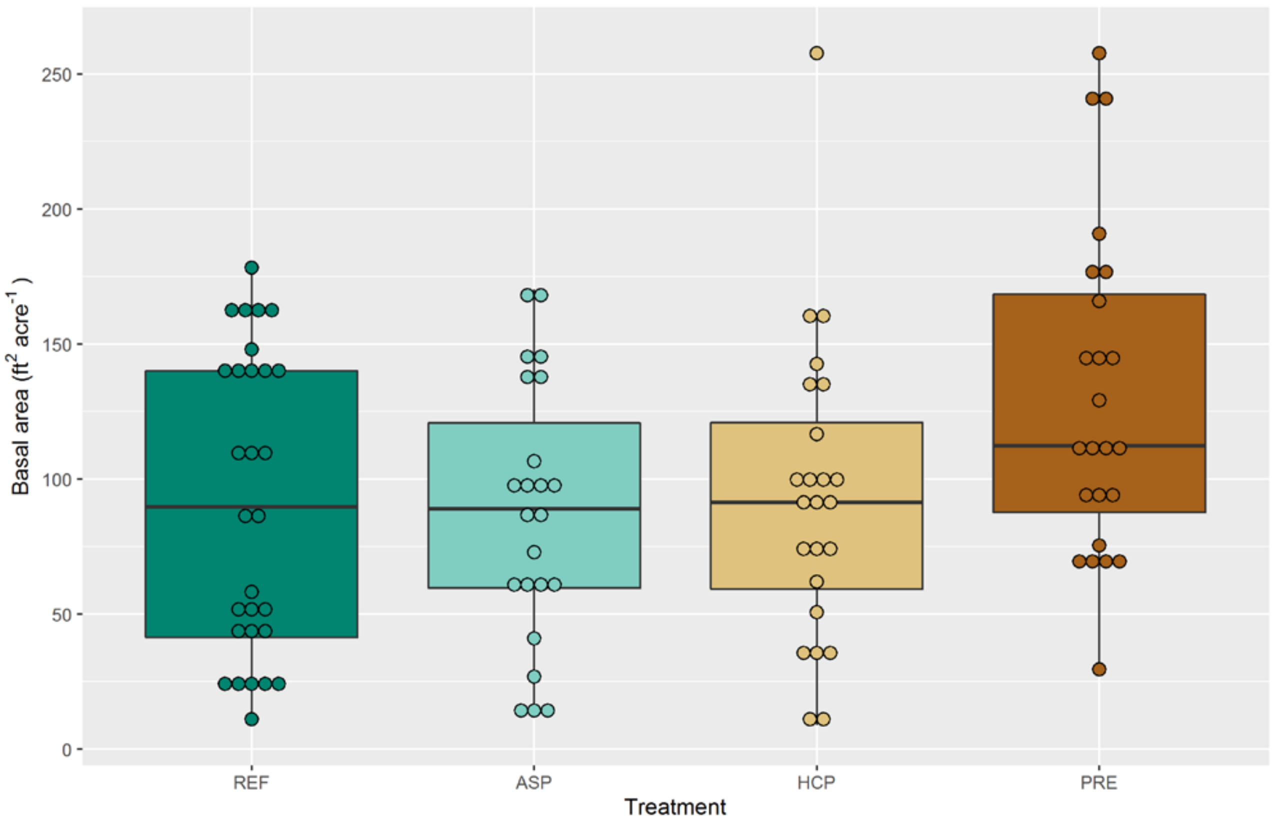
- Data:
  - Tree species
  - Tree diameter
  - Basal area
  - Canopy class (D, CD, U)
  - Mortality agent or decay class
  - Hemispherical photos for canopy closure

- Pre-harvest – collected 2019–2020
- Post-harvest – collecting 2021–2022

# Riparian mensuration data – Pre-harvest

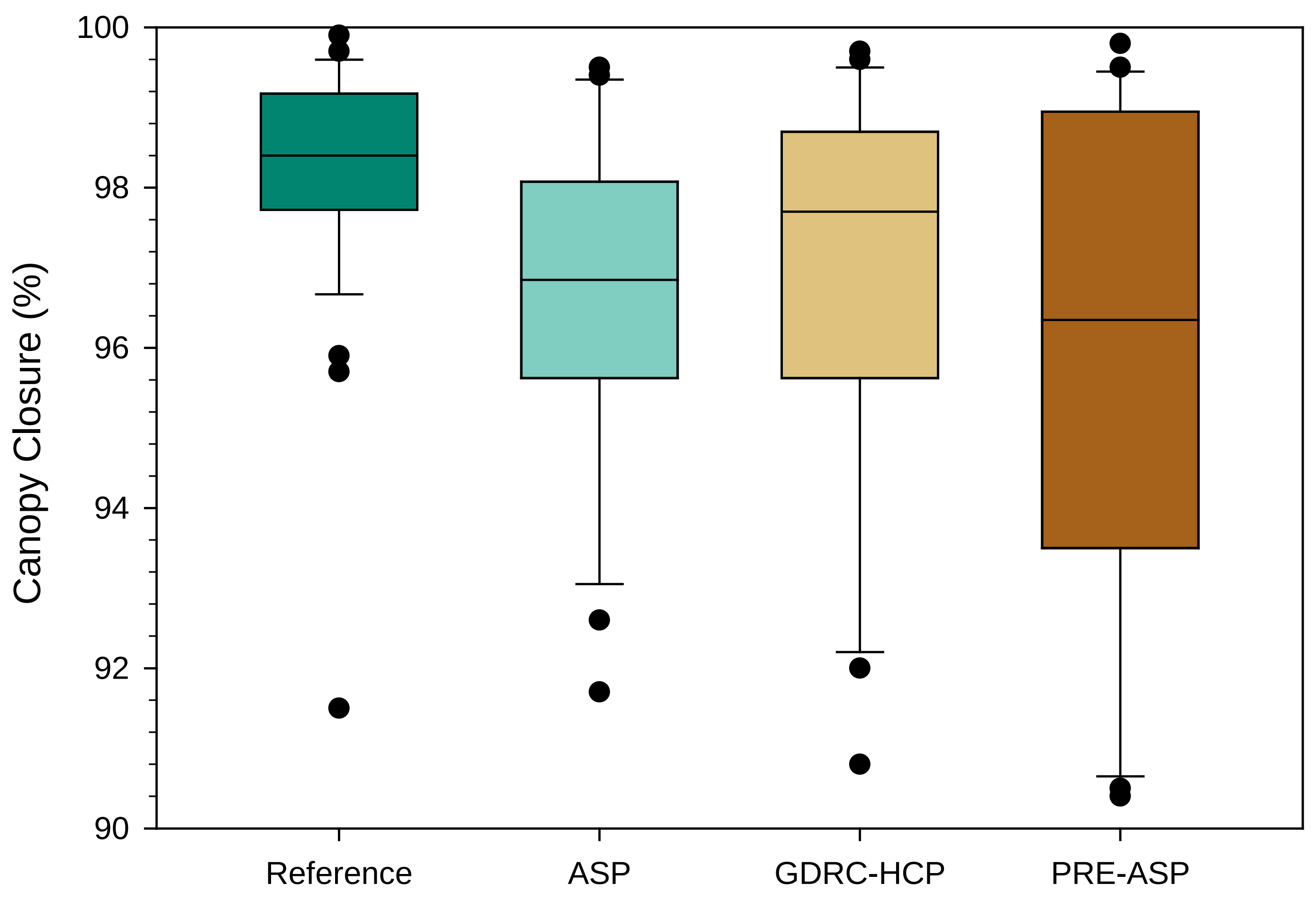



- REF: 168.3 ± 112.2 trees $ac^{-1}$
- ASP: 122.6 ± 70.1 trees $ac^{-1}$
- GDRC-HCP: 141.3 ± 67.4 trees $ac^{-1}$
- PRE-ASP: 152.1 ± 71.7 trees $ac^{-1}$



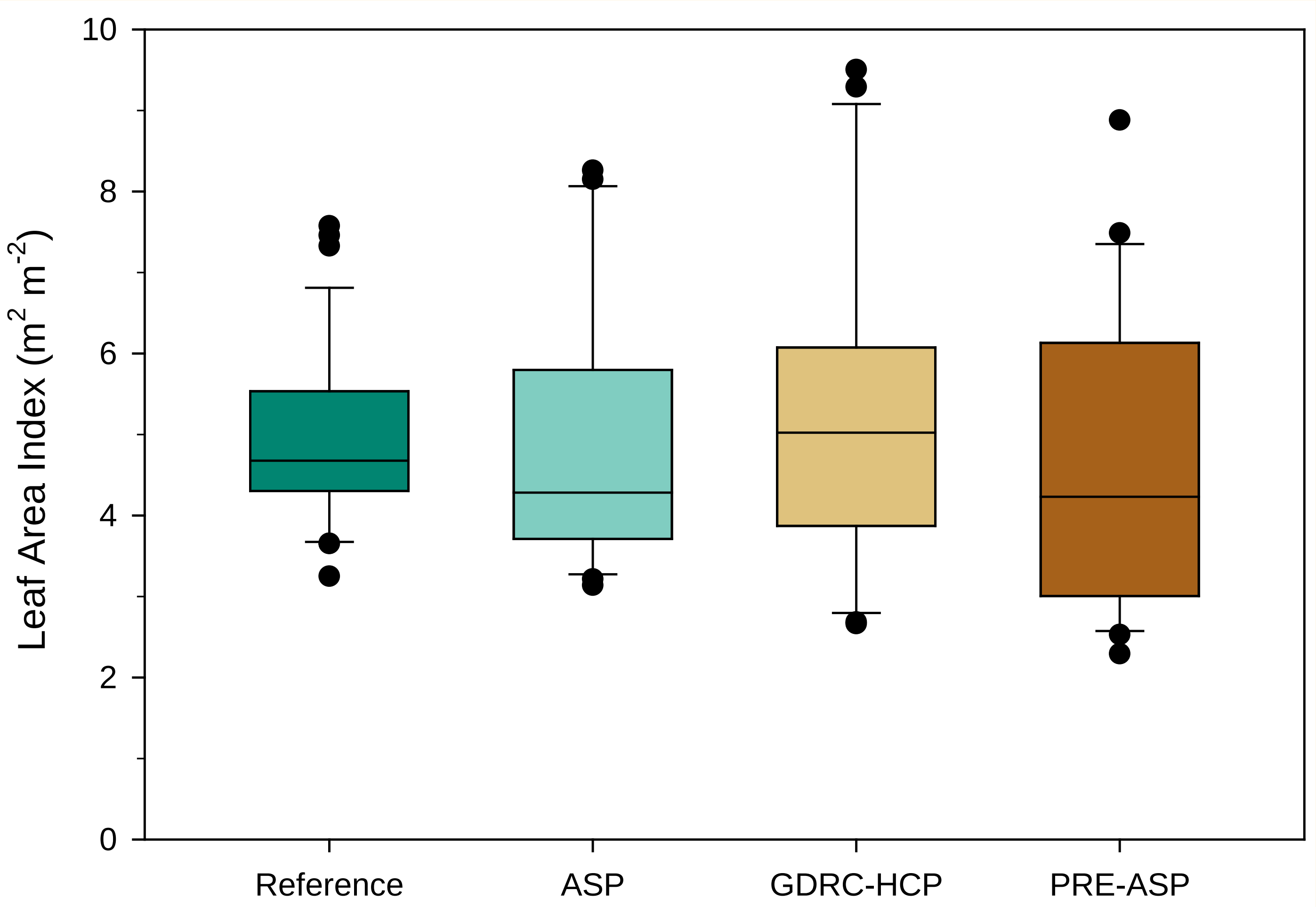

- REF: 91.4 ± 55.1 $ft^2$ $ac^{-1}$
- ASP: 87.0 ± 47.9 $ft^2$ $ac^{-1}$
- GDRC-HCP: 93.6 ± 55.1 $ft^2$ $ac^{-1}$
- PRE-ASP: 87.0 ± 47.9 $ft^2$ $ac^{-1}$

# Riparian mensuration data – Pre-harvest



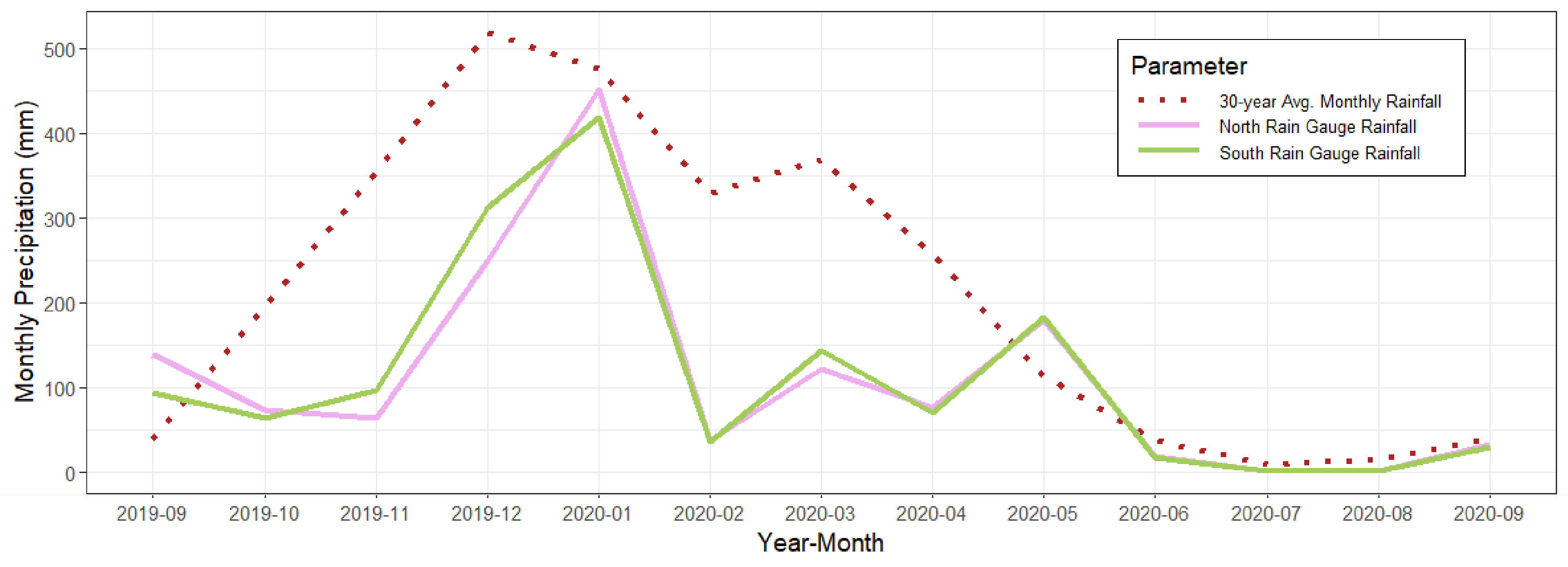

- REF: 98.2 ± 1.5 %
- ASP: 96.6 ± 2.1 %
- GDRC-HCP: 96.9 ± 2.5 %
- PRE-ASP: 96.1 ± 3.1 %

# *Riparian mensuration data – Pre-harvest*

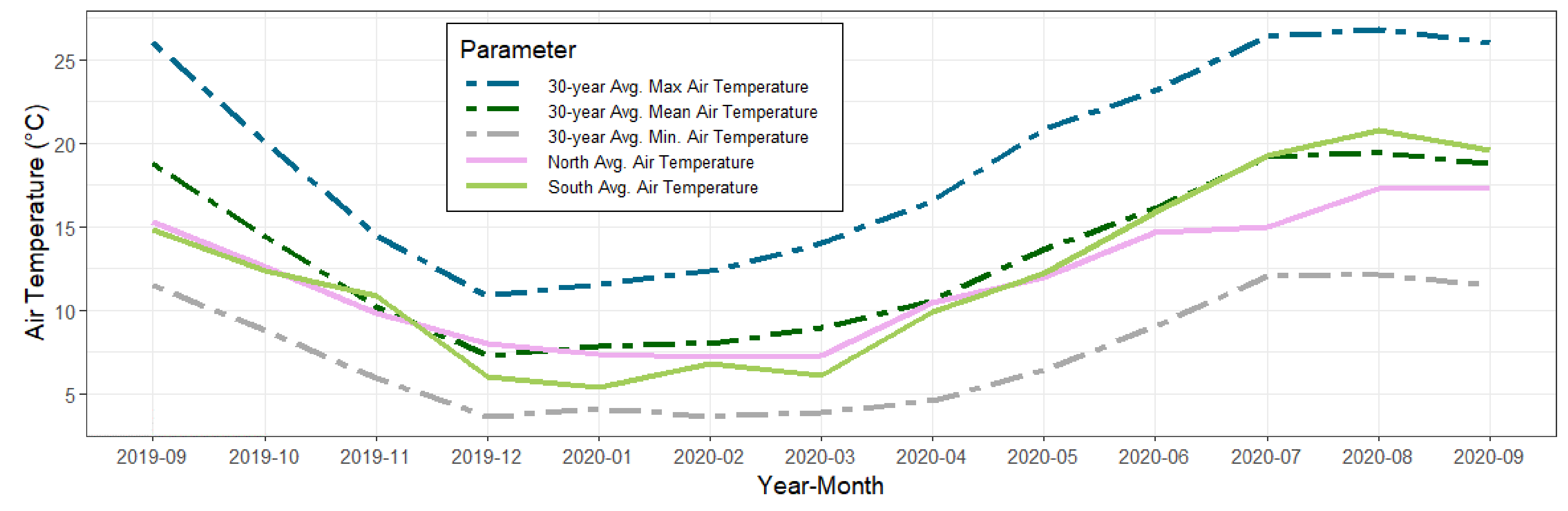



- REF: 5.0 ± 1.1 $m^2\ m^{-2}$
- ASP: 4.9 ± 1.6 $m^2\ m^{-2}$
- GDRC-HCP: 5.3 ± 2.0 $m^2\ m^{-2}$
- PRE-ASP: 4.6 ± 1.8 $m^2\ m^{-2}$

# Precipitation and Air Temperature



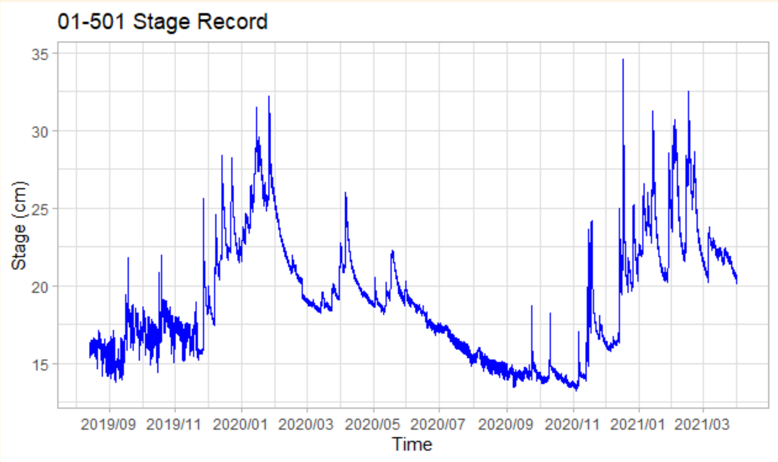

- $P$: 1,441–1,463 mm yr$^{-1}$
  - Aug: 0.8–1.2 mm
  - Jan: 418–451 mm
- $P_{30\text{-}year}$: ~2,752 mm yr$^{-1}$

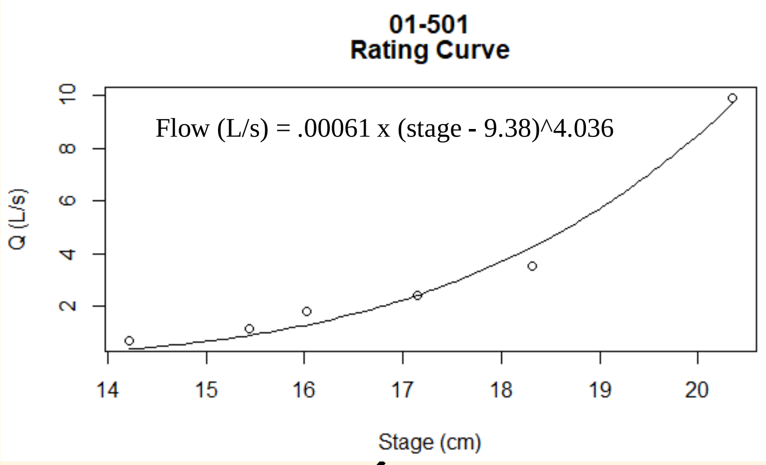


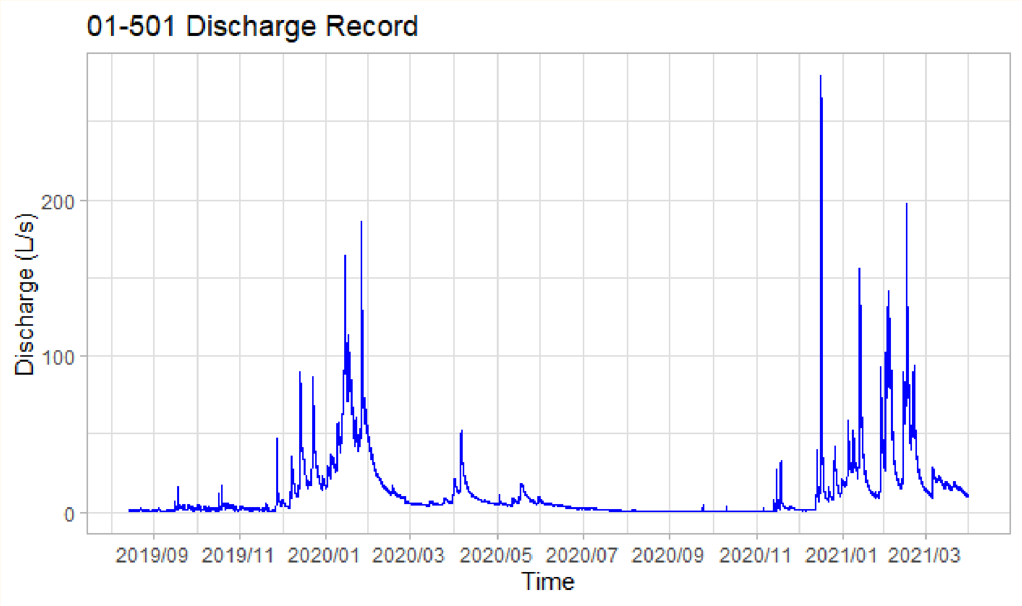

- $T_{air}$: 11.8–12.3 °C
  - Aug: 17.3–20.8 °C
  - Jan: 5.4–7.4 °C
- $T_{air\ 30\text{-}yr}$: 13.3 °C

# *Stage and discharge data*

- Record stream stage (every 15 mins) in all 18 streams
- Salt dilution gauging to develop unique rating curve for each stream
- Using rating curve relationship to estimate stream discharge



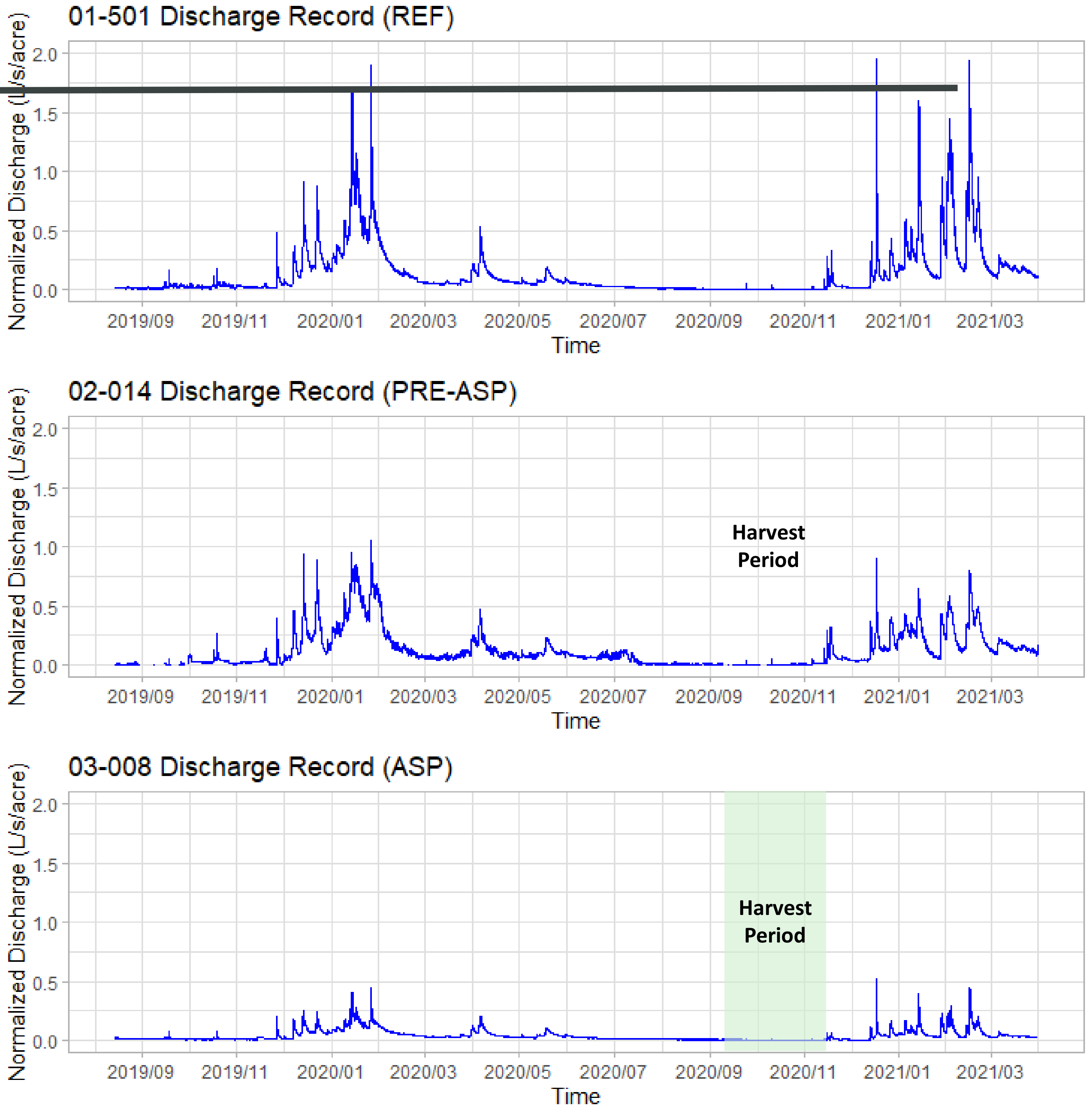



# *Discharge data - Preliminary*

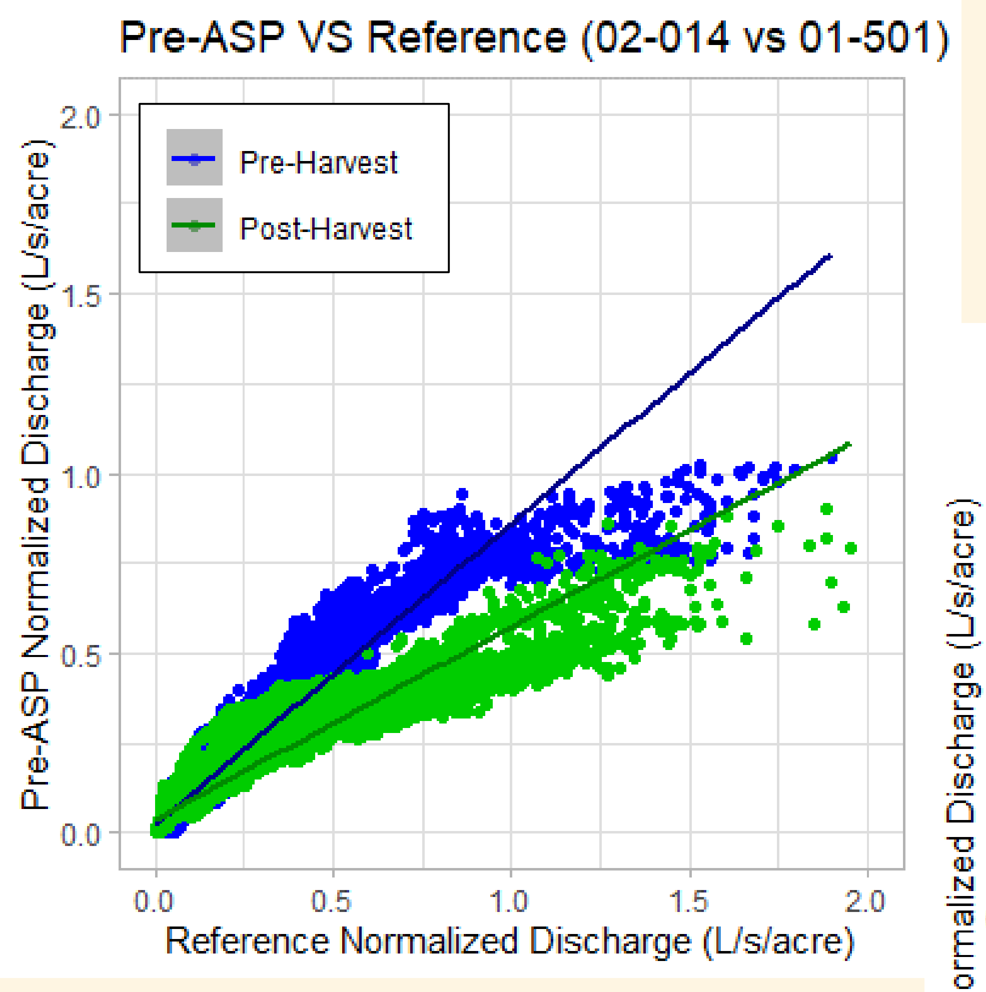
| Site Type | Pre-harvest | Post-harvest |
|---|---|---|
| REF | 0.11 ± 0.18 | 0.16 ± 0.25 |
| PRE-ASP | 0.12 ± 0.16 | 0.13 ± 0.14 |
| ASP | 0.04 ± 0.05 | 0.04 ± 0.05 |

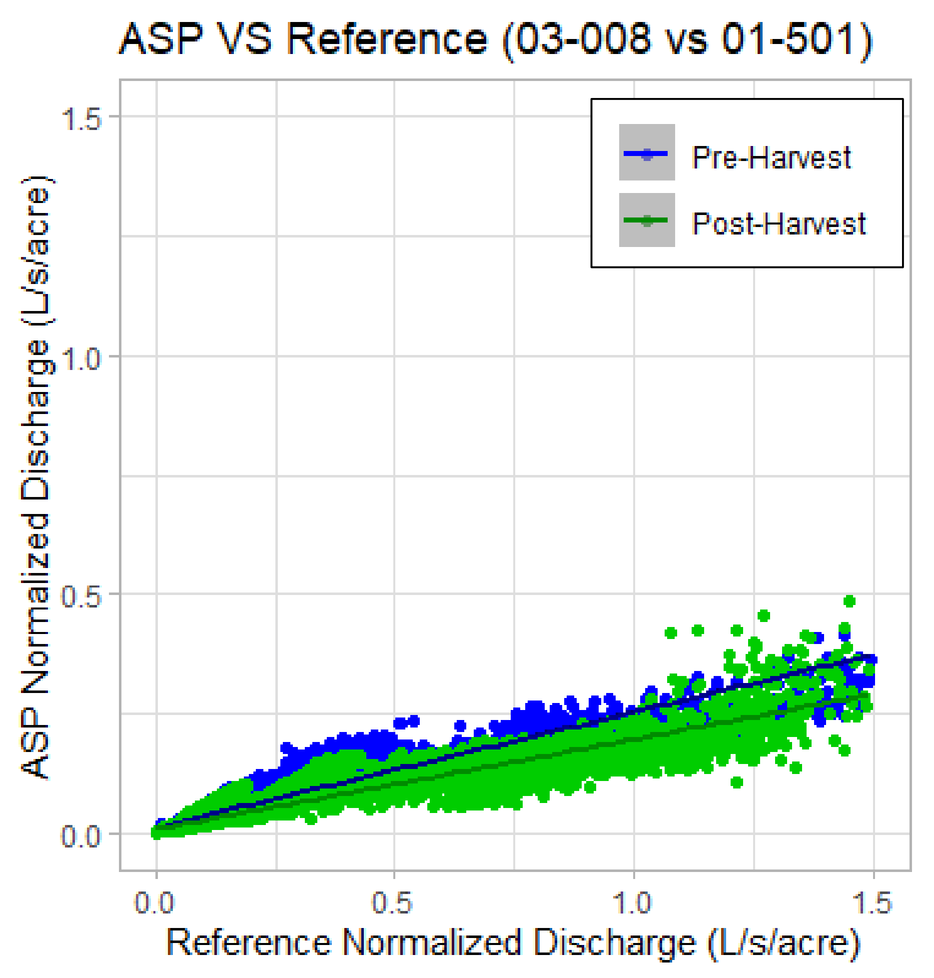
- Need to incorporate all sites (replication)
- Need to investigate seasonality and event responses



# *Discharge data - Preliminary*

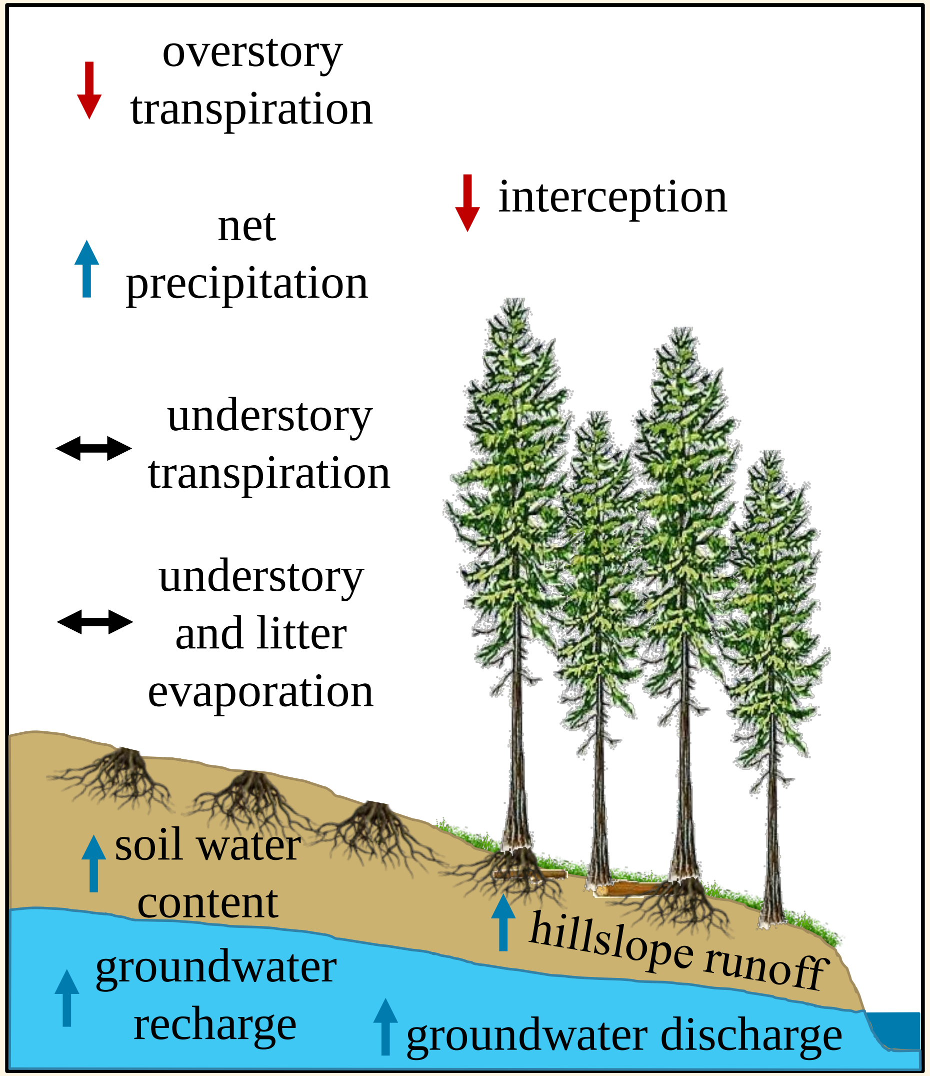
- Classic before-after, paired catchment approach to investigate effects
- Will also explore other analytical approaches (e.g., Kolmogorov–Smirnov statistics for comparing flow duration curves) as effect sizes are likely to be small and hard to detect

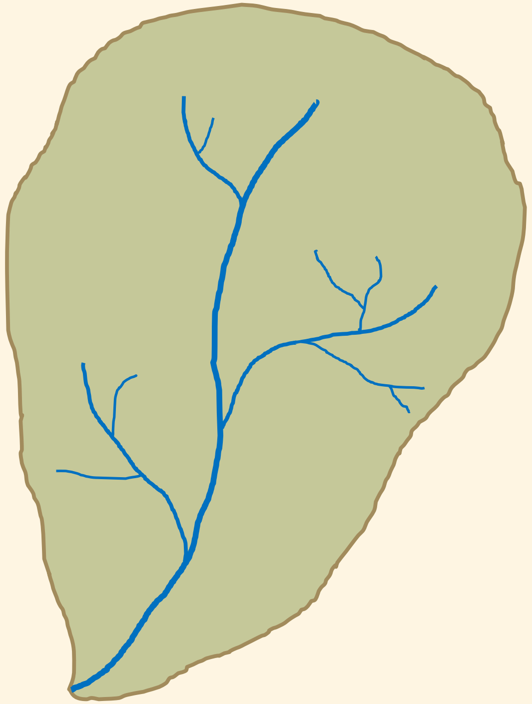


# Groundwater

- Installed 27 groundwater wells along hillslope transects in 3 streams (Apr. 2021)
- Insights into how hillslope hydrologic processes change to help interpret discharge

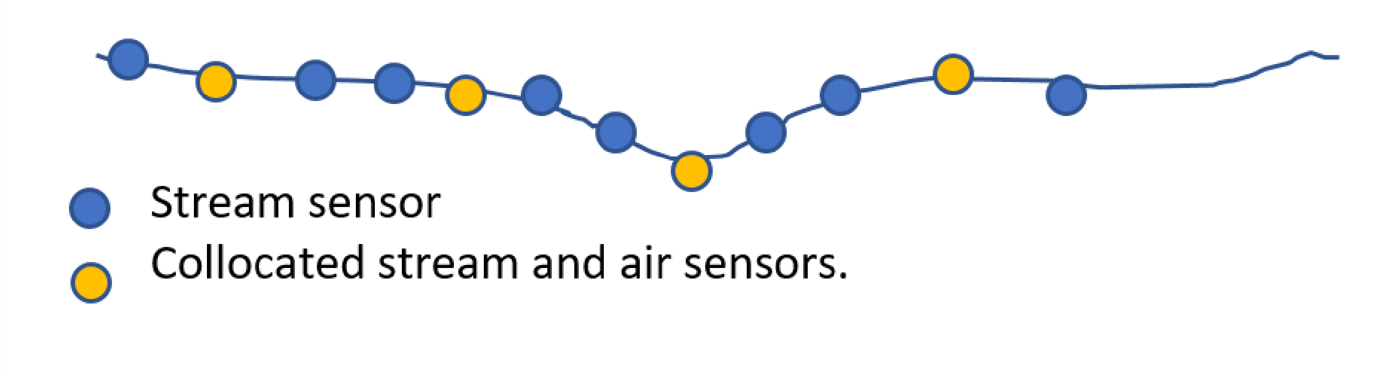


Q ↑ or ↓ ?

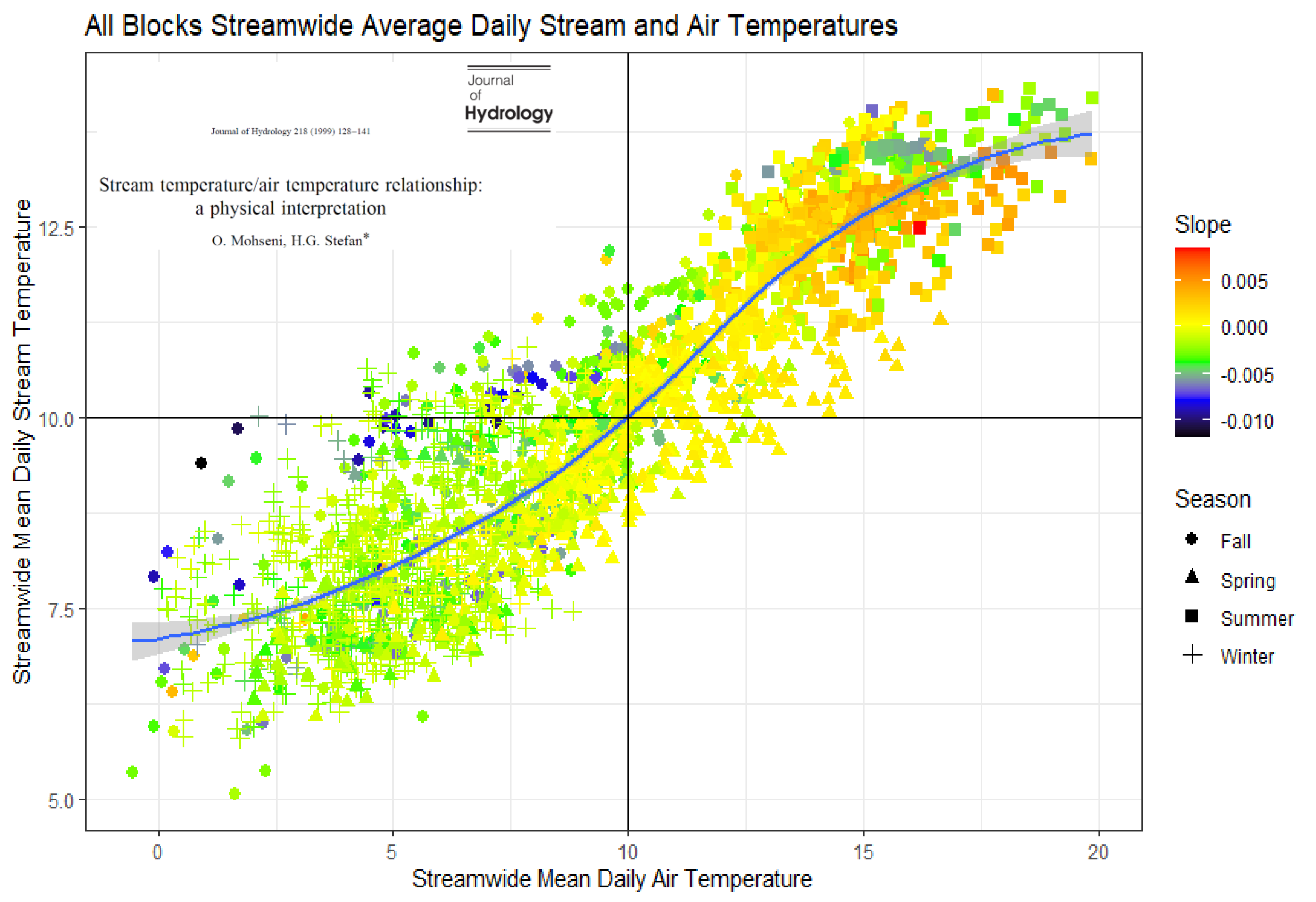
# Stream and air temperature

- Installed longitudinally along the ~300 m (1000 ft) of each of the 18 study streams:
    - 12 stream temperature sensors
    - 4 air temperature sensors
    - Total: 288 sensors

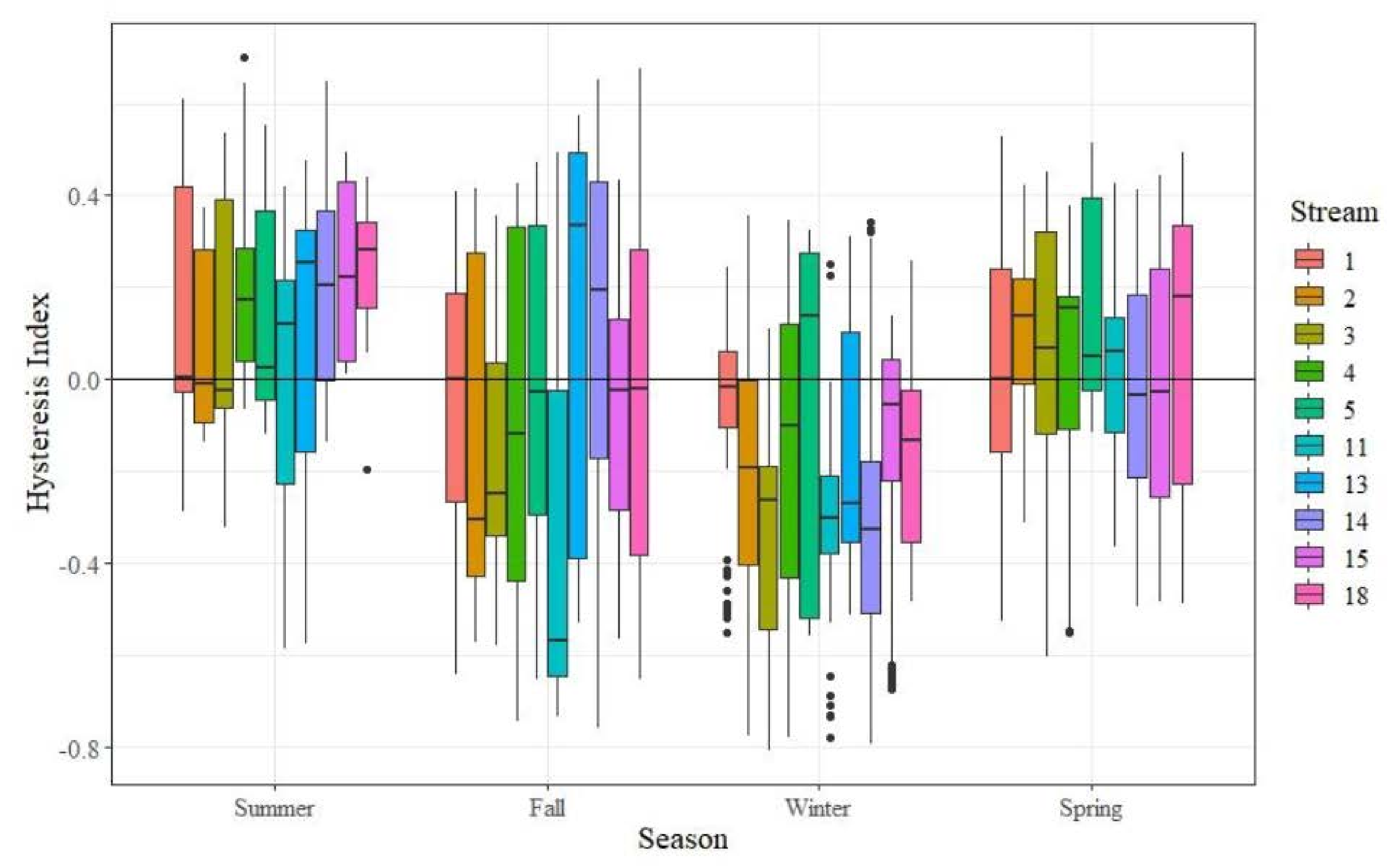



- Sensors measure every 60 seconds and store data every 15 minutes

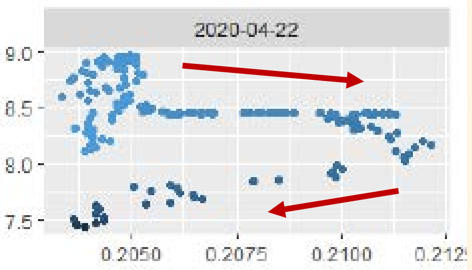
# Stream temperature and air temperature relationship



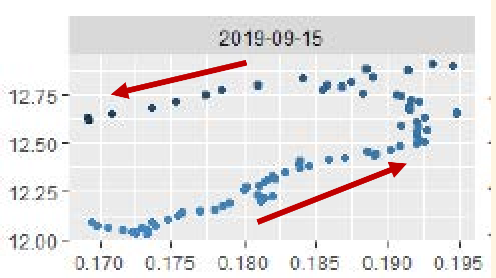
# $T_s$ – Seasonal hysteretic behavior during P events




- Clockwise hysteresis during summer and spring

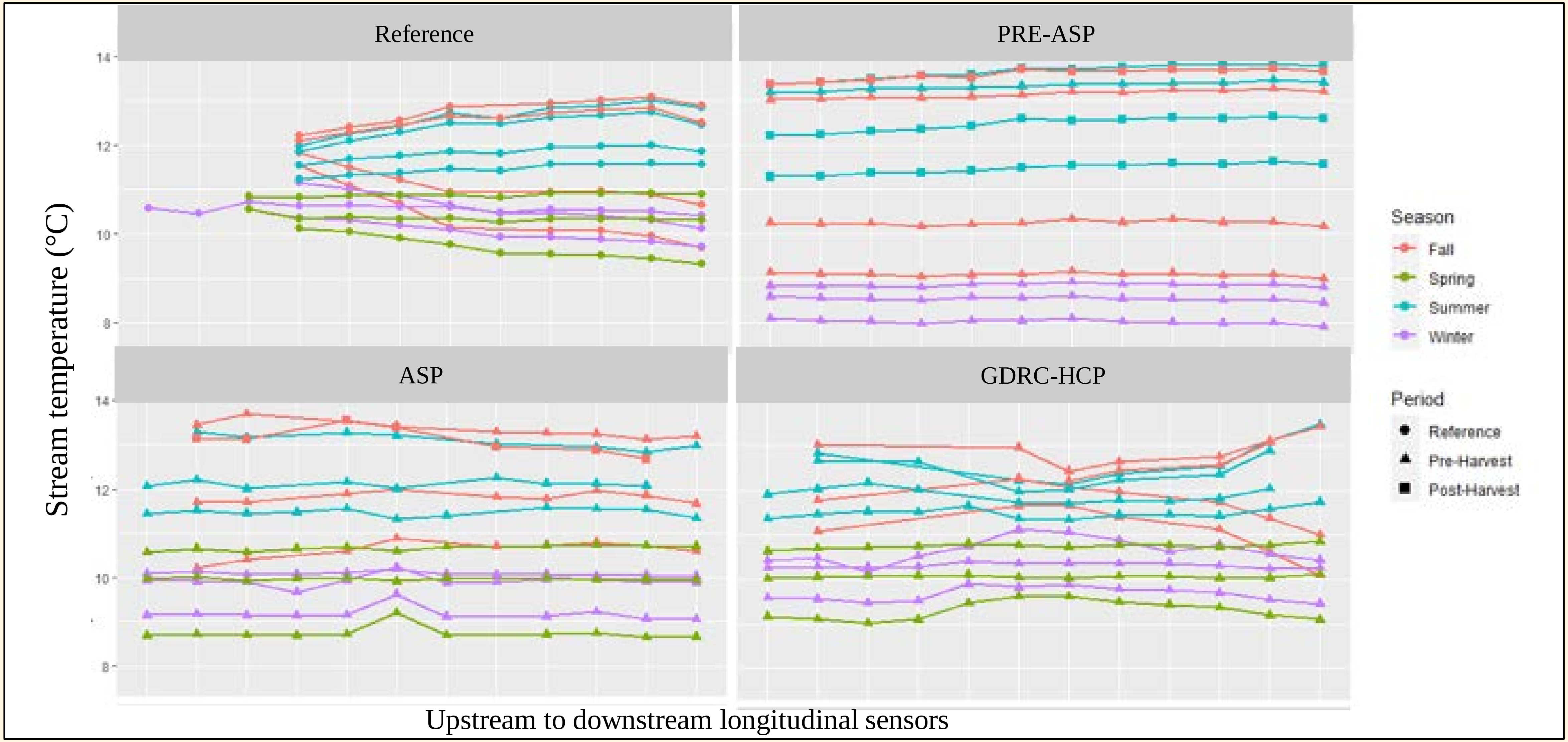



- Anti-clockwise during fall and winter




- Potential differential runoff behavior influencing stream temperature at different times of year

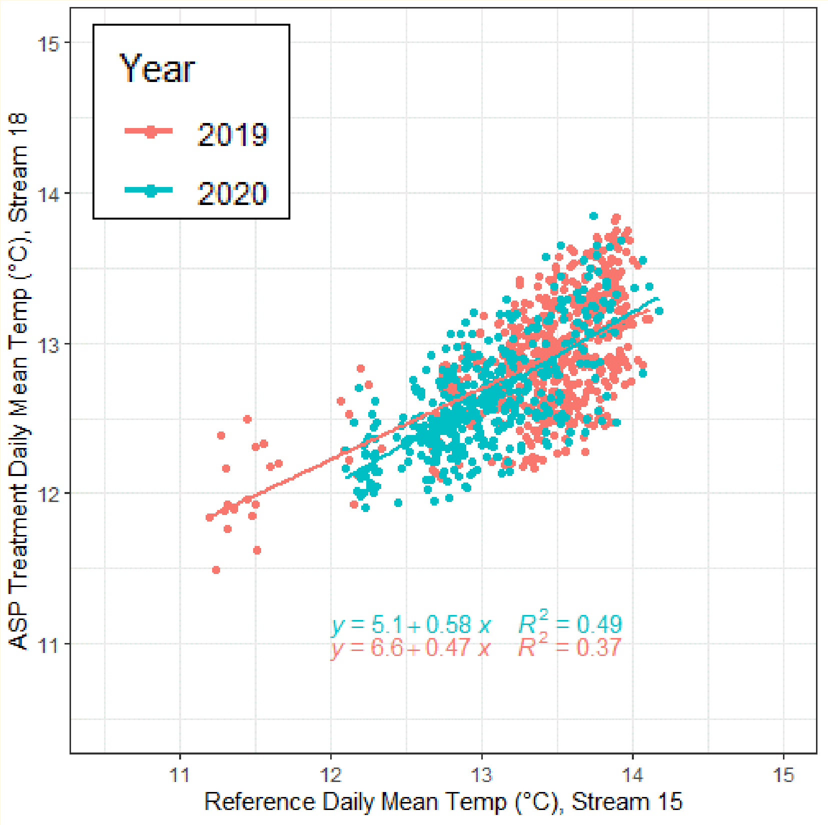
# Longitudinal stream temperature




- Little evidence of discrete locations of groundwater discharge
- Fall stream temperatures in PRE-ASP slightly warmer?

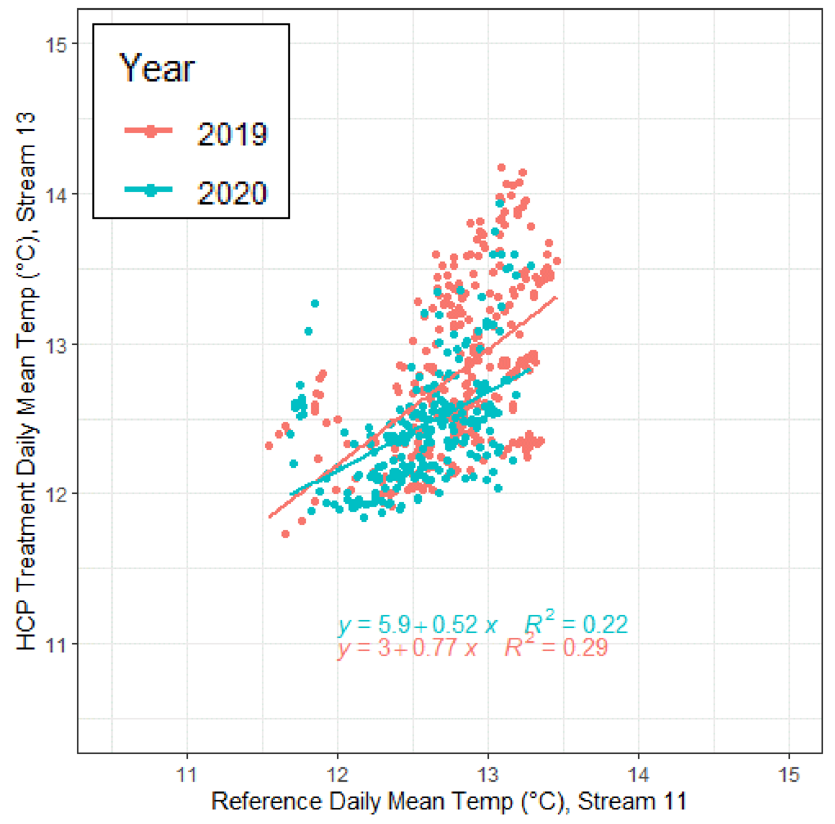
# Stream temperature – Pre- vs. Post-harvest

## REF v. ASP



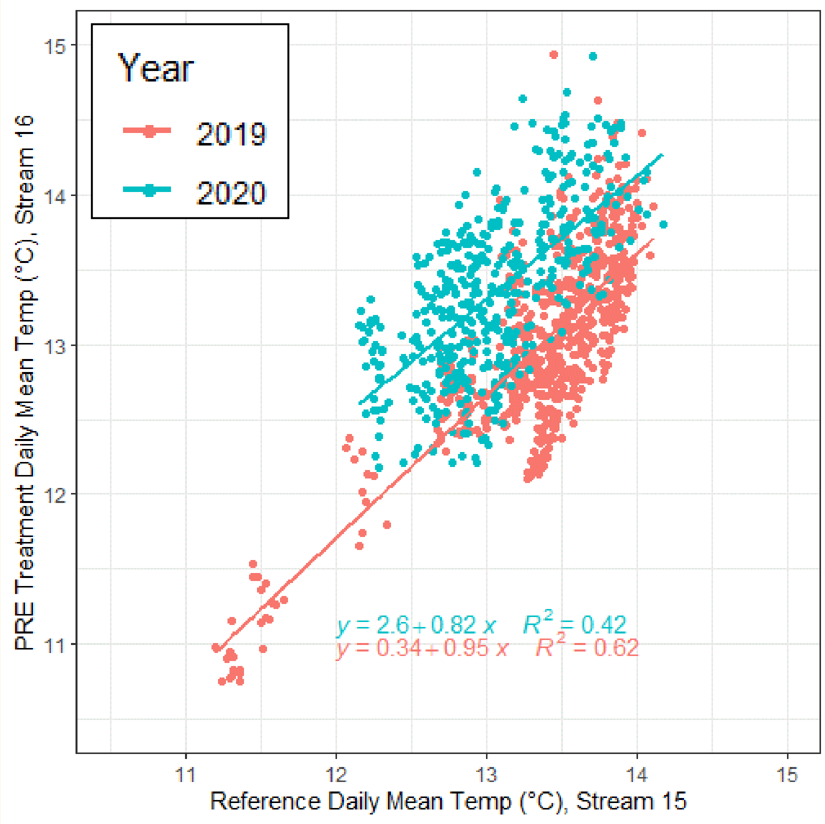

| Site Type | Pre-harvest | Post-harvest |
|---|---|---|
| REF | 13.4 ± 0.5 | 13.1 ± 0.4 |
| ASP | 12.9 ± 0.4 | 12.7 ± 0.4 |

## REF v. HCP




| Site Type | Pre-harvest | Post-harvest |
|---|---|---|
| REF | 12.7 ± 0.4 | 12.5 ± 0.4 |
| HCP | 12.8 ± 0.5 | 12.5 ± 0.4 |

## REF v. PRE-ASP




| Site Type | Pre-harvest | Post-harvest |
|---|---|---|
| REF | 13.4 ± 0.5 | 13.1 ± 0.4 |
| PRE | 13.0 ± 0.6 | 13.3 ± 0.6 |

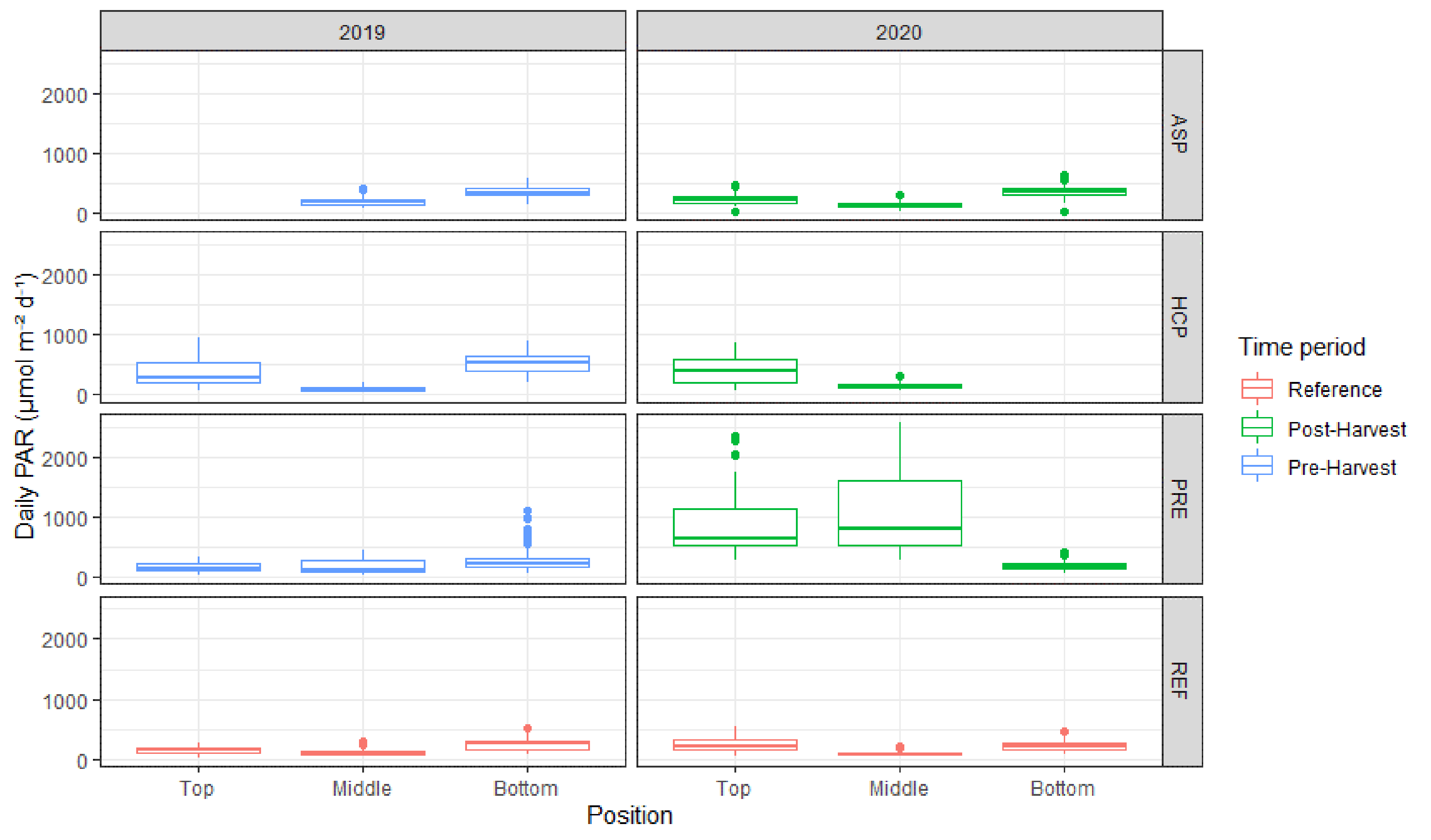
# PAR and Dissolved Oxygen

- DO sensors installed at outlet of all 18 catchments

- PAR sensors installed at outlet, mid-reach, and upper reach of all 18 catchments

- Sensors measure every 60 seconds and store data every 15 minutes

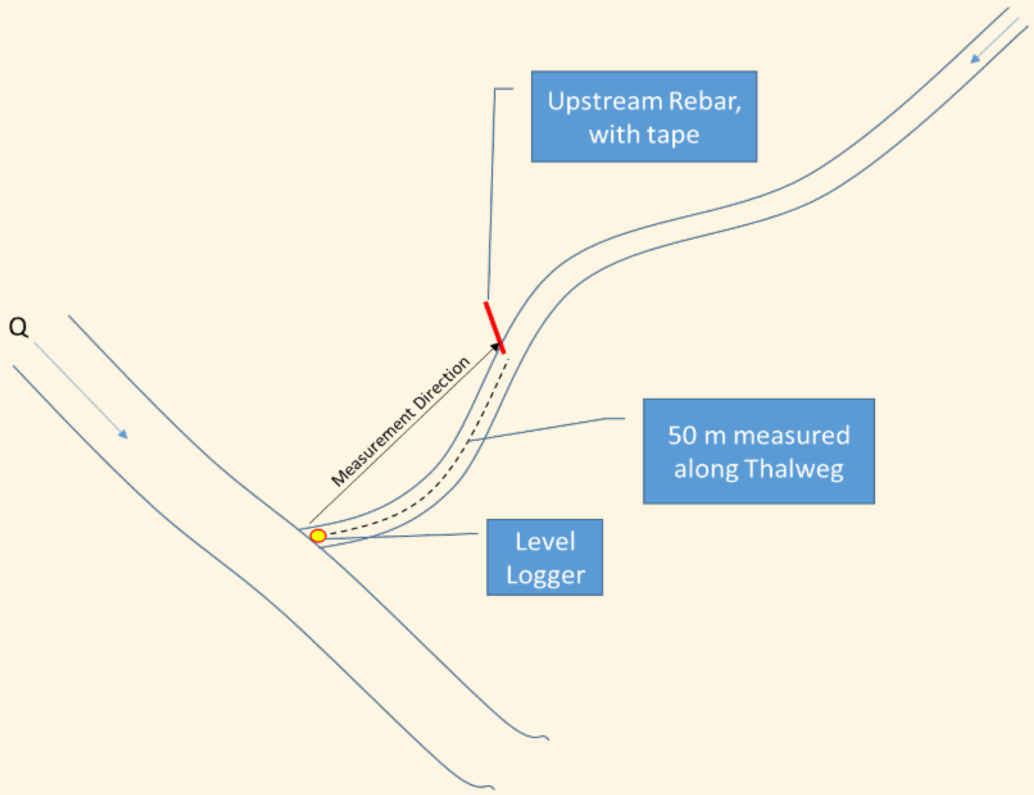

# Photosynthetically Active Radiation




| Site Type | Pre-harvest | Post-harvest | % Change |
|---|---|---|---|
| ASP | 245.8 ± 116.4 | 240.4 ± 116.6 | -2 |
| HCP | 377.8 ± 238.4 | 274.2 ± 203.5 | -27 |
| PRE | 205.9 ± 156.8 | 707.8 ± 608.0 | 244 |
| REF | 309.0 ± 440.6 | 332.8 ± 506.4 | 8 |

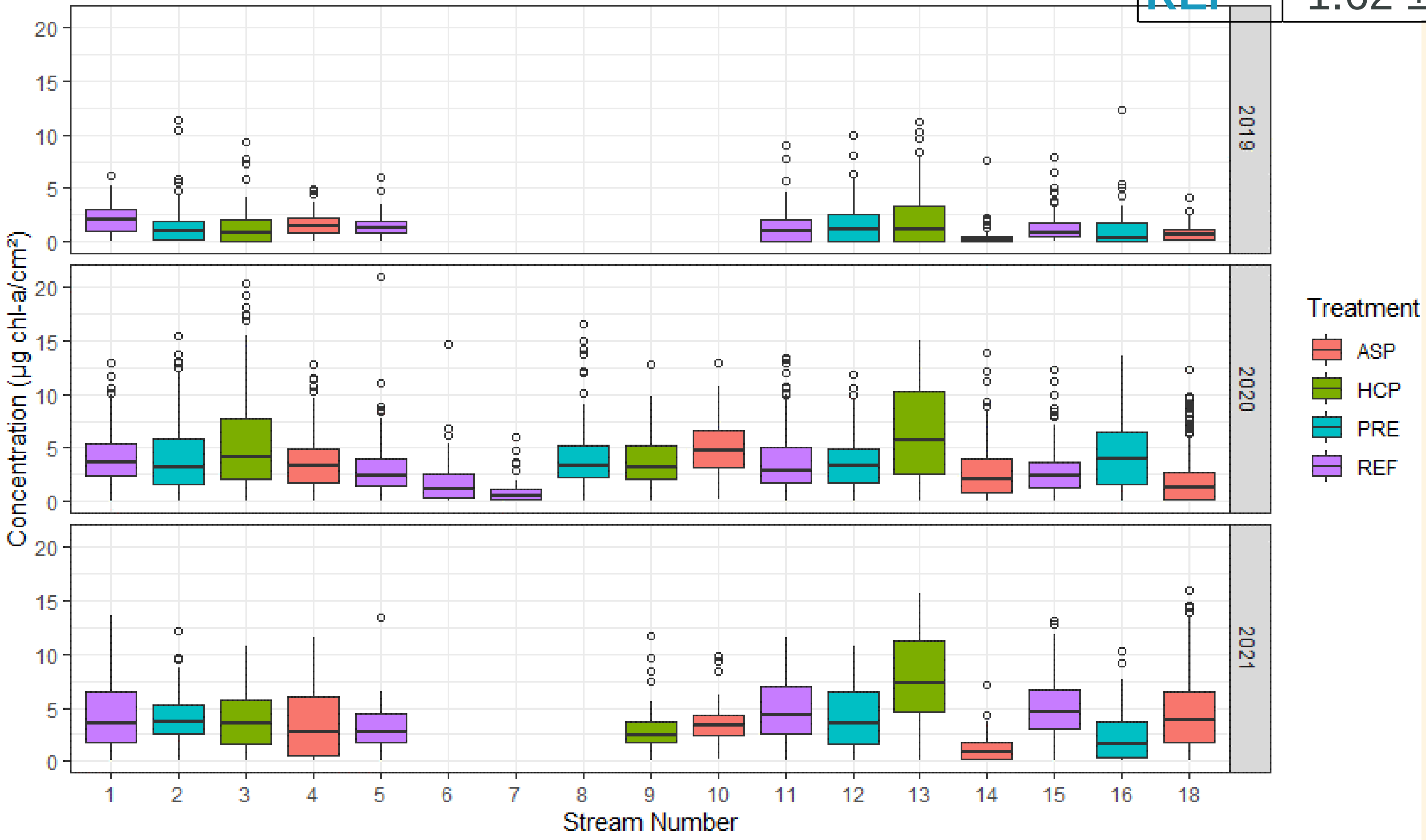
# *Primary productivity*

- benthic chlorophyll *a* concentrations of in-stream substrate
- 100 measurements per stream, measuring every 50 cm along the thalweg




# *Primary productivity*

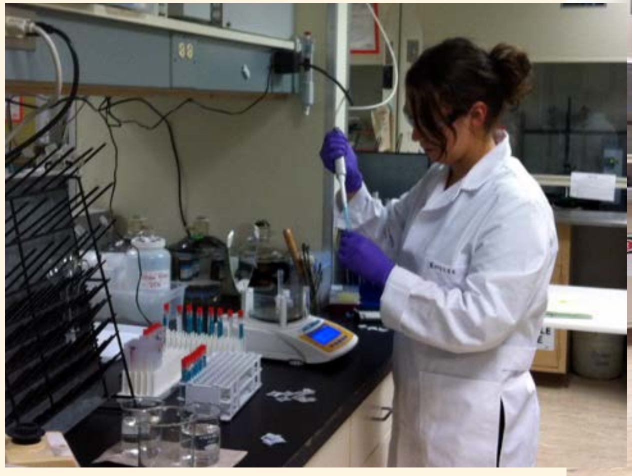
| Site Type | Mean chlorophyll-a (μg cm$^{-2}$) | | |
|---|---|---|---|
| | 2019 | 2020 | 2021 |
| ASP | 1.17 ± 3.18 | 3.37 ± 1.15 | 2.67 ± 3.03 |
| HCP | 1.76 ± 5.06 | 4.35 ± 2.29 | 3.85 ± 3.49 |
| PRE | 1.52 ± 3.95 | 3.48 ± 1.99 | 2.91 ± 2.71 |
| REF | 1.62 ± 3.06 | 4.48 ± 1.46 | 2.37 ± 3.11 |



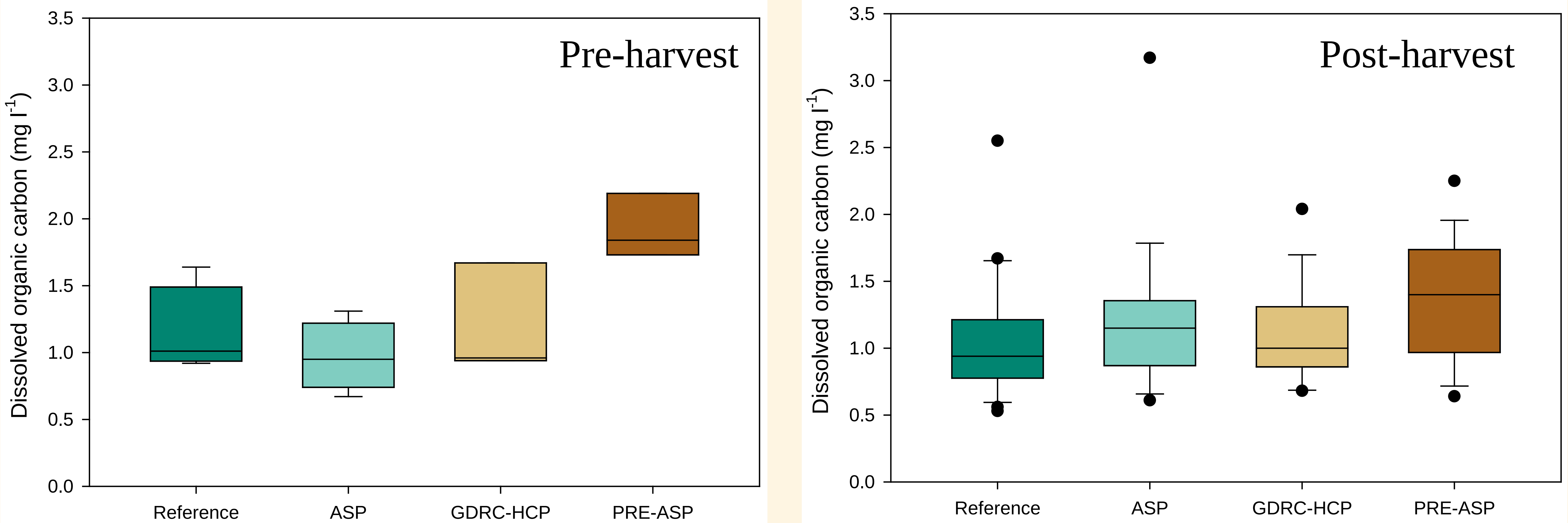
# *Chemical water quality*

- Monthly grab sample of water from each stream (Pre-harvest: 2019, Post-harvest 2020–2022)

- Analyzed in the laboratory for $NO_3^-$, $PO_4^{3-}$, and DOC

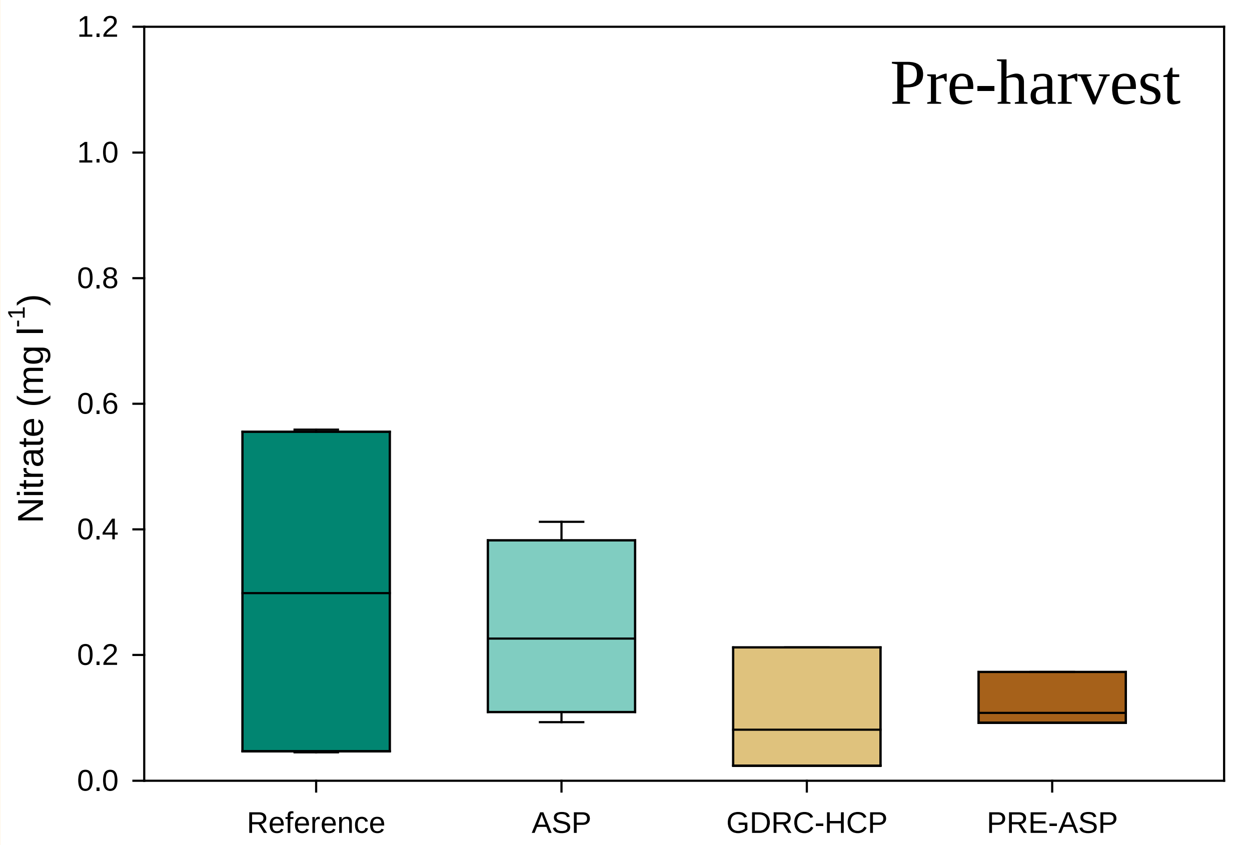


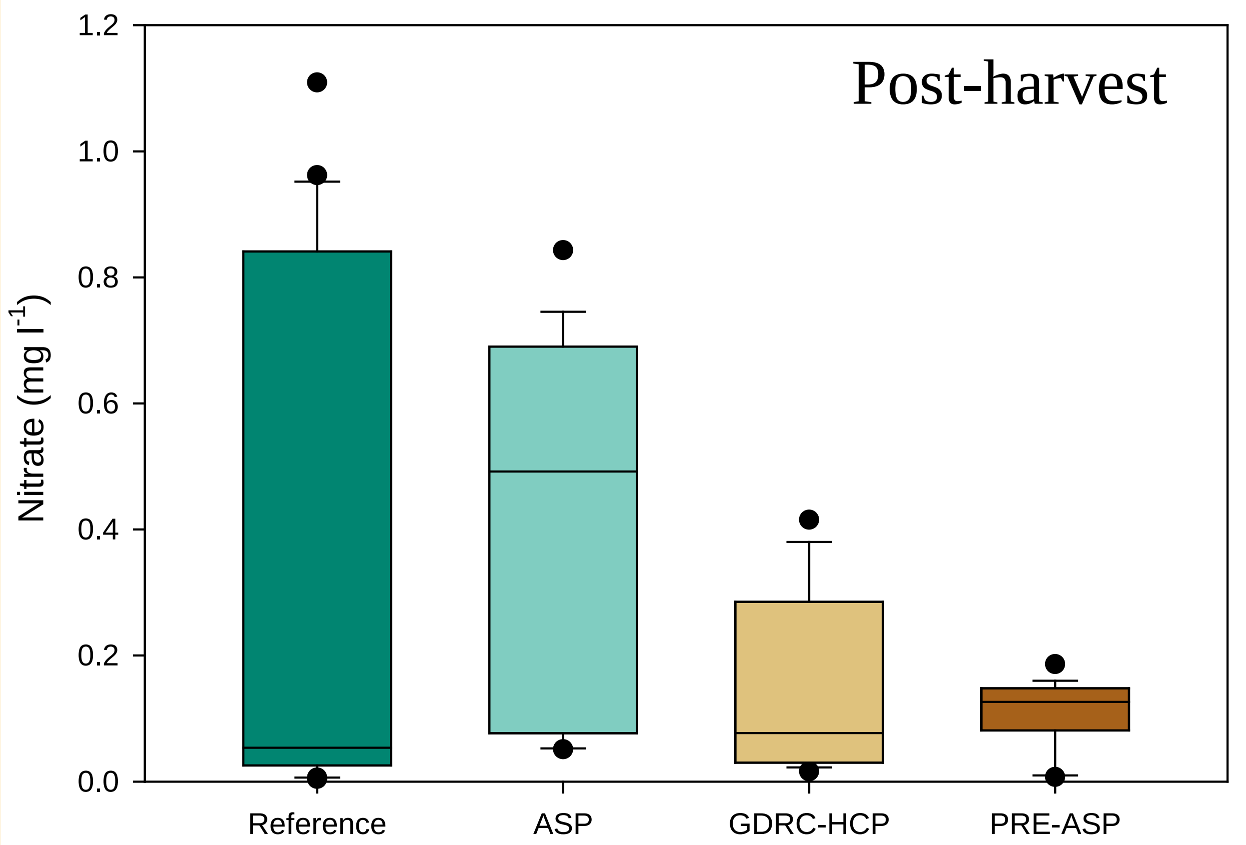
# *Chemical water quality – dissolved organic carbon*




- Reference: $1.06 \pm 0.46$ mg l$^{-1}$
- ASP: $1.07 \pm 0.28$ mg l$^{-1}$
- GDRC-HCP: $1.09 \pm 0.30$ mg l$^{-1}$
- PRE-ASP: $1.50 \pm 0.50$ mg l$^{-1}$

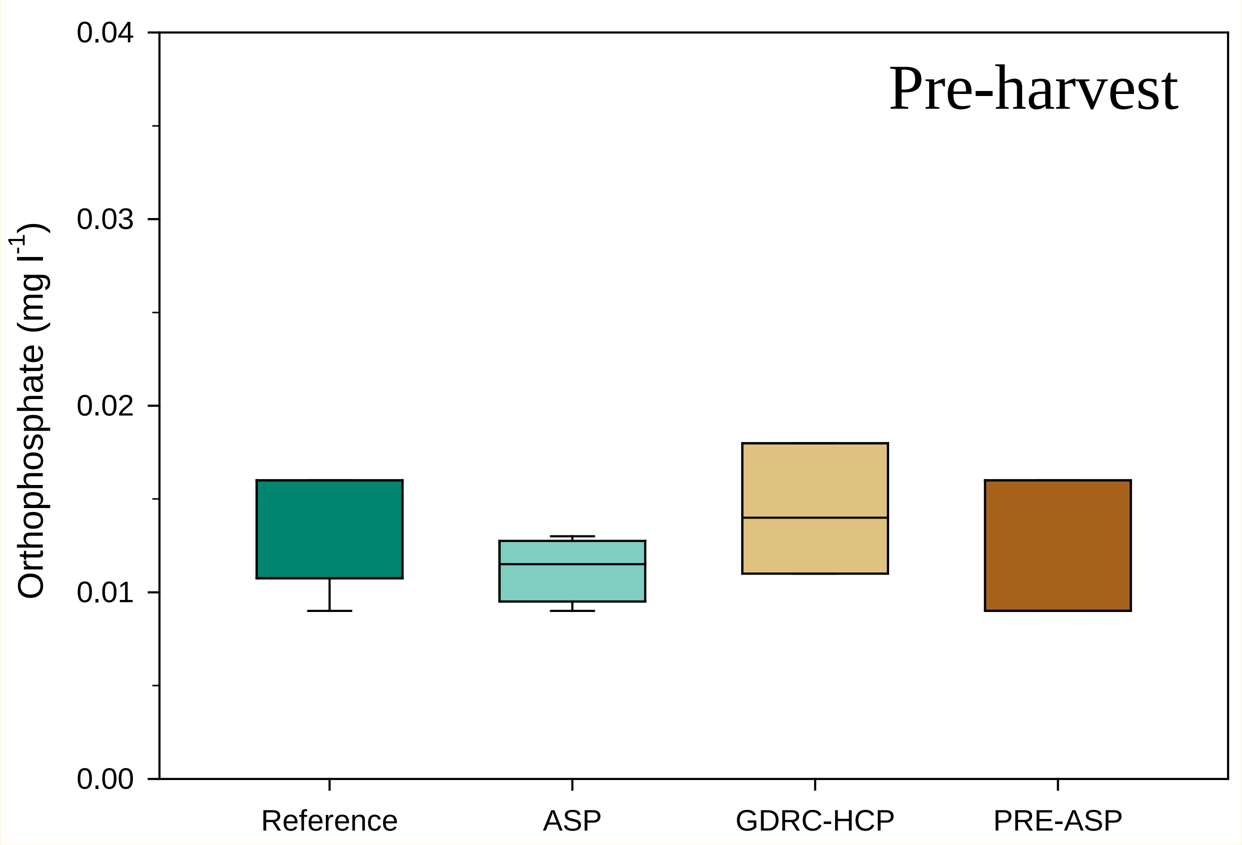
# *Chemical water quality – nitrogen*

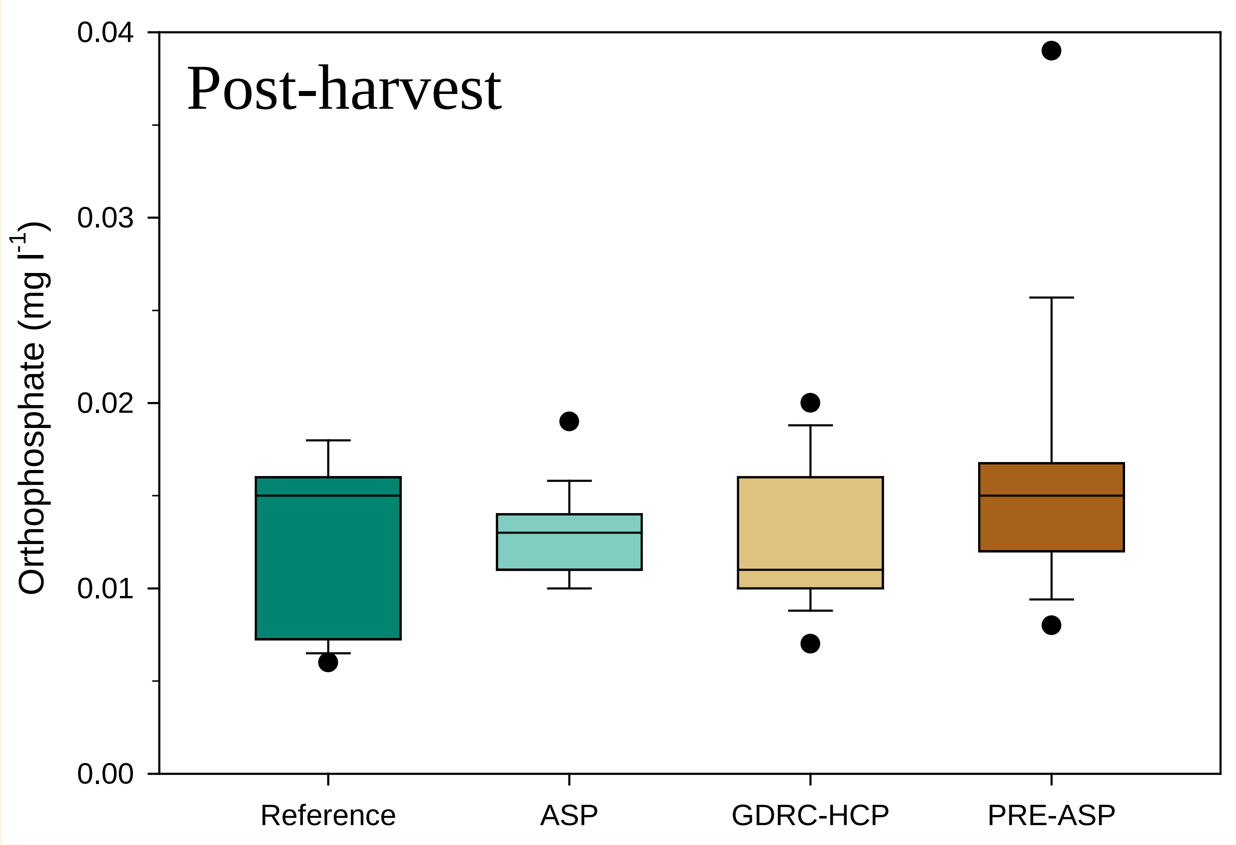



- REF: 0.34 ± 0.40 mg $l^{-1}$
- ASP: 0.35 ± 0.27 mg $l^{-1}$
- GDRC-HCP: 0.15 ± 0.14 mg $l^{-1}$
- PRE-ASP: 0.11 ± 0.05 mg $l^{-1}$

# *Chemical water quality –phosphorus*

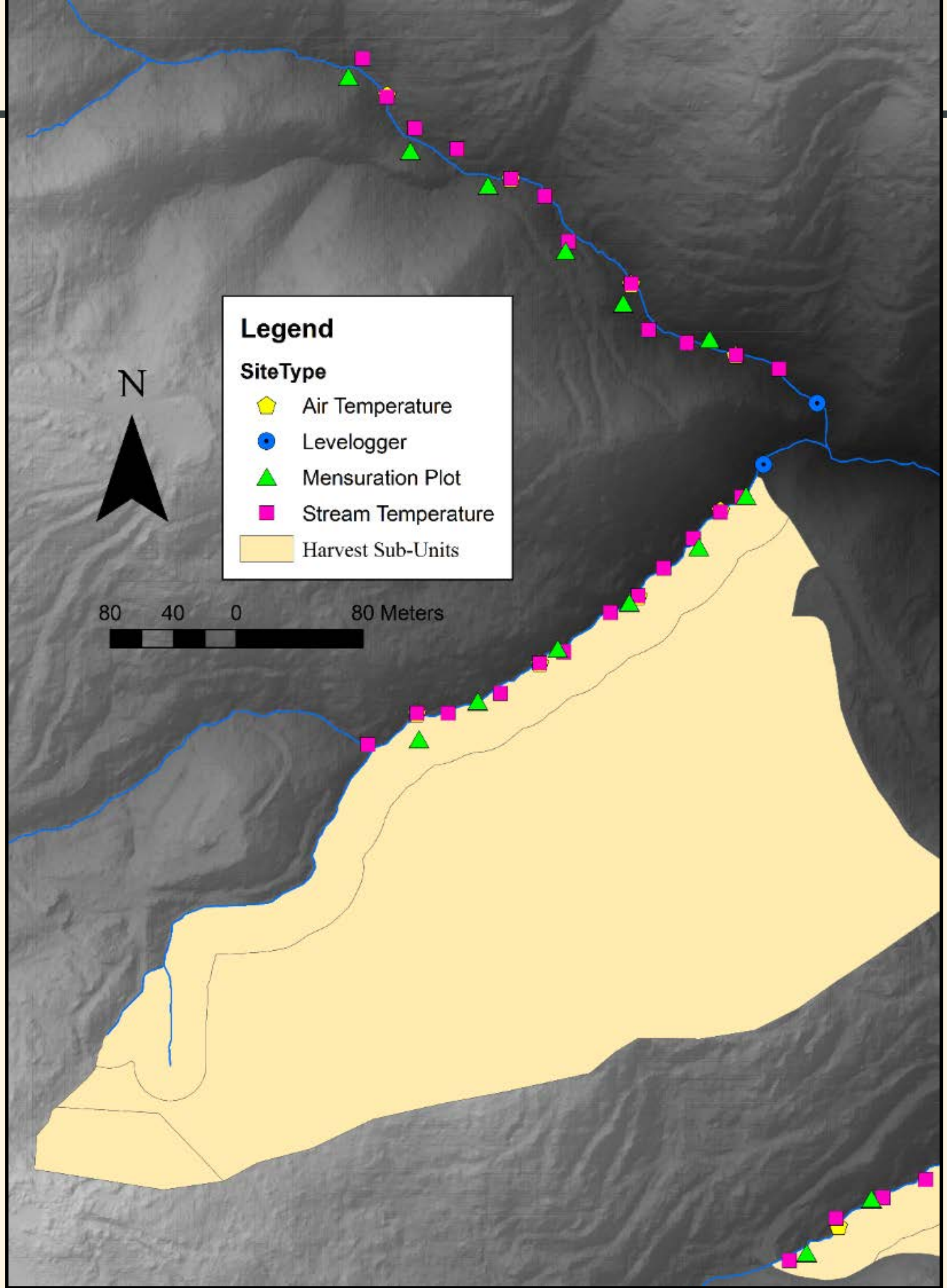



- REF: 0.013 ± 0.004 mg $l^{-1}$
- ASP: 0.012 ± 0.002 mg $l^{-1}$
- GDRC-HCP: 0.013 ± 0.004 mg $l^{-1}$
- PRE-ASP: 0.015 ± 0.0075 mg $l^{-1}$

# Sensor instrumentation summary

- Stream temperature (x 216)
- Air temperature (x 72)
- Streamflow (x 18)
- Dissolved oxygen (x 18)
- Photosynthetically active radiation (x 54)
- Benthic chlorophyll *a* (monthly)
- Water quality grab samples (monthly)
- Riparian mensuration plots (x 108)
- Meteorological stations (precipitation, air temperature, wind speed, wind direction, relative humidity, vapor pressure deficit, soil moisture)

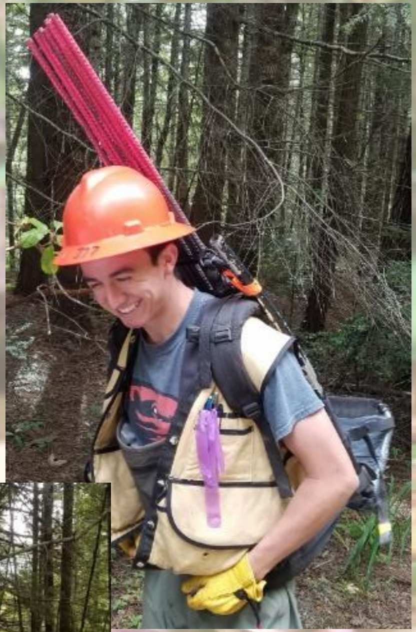


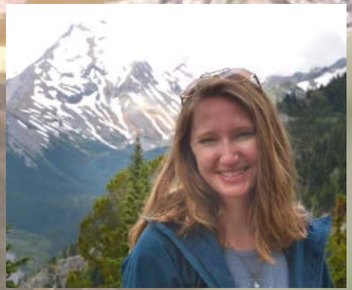
# Next steps…

- Continued data collection and sampling across all 18 catchments
- QA/QC and analyze post-harvest data
- Publish pre-harvest stream temperature manuscript from M.S. student Wissler (target early 2022)
- Publish streamflow response paper from M.S. student Nicholas (targe late 2022)
- Start of post-doctoral scholar in Oct. 2021 to complete longer term analysis:
    - Develop models to quantify and compare treatment effects on stream metabolism

# Acknowledgements

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Catalina Segura Lab

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