Steady flows, unsteady habitat: the role of watershed disturbance and dynamic channel morphology in varying salmon habitat through time at Carnation Creek, B.C.

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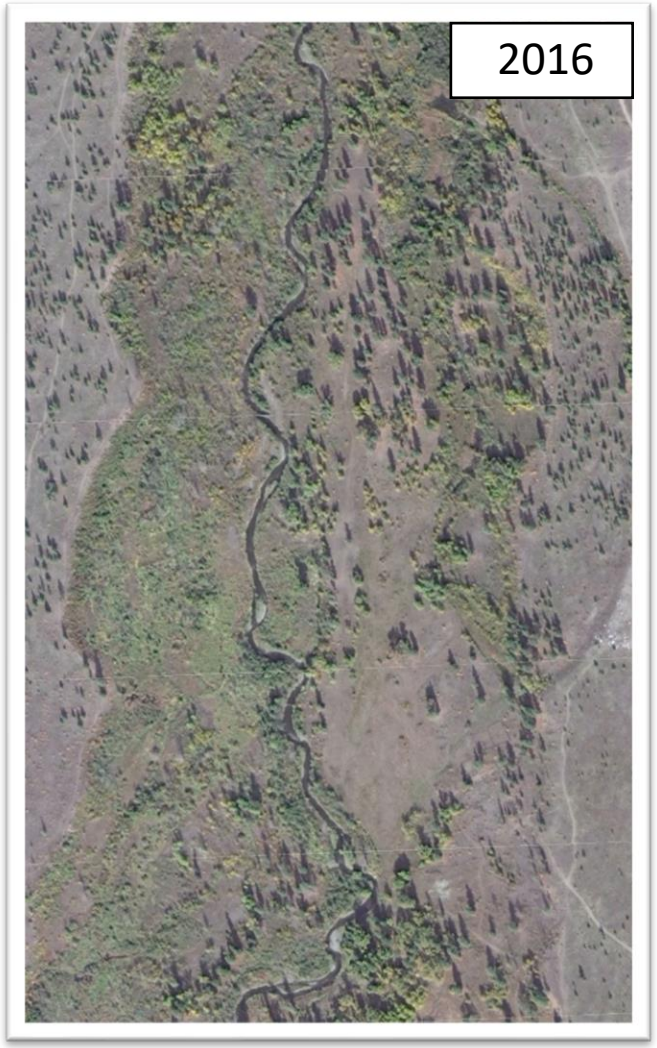
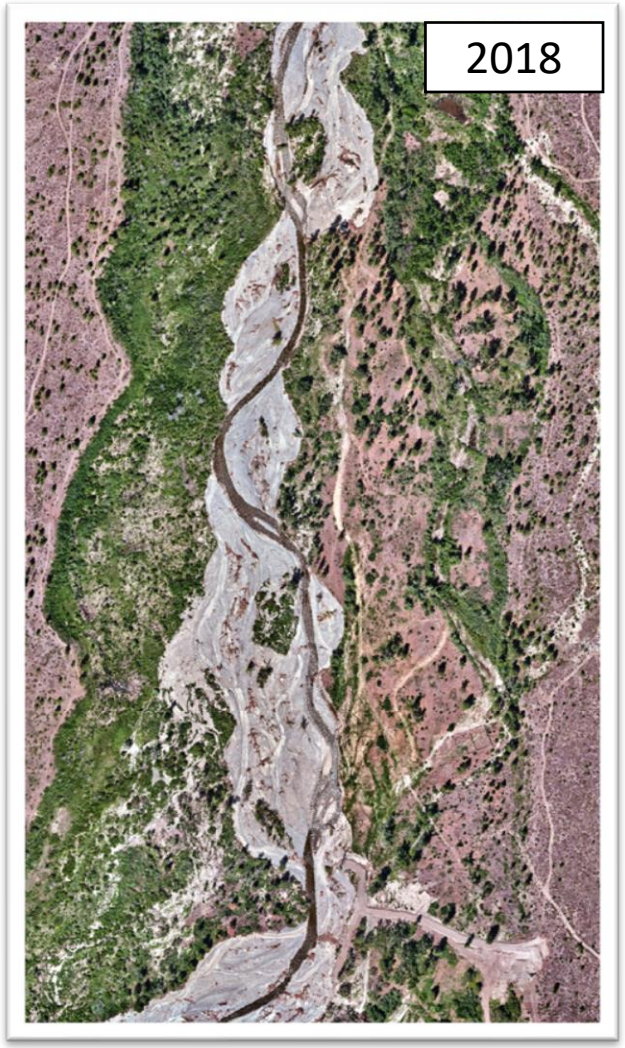
AFS Virtual Spring Conference, April 2020

Background





Guichon Creek, B.C. Images courtesy of Hyrum Peterson

- Land cover change and natural watershed processes lead to variation in stream channel form.
- Changes to channel morphology and geometry (i.e. channel dimensions and topography) will result in different local flow conditions.
- Changes to local flow conditions and physical channel structure are important for aquatic habitat.
- Likely implications for decision-making around environmental flows.

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Research questions

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1. For a given flow level, how much variability in habitat can changes in channel morphology/wood abundance induce? (do flow-habitat relationships remain static through time?)

2. Can historical forest practices (i.e. catchment and riparian logging) lead to differences in habitat availability at a given flow level?

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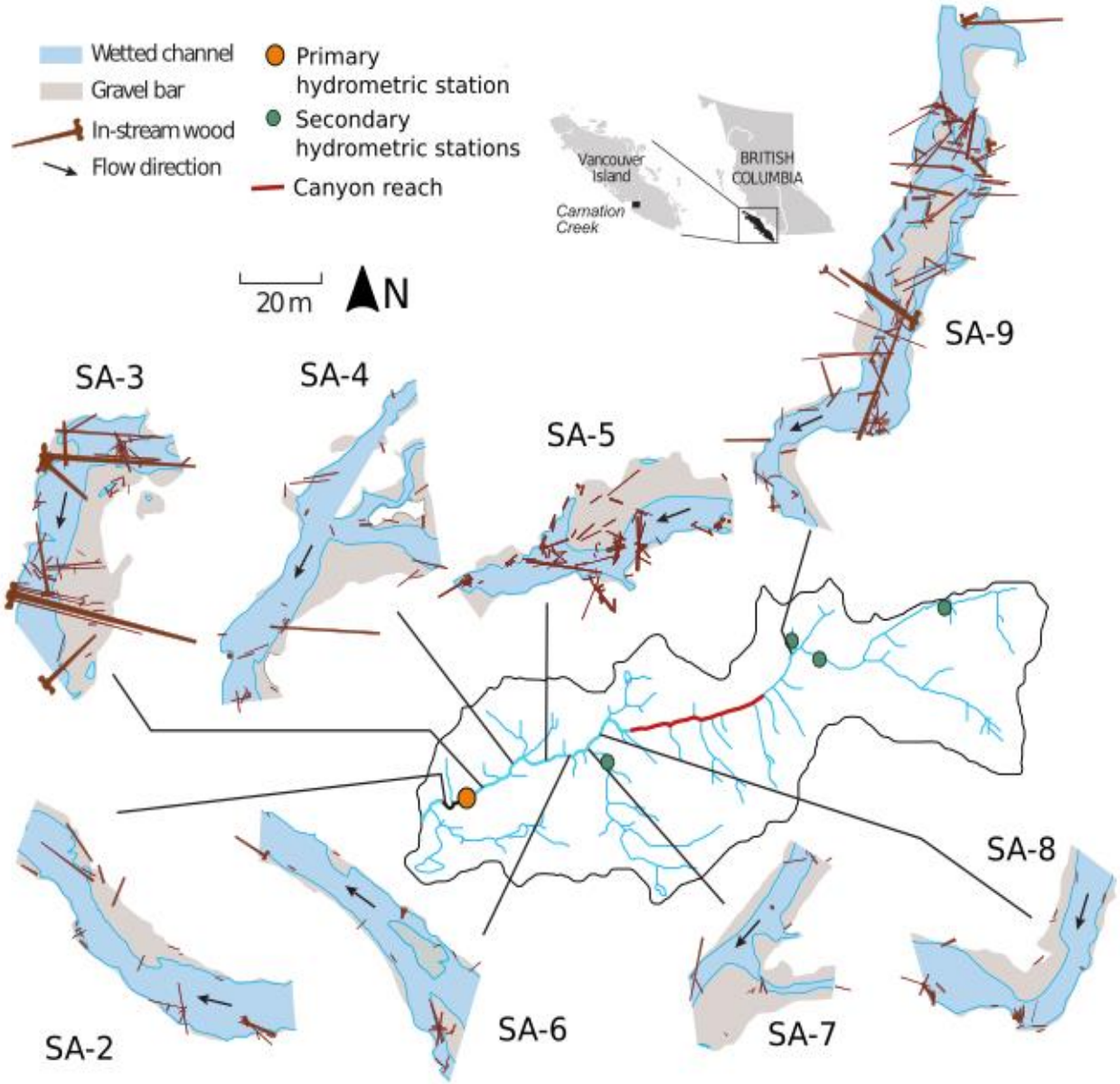
Study area and data

- 11 km^2 coastal temperate catchment
- Coho/chum stream
- Studied since 1970, data collection ongoing
- 45-year record of annual surveys in eight channel sections:
  - Channel topography
  - In-stream wood
- Logging in riparian zone and throughout watershed



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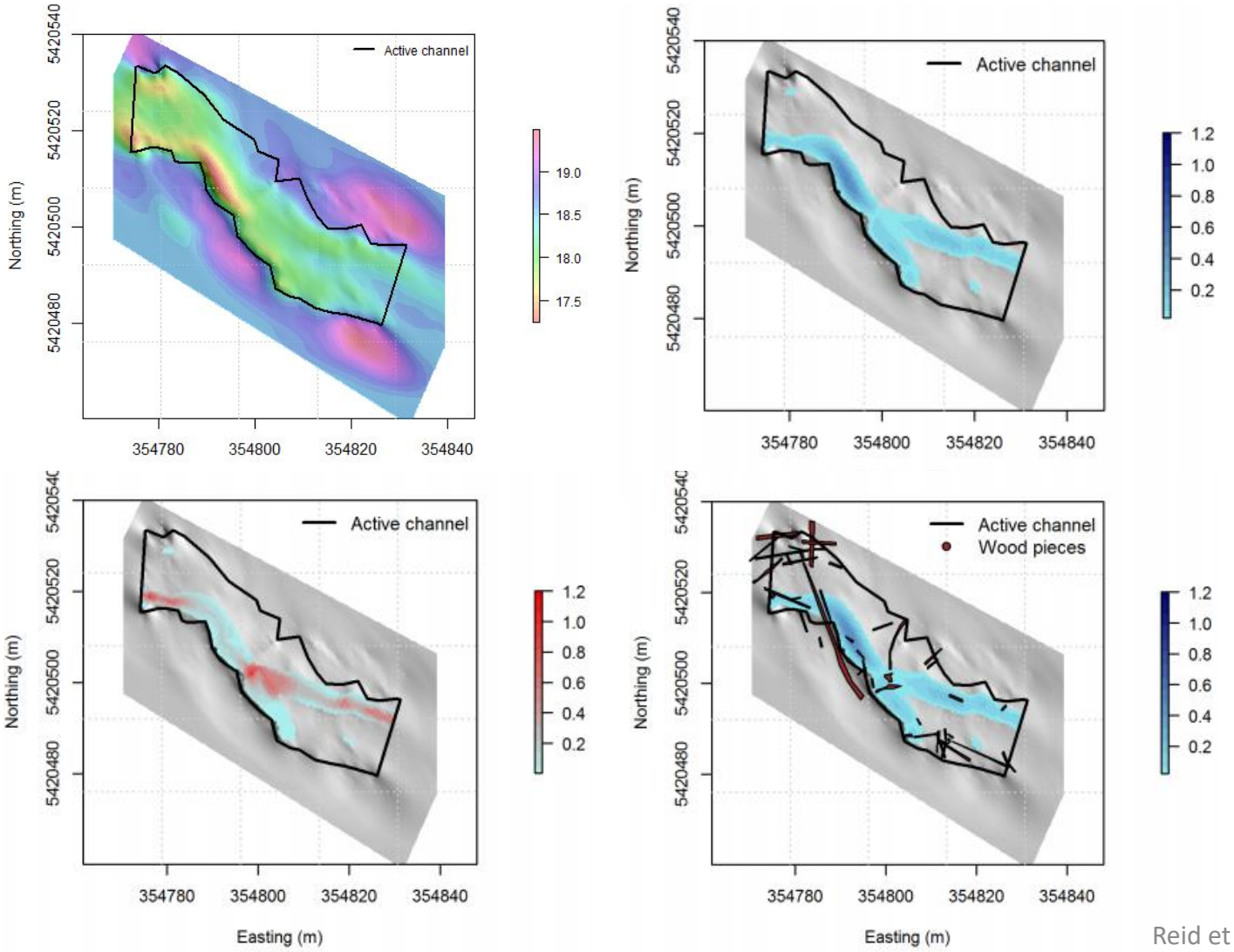
Methods: hydrodynamic modeling



- Use Nays2DH model
- Simulate 9 flow levels: (7Q10 to 400% mean annual discharge)
- Annually varying bed topography: 45 year record x 8 sites x 9 flow levels = >3000 simulations
- Model output evaluated against field depth and velocity measurements

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Methods: data analysis

Variable	Definition
Wetted width (m)	Wetted area / reach length
Shallow wetted areas	Flow depth < 0.1 m
High-velocity flow areas	Velocity > 0.6 m/s
Pool area	Depth > 0.1 m, Velocity 0.3-0.6 m/s
Pool area with wood cover	Pool areas overlain by wood pieces

California Department of Fish and Wildlife, 2020

- Variables of interest
  - Focus on juvenile coho
  - High-value and marginal habitat
- Non-linear mixed-effects modeling
  - Focus on pre-post harvesting differences in habitat availability
  - Use logistic growth approximation
  - Fixed effects: flow level, harvest state
  - Random effects: study section

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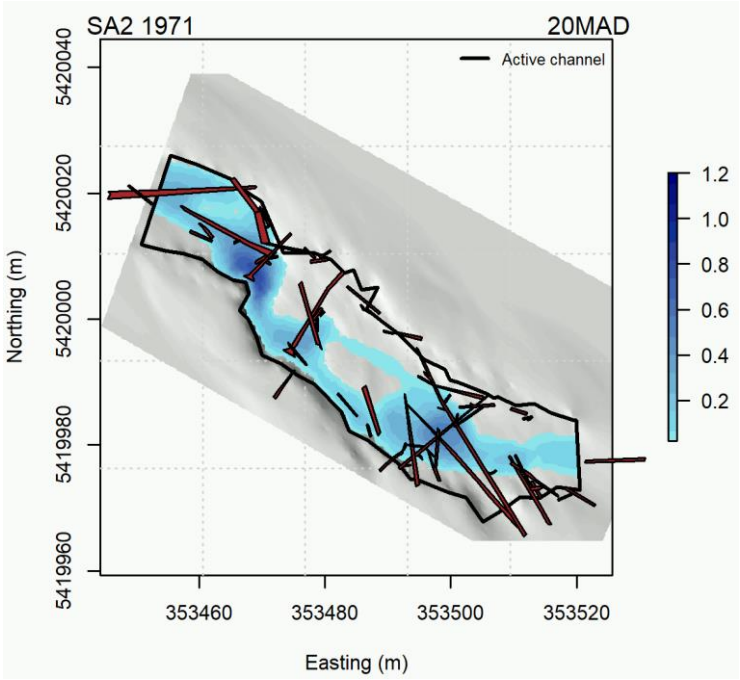
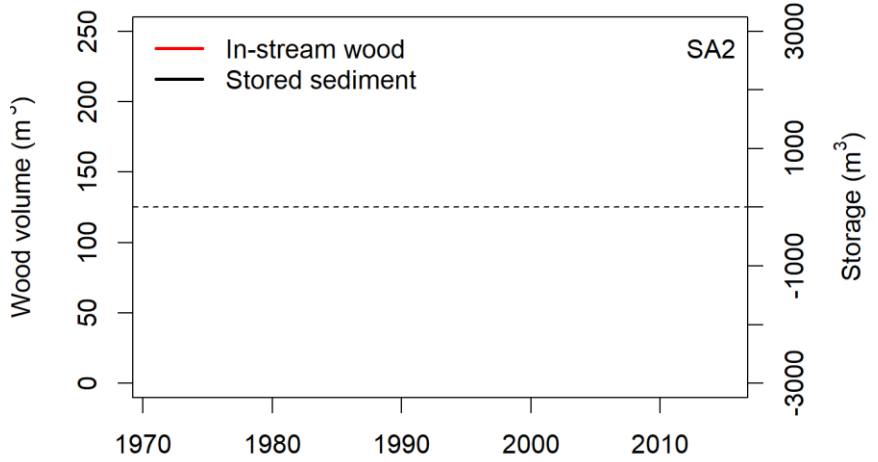
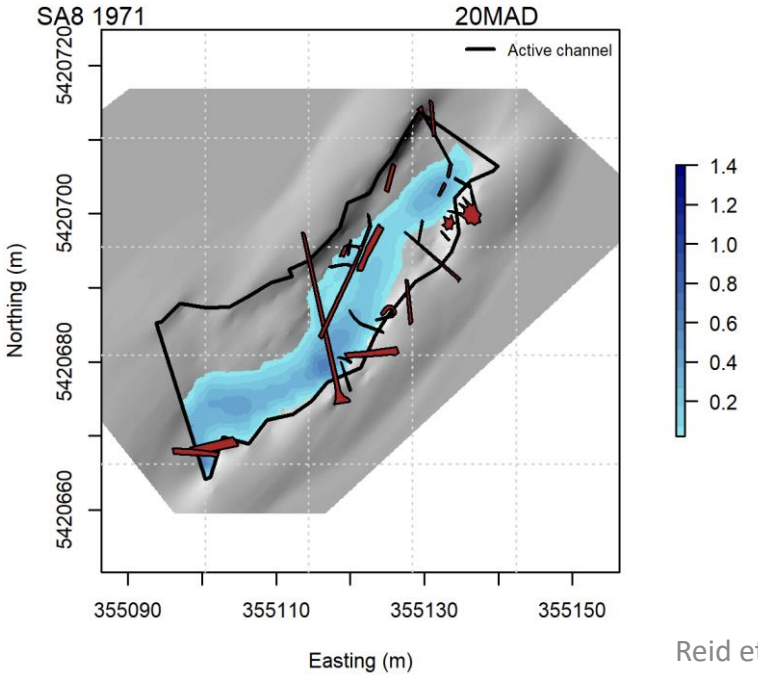
Results: example output

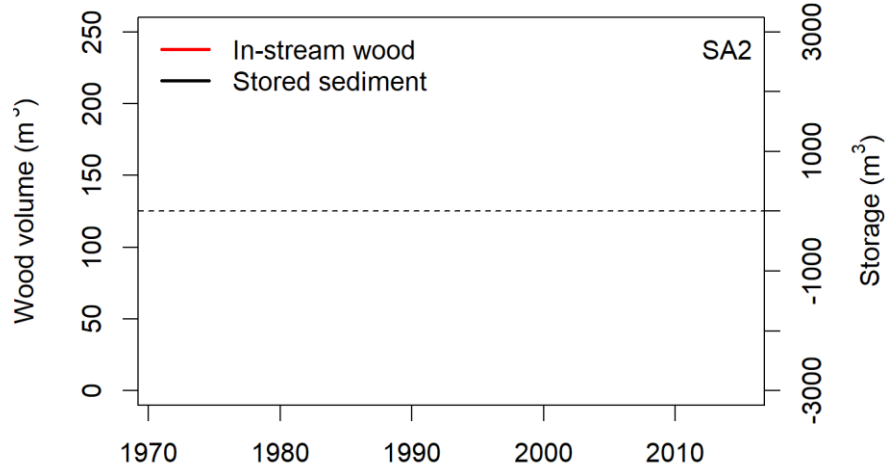
Stable site





Unstable site





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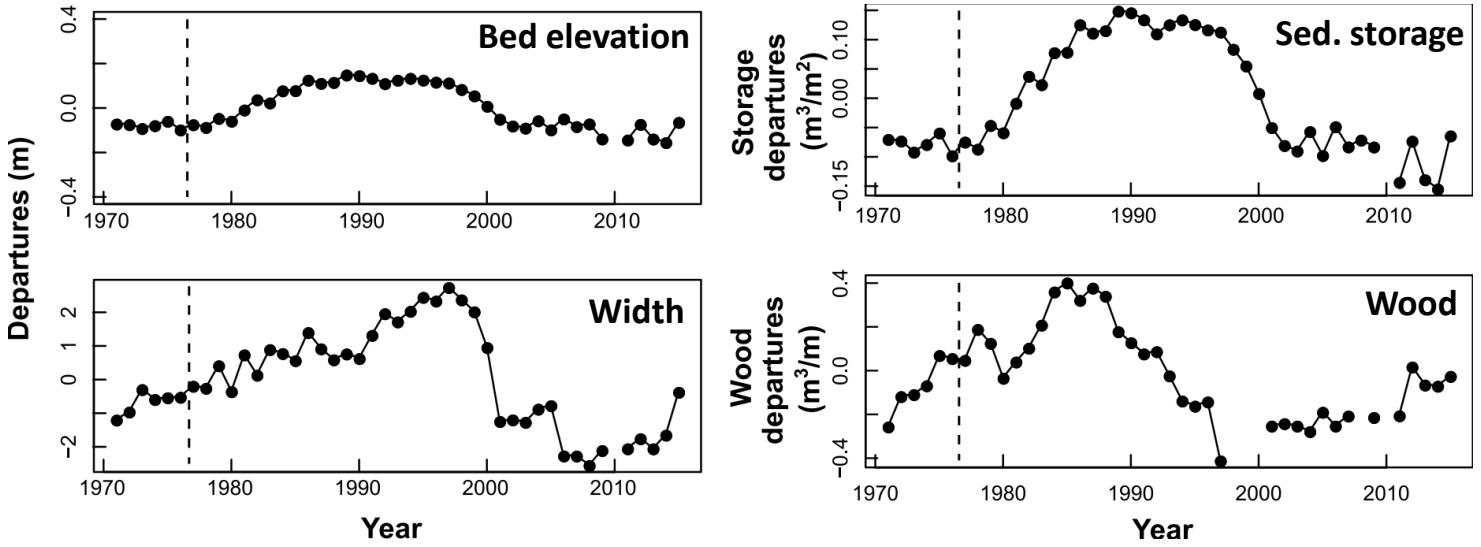
Results: Channel form (8-site avg.)



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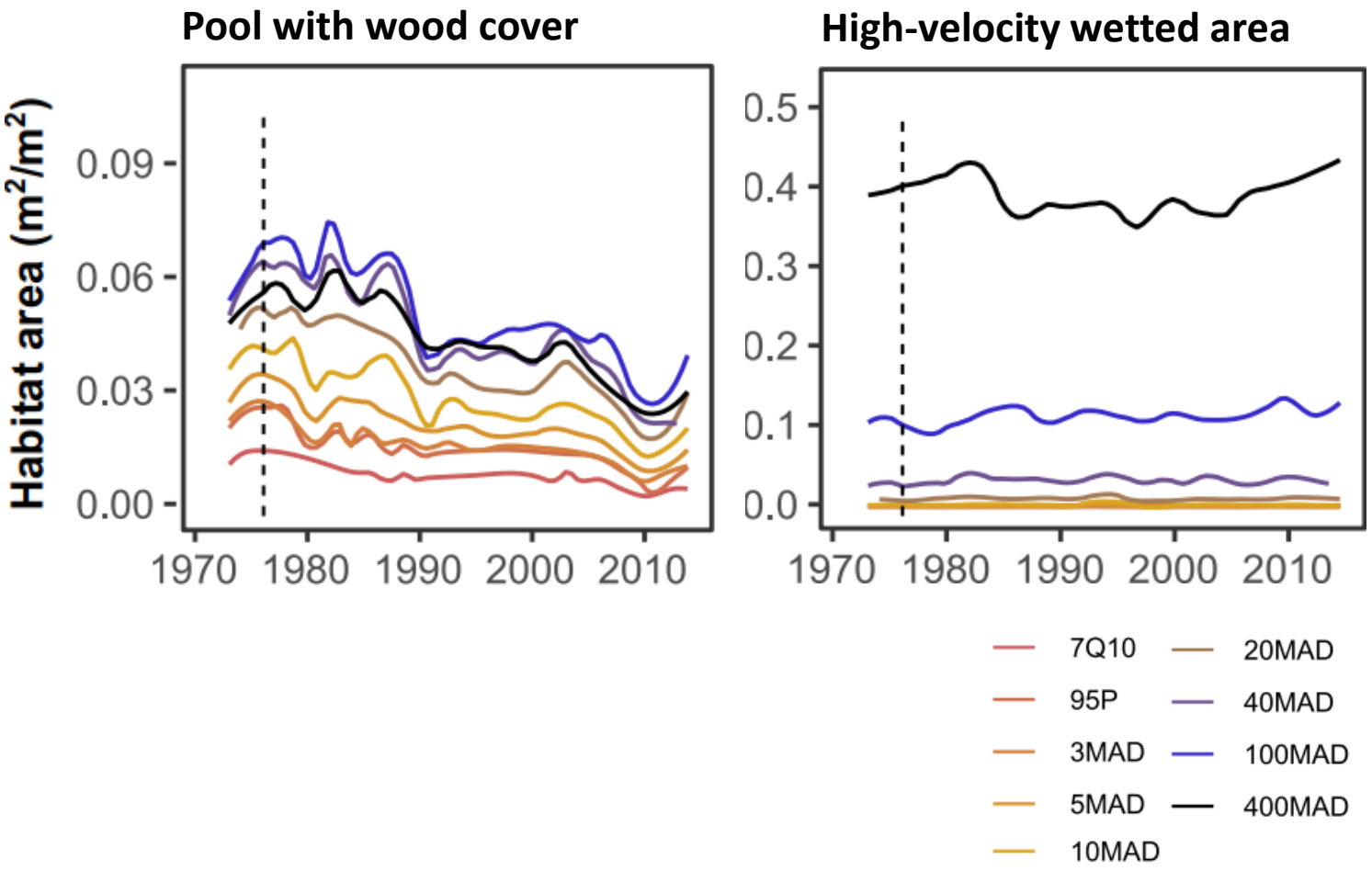
- All variables show an increase, then decrease
- Depth: comparatively “smooth” pattern
- Width: steady increase until late 1990s
- Sediment storage: combination of depth and width. Logjams important?
- Wood volume: pattern dominated by several logjams

Results: Modeled habitat timeseries



- **Pool area with wood cover:**
  - Reflects patterns in pool areas and wood abundance
  - Occupies small area of active channel (<10%)
  - Variability at all flow levels, but trend of decline at most levels
- **High-velocity wetted area:**
  - Effectively no high-velocity flows <20% MAD but up to 40% of channel at 400% MAD
  - Clear evidence of a trend lacking

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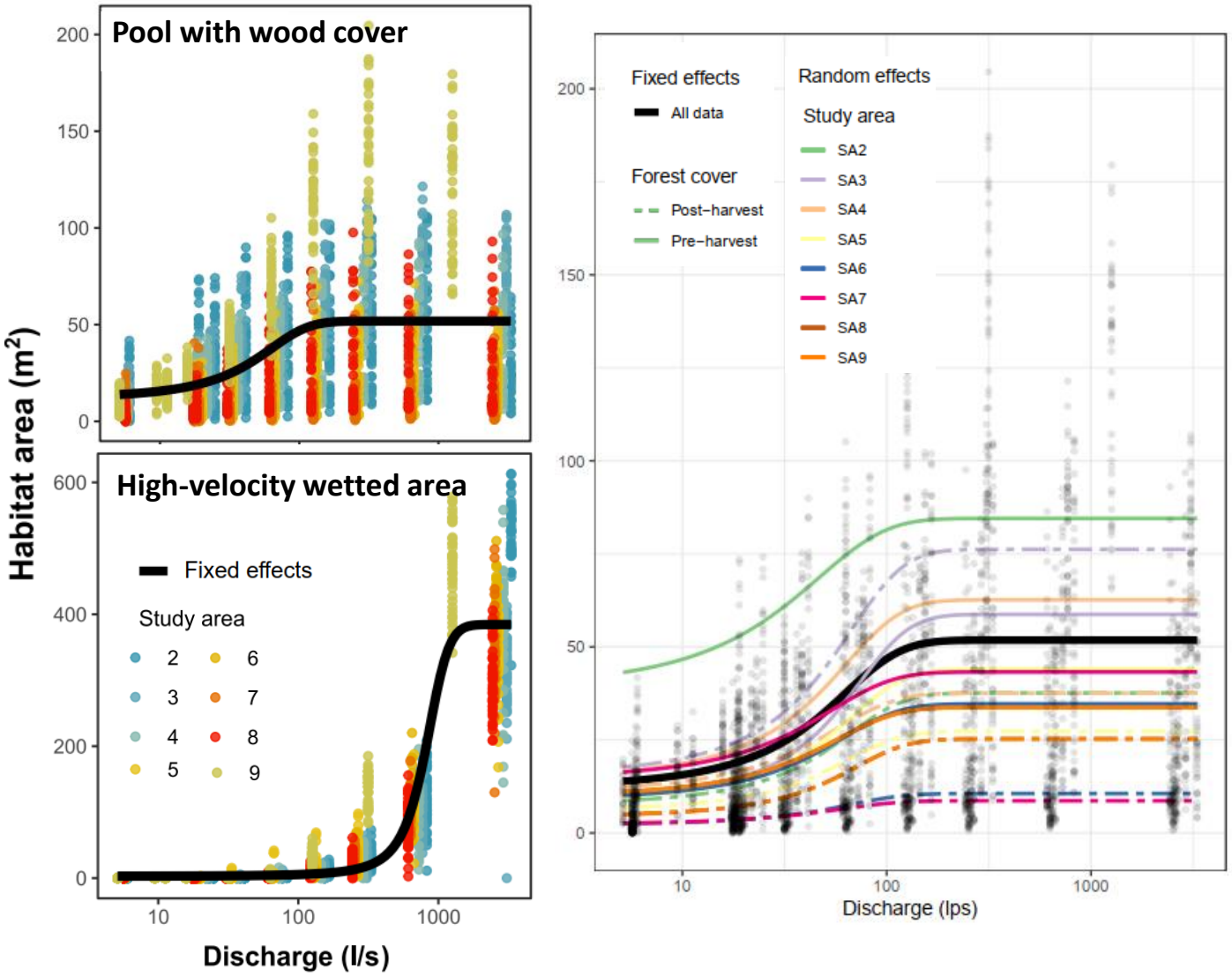
Results: Logistic growth models



- Model appears to fit data reasonably well
- Note that these models really just apply to low flows. Quadratic might be better in some cases
- Pool areas: asymptote near 200 l/s (~20%+ MAD at downstream site)
- High-velocity flow areas: asymptote near max flows
- Significant difference in models with harvest state as a predictor

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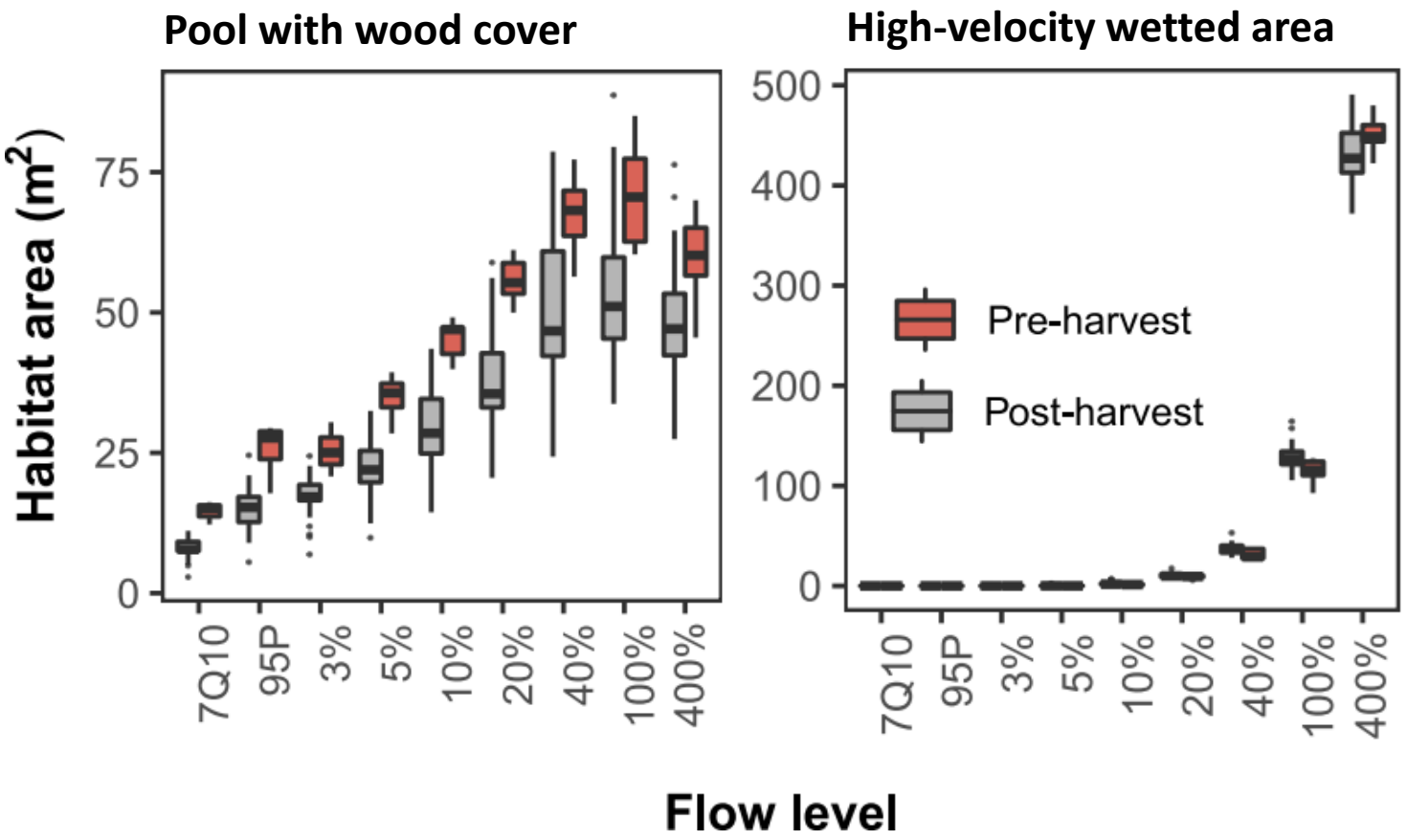
Results: pre-post harvesting



- Looking at the data another way:
  - Post-harvest reduction at all flow levels for pool area with wood cover
  - High-velocity flow only present at and above 20% MAD, with slight (but significant) post-harvest increase
  - Boxplots give some indication of the variability over time of flow-habitat relationships

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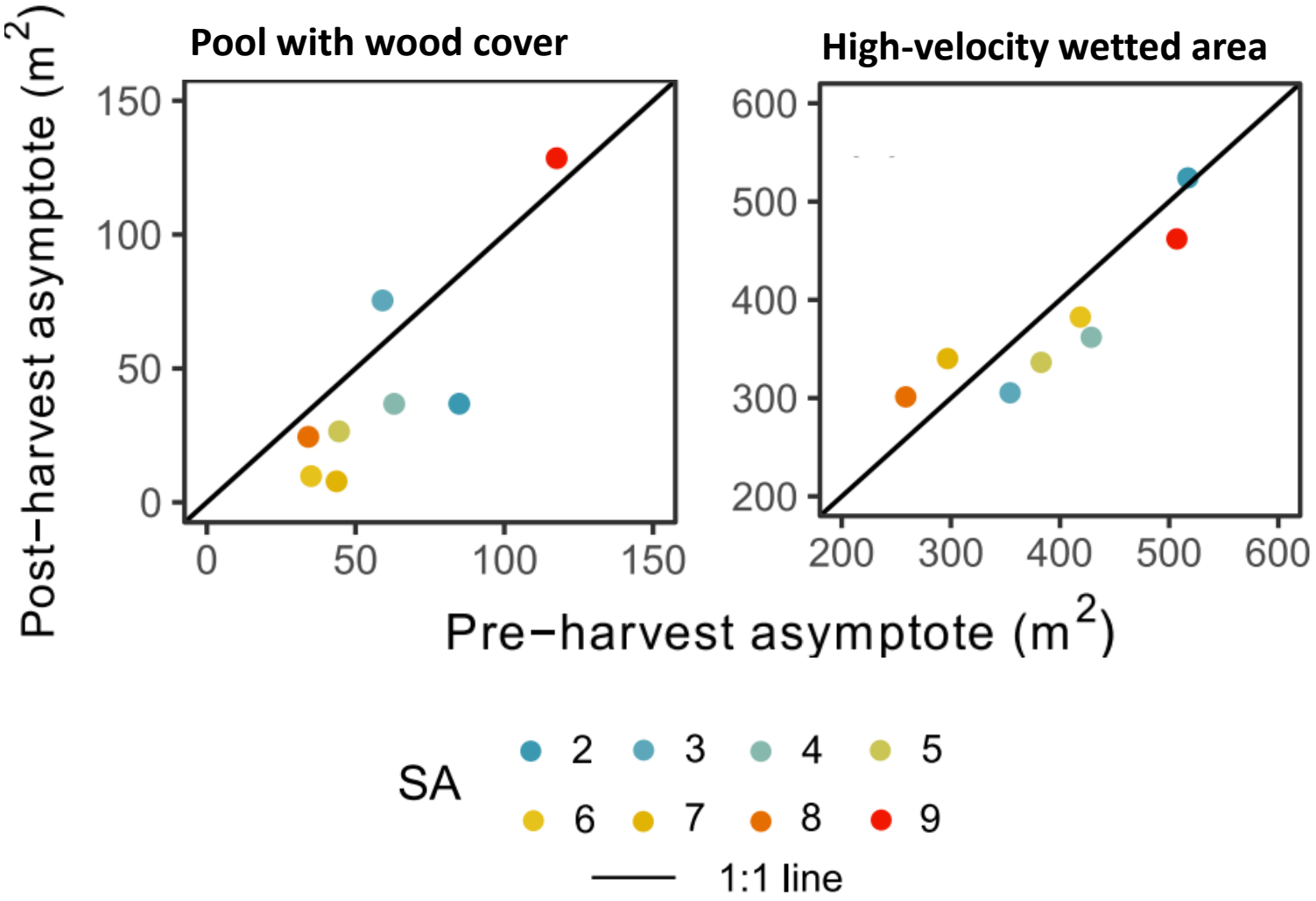
Results: Maximum attainable habitat



- Asymptotes: provide some information on whether higher flows can compensate for channel conditions leading to reduced habitat availability
- Pool area with wood cover:
  - Fairly substantial downward shift in model asymptotes after harvesting in six of eight sites
- High-velocity wetted area:
  - Downward shift in five of eight sites

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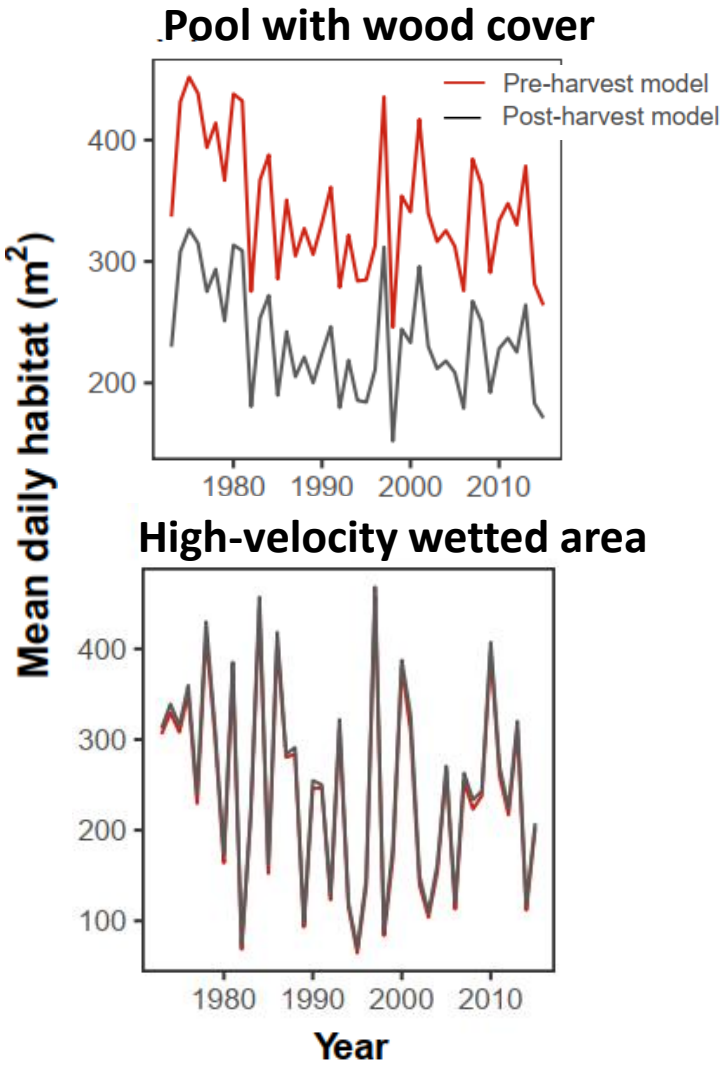
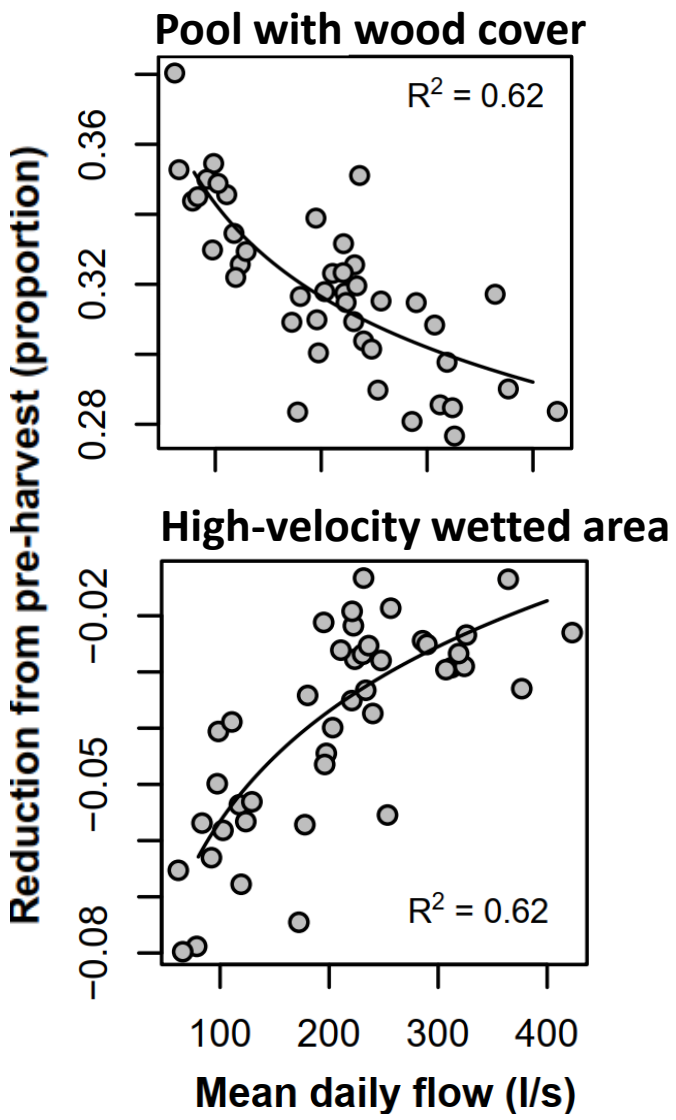
Results: predicted habitat timeseries





- Applying pre-and post-harvest logistic models to flow data gives a sense of the magnitude of difference stemming from harvesting:
  - Fairly large (28-38%) reduction in modeled mean daily pool w/ wood cover
  - Little change in high-velocity flow area (gain of 1-8%)
  - Drier years see greater changes in predicted habitat from harvesting

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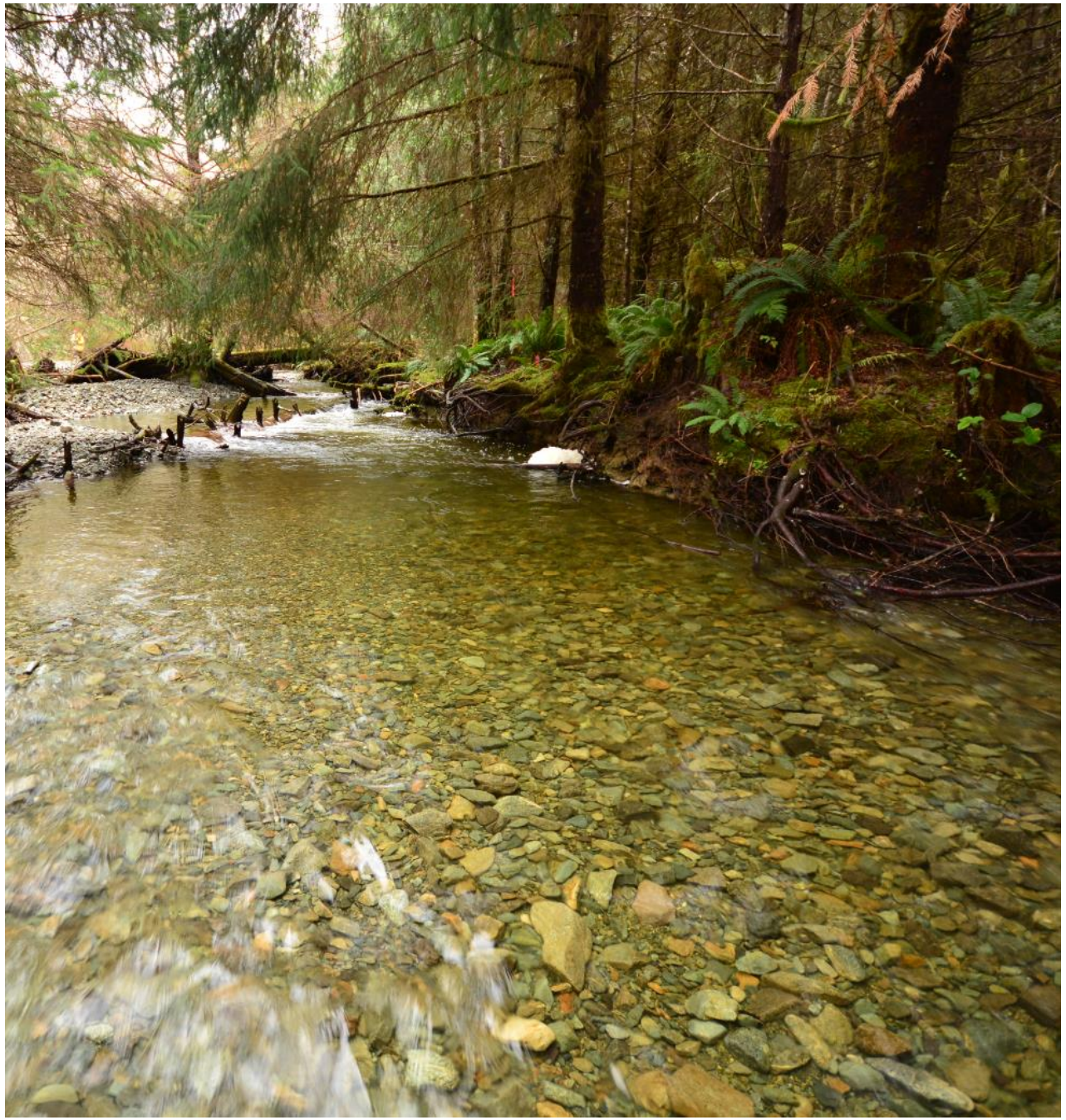
Discussion

- Temporal variability in habitat
  - Wood abundance and channel form
  - Variability at all flow levels but not as pronounced at lowest flows
- Implications for EFN:
  - Important to understand processes governing channel form in a particular catchment
  - Scale considerations



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Discussion

- Timber harvesting known to change flow characteristics and change channel morphology through wood loading/sediment supply
- Some evidence that catchment and riparian harvesting leads to reduction in habitat availability in Carnation Creek
- Mechanisms behind the changes: loss of wood supply; change in sediment supply.
- Limitations with the approach
  - One catchment
  - Flow-based variables
  - Short pre-harvest record
  - Style of harvesting no longer common

Image courtesy of Dan Hogan

Summary – main points

- Evidence of variability in habitat availability through time at constant flow levels
- Changes to sediment supply and wood abundance driving variability
- Evidence of some change driven from historical forestry practices
- Implications for streamflow management
    - Important to consider sediment supply regime, landscape history, and land use history

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Thanks for listening!

Email questions/comments to: david.reid@geog.ubc.ca

More info on Carnation Creek and methods:

Reid, D. A., Hassan, M. A., Bird, S., and Hogan, D. (2019) Spatial and temporal patterns of sediment storage over 45 years in Carnation Creek, BC, a previously glaciated mountain catchment. *Earth Surf. Process. Landforms*, 44: 1584–1601. https://doi.org/10.1002/esp.4595.

Reid, D. A., Hassan, M. A., Bird, S., Pike, R., and Tschaplinski, P. (2020) Does variable channel morphology lead to dynamic salmon habitat?. *Earth Surf. Process. Landforms*, 45: 295– 311. https://doi.org/10.1002/esp.4726.