Spatial and seasonal variations in microplastic concentrations in Portland's freshwater

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Clackamas River Water Providers
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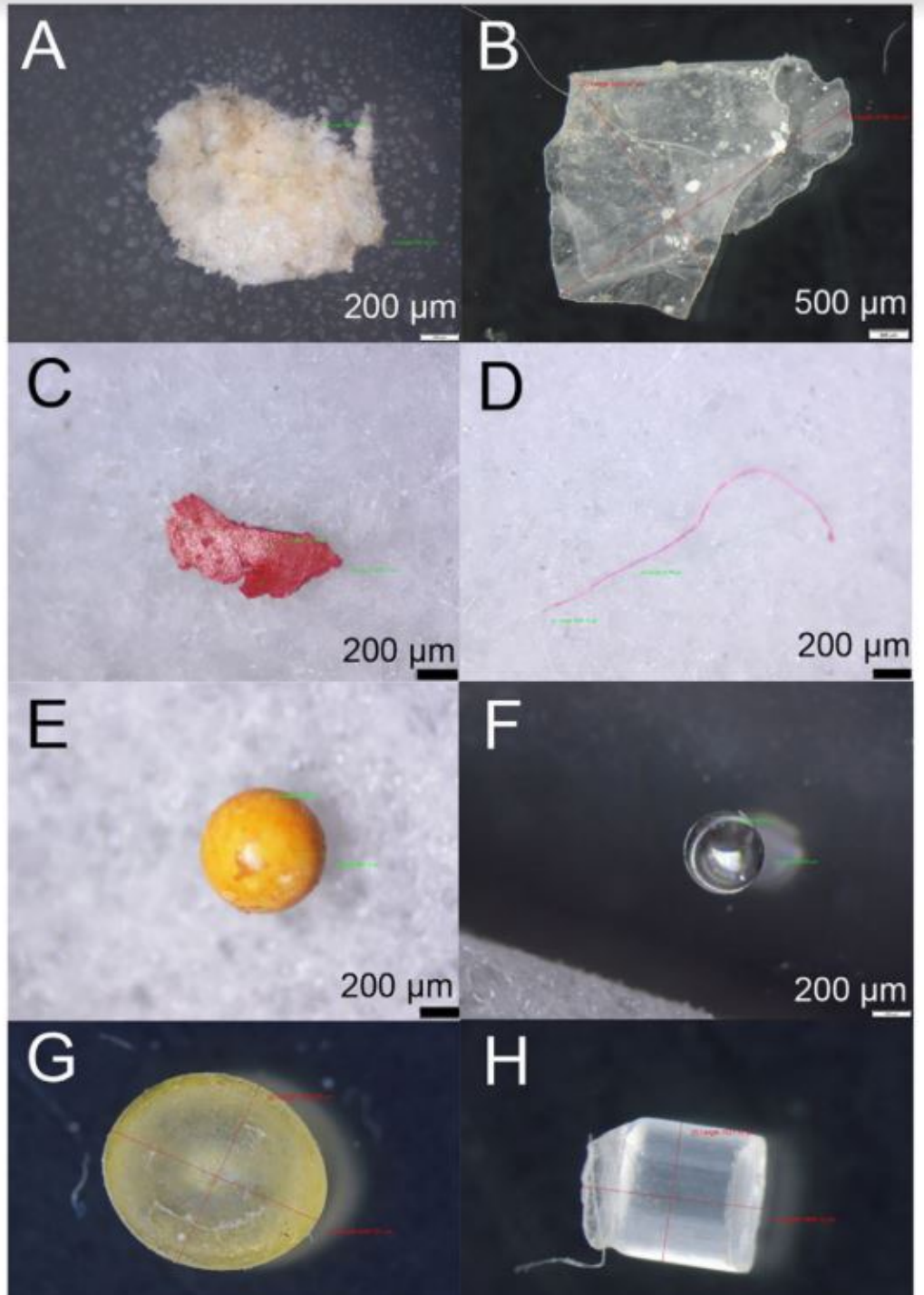
Microplastics

- Pieces of plastic ≤ 5mm
- Primary vs. secondary production (Horton et al. 2017)
- Various forms – fiber, fragment, film, foam, pellet
  - Can be indicative of sources (Xiong et al. 2019)



Mani and Burkhardt-Holm 2020

Links with Spatial Factors

- Urban land use
  - Plastic production, hotspots for litter (Deng et al. 2020)
  - Wastewater treatment plants (McCormick et al. 2016)
- Population density (Fan et al. 2019, Grbić et al. 2020
- Agricultural land use
  - Biosolids (Mahon et al. 2017)
  - High plastic use (Campanale et al. 2020)

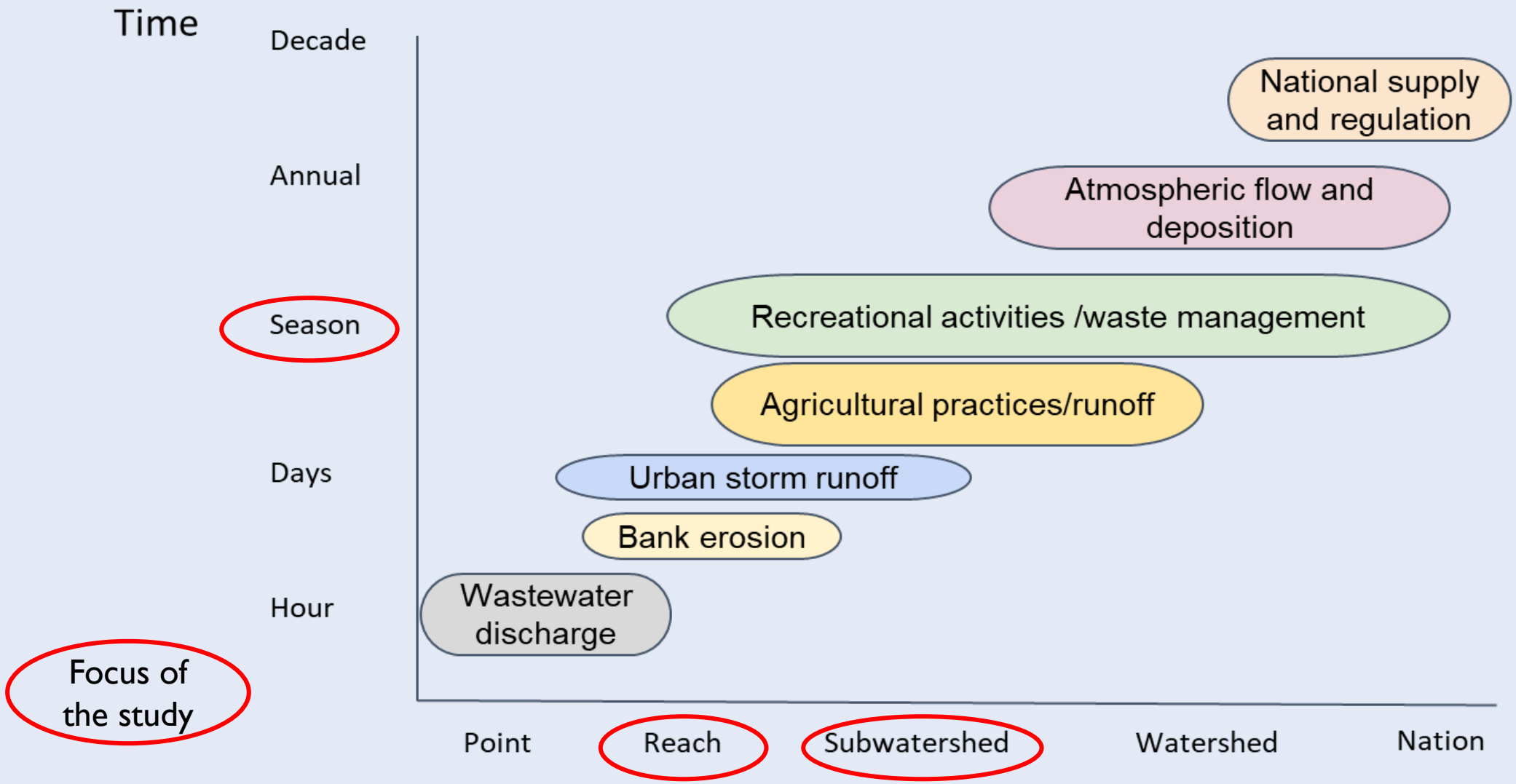
Links with Temporal Factors

- Seasonality and precipitation
  - Variations in MP concentrations between dry and wet seasons (Campanale et al. 2020, Eo et al. 2019)

- Flow rates
  - Lower flow rates → Accumulation of MPs (Barrows et al. 2018, Kapp and Yeatman 2018)

Photo: B. Talbot

Scale issues



Source: Talbot and Chang 2022

Research Questions

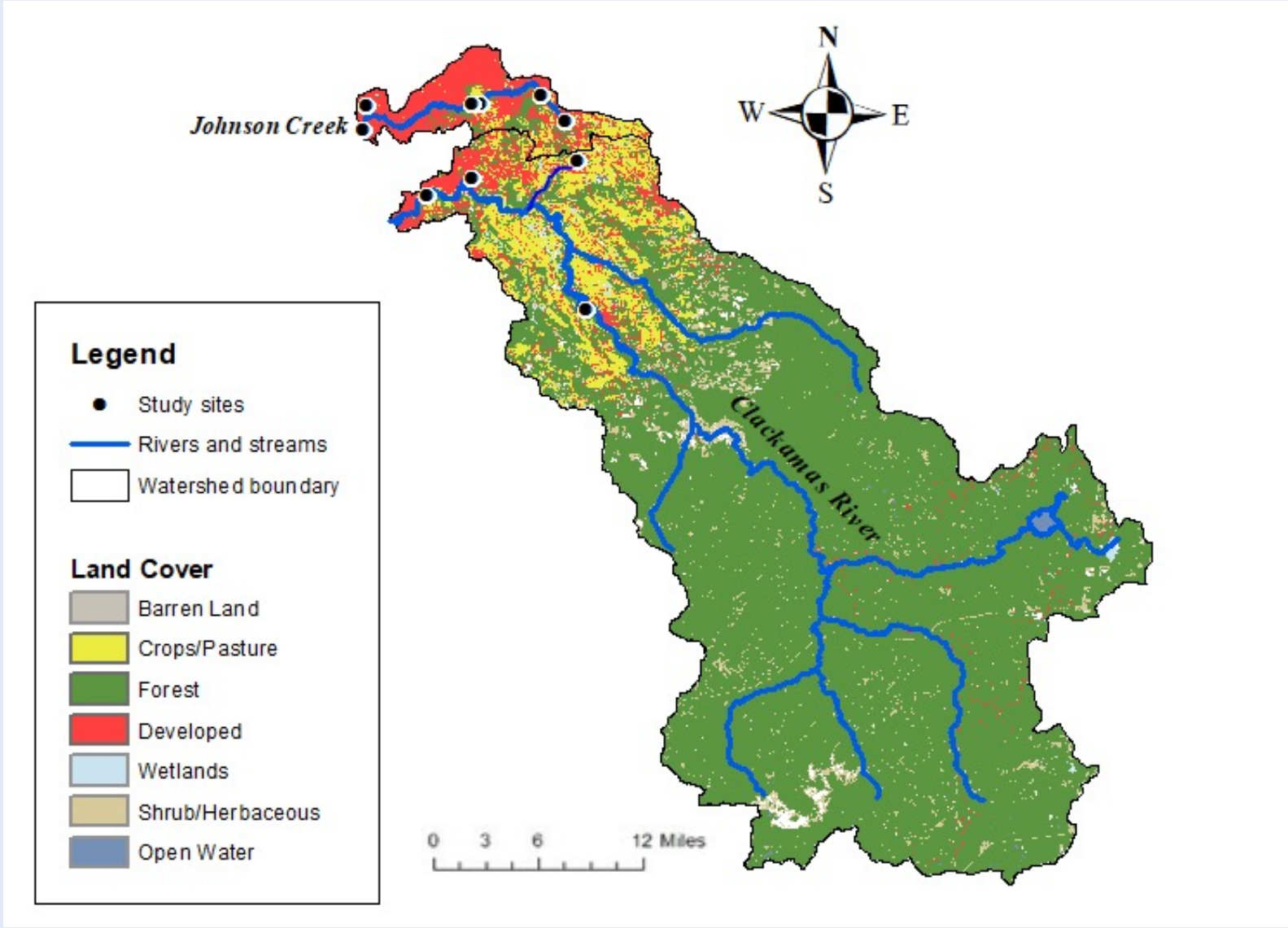
- *Examine MP spatiotemporal distributions in Portland watersheds that have varying degrees of urban development and differing land cover types at different spatial scales*

  - How are MP concentrations influenced by:
    - Watershed attributes (e.g., land use, elevation)
    - Seasonality (Flow rate and precipitation)

  - What morphologies of MPs are present, and what ties can be made to potential sources?

Study Area

- Johnson Creek watershed
  - Telford
  - Regner
  - Kelley Creek
  - Sycamore
  - Milwaukie
  - Crystal Springs Creek
- Clackamas watershed
  - Estacada
  - Deep Creek
  - Rock Creek
  - Near Oregon City



Data Collection

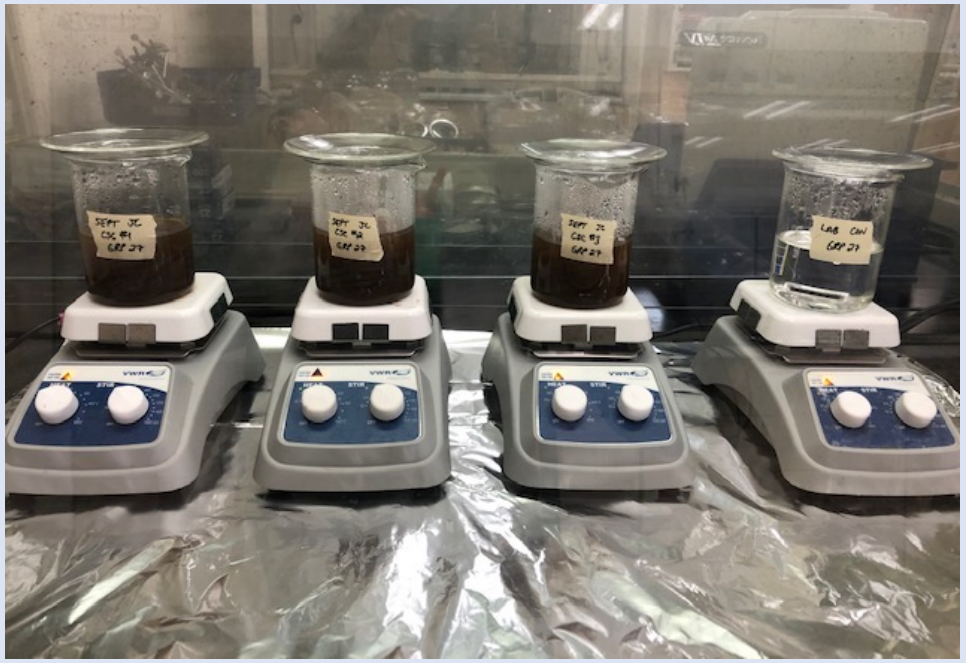
- Surface water samples
  - Plankton tow net (mesh = 64µm) equipped with flow meter
  - Samples collected for 15-minute intervals
  - 3 samples/site

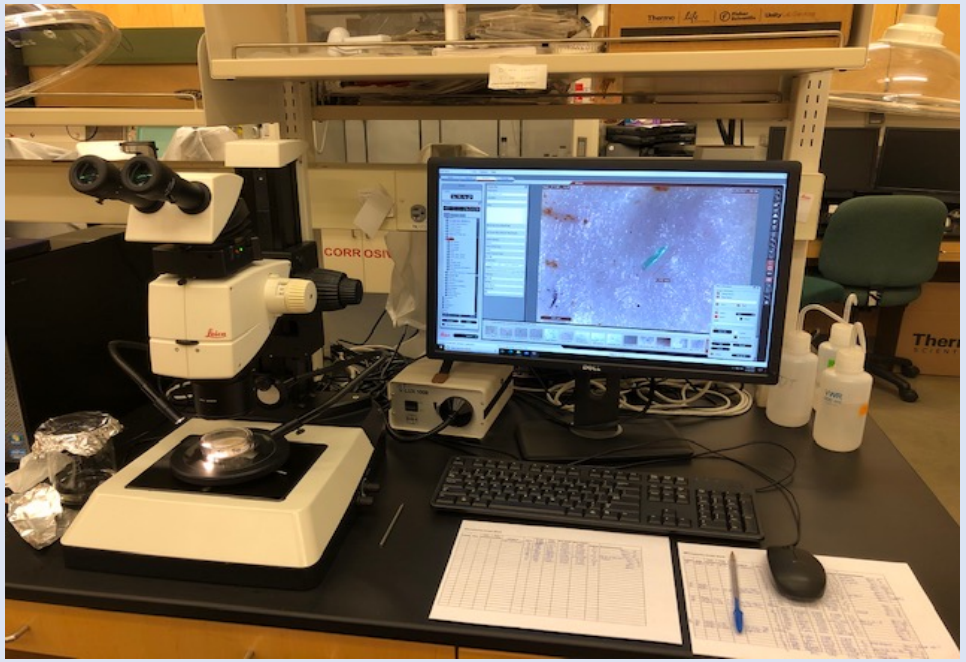
- 3 sampling sessions
  - Dry season – August
  - Wet season – September and February

Photo: E Granek

Sample Analysis

- Organic matter digestion
  - 10% KOH solution
- Density separation
  - Hypersaline solution
  - Vacuum filtration
- Microscope analysis
- µFTIR analyses
  - Identify specific polymers



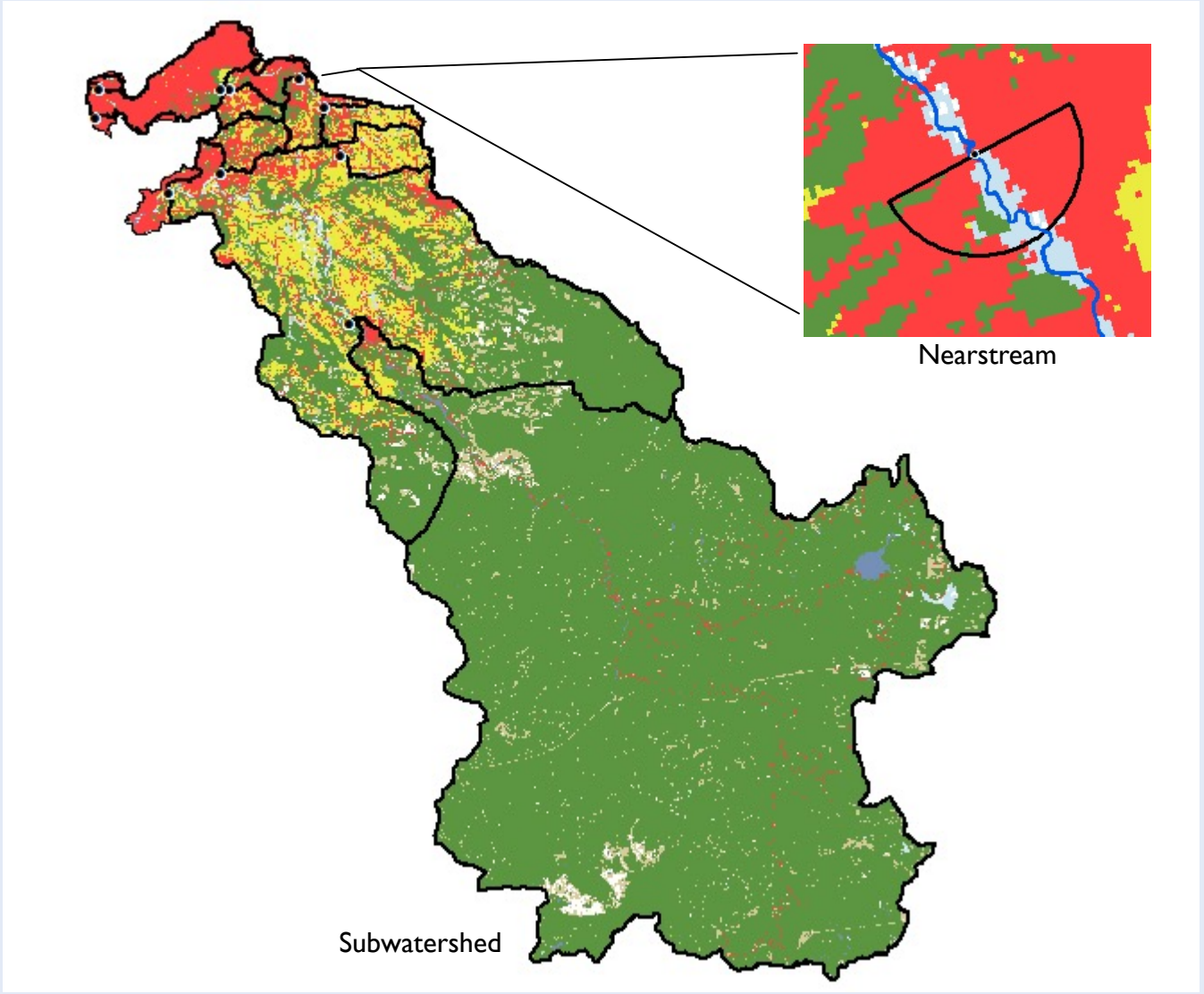


Photos: B. Talbot

Data Analysis

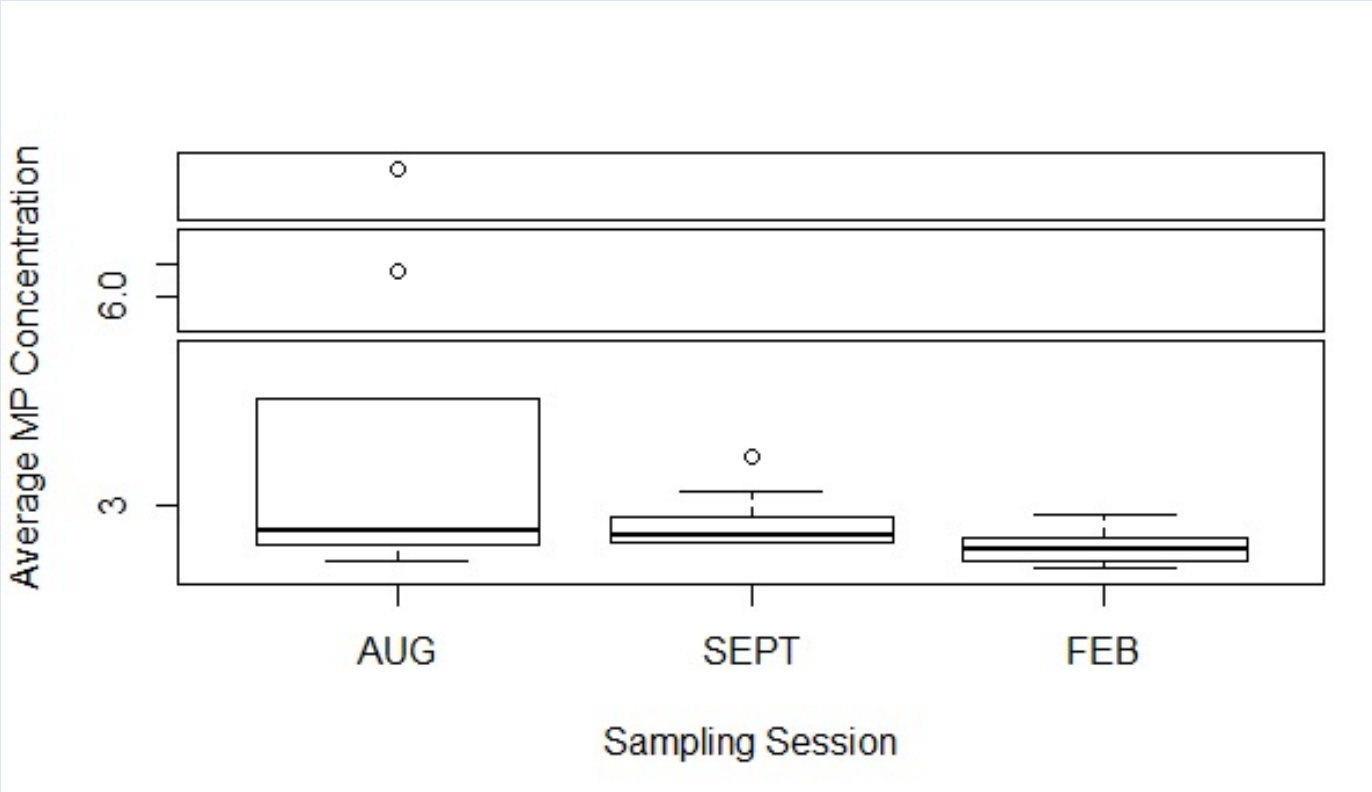
- Nonparametric statistics
  - Kruskal-Wallis for seasonal comparison
  - Spearman rank for relating MP to watershed variables

- Two spatial scales of analysis
  - Subwatershed (delineated in ArcGIS)
  - Nearstream (500m upstream buffer)



Results: Influence of Seasonality

- MP concentrations vary across seasons
  - Significant differences in MPs between August and February ($H = 6.1342$, $p < 0.05$)
    - Dry season – potential accumulation of MPs
  - No significant first flush effect observed



Flow and Precipitation

- Flow rate
  - Negative correlation between flow rate and MPs in August ($r = -0.85$, $p<0.05$)
    - Decreased flow rate facilitated the accumulation of MPs
  - Wet season - no correlations observed between MPs and flow
- Precipitation
  - Positive correlation between MPs and antecedent precip (24hr) in February

August

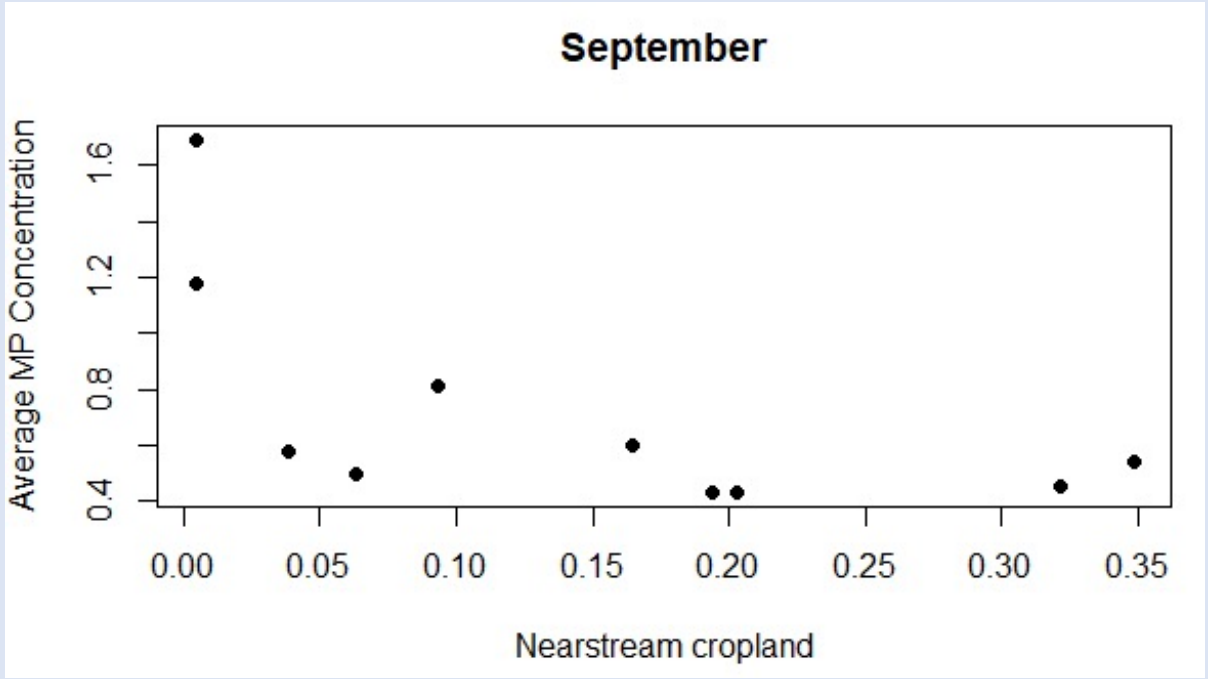
February

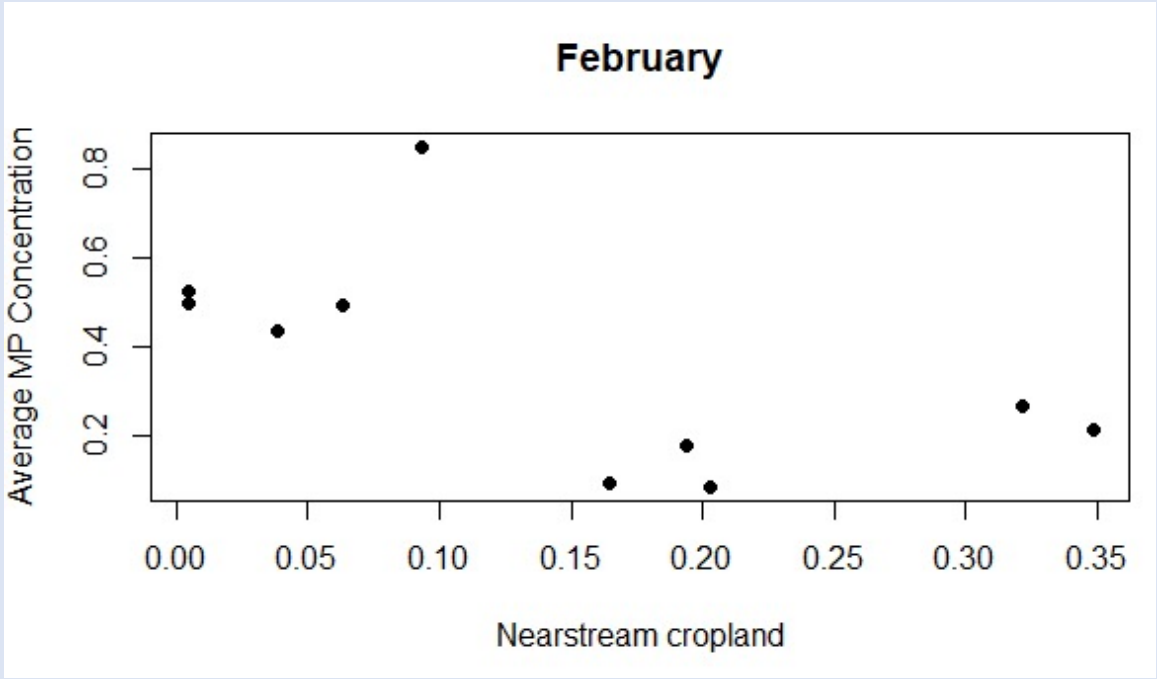
Johnson at Sycamore

Photos: R. Wood, B. Talbot

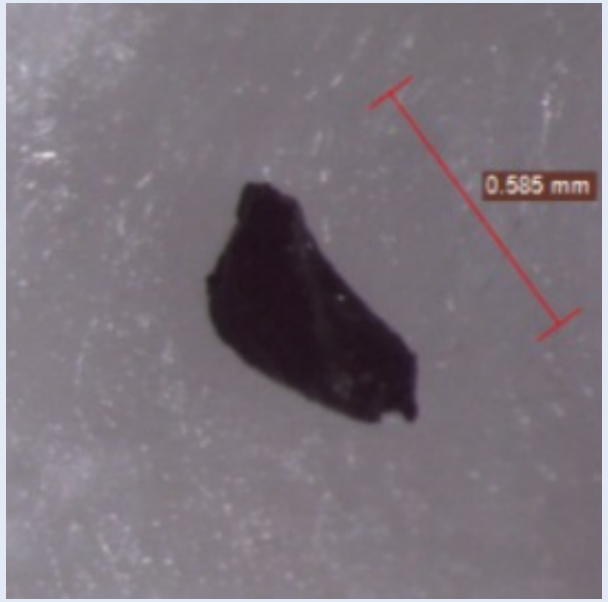
Land Cover

- Nearstream scale
  - Negative correlation with agricultural lands
    - September ($r = -0.72$, $p < 0.05$)
    - February ($r = -0.67$, $p < 0.05$)



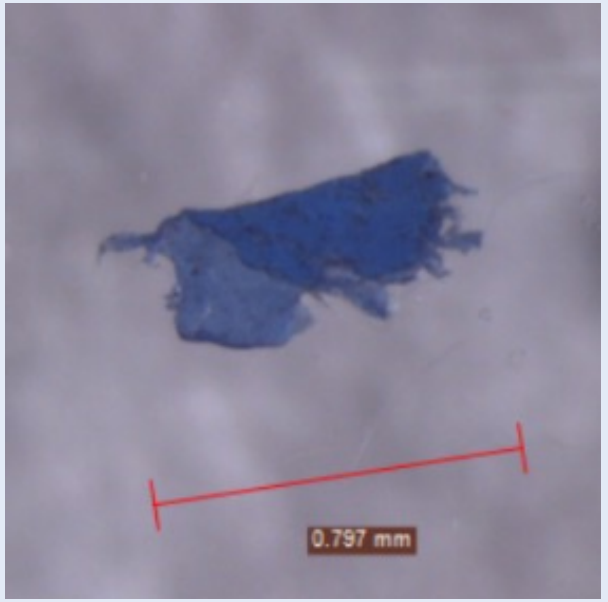


Microplastic Morphologies

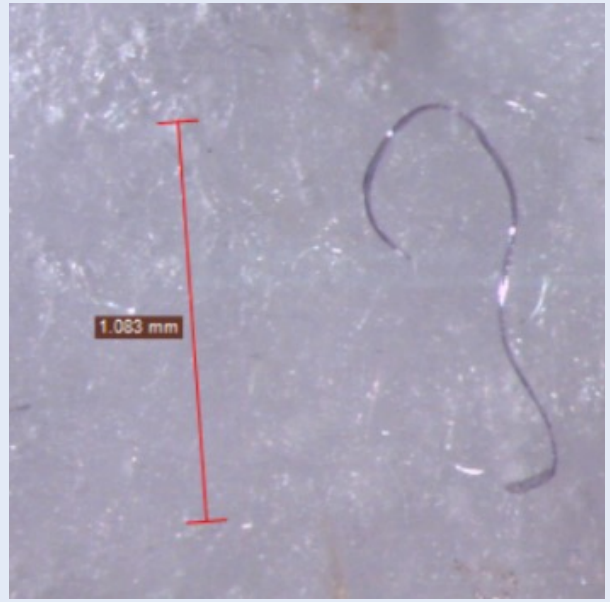


Foam

Fragment



Film



Fiber

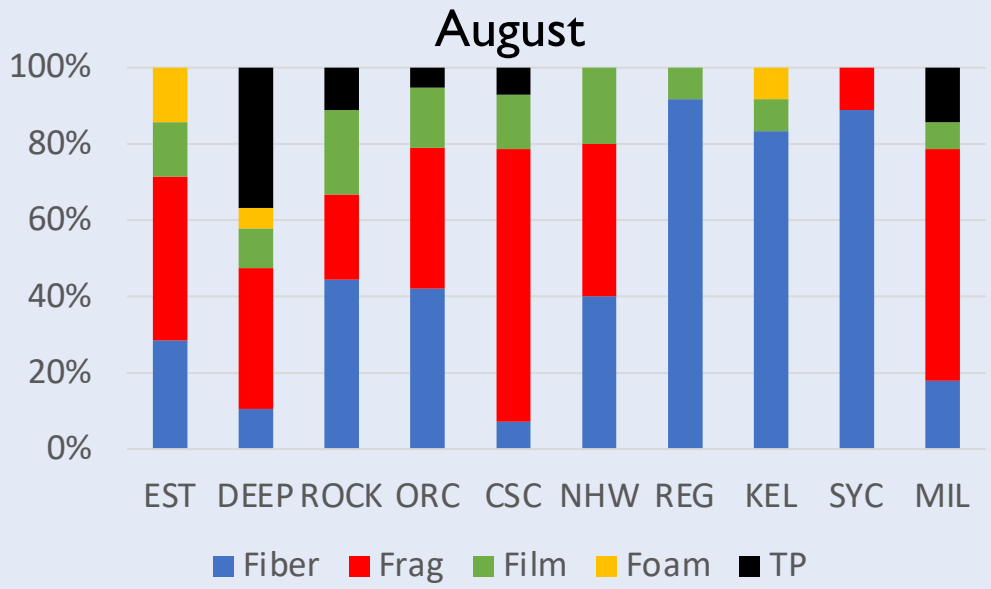
Photos: B. Talbot

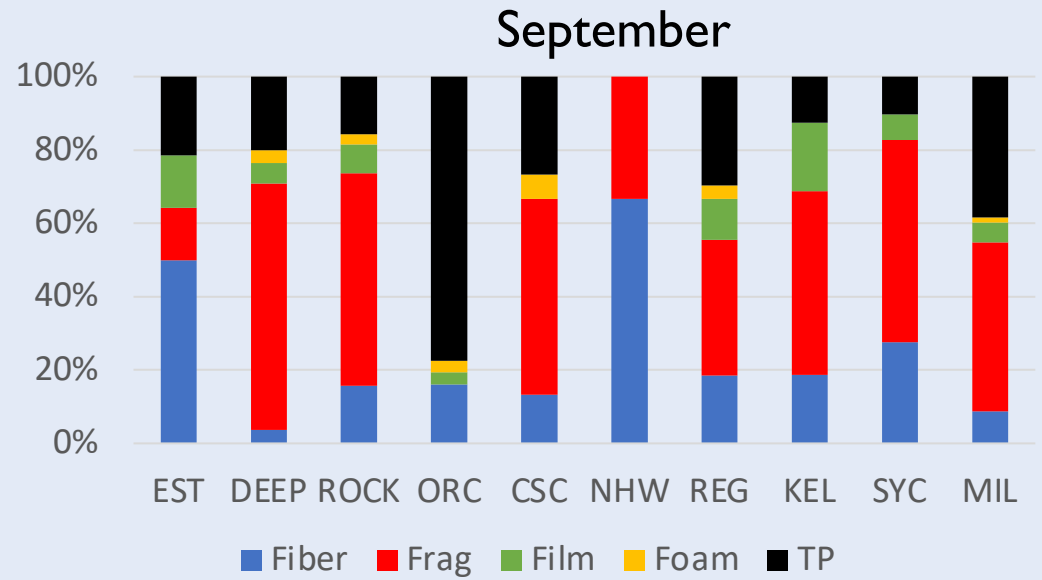
Tire Wear Particles (TWP)

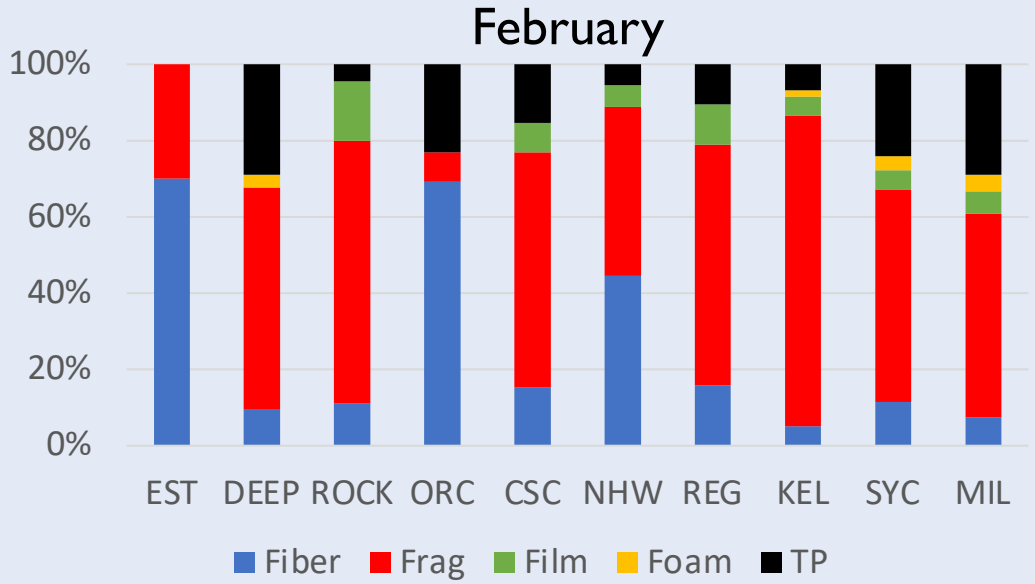
- Significant difference in TWP concentrations between August and September
  - TWPs flushed into waterways at the onset of the wet season
  - Pose a severe threat to salmon (Tian et al. 2020)

Photos: B. Talbot

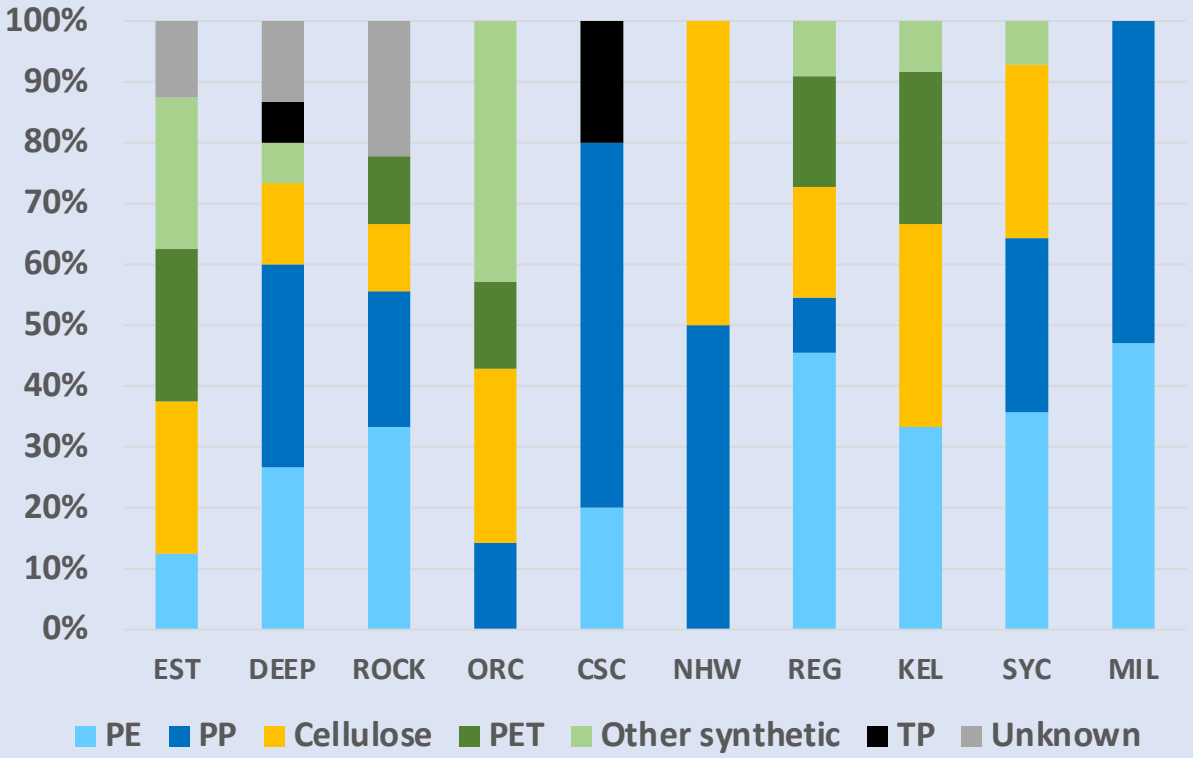
Microplastic Morphologies



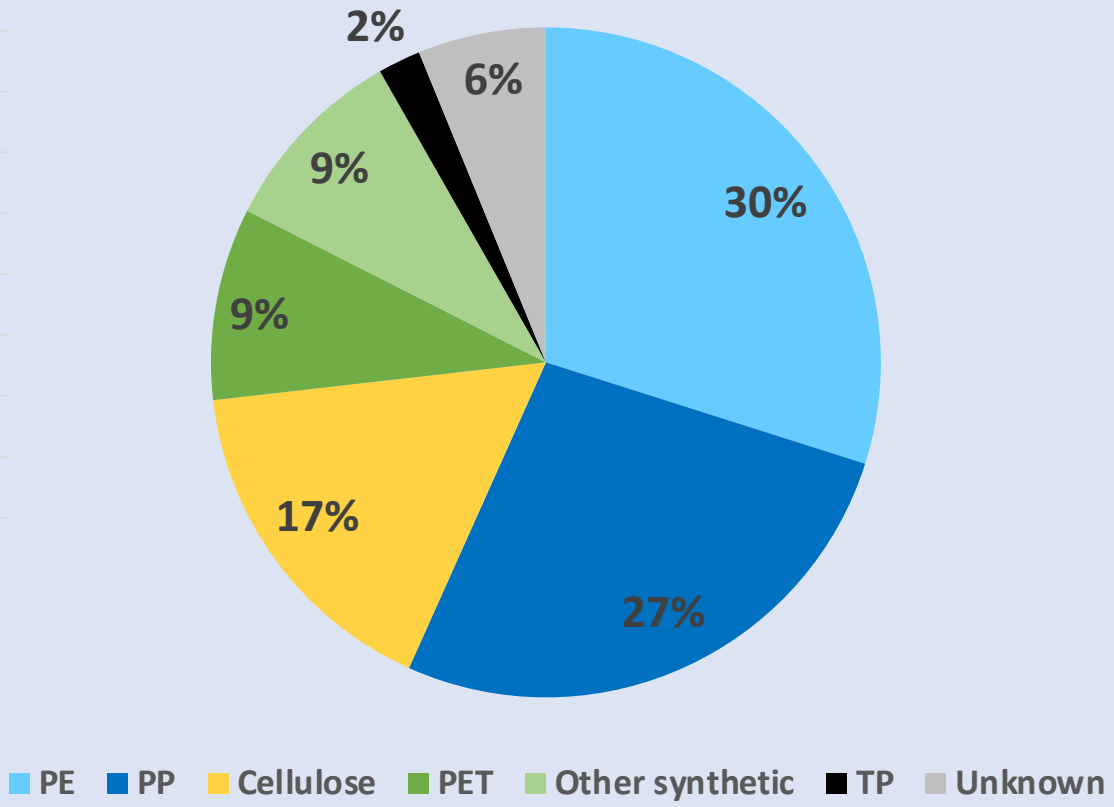




Polymer Identification



- Polyethylene (PE): Plastic bags
- Polypropylene (PP): Packaging materials, clothing
- PET (Polyethylene terephthalate)
  - Plastic bottles



Summary

- Links with several spatial and temporal variables
  - Not necessarily true for every sampling session
- Importance of nearstream analyses and emphases on specific point sources (Barrows et al. 2018, Dikareva and Simon 2019)
- Early rains flush tire wear particles into freshwater environments
- Fragments and fibers were the dominant microplastic morphologies
- Polyethylene and polypropylene were the most common polymers
  - Consistent with previous research (e.g., Fan et al. 2019, Xiong et al. 2019)

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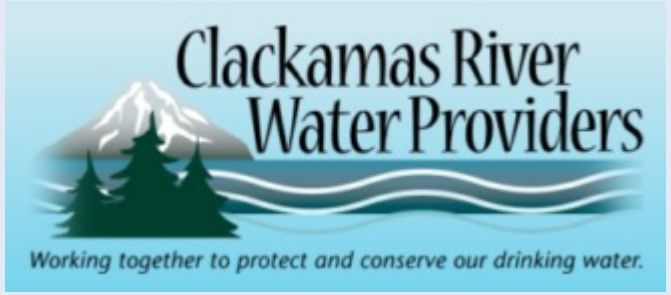

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