VELMA
Visualizing Ecosystem Land Management Assessments

Strategies for reducing uncertainties in modeled urban stormwater runoff and contaminant loads in Puget Sound nearshore streams

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Longfellow Creek watershed, West Seattle, WA

The Seattle Times

Stormwater pollution in Puget Sound streams killing coho before they can spawn

October 18, 2017

1 of 2 | Coho salmon, including females full of eggs, are dying before they can spawn in Puget Sound streams polluted with stormwater runoff. (NOAA Fisheries)

Science Tian et al. 2021 REPORTS

6PPD-quinone

Cite as: Z. Tian *et al.*, *Science* 10.1126/science.abd6951 (2020).

A ubiquitous tire rubber-derived chemical induces acute mortality in coho salmon

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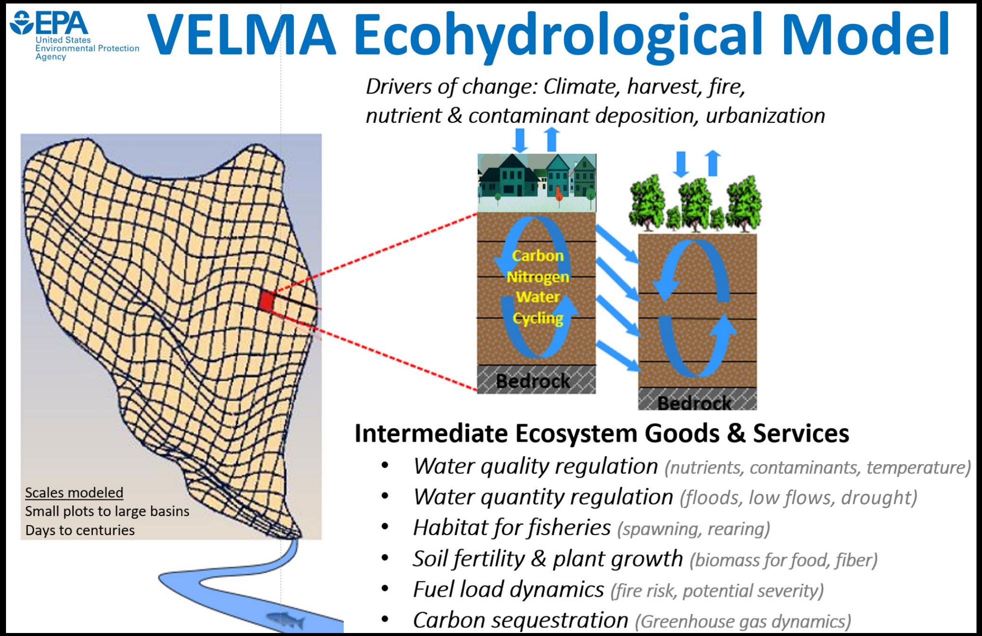
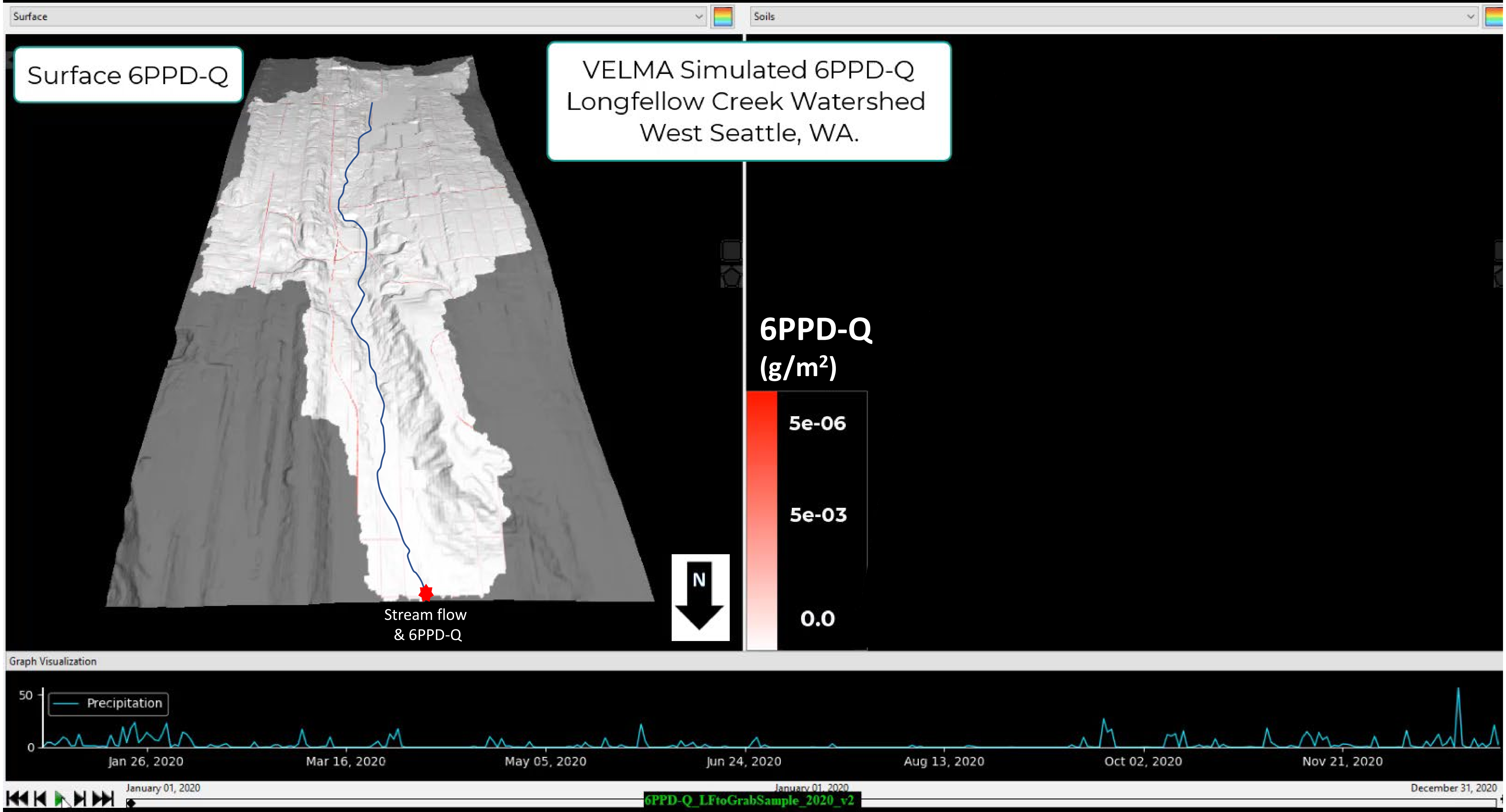
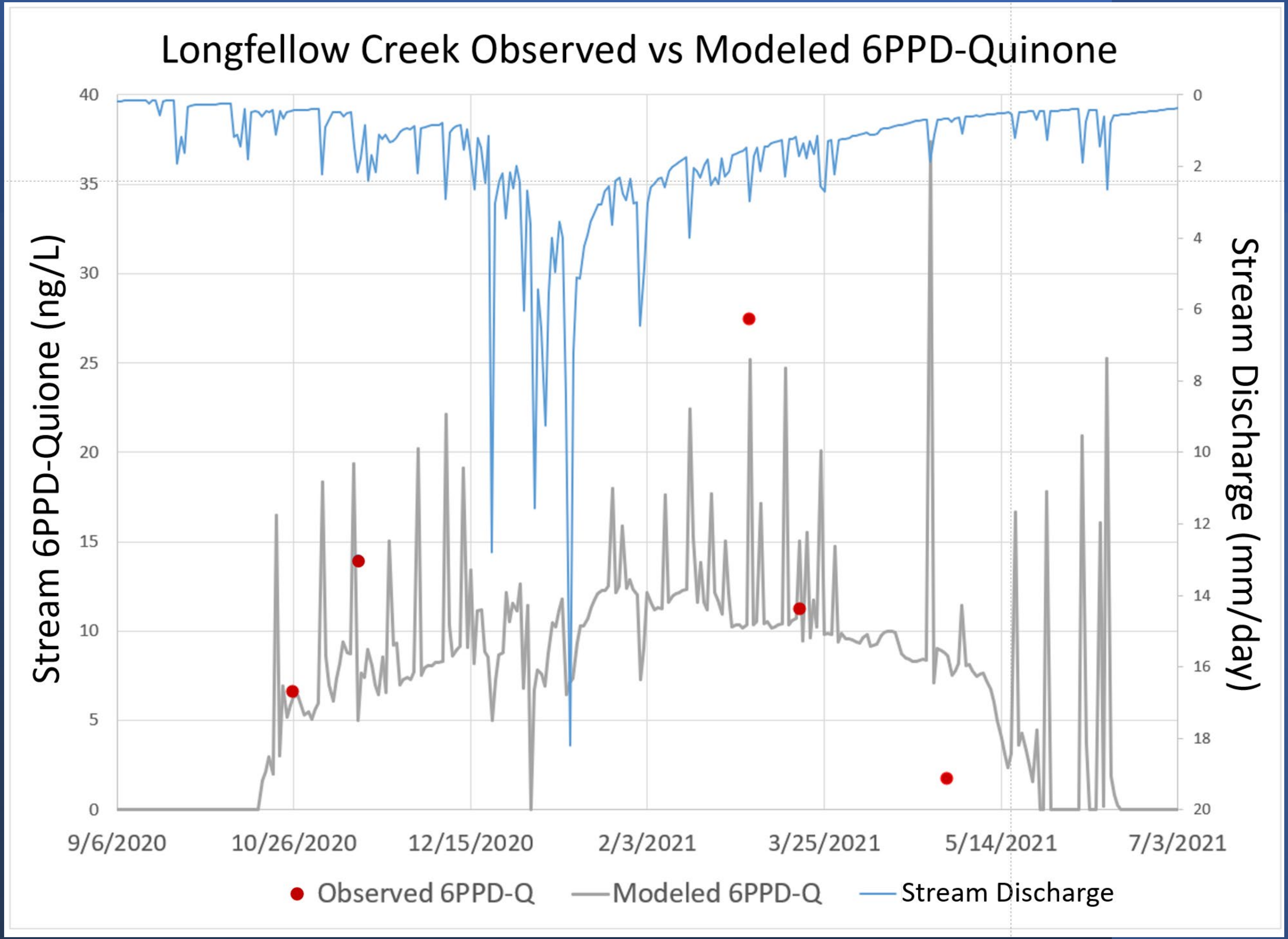



Surface
Soils
Surface 6PPD-Q
VELMA Simulated 6PPD-Q
Longfellow Creek Watershed
West Seattle, WA.
6PPD-Q
(g/m²)
5e-06
5e-03
0.0
N
Stream flow
& 6PPD-Q
Graph Visualization
Precipitation
50
0
Jan 26, 2020
Mar 16, 2020
May 05, 2020
Jun 24, 2020
Aug 13, 2020
Oct 02, 2020
Nov 21, 2020
January 01, 2020
January 01, 2020
December 31, 2020
6PPD-Q_LFtoGrabSample_2020_v2


Longfellow Creek Observed vs Modeled 6PPD-Quinone
Stream 6PPD-Quione (ng/L)
Stream Discharge (mm/day)
40
35
30
25
20
15
10
5
0
0
2
4
6
8
10
12
14
16
18
20
9/6/2020
10/26/2020
12/15/2020
2/3/2021
3/25/2021
5/14/2021
7/3/2021
Observed 6PPD-Q
Modeled 6PPD-Q
Stream Discharge

Sources of uncertainty in modeled stormwater runoff and contaminant loads

Sources of Uncertainty	Key Questions
1) Model equations and parameters	Does the model adequately represent the processes controlling the outputs of interest? *For example, runoff via natural (soil matrix) and engineered (stormwater infrastructure) flow paths.*
2) Data for model implementation	Do the data accurately represent the system at the scales required to model the outputs of interest?
3) Calibration methods	Has the problem of equifinality been minimized? *Can we systematically disqualify solutions for which calibrated parameters provide the right answers for the wrong reasons?*
4) Propagation of uncertainty among submodels	Has model calibration reduced model uncertainty and its propagation among submodel components? *What model performance tests can help address these questions?*

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Roadway daily additions of 6PPD-Q (g m^{-2} d^{-1})

Parameters used to calculate roadway tire wear particle (TWP) deposition and 6PPD-Q daily loads	Low Range	High Range	Longfellow watershed value	References
TWP mg/km per vehicle counted	100 (cars)	600 (trucks)	Function of car/truck traffic count data	• TWP deposition per Kole et al. 2017 • Traffic count data per City of Seattle & WSDOT
6PPD g / tire rubber g	0.004	0.02	0.02	Tian et al., 2021
6PPD-Q yield g / 6PPD g	0.01	0.75	0.38	Tian et al., 2021

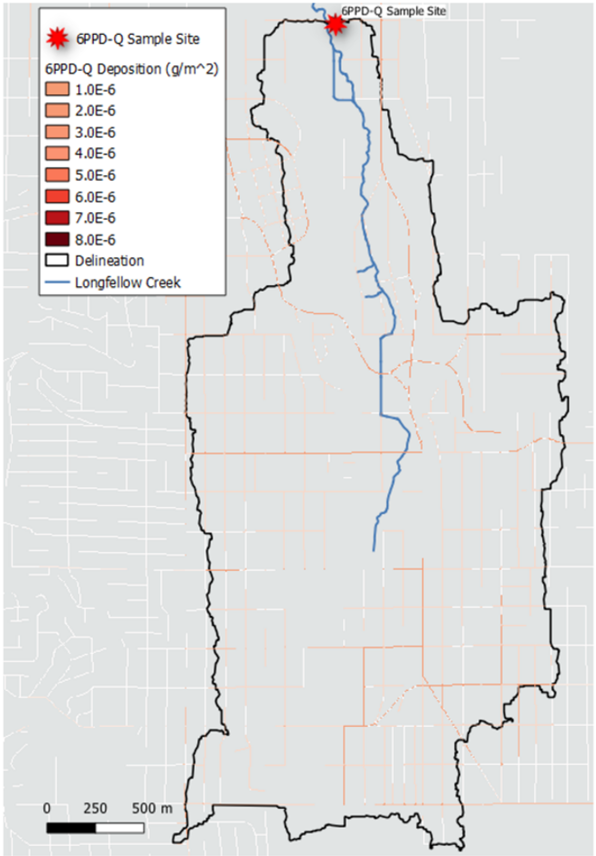
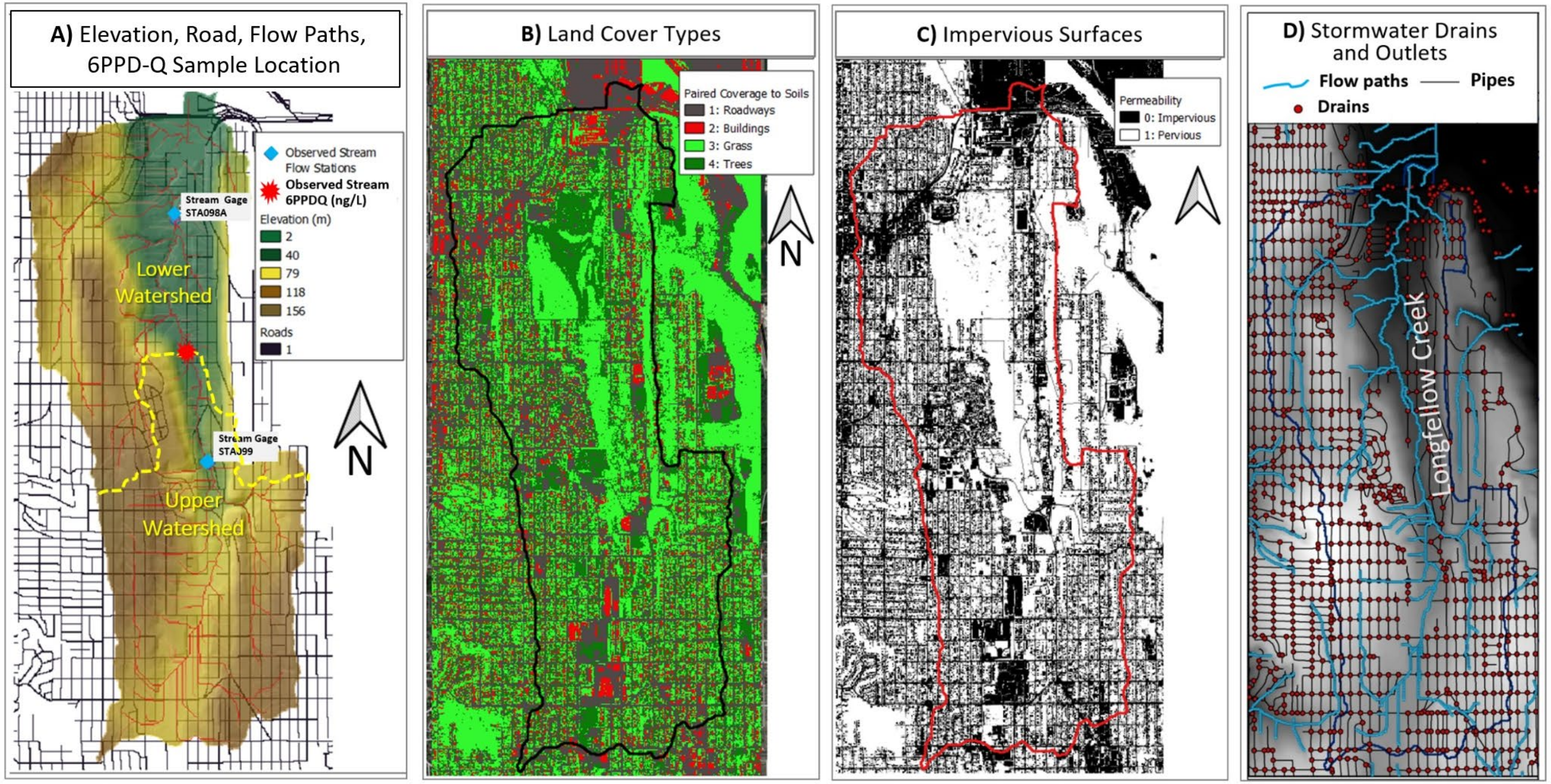


Figure 4. Spatial pattern of 6PPDQ deposition (g m^{-2} d^{-1}) on roads within the Longfellow Creek upper watershed, based on methods described in section 2.3.2.

Sources of Uncertainty	Key Questions
2) Data for model implementation	Do the data accurately represent the system at the scales required to model the outputs of interest?

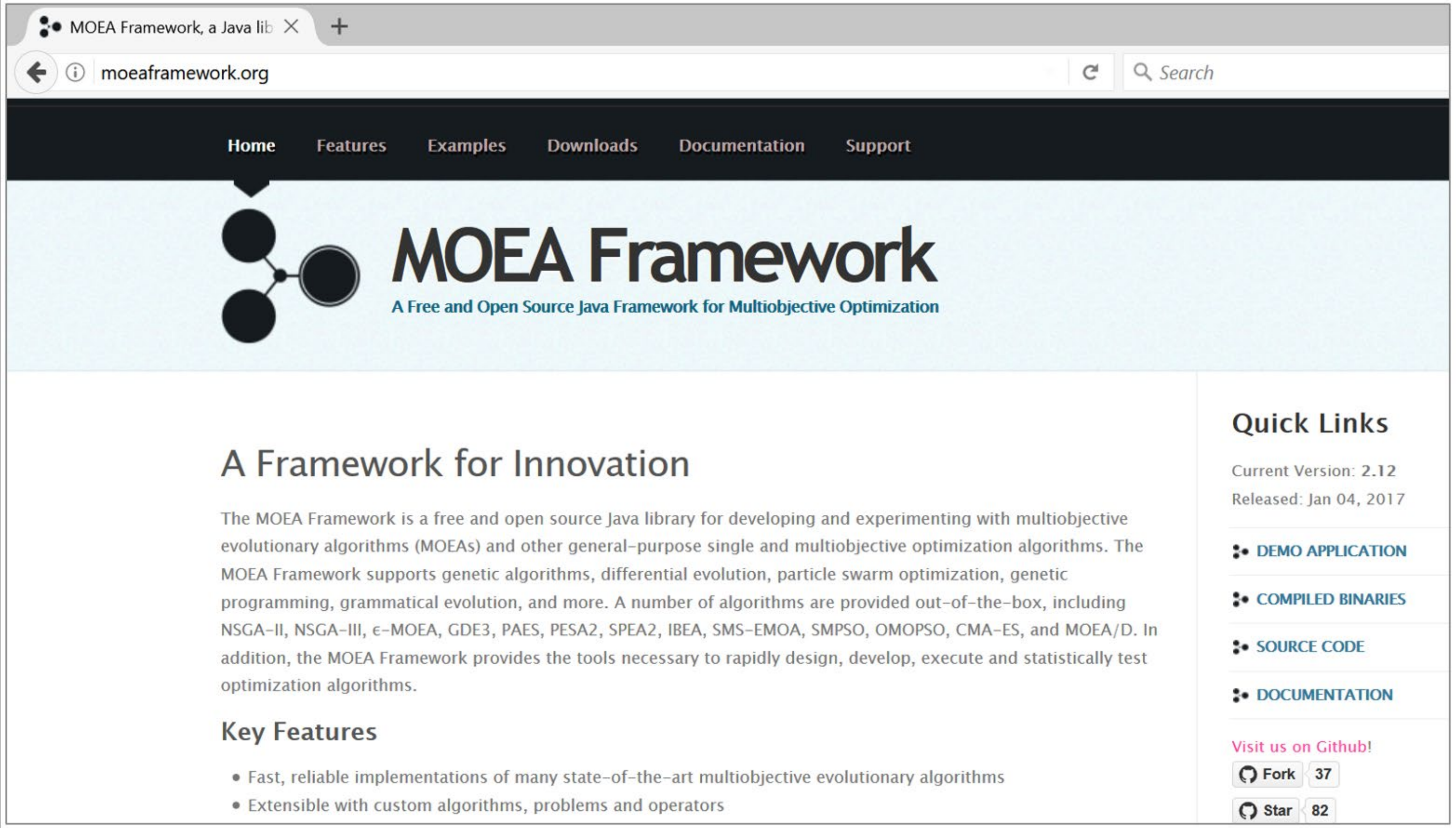
VELMA Urban Spatial Data Layers (5-meter Grid)



Halama et al., In review. Improved urban runoff prediction using high-resolution land-use, imperviousness, and stormwater infrastructure data applied to a process-based ecohydrological model.

Sources of Uncertainty	Key Questions
3) Calibration methods	Has the problem of equifinality been minimized? *Systematically disqualify solutions for which calibrated parameters provide the right answers for the wrong reasons.*

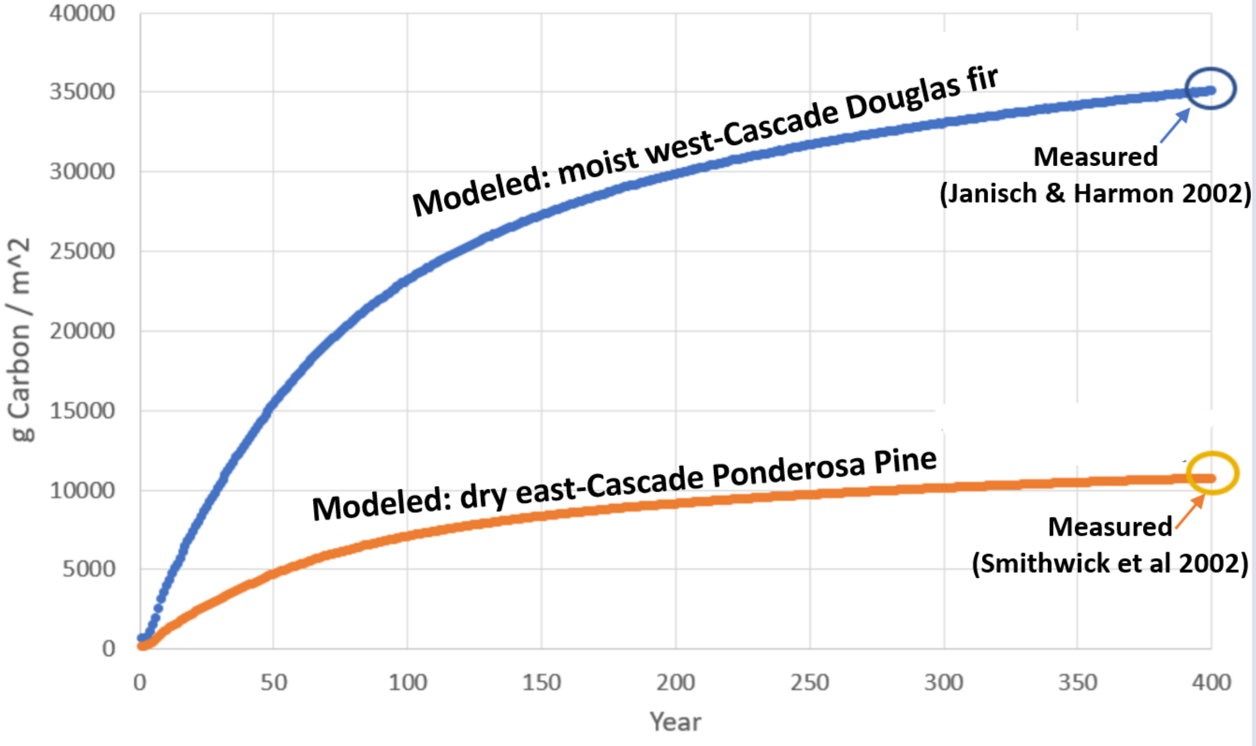
VELMA is calibrated using a Multi-Objective Evolutionary Algorithm (MOEA) that optimizes overall model performance for multiple outputs, e.g., runoff, soil moisture, decomposition, plant growth…..



Sources of Uncertainty	Key Questions
4) Propagation of uncertainty among submodels	Has model calibration reduced model uncertainty and its propagation among submodel components? *What model performance tests can help address these questions?*

Severe performance test: Are parameters calibrated for one location transferable to other locations?

- Modeled forest regrowth for moist (blue) & dry (orange) ecosystems in Oregon
  - Both were modeled using the same Douglas-fir VELMA parameter values



VELMA model parameters calibrated for a single forest calibration site (HJ Andrews★) accurately predict, with minimal adjustment, forest ecohydrological processes at other sites (★) located across steep regional climate and soil nutrient gradients

***Possible exception, currently under study**

Reference: U.S. EPA. Comparative Assessment of the Impacts of Prescribed Fire Versus Wildfire (CAIF): A Case Study in the Western U.S. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-21/197, 2021.

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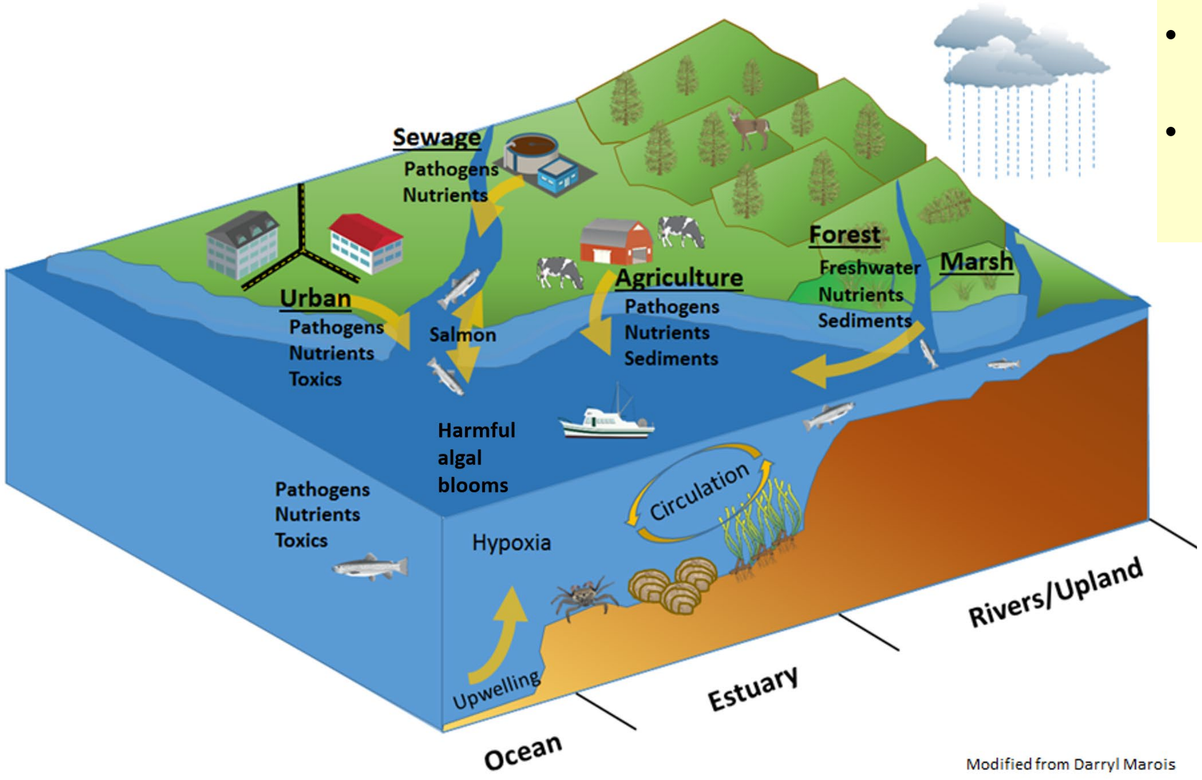
and to linked external models



Modified from Darryl Marois

Integrated terrestrial-marine models are needed to

- Synthesize decades of terrestrial & marine data
- Identify comprehensive recovery solutions across habitats & scales…

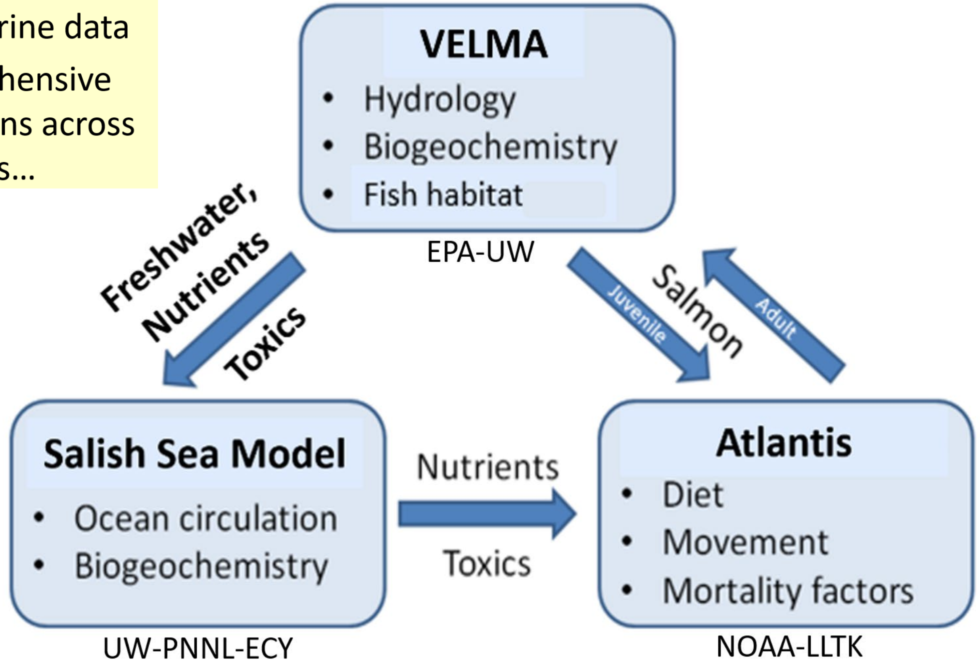


Image from: Vision Statement for a Puget Sound Basin Coupled Environmental and Human Systems Modeling Framework (2018 unpublished). Bob McKane, Tarang Khangaonkar, Isaac Kaplan, Chris Harvey, Hem Nalini Morzaria Luna, Tessa Francis, Phillip Levin, Emily Howe, Jesse Israel, Michael Schmidt, Jonathan Halama, Allen Brookes, Kevin Djang