Bob Mitchell – 9/2021

Current Research

My current actionable science research has primarily focused on the modeling of watershed hydrology and hillslope processes in mountainous regions to assess how climate change affects the availability and quality of fresh water in the Pacific Northwest. These efforts are supported by external funding, involve collaborators at the University of Washington (UW), and include numerous students. Our modeling approaches using the Distributed Hydrology Soil Vegetation Model (DHSVM) and supporting models has produced outcomes that are publishable, and are informing government agencies and Indian Tribes in management and policy decisions regarding water quantity and quality.

A. Climate Change Impacts on the Nooksack River Basin

The Nooksack River drains an approximately 2300 km^2 watershed in the North Cascade Mountains in Washington State, and serves as a valuable fresh-water resource for commercial, municipal, industrial, irrigation, and domestic uses as well as for fish habitat. The Nooksack, like other basins in the PNW, is sensitive to climate warming because it has a low rain-snow threshold due to the regions mild, maritime climate, thus raising concerns about future water resource availability and quality. Climate change projections predict a warming rate over the next century of 0.1-0.6°C/decade and variable changes in precipitation for the Pacific Northwest, which is driving planning strategies by stakeholders for regional rivers. Regional Indian Tribes are concerned how changing basin hydrology will impact valuable habitat for endangered salmon species, including streamflow quantity, temperature and sedimentation.

Past research in the Nooksack basin has included:

1. Projected modeling of streamflow.

   Dickerson, Susan E., Modeling the effects of climate change forecasts on streamflow in the Nooksack River Basin (2010). WWU Masters Thesis Collection. 65.http://cedar.wwu.edu/wwuet/65

   Dickerson-Lange, S. and R. Mitchell, 2013. Modeling the effects of climate change forecasts on streamflow in the Nooksack River basin, Northwest Washington. Hydrological Processes DOI: 10.1002/hyp.10012.

2. Projected modeling of hydrology and glacier recession.

   Murphy, Ryan D., Modeling the Effects of Forecasted Climate Change and Glacier Recession on Late Summer Streamflow in the Upper Nooksack River Basin (2016). WWU Masters Thesis Collection. 461. http://cedar.wwu.edu/wwuet/461

3. Projected modeling of stream temperatures.

   Truitt, Stephanie (Winter 2018) Modeling the Effects of Climate Change on Stream Temperature in the Nooksack River Basin. WWU Graduate School Collection. 642. https://cedar.wwu.edu/wwuet/642

4. Projected modeling of mass-wasting susceptibility.

   Knapp, Kevin (Fall 2018) The Effects of Forecasted Climate Change on Mass Wasting Susceptibility in the Nooksack River Basin. WWU Graduate School Collection. 807. https://cedar.wwu.edu/wwuet/807

Projected Modeling of Peak Flows (current)

I recently received funding from the Nooksack Indian Tribe to model the effects of forecasted climate change on peak flows in the Nooksack River that is supporting my current graduate student, Evan Paul. Our projected modeling in the Nooksack River basin indicates warming winter temperatures will cause more precipitation falling as rain rather than snow, resulting in a 60-90% reduction in basin-wide snowpack and a 40-80% increase in winter streamflow (Dickerson-Lange and Mitchell, 2014; Murphy et.al., 2015). Moreover, rainfall magnitude and intensity is projected to increase, (e.g., Warner et al. 2015) into the 21st century. As snowlines are projected to increase in elevation into the 21st century, more landscape will be exposed to winter rainfall events resulting in higher peak flows (e.g., Salathé et al. 2014; Lee et al., 2018) and sediment delivery to streams potentially jeopardizing critical salmon habitat, farmland, and municipal flood control systems.

To more accurately assess winter peak-flows in the Nooksack basin into the 21st century, we will apply the DHSVM with new forcing meteorological data produced by researchers from the UW-CIG (e.g., Mauger et al., 2018). The new historical and projected (downscaled) meteorological data are informed by the Weather Research and Forecasting model (WRF, Skamarock et al. 2005) and a reanalysis-based on historical WRF runs from PNNL (a 30-year 6-km hourly WRF data over the Western U.S.; Guillaume Mauger, personal communication, 2019). The new forcing data are processed at 1-hr time steps, thus better capture rainfall intensity. Our peak flow modeling and analysis will follow the methods of a recent study performed by UW-CIG researchers in rivers in King County (Lee et al., 2018). The results of our study will inform stream restoration designs (e.g., log jams), assist water managers in storm-water design (e.g., culvert and levees) and better inform future mass-wasting and sediment modeling in the basin.

B. Climate Change Impacts on the Stillaguamish River Basin

Draining an area of about 1725 km^2, the Stillaguamish is the fifth largest river discharging to the Puget Sound. The river provides water resources to local municipalities, industry, agriculture, and First Nations Tribes, and is an important salmon habitat. The Stillaguamish Tribe of Indians relies on the Stillaguamish River for both traditional and economic salmon fishing and for promoting cultural environmental stewardship practices.

Past research in the Stillaguamish River basin has included projected modeling of hydrology and stream temperatures in the North and South forks

The Stillaguamish River is currently subject to a temperature TMDL by the EPA and there is concern how future warming climates will further impact stream temperatures and valuable salmon habitat. We are collaborating with the Stillaguamish Tribe of Indians and Dr. John Yearsley an affiliate professor in the Computational Hydrology Group at the University of Washington to examine future climate variability on hydrology and stream temperatures in the North Fork (734 km^2) and South Fork (660 km^2) of the Stillaguamish River. Hydrology modeling will employ the DHSVM 3.2.1 and stream temperature modeling will be conducted using the stream temperature River Basin Model (RBM). Both models are physically based and distributed, and have been applied in mountainous terrain in the Pacific Northwest. Funding for these modeling projects has come from the Stillaguamish Tribe of Indians and the NW Climate Adaptation Science Center Fellowship Program. Research products include:

Freeman, Kyra (2019) Modeling the Effects of Climate Variability on Hydrology and Stream Temperatures in the North Fork of the Stillaguamish River. WWU Graduate School Collection. 855. https://cedar.wwu.edu/wwuet/855

Clarke, Katherine (2020) Modeling the effects of climate change on streamflow and stream temperature in the South Fork of the Stillaguamish River. WU Graduate School Collection. 983 https://cedar.wwu.edu/wwuet/983

1. Projected Modeling of Peak Flows in the Stillaguamish (completed)

Historically, peak flows have been increasing in the Stillaguamish River, primarily due to forest harvesting and long-term climate trends that have caused more rainfall than snowfall (Hall et al., 2014). Recent projected modeling in the North Fork of the Stillaguamish River basin indicates that warming winter temperatures will cause more precipitation falling as rain rather than snow, resulting in a 60-90% reduction in basin-wide snowpack and a 40-80% increase in winter streamflow by the end of the 21st century (Freeman, 2019). Moreover, rainfall magnitude and intensity is projected to increase, (e.g., Warner et al. 2015) further increasing the risk of higher peak flows. To more accurately assess winter peak-flows in the Stillaguamish basin into the 21st century, we will apply new forcing met data produced by researchers from the UW-CIG (e.g., Mauger et al., 2018). The new historical and projected (downscaled) met data are informed by the Weather Research and Forecasting model (WRF, Skamarock et al. 2005) and a reanalysis-based on historical WRF runs from PNNL (a 30-year 6-km hourly WRF data over the Western U.S.; Guillaume Mauger, personal communication, 2019).

Funding is coming from the Stillaguamish Tribe of Indians, a NW Climate Adaptation Science Center (NW CACS) Fellowship, and from the Climate Impacts Group of the University of Washington.

Mauger, G.S., J. Robinson, R.J. Mitchell, J. Won, and N. Cristea (2021). New Flood Projections for Snohomish County: Fine-scale Modeling and Dynamically-Downscaling. Report prepared for Snohomish County. Climate Impacts Group, University of Washington

Current graduate student James Robinson worked on this project for his thesis and will be defending in the fall of 2021.

2. Projected Modeling of Stream Temperatures in the Stillaguamish (current)

I recently received a grant from the Stillaguamish Tribe to pursue further stream-temperature modeling in the remaining basins in the Stillaguamish River basin (mainly the Pilchuck) that is supporting my current graduate student, Emily Smoot. Hydrology modeling will employ the DHSVM and stream temperature modeling will be conducted using the stream temperature River Basin Model (RBM) and will follow the methods of Freeman and Clarke, but using the new WRF forcing data.

Related Abstracts/Presentations (* MS student advisee)

Robinson*, J., and Mitchell, R. J., 2021, Applying dynamically downscaled climate projections to a mountainous watershed in Western Washington to estimate future peak flows, Geological Society of America Abstracts with Programs. Vol. 53. GSA Annual Meeting, Portland, OR, Oct 10-13, 2021.

Robinson*, J., Mitchell, R. J., and Mauger, G. 2021, Modeling the effects of climate change on peak flows in the Stillaguamish Watershed, Northwest Climate Conference, April 6-8, 2021, University of Washington (virtual).

Mitchell, R. J., Robinson*, J. and Mauger, G. 2020, Modeling the effects of projected peak flows in the Stillaguamish River, Geological Society of America Abstracts with Programs. Vol. 52. GSA Annual Meeting, Montreal, CA.Clarke*, K. M., R. J. Mitchell, and J.R. Yearsley, 2019. Modeling the effects of climate change on streamflow and stream temperature in the South Fork of the Stillaguamish River. 10th Annual Northwest Climate Conference, Portland, OR.

Mitchell, R. J., K.M. Clarke*, K. M. and J.R. Yearsley, 2019. Modeling the effects of climate change on streamflow and stream temperature in the South Fork of the Stillaguamish River. Geological Society of America Abstracts with Programs. Vol. 51. GSA Annual Meeting, Phoenix, AZ.

Clarke*, K. M., R. J. Mitchell, and J.R. Yearsley, 2019. Modeling the effects of climate change on streamflow and stream temperature in the South Fork of the Stillaguamish River. 12th Washington Hydrogeology Symposium. April 9-11, 2019, Tacoma, WA.

Mitchell, R. J., K. M. Freeman*, and J.R. Yearsley, 2019. The Effects of Forecasted Climate Change on Hydrology and Stream Temperature in the North Fork of the Stillaguamish River Basin. 12th Washington Hydrogeology Symposium. April 9-11, 2019, Tacoma, WA. Invited along with participation on a climate change panel.

Mitchell, R. J., K. M. Freeman*, and J.R. Yearsley, 2018. Modeling the effects of climate change on hydrology and stream temperature in the North Fork of the Stillaguamish River Basin. Geological Society of America Abstracts with Programs. Vol. 50. GSA Annual Meeting, Indianapolis, IN.

Freeman*, K., R. Mitchell, R., J. Yearsley, Effects of Forecasted Climate Change on Hydrology and Stream Temperature in the North Fork of the Stillaguamish River Basin. October 10, 2018, Northwest Climate Conference, Boise ID.

Freeman*, K., R. Mitchell, R., J. Yearsley. Effects of Forecasted Climate Change on Hydrology and Stream Temperature in the North Fork of the Stillaguamish River Basin. November 3, 2018, Graduate Climate Conference, Pack Forest WA.

Truitt*, S., R. Mitchell, J. Yearsley, and O. Grah, 2018. The effects of climate on Stream Temperature in the Nooksack River Basin. 30th Anniversary Salish Sea Ecosystem Conferences, April 4-6, Seattle, WA.

Freeman*, K. M., R. J. Mitchell, and J.R. Yeasley, 2017. Calibration of a Hydrologic and stream temperature model to the North Fork of the Stillaguamish River for Climate Change Modeling. Geological Society of America Abstracts with Programs. Vol. 49, No. 6 doi: 10.1130/abs/2017AM-306102

Knapp*, K., R. J. Mitchell, and O. Grah, 2017. The potential effects of forecasted climate change on mass wasting susceptibility in the Nooksack River Basin. Geological Society of America Abstracts with Programs. Vol. 49, No. 6 doi: 10.1130/abs/2017AM-307248

Mitchell, R., 2017, Modeling the Effects of Forecasted Climate Change on Hydrology in the Nooksack River Basin, Baker-to-Bay Symposium (invited), September 20-21, Ferndale Events Center, Ferndale, WA.

Truitt*, S., R. Mitchell, J. Yearsley, and O. Grah, 2017. Calibration of a Hydrologic and Stream Temperature Model to the Nooksack River Basin for Climate Change Modeling. 11th Washington Hydrogeology Symposium. May 14-16, 2017 Tacoma, WA.

Knapp*, K., R. Mitchell, and O. Grah, 2017. Examining the Potential Effects of Forecasted Climate Change on Sedimentation in the Nooksack River Basin. 11th Washington Hydrogeology Symposium. May 14-16, 2017 Tacoma, WA.

Mitchell, R., R. Murphy*, C. Bandaragoda, and O. Grah, 2016. Impacts of Forecasted Climate Change on Snowpack in the Nooksack River Basin, presented at the 2016 Mountain Climate (MtnClim) Conference, Leavenworth, WA, October 17-21, 2016.

Matthews, R., M. Hilles, J. Vandersypen, G. Matthews, R. Mitchell, 2016. Lake Whatcom reflections, 1988-2016. Washington State Lake Protection Association 29th Annual Conference, October 5-7, Bellingham, WA.

Mitchell, R. and K. Beeler*, 2016: Sediment and phosphorus inputs from perennial streams to Lake Whatcom, Northwestern Washington State: Washington State Lake Protection Association 29th Annual Conference, October 5-7, Bellingham, WA.

Grah, O., R. Mitchell, C. Bandaragoda, R. Murphy*, G. Beaulieu, M. Pelto, C. Frans, 2016. Impacts of Climate Change on Water Supply as a Result of Glacier Ablation and Altered Hydrologic Regime of the Nooksack River, presented at the Water Law in Washington Conference- Law Seminars International, Seattle, WA, July 19, 2016.

Mitchell, R., R. Murphy* C. Bandaragoda, C., and O. Grah, 2016. Modeling the effects of Forecasted Climate Change on Streamflow in the Nooksack River Basin, presented at the 2016 Salish Sea Ecosystem Conference, Vancouver, British Columbia, April 13-15, 2016.

Murphy*, R., R. Mitchell, C. Bandaragoda, C., and O. Grah, 2015. Impacts of Forecasted Climate Change on Snowpack, Glacier Recession, and Streamflow in the Nooksack River Basin, presented at the 2015 Fall Meeting, AGU, San Francisco, CA, Dec, 14-18, 2015.

Grah, O., G. Beaulieu, R. Mitchell, C. Bandgaragoda, and R. Murphy*, 2015. Instrumenting a Glacier Served Watershed in the Nooksack River, 6th Annual Northwest Climate Change Conference, Codeur D'Alene, ID, November 3-5, 2015.

Murphy*, R. and R. Mitchell, 2015. Calibration of a Hydrologic and Dynamic Glacier Model to the Nooksack River Basin Using Gridded Surface Climate Data. 10th WA State Hydrogeology Symposium. April 14-16, 2015 Tacoma, WA.

Murphy*, R. and R. Mitchell, 2014. Hydrologic Modeling in the Nooksack River Basin Using Downscaled Gridded Surface Climate Data: Geological Society of America Abstracts with Programs, Vol. 46, No. 6, p.97.