

Overview

Dr. Boehlert specializes in water resources engineering and economics, with a focus on climate change and water systems analysis. He has extensive experience analyzing the effects of changes in water availability and allocation, climate change impacts and adaptation responses, the economic impacts of environmental regulations, and the costs of damages to natural resources. Drawing on his academic background in economics and engineering, he frequently employs analytical methods and tools from both fields in his often interdisciplinary project work. Dr. Boehlert's clients include the World Bank, U.S. Environmental Protection Agency, U.S. Department of Interior, U.S. Department of Justice, Tennessee Valley Authority, various state agencies, and clients in the private sector. He has published peer-reviewed articles in journals such as *Water Resources Research*, *Environmental Research Letters*, *Journal of Climate*, and *Philosophical Transactions of the Royal Society*, and has served as reviewer for several journals, including *Climatic Change and Applied Energy*. Dr. Boehlert is also a Research Affiliate with the Massachusetts Institute of Technology (MIT) Joint Program on the Science and Policy of Global Change.

Education

Ph.D. in Environmental and Water Resources Engineering, Tufts University

Master of Science in Natural Resource Economics, Oregon State University

Bachelor of Arts in Engineering, Dartmouth College

Project Experience

For the **WORLD BANK**, managed an analysis in Uganda of the vulnerability and adaptability of existing catchment management and project infrastructure plans under climate change. Analyzed the robustness of possible alternative infrastructure designs to a wide range of climate futures. Co-led a set of capacity building workshops focused on transferring technical knowledge of river basin planning tools to Ugandan counterparts.

For the **U.S. DEPARTMENT OF INTERIOR, OFFICE OF POLICY ANALYSIS**, leading an analysis of the costs of climate change inaction on lands managed by the Department of Interior in the U.S. southeast. Estimating impacts on coastal and inland infrastructure, coastal wetlands, recreation, and invasive species management, and evaluating the economic benefits of adaptation.

For the **U.S. ENVIRONMENTAL PROTECTION AGENCY**, leading an analysis of the economic impacts of harmful algal blooms (HABs) under climate change. Worked collaboratively with experts to integrate HABs functionality into a detailed contiguous U.S.-wide water systems and quality model built by IEc. Valuing impacts to reservoir recreation and municipal water supply. Results will be published in a peer reviewed journal.

For the **INSTITUTE OF CLIMATE AND CIVIL SYSTEMS**, analyzing the macroeconomic impacts on Egypt of various Grand Ethiopian Renaissance Dam filling strategies. Built a water systems model of the High Aswan Dam, and running that model dynamically with a computable general equilibrium (CGE) model. Study results will be used to inform decisionmaking over transboundary water management.

For the **U.S. DEPARTMENT OF INTERIOR, SECRETARY OF INDIAN WATER RIGHTS OFFICE**, leading a study of the economic benefits of Indian water rights settlements. Evaluating the economic effects of four settlements on ecosystem services, incomes, employment, and a number of other outcomes. Study will provide much needed input on the benefits of these programs to the Office of Management and Budget and others.

For the **WORLD BANK**, providing expert guidance to Zimbabwe's Ministry of Environment, Water, and Climate (MEWC) in developing Terms of Reference (TORs) for their National Water Resources Master Plan. Once a consultant has been selected, will serve as a technical advisor to the World Bank and MEWC to ensure the TORs are being followed and that climate change and other uncertainties are carefully considered.

For the **U.S. ENVIRONMENTAL PROTECTION AGENCY**, leading a study that compares the baseline and projected outputs of two water quality models for the contiguous U.S.: QUALIDAD (built by IEc) and HAWQS (from Texas A&M). Although the models produce different baseline water quality patterns, projected changes in a water quality under climate change are similar. Results will be published in a peer reviewed journal.

For the **WORLD BANK**, managed an economic analysis of a proposed \$1 billion groundwater management investment program in India. Employed two approaches: (1) an input-output modeling approach to evaluate the macroeconomic benefits of improved management, and (2) a case study approach, focusing on the benefits and costs of specific interventions envisioned under the program.

For the **U.S. ENVIRONMENTAL PROTECTION AGENCY**, led a study analyzing the economic impacts of climate change on hydropower generation across the contiguous U.S., and the economic benefits of greenhouse-gas mitigation. Analyzed changes in generation across 18 climate change scenarios at over 500 facilities, using a water systems model of the U.S., and published the work in *Applied Energy*.

For the **ZAMBEZI WATERCOURSE COMMISSION**, analyzing the benefits and costs of various water-related investments as part of the Zambezi Strategic Investment plan. Will run a water systems model under a range of future climates to test the robustness of these investments to uncertainty. Results will inform investments and planning in the basin for the next 20 years or more.

For the **U.S. ENVIRONMENTAL PROTECTION AGENCY**, leading a study of the economic impacts of fire occurrence in Alaska under climate change. Managing subcontractors at the University of Alaska at Fairbanks, who built a stochastic wildfire model. Work submitted to *Climatic Change Letters*.

For the **ENVIRONMENTAL DEFENSE FUND**, serving as an expert on modeling of the economic impacts of harmful algal blooms (HABs). EDF is evaluating the potential benefits of agricultural management practices in the Upper Mississippi basin that lower nutrient loadings.

For the **U.S. ENVIRONMENTAL PROTECTION AGENCY**, leading a study of the economic implications of climate change on public infrastructure in Alaska. This study focuses on impacts of freeze thaw events, permafrost thaw, coastal erosion, and a range of other drivers that affect buildings, roads, and other infrastructure. Work submitted to *Proceedings of the National Academy of Sciences*.

For the **TENNESSEE VALLEY AUTHORITY**, evaluated anticipated effects of climate change on water, agricultural, and recreational resources in the Tennessee Valley. Coordinated with experts in these fields to produce a final report to TVA synthesizing and summarizing ranges of potential impacts based on conclusions of the latest literature.

For **UGANDA'S MINISTRY OF WATER AND ENVIRONMENT**, managed an analysis of the contribution of water resources development and environmental management to Uganda's economy. The study integrates biophysical and macro-economic models to estimate the GDP and employment implications of a range of management and investment strategies under an uncertain future. Coordinated a one-year training program to build the technical capacity of local counterparts.

For the **TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION**, developed guidance for Tennessee's anti-degradation policy. Developed methods for the department to quantify and monetize the socioeconomic benefits of a proposed project, so that they can compare those to the environmental costs.

For the **U.S. ENVIRONMENTAL PROTECTION AGENCY**, managed an assessment of the potential economic effects of water quality changes that would result from climate change mitigation. Constructed a water supply and demand model of the US water system, the outputs of which will be inputs to a water quality module. Managing the efforts of international experts on water resource engineering and surface water quality, and published the work in *Journal of Advances in the Modeling of Earth Systems*.

For the **WORLD BANK**, assessed the economic performance of various green growth infrastructure trajectories in Romania and FYR Macedonia using a number of biophysical models and water resource availability forecasts under a range of climate models and emissions scenarios. Analyzed the economic implications on municipal and industrial water availability, hydropower generation, and irrigator revenues, with the goal of feeding these results into Computable General Equilibrium (CGE) models of the countries' economies to evaluate overall economic outcomes.

For the **ATLANTA REGIONAL COMMISSION**, estimated the economic impacts of reductions in water availability to Atlanta stemming from a recent federal court ruling. Worked with hydrologists to create a hydrologic-economic model to evaluate the relative benefits and costs of changes in water availability in various parts of the Apalachicola-Chattahoochee-Flint (ACF) river system. Focused on economic impacts to the municipal and industrial supply, hydropower, and reservoir recreation sectors.

For the **WORLD BANK**, modeled the hydrology and economics of agricultural systems in Albania, Macedonia, Moldova, and Uzbekistan to evaluate vulnerability to climate change, and to identify the most effective adaptation options for these systems. Spent several weeks in each country consulting with farmers and policymakers. Presented findings of water resource analyses at National Conferences in Uzbekistan and Moldova. This study won the prestigious World Bank green award for mainstreaming environmental concerns into development assistance strategies, programs, and projects.

For the **U.S. ENVIRONMENTAL PROTECTION AGENCY**, analyzed drought risk across the U.S. under various climate change scenarios. This analysis applied the most recent global circulation model (GCM) outputs coupled with various definitions of drought to develop geographic representations of drought risk under climate change in the U.S. Culminated in a publication in *Environmental Research Letters*.

For the **WORLD BANK**, modeled the implications of climate change on water resource availability in Armenia, Azerbaijan, and Georgia, and coupling these results with crop yield projections to evaluate the benefits and costs of various adaptation responses for the agricultural sector. Worked in-country with farmers and other stakeholders to evaluate the practical efficacy of these responses.

For the **WORLD BANK**, analyzing the climate vulnerability of Africa's infrastructure in seven of Africa's primary river basins. Bias corrected and downscaled over 120 climate model outputs relative to an observed gridded dataset. Subsequently, developed and applied an economic optimization tool used to analyze "perfect foresight" water resource adaptation options under these scenarios, and potential regrets.

For the **WORLD BANK**, managing an analysis of climate risks to Madagascar, including changes in drought frequency, river runoff, sea level rise, and cyclone risk. Developed several reports documenting findings, and delivered a one-week training at Madagascar's national meteorological institute in Antananarivo aimed at transferring the technical methodologies employed in our analysis to in-country experts.

For the **WORLD BANK WATER ANCHOR**, analyzing the effect of climate change on hydrological indicators in nearly 9,000 river basins around the globe. These indicators include storage yield, flood and drought risk, and mean annual runoff, among others. Data and analytical outputs are available on the World Bank data portal, where they will be used by Bank staff and others as a screening tool for planning and investment.

For the **WORLD BANK**, analyzed the potential conflicts between planned hydropower and irrigation projects in the Zambezi basin under climate change. Used a hydrological model to project runoff in the basin between 2011 and 2100 under the full range of IPCC AR4 GCM/SRES outputs. Results will be used to inform World Bank infrastructure investment decisions.

For Canada's **NATIONAL ROUNDTABLE ON THE ENVIRONMENT AND THE ECONOMY**, analyzed how climate change will affect storage yield in Canada's river basins using inputs from dry, mid-level, and wet general circulation models (GCMs). Used these changes in yield to estimate potential adaptation costs.

For the **FORESIGHT PROGRAM**, reviewed competing uses of water that could affect worldwide water for agriculture, and coupled these uses with changing water availability under climate change to assess how total water available for agriculture could change. Model outputs identified river basins where water for the food system is most threatened. Culminated in a published article in *Philosophical Transactions of the Royal Society*.

For the **U.S. ENVIRONMENTAL PROTECTION AGENCY**, analyzed the effect of climate change on storage yield in U.S. basins using a range of GCM/SRES scenarios. Quantified the potential costs of adapting to modeled reductions in storage yield.

For the **WORLD BANK'S** Economics of Adaptation to Climate Change (EACC) study, developed a river basin model for Ethiopia to assess the impacts of climate change and growing water demand on irrigated agriculture, hydropower, municipal and industrial water supply, and Nile River flows to downstream Sudan and Egypt. Analyzed these impacts under four climate change scenarios.

For the **WORLD BANK'S** EACC study, analyzed the impacts of rising temperatures on livestock incomes in Ethiopia, Mozambique, and Ghana. In addition, developed a reduced-form statistical model of regional drought occurrences and cost of government response to drought relief in Ethiopia. Time series of projected yearly livestock income impacts and drought expenditures were added to the Computable General Equilibrium (CGE) models for each country to estimate overall economic impacts of climate change.

For a private law firm, valued in situ groundwater in the Memphis Sands Aquifer underlying Memphis, Tennessee and critiqued the valuation approaches of the plaintiff's experts. In this case, Mississippi argued

that Memphis had been illegally pumping groundwater over the border for over four decades, and was seeking both welfare- and market-based damages totaling roughly \$1 billion.

For **MCELROY, MEYER, WALKER & CONDON, P.C.**, valued a right-of-way through the Kaibab Indian Reservation for the state of Utah's proposed Lake Powell water pipeline, which will convey water from Lake Powell to southwestern Utah. Estimated direct costs of the right-of-way to the Tribe, the added costs of an alternate pipeline route, and the benefits of the pipeline to the state.

For the **MISSOURI DEPARTMENT OF NATURAL RESOURCES**, developed a model of economic damages to recreational fisheries due to lead contamination in eastern Missouri.

For the **U.S. DEPARTMENT OF ENERGY**, provided technical assistance in estimating damages to commercial fisheries due to contamination of the Watts Bar Lake in Tennessee.

For the **U.S. DEPARTMENT OF THE INTERIOR, MINERALS MANAGEMENT SERVICE**, conducted a cost benefit analysis to support the rulemaking process for 30 CFR 285 governing alternative energy production on the outer continental shelf. Developed a financial model that identified whether specific wind, wave, and current projects met minimum financial requirements and estimated the government revenues and costs from the proposed regulatory rule.

For the **U.S. DEPARTMENT OF JUSTICE**, provided technical assistance in estimating natural resource damages to an area of southwestern Ohio above a contaminated aquifer.

For the **U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE**, managed an analysis of the potential costs of designating critical habitat for the threatened Oregon chub. Focused on potential impacts to water management-related activities (e.g., hydropower generation and reservoir recreation), agriculture, forestry, and transportation activities.

For the **U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE**, managed an analysis of the incremental costs of designating critical habitat for the Altamaha Spiny mussel critical habitat in Georgia. Key activities analyzed were recreation, forestry, and agriculture.

For the **U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE**, analyzed potential economic impacts related to the proposed critical habitat designation for the endangered Alabama sturgeon. Focused on the potential impacts to a variety of economic activities affected by water management in the Alabama and Cahaba River systems, including hydropower generation, reservoir recreation, barging, and a variety of industries that may be affected by changes in water quality standards to benefit the sturgeon. Presented findings during a public hearing and in a report to FWS.

For the **U.S. DEPARTMENT OF THE INTERIOR, MINERALS MANAGEMENT SERVICE**, created a framework of the social costs and benefits associated with offshore renewable energy production and identified which of these costs and benefits were readily quantifiable given currently available information. Developed a model that aggregated available information to monetize the annual social benefits of typical wind, wave, and current projects.

For the **U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE**, developed economic models investigating the potential welfare and distributional impacts associated with designation of proposed critical

habitat for seven species of threatened freshwater mussels in Georgia, Florida, and Alabama. The models estimated economic impacts to the agricultural and recreational sectors associated with decreases in irrigation deliveries and lower reservoir levels, respectively.

For the **U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE**, developed an analysis evaluating the potential costs associated with proposed critical habitat designation for the threatened Flatwoods salamander in Georgia, South Carolina, and Florida. Created economic models estimating these potential impacts to the timber and development industries associated with the proposed designation. Presented these findings during a public hearing.

For the **U.S. DEPARTMENT OF THE INTERIOR, NATIONAL PARK SERVICE**, assisted national experts in developing stated preference surveys to evaluate the public's willingness to pay for improved visibility in U.S. National Parks. Collected data from focus groups and analyzed the resulting statistics to improve the efficacy of the survey instrument. The survey results will be used to evaluate the potential benefits of Federal efforts that may affect visibility such as the Regional Haze Rule.

For the **U.S. DEPARTMENT OF HOMELAND SECURITY**, managed the development of a database and accompanying report describing and summarizing available literature on the costs of terrorist attack events. DHS intends to use this database, which contains over 150 citations, for future break-even analyses of proposed regulations.

For the **U.S. DEPARTMENT OF THE INTERIOR, NATIONAL PARK SERVICE**, developed an organizational framework comparing the indirect cost accounting practices of six Department of Interior Bureaus (Fish and Wildlife Service, National Park Service, U.S. Geological Survey, Bureau of Reclamation, Bureau of Indian Affairs, and Bureau of Land Management).

For **U.S. DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE**, modeled the economic impacts of the proposed critical habitat designation for the Canada Lynx on development and wind power activities in parts of Maine, Montana, Minnesota, Washington, and Wyoming. Summarized findings in a report to FWS.

For a private law firm, developed a hedonic model of impacts to housing prices related to the presence of a groundwater contaminant plume in a mid-Atlantic urban area.

For a private law firm, estimated added cost damages to a northeastern water utility associated with contamination of a wellfield.

For the **U.S. DEPARTMENT OF THE INTERIOR, NATIONAL PARK SERVICE**, aided in an assessment of how the Park Service's current cost accounting systems accumulate and report indirect costs associated with damage assessment and restoration activities.

For the **U.S. ENVIRONMENTAL PROTECTION AGENCY**, investigated how to more effectively design and implement a range of voluntary environmental programs for businesses in a variety of sectors.

For **OREGON STATE UNIVERSITY EXTENSION SERVICE**, developed a set of metrics to more accurately compare the economic, environmental, and technical dimensions of the various renewable and non-renewable electricity sources.

For a private party, provided technical support in designing a remediation plan for three separate responsible parties to a site significantly impacted by soil and groundwater contamination in Los Angeles, California.

For the **SONOMA COUNTY WATER AGENCY**, investigated the downward migration of contaminants through drinking water filtration basins in Santa Rosa, California.

For numerous private parties, provided technical oversight and consultation on the environmental quality of properties for potential buyers and sellers. Participated and directed Phase II and/or remediation efforts in the event that contaminated soil or groundwater was encountered.

Selected Publications and Presentations

Peer-Reviewed Publications

Chapra, S., B. Boehlert, C. Fant, J. Henderson, D. Mills, D. Mas, L. Rennels, L. Jantarasami, J. Martinich, K. Strzepek, V. Bierman, Jr., H. Paerl. (In review) Climate Change Impacts on Harmful Algal Blooms in U.S. *Environmental Science & technology*.

Melvin, A.M., Murray, J., Boehlert, B., Martinich, J.A., Rennels, L., and T.S. Rupp. 2017. Estimating wildfire response costs in Alaska's changing climate. *Climatic Change*. doi:10.1007/s10584-017-1923-2.

Fant, C., R. Srinivasan, B. Boehlert, L. Rennels, S. Chapra, K. Strzepek, J. Corona, A. Allen, J. Martinich. 2017. Climate Change Impacts on US Water Quality using two Models: HAWQS and US Basins. *Water*. doi:10.3390/w9020118

Boehlert, B., K. Strzepek, Y. Gebretsadik, R. Swanson, A. McCluskey, J. Neumann, J. McFarland, and J. Martinich. 2016. Climate change impacts and greenhouse gas mitigation effects on US hydropower generation. *Applied Energy*. doi: 10.1016/j.apenergy.2016.09.054.

Melvin, A., P. Larsen, B. Boehlert, J. Neumann, P. Chinowsky, X. Espinet, J. Martinich, M. Baumann, L. Rennels, A. Bothner, D. Nicolsky, and S. Marchenko. 2016. Climate change damages to Alaska public infrastructure and the economics of proactive adaptation. *Proceedings of the National Academy of Sciences*. doi: 1611056113v1-201611056.

Boehlert, B., S. Solomon, K.M. Strzepek. 2015. Water under a changing and uncertain climate: Lessons from climate model ensembles. *Journal of Climate*. doi: 10.1175/JCLI-D-14-00793.1.

Boehlert, B., Strzepek, K. M., Chapra, S. C., Fant, C., Gebretsadik, Y., Lickley, M., Swanson, R., McCluskey, A., Neumann, J. E. and Martinich, J. 2015, Climate change impacts and greenhouse gas mitigation effects on U.S. water quality. *J. Adv. Model. Earth Syst.*. doi:10.1002/2014MS000400.

Boehlert, B., E. Fitzgerald, J. Neumann, K. Strzepek, and J. Martinich, 2015. The effect greenhouse gas mitigation on drought impacts in the U.S. *Weather, Climate, and Society*. doi: 10.1175/WCAS-D-14-00020.1.

Strzepek, K., J. Neumann, J. Smith, J. Martinich, B. Boehlert, M. Hejazi, J. Henderson, C. Wobus, R. Jones, K. Calvin, D. Johnson, E. Monier, J. Strzepek, J.-H. Yoon (2014) Benefits of greenhouse gas mitigation on the supply, management, and use of water resources in the United States. *Climatic Change*. doi: 10.1007/s10584-014-1279-9.

Strzepek, K., M. Jacobsen, B. Boehlert, and J. Neumann. 2013. Toward evaluating the effect of climate change on investments in the water resources sector: insights from the forecast and analysis of hydrological indicators in developing countries. *Environmental Research Letters* 8 044014 doi:10.1088/1748-9326/8/4/044014

Boyle, K., C. Parmeter, B. Boehlert, and R. Paterson. 2013. Due Diligence in Meta-Analysis to Support Benefit Transfers. *Environmental and Resource Economics*. 55(3): 357-386.

Strzepek, K., G. Yohe, J. Neumann, and B. Boehlert. 2010. Characterizing changes in drought risk for the United States from climate change. *Environmental Research Letters*. 5(4). doi: 10.1088/1748-9326/5/4/044012.

Boehlert, B., and W. Jaeger. 2010. Past and future water conflicts in the Upper Klamath Basin: An economic appraisal, *Water Resources Research*, 46, W10518, doi:10.1029/2009WR007925.

Strzepek, K. and B. Boehlert. 2010. Competition for Water for the Food System. *Philosophical Transactions of the Royal Society: Biological Sciences*. 365(1554): 2765-3097.

Selected Presentations

Boehlert, B., W.H. Farmer, K.M. Strzepek. 2015. Improved bias correction approaches for climate change impact analysis. *World Environmental & Water Resources Congress*, Austin, Texas.

Boehlert, B., S. Solomon, K.M. Strzepek. 2014. Water under a changing and uncertain climate: Lessons from climate model ensembles. *American Geophysical Union*, San Francisco, California.

Vogel, R., W. Farmer, B. Boehlert. 2014. Blunders and Bias in Flood and Drought Frequency Analysis. *European Geophysical Union General Assembly Conference*.

Boehlert, B. 2013. Responding to Climate Change in the Agricultural Sector: Water Resources Impact Assessment. *National Conferences on Adapting to Climate Change in Agricultural Systems*, Azerbaijan and Armenia.

Boehlert, B., R. Paterson, K. Boyle, and C. Parmeter. 2010. Sample Selection and Robust Meta-Analysis based on Benefit Transfers. *World Congress of Environmental and Resource Economists*, Montreal, Canada.

Boehlert, B. 2010. Sustainable Water Management for the 21st Century: Engineering, Economics, and Policy. Guest speaker at the *Chi Epsilon Honors Engineering Fraternity Annual Dinner*, Massachusetts Institute of Technology (MIT).

Boehlert, B. and K. Strzepek. 2010. Competition for Water for the Food System. *NE Chapter for the Society for Risk Analysis (SRA)* annual meeting.

Boehlert, B. 2006. Towards Greater Certainty in Upper Klamath Basin Water Management. Presentation. *Western Agricultural Economics Association (WAEA)* annual meeting; *Universities Council on Water Resources (UCOWR)* Annual Meeting.