Water Quality Program

Using Uncertainty Reduction Analysis to Inform Water Quality Modeling, Monitoring, and Restoration

March 27, 2019
11th National Water Quality Monitoring Conference
Denver, CO

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Total Maximum Daily Loads (TMDLs)

TMDL = LA + WLA + RC + MOS

- LA – Load Allocation (nonpoint sources)
- WLA – Waste Load Allocation (point sources)
- RC – Reserve Capacity
- MOS – Margin of Safety

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Implicit vs. Explicit MOS

- Implicit: Conservative assumptions
  - Model
  - Targets
  - Implementation activities
  - Other

- Explicit: Portion of loading capacity set aside
  - Often a percent of loading capacity
  - “Black box” approach

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Alternative approach for explicit MOS

- Utilize uncertainty in water quality modeling

- Use to inform TMDL Monitoring

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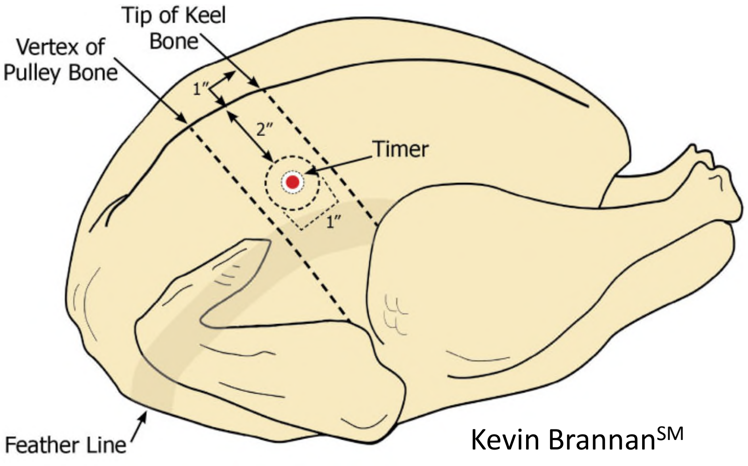
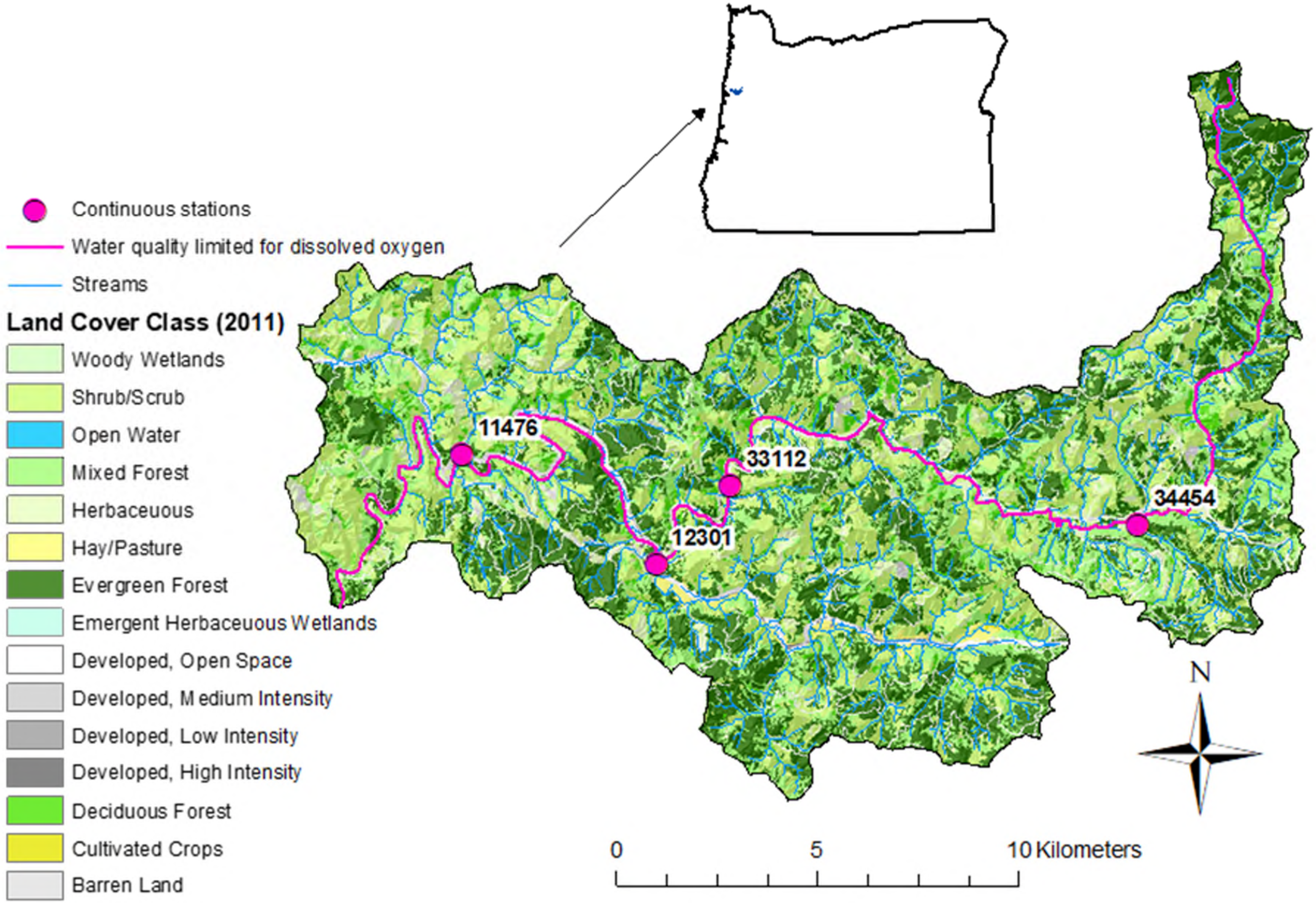
Uncertainty reduction analysis

- Identify important parameter and structural uncertainties
- Quantify these uncertainties to optimize models
- Design monitoring to address these uncertainties



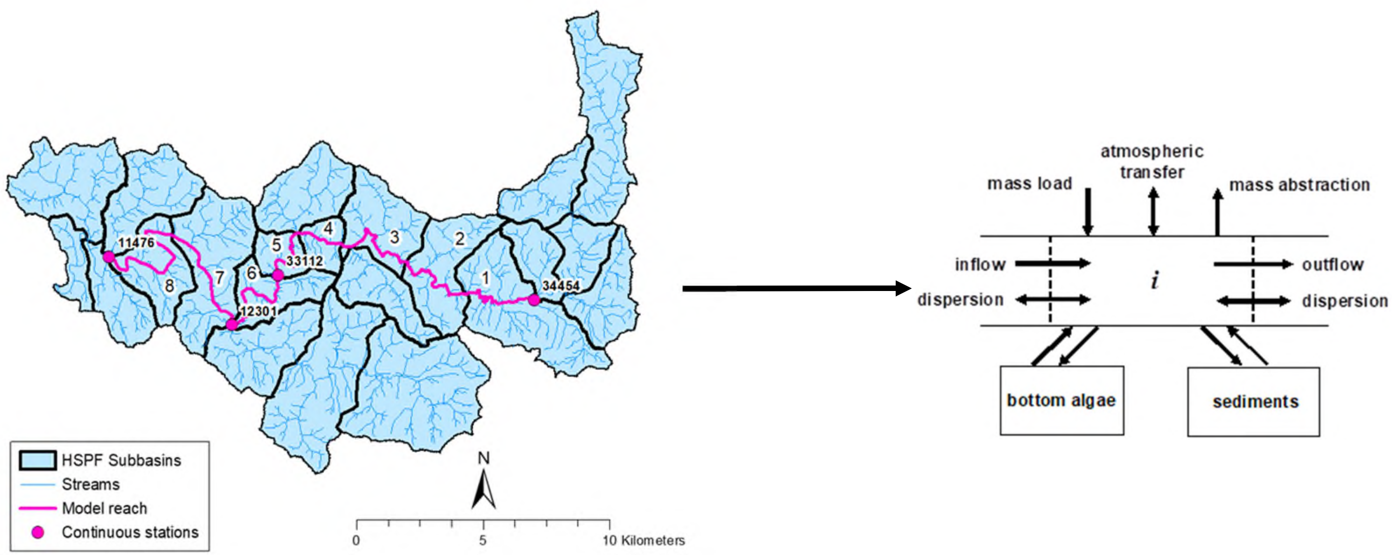
Kevin Brannan[SM]

Upper Yaquina River - 1710020401



Field data and model development

- Continuous water quality data and supporting chemistry grab samples in July 2016
- QUAL2Kw water quality model
  - 130 parameters to calibrate (!)
  - Calibrated with PIKAIA genetic algorithm (Pelletier et al. 2006)



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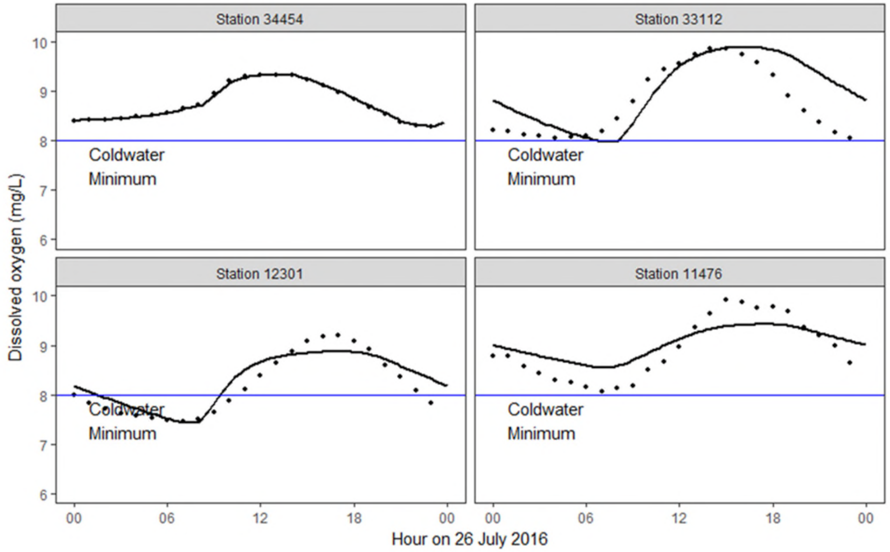
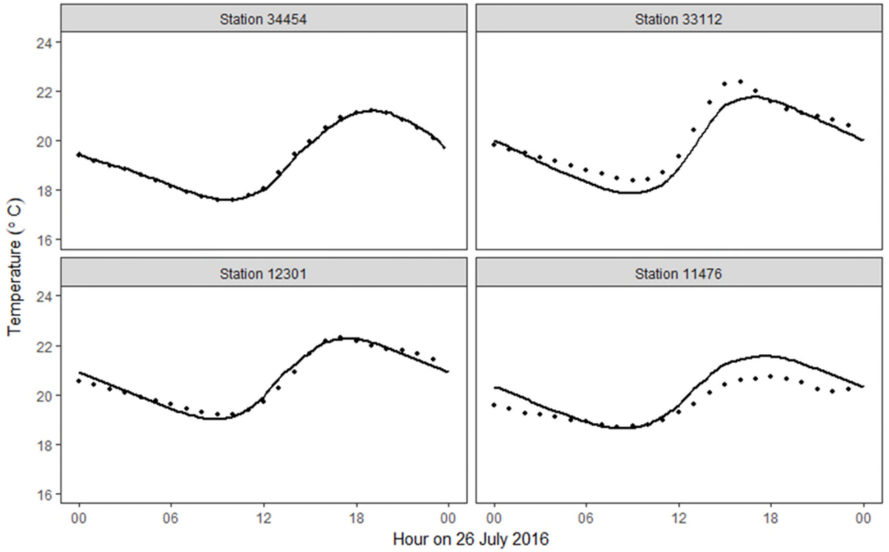
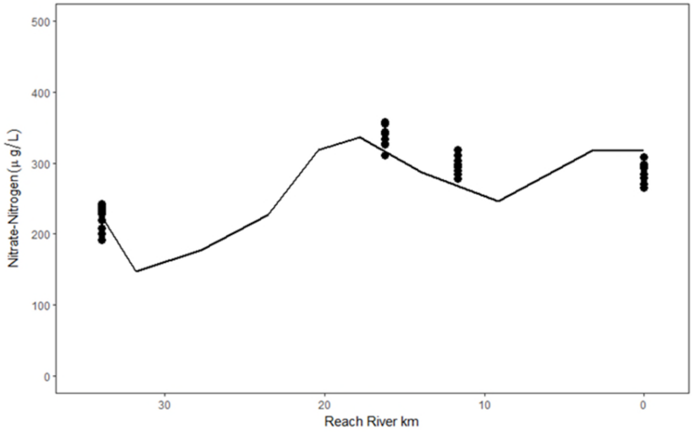
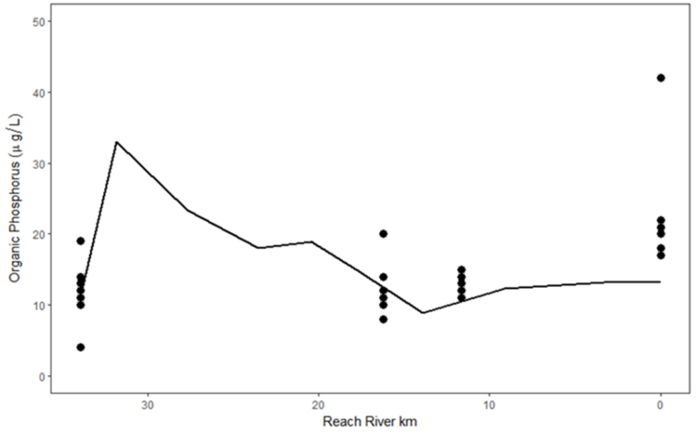
QUAL2Kw model calibration









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Parameter Estimation and Uncertainty Analysis (PEST) Software

- Model-Independent Parameter Estimation and Uncertainty Analysis
- Automated system for optimizing model parameter values
- Minimizes difference between observed and simulated values of User specified goodness-of-fit criteria
- Used throughout the world on many different types of environmental models
- More information at:
  - http://www.pesthomepage.org/Home.php
  - http://pubs.usgs.gov/sir/2010/5169/
  - http://pubs.usgs.gov/sir/2010/5211//

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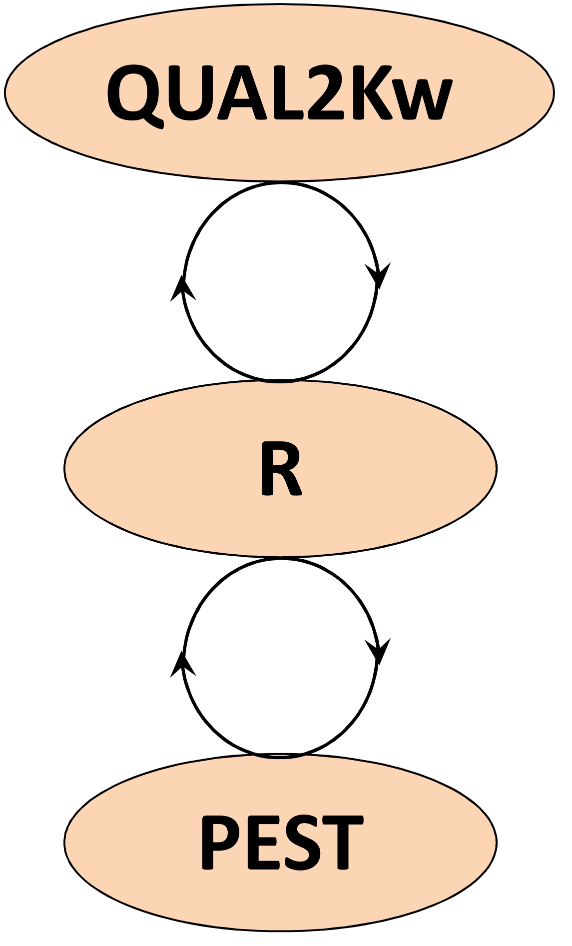
PEST-QUAL2Kw setup

- Adjusted 89 parameters
  - 15 groups by similar processes
- 668 measured values used for comparisons
- Critical observation: minimum DO

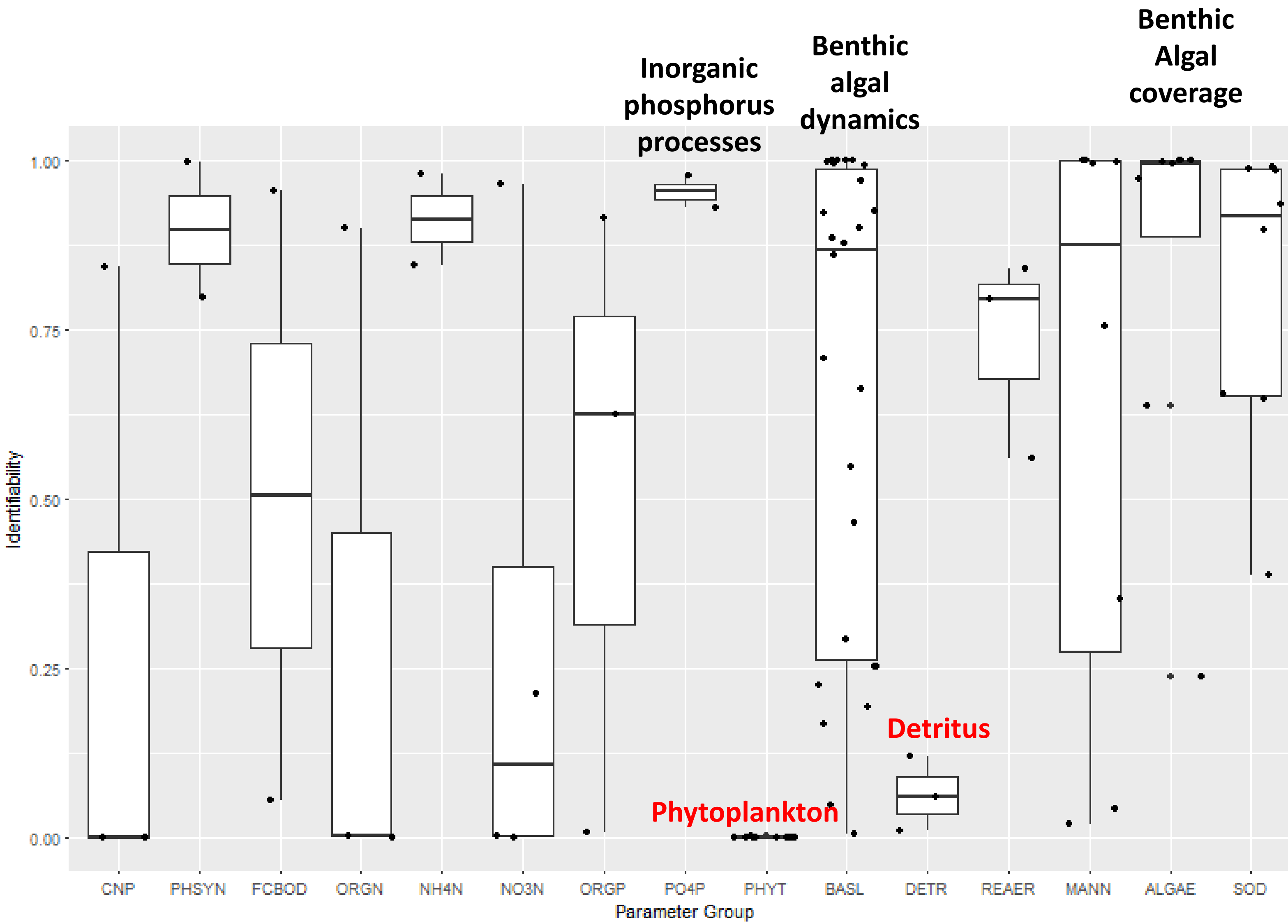


Analysis methods

- Parameter "Identifiability"

- Contribution of parameters to predictive uncertainty
- "Information worth" of data for calibration

Identifiability



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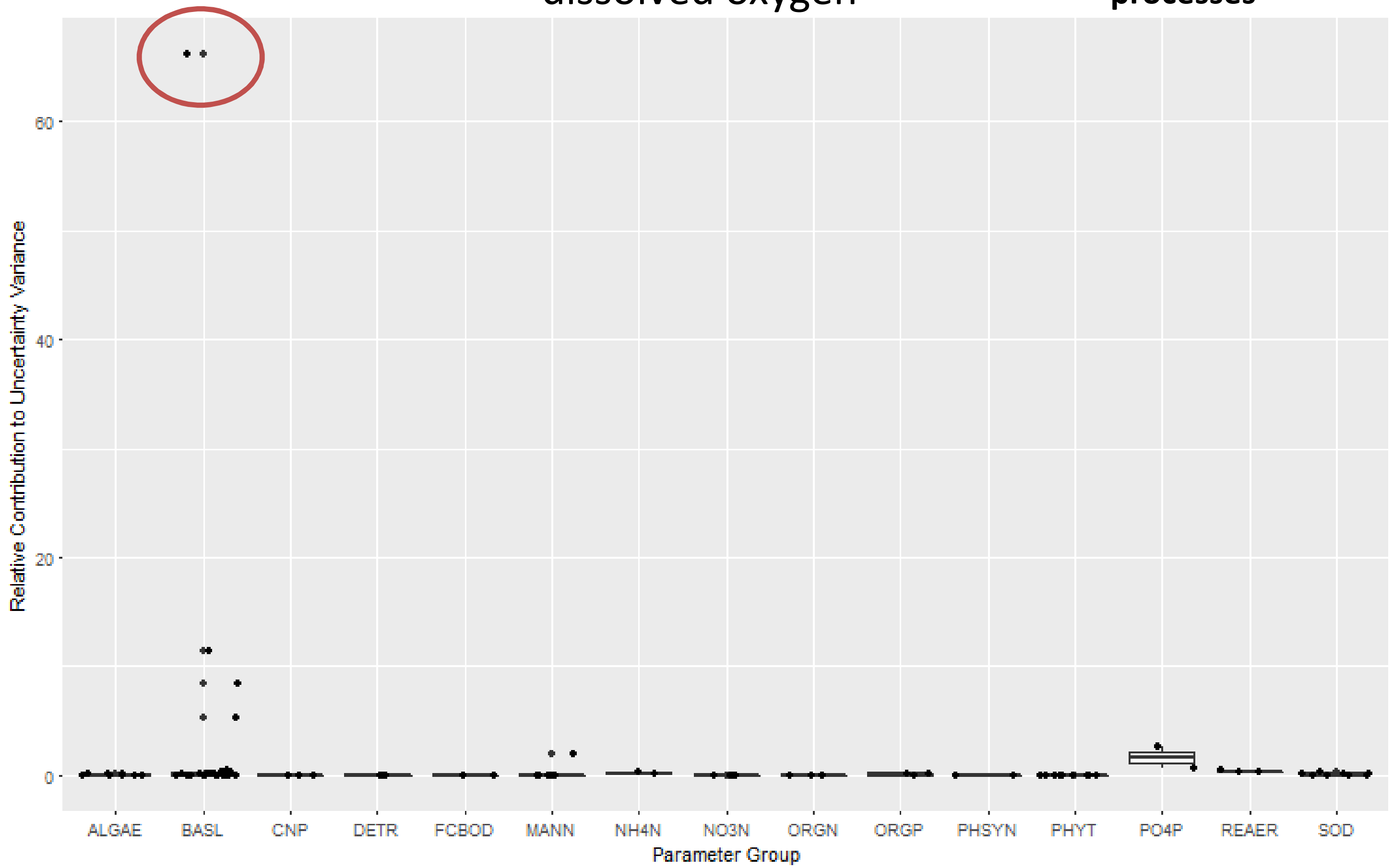
Predictive uncertainty

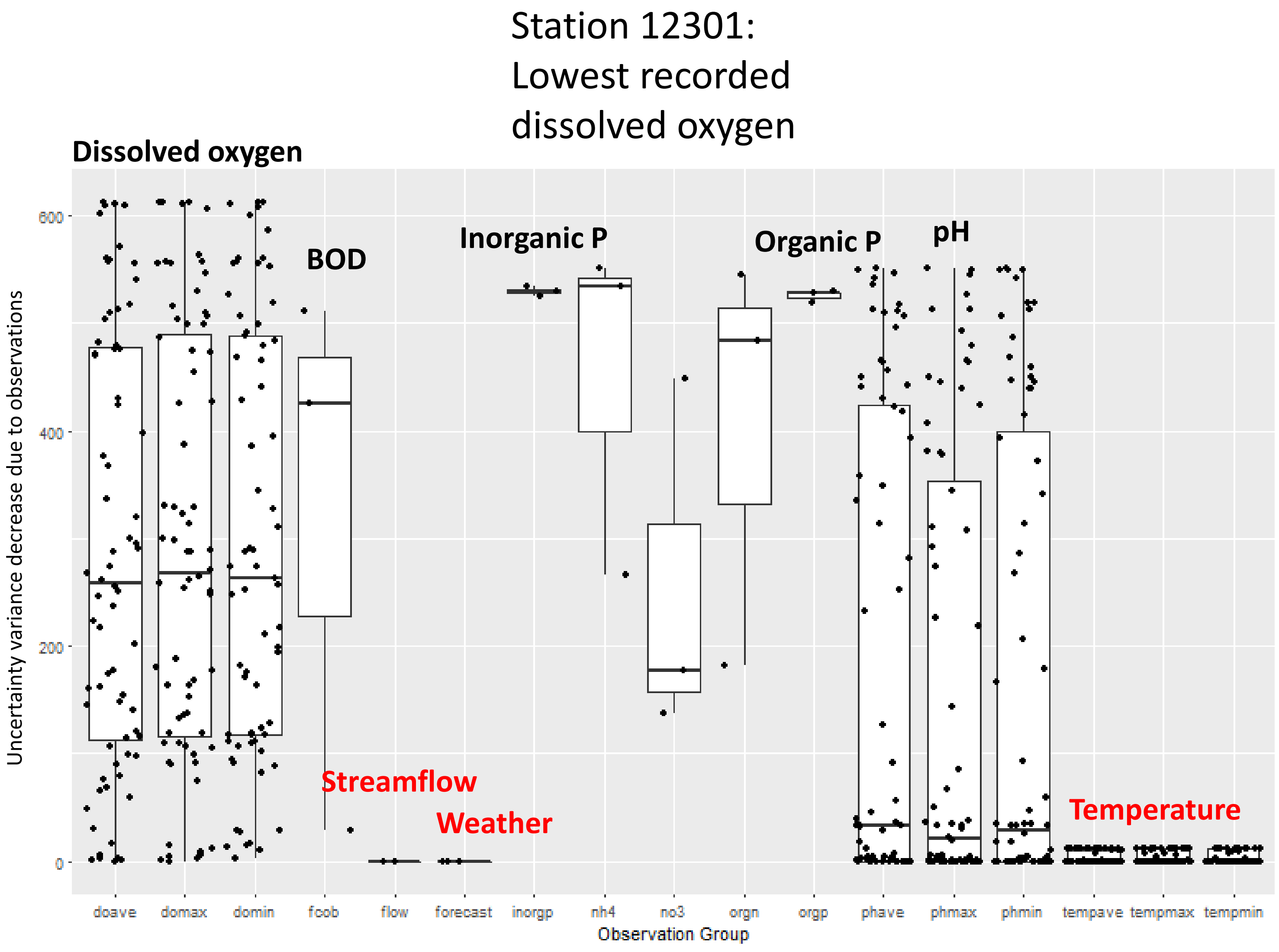
Benthic algal processes

Station 12301: Lowest recorded dissolved oxygen

Inorganic phosphorus processes



Information worth



Takeaways thus far

- For future model refinements and monitoring, improve measurement of benthic algal characteristics

- Improve frequency and/or timing of water quality monitoring for nutrients (phosphorus)
    - Less focus on streamflow, weather, and temperature data

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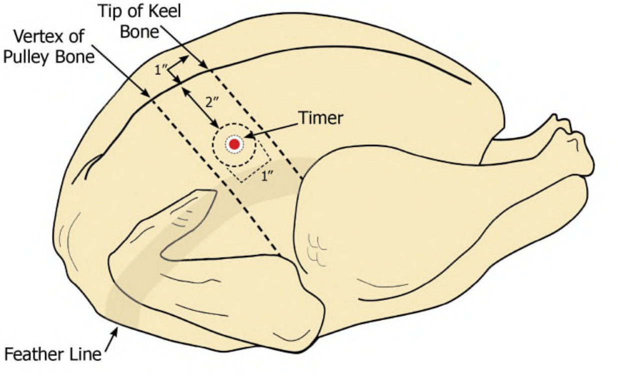
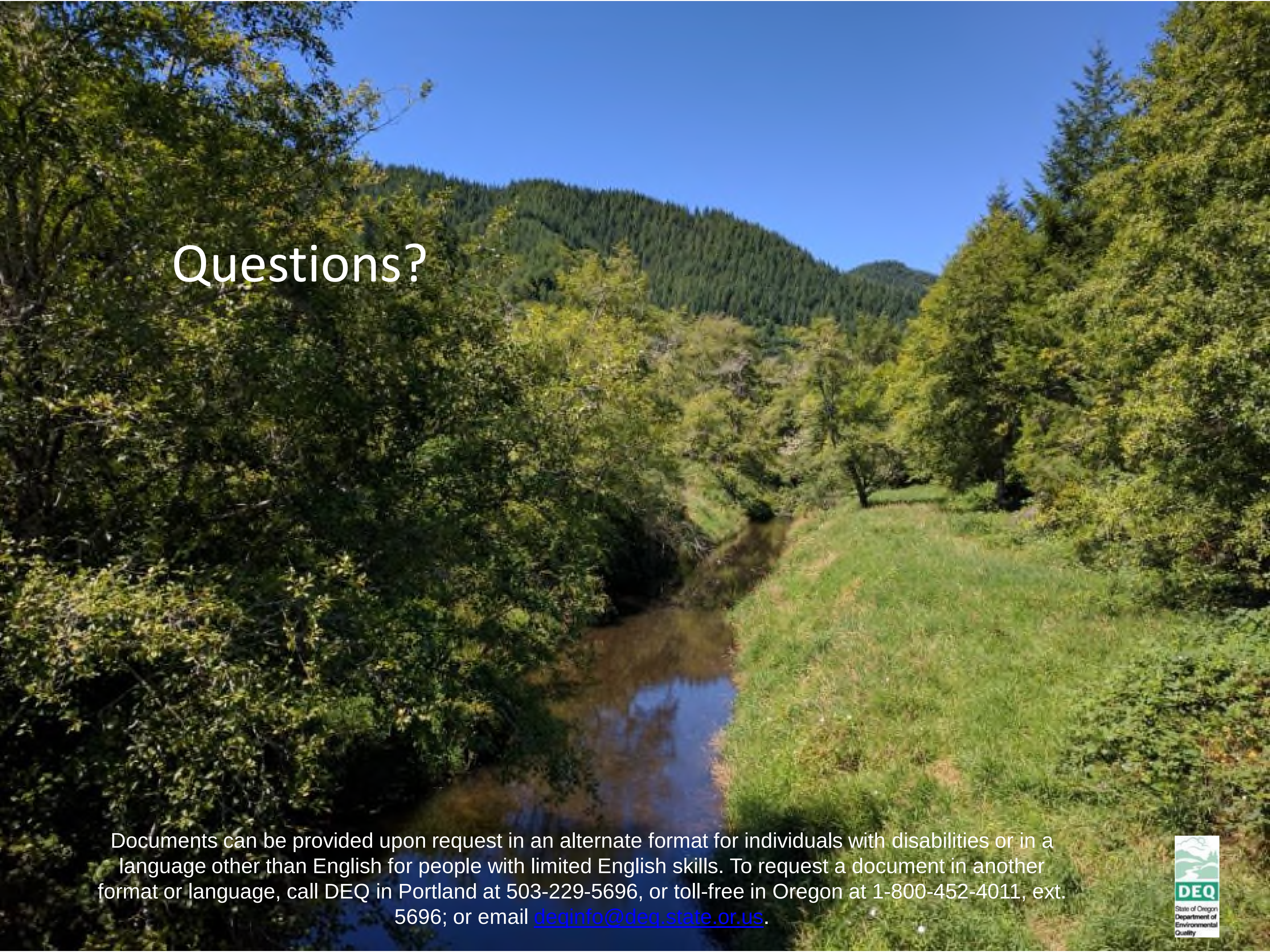
Next steps

- Reduce the number of parameters to estimate
  - Tikhonov – prior information and relationships among parameters integrated into optimization process
  - Singular Value Decomposition (SVD) – solution space dimensions and super parameters
- Pareto analysis ("Biggest bang for the buck"):
  - Allocation scenarios
  - Monitoring locations



Acknowledgements

- Oregon DEQ Watershed Management Section
- US EPA Region 10
- Washington Department of Ecology



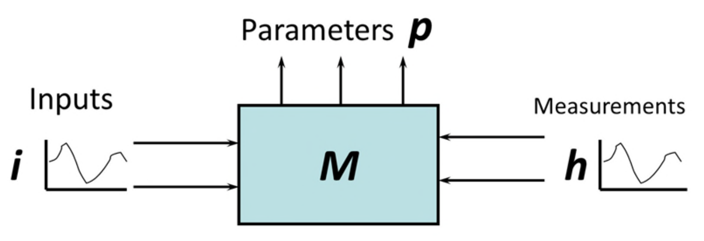
Questions?

Documents can be provided upon request in an alternate format for individuals with disabilities or in a language other than English for people with limited English skills. To request a document in another format or language, call DEQ in Portland at 503-229-5696, or toll-free in Oregon at 1-800-452-4011, ext. 5696; or email deqinfo@deq.state.or.us.

Test approach

- Parameter and model uncertainty
- Information worth of observations
- Predictive uncertainty

The Inverse Problem



x - describes system configuration

$$p = M^{-1}(x,i,h)$$