# W\_TEMP\_5190: Management and Policy Challenges in a Water-Uncertain World

**Revised**

**Duration** 10/01/2024 to 09/30/2029

Non-Technical Summary

Urban and agricultural water demand exerts pressure on increasingly scarce and uncertain water supplies. In its inaugural iteration, this committee anticipated that water conservation acquired through traditional cost-share conservation programs would be insufficient to meet the needs of growing non-agricultural water demands. Irrigation efficiency has steadily improved; yet, irrigated acreage in the west has declined alongside the supporting aquifers. There is dissatisfaction with the efficacy of prevailing water allocation laws, institutions, and procedures to efficiently, equitably, and sustainably allocate water among various uses and users. This multistate committee will account for the emerging water management uncertainties while satisfying public equity requirements by characterizing water resource and human systems the responses to climatic and anthropogenic perturbations; quantifying the value of water in different stages of the water cycle; and evaluating alternative water management strategies and institutions, and the relationship to ecosystem, communities, land, and energy uses.

W5190 will serve stakeholders including agricultural producers, irrigation, conservation, and water management districts, private water-supply organizations, state environmental/water quality management programs, and federal agencies. It will achieve its goal by developing data, measurement, and theoretical approaches to understand the factors that affect the value of water as a natural capital, as well as its use and non-use values. Agricultural and natural resource economists comprise the largest portion of the committee, followed by soil scientists. Solutions to water management challenges are inherently interdisciplinary. W5190 welcomes colleagues from irrigation engineering, agronomy, hydrology and water quality, as well as other social sciences besides economics.

# Statement of Issues and Justification

Climate change, with increased precipitation variability and drought conditions have led to uncertain water supplies and timing. Increases in urban and agricultural water use have put upward pressure on water demand as supplies have become more uncertain. With projected changes in the timing of precipitation and reduction of snowpack, declines in groundwater storage and availability, and increased competition for water resources, disentangling both the extent of water resource changes and the repercussions to water users is essential. Beyond knowing the extent of the problem, careful research also needs to be conducted on water management strategies that are effective and equitable. Given complexities in differing hydrological systems, as well as differences in water users and needs, it is not feasible to design universal management schemes that provide sufficient resources to all current and future water users (human and environmental), while preserving water quality. Historically, water management has suffered from a mismatch in spatial resolution, where water problems are local, but the management or policies are implemented at a much broader scale of political demarcation that may or may not coincide with relevant hydrological boundaries. Knowing the conditions under which water management policies are effective, and at what scale, remains critical.

Some twenty years ago, in its inaugural proposal, this committee anticipated that water conservation acquired through traditional cost-share conservation programs would be insufficient to meet the needs of growing non-agricultural water demands, particularly for environmental purposes. Despite the technical progress that has steadily improved irrigation efficiency, and the resulting reduction in applied water, irrigated acreage in the west has been declining alongside the supporting aquifers (Hrozencik and Aillery, 2021). Work from this group warned that the reliance on technical progress in the form of increased irrigation efficiency may not result in total water savings (Peterson and Ding, 2005; Huffaker, 2008; Ward, F. A., and M. Pulido-Velazquez. 2008; Warziniack and Brown 2019; Brown et al. 2019). The adoption of technological solutions has been incentivized with public funding with various degrees of success but generally at great cost.

Consequently, there is dissatisfaction with respect to the efficacy and effectiveness of the prevailing water allocation laws, institutions, and procedures to efficiently, equitably, and sustainably allocate water among emerging water uses and users. In recent work, our members have provided significant insights into existing and potential institutional water management arrangements. For instance, sharing information about nearby farmers’ groundwater use induced reductions in subsequent water use of 4% compared to farmers that did not receive comparison information (Hrozencik et al., 2023). The equity in outcomes of the allocations of water that result from established water and property rights in rural and indigenous communities in the face of water scarcity or uncertainty have also been assessed by our members (Sanchez, L., Leonard, B., & Edwards, E. C., 2023). This multistate committee will continue to evaluate alternative institutional arrangements to account for the emerging uncertainties related to water management, while also satisfying public equity requirements.

This proposal for W5190 lays out the plans to continue developing on its historic themes and expand based on important emerging issues. This iteration includes an explicit goal to contribute by developing data, measurement, and theoretical approaches to understand the factors that affect the value of water as a natural capital, as well as its use and non-use values (see Objective 2). Serving stakeholders is a goal of W5190. This group of stakeholders includes agricultural producers, irrigation, conservation, and water management districts, private water-supply organizations, state environmental/water quality management programs, federal agencies such as the Bureau of Reclamation, Army Corps of Engineers, USDA (e.g., NRCS, NIFA, RMA, and FSA) and the EPA, and non-governmental organizations such as the Western States Water Council, the Western Governors Association, and the Nature Conservancy. Potential collaborators include Trout Unlimited, Ducks Unlimited, The Nature Conservancy, Western States Water Council, conservation districts, groundwater management districts, and state agencies.

Across objectives, W5190 includes tasks aimed at explicitly reflecting the work its members will carry out in terms of translational economics in the form of outreach, extension, teaching, media, and policy briefing activities related to their respective areas of expertise. Translating the theoretical and empirical findings from this group is critical to inform water managers and policy makers at local, state, and federal levels. The Infrastructure Investment and Jobs Act (IIJA) provides generational investments in ecosystem restoration and wildfire risk reduction; and the Inflation Reduction Act includes $4 billion for water management in the Colorado Basin in addition to $8.3 billion for drought mitigation in Western states. The investments in water management infrastructure and institutions must be informed by the economic and behavioral insights that emerge from work in this committee. We explicitly aim at producing such informative output over the next 5 years.

Although DEI has not been an explicit goal of our multi-state group, it has consciously increased the number of women, researchers of color, and early career participants. For example, in the inaugural W1190 report, 6 female participants were listed (20% of membership) in the project while our terminal W4190 membership counts 23 female economists (34% membership). In terms of leadership, the committee started with no female representation in the inaugural committee leadership to being represented in the last 3 years of W4190 and in the inaugural W5190. We do not ask members to self- identify in terms of demographics so we shall not provide an estimate with regard to other under-represented groups, but suffice it to mention that we have made conscientious efforts towards inclusion. Our proposal will continue these efforts by encouraging participation of underrepresented groups both in membership and leadership.

Importance of Work: The research proposed for W5190 responds to stakeholder needs for information and analysis, addressing national and regional priorities for water management. The National Academy of Sciences (NAS) identified ten research questions to address the highest priority water resource and science challenges for the U.S. over the next 25 years (National Academy of Sciences, Engineering and Medicine, 2018). Five of those questions relate directly to the research proposed for W5190: 1) How do human activities affect water quantity and quality; 2) How does changing climate affect water quality, quantity, and reliability, as well as water-related hazards and extreme events; 3) How can long-term water-related risk management be improved; 4) How do institutions, governance, and institutional resilience impact the quantity and quality of water; and 5) How can competing uses for water resources be managed and maintained to sustain healthy communities and ecosystems in a changing world. The National Strategy to Develop Statistics for Environmental- Economic Decisions, creates a system to account for natural assets and track their condition, quantify their value and understand their economic role in order to ultimately improve the nation’s ability to fight the climate crisis, build a strong and sustainable economy, and advance economic equity (White House, 2023). These topics are at the heart of the W5190 proposal.

Advantages of Multistate Collaboration: Research and outreach on water management lend themselves naturally to multistate collaborations particularly as rivers and groundwater aquifers do not respect state boundaries. Policymakers from adjacent states regularly work together to manage shared water resources; water resource researchers similarly collaborate across state boundaries to address shared water management challenges. The collaborative relationships facilitated by W5190 also improve the flow of information and ideas across state boundaries. Tools implemented successfully in one location can rarely be applied entirely to other locations without some adaptation to local circumstances, but inspiration for management approaches and institutions can often be found by examining what has worked well in other locations. This cross-fertilization and testing of new ideas also improves stakeholder engagement and facilitates transmission of knowledge from one generation of researchers to the next through mentorship.

Members of this multistate group have expressed an intention to work and collaborate in the following cross-state groupings (in no particular order): (i) Texas-Colorado-New Mexico; (ii) Montana-California; (iii) Kansas-Texas-Colorado-Nebraska-Tennessee; (iv) South Carolina-Tennessee-Indiana-Georgia-Delaware-Nebraska; (v) California-Oklahoma-Minnesota; (vi) Nebraska-Kansas-Missouri-South Dakota-Iowa; (vii) Mississippi-Louisiana-Arkansas-Missouri-Tennessee-Texas-Oklahoma; (viii) Missouri-Illinois-Montana-Oklahoma; (ix) Texas-Tennessee-Mississippi-Colorado-Georgia; (x) Kansas-California-Kentucky- -Nebraska-Oklahoma; (xi) Nebraska-Colorado-Rhode Island-South Carolina-Wyoming; (xii) Michigan-California-Kansas\_Nebraska-Oklahoma-Texas-Ohio-Indiana-Illinois-New York-Wisconsin. We expect more combinations to emerge as the multistate group expands.

One of the goals of multi-state groups is to foster development of projects that can address the various agency priority areas. Our group has been successfully addressing these priority areas and securing extramural funding from various sponsors. Examples from the previous iteration of this project include dozens of funded grants totaling more than $7 million (see appendix A).

Technical Feasibility of the Proposed Research: The proposed research has a high degree of technical feasibility. Our multistate team includes water professionals with rigorous training in conceptual, theoretical, and applied aspects of biophysical sciences and water resource economics. Team members also have extensive experience analyzing water management practices, policies, and institutions. Current membership of W4190 includes 55 researchers from 26 states (half of which are located east of the 100 meridian, a region where water quantity concerns are now developing), USDA- ARS, USDA/FS, and USDC-NOAA; we anticipate many current W4190 members will sign up for W5190. Agricultural and natural resource economists comprise the largest portion of the team, followed by soil scientists. Solutions to water management challenges are often inherently interdisciplinary. We enthusiastically welcome colleagues from irrigation engineering, agronomy, and hydrology and water quality, as well as other social sciences besides economics.

# Related, Current and Previous Work

This proposal is for the renewal of W4190 as the premier multistate group of scholars and practitioners focusing on the economics of water management across the country. The diversity of this group’s members in terms of their backgrounds, expertise and distribution across the nation matches the broadness and complexity of water-related issues around the world. From its beginning, the group has grown in its membership’s combined capabilities to address broader and more complex water-related issues with more and better methods. The overarching theme of W1190 was the valuation of water in various uses and the evaluation of practices and institutions to increase the value of said uses or to reallocate limited supplies to higher value uses. W2190 added water conservation in, and transfers from agricultural uses in the western states with a consideration for equity and economic implications for rural communities resulting from diminished irrigation allocations. W3190 emphasized water management and policy advancements in light of climate change, depletion of major aquifers, urban growth in water-scarce areas, and increasing demand for environmental goods and services with an overarching goal of increasing society’s net benefit from limited water resources. In W4190, the committee continued to assess the physical and economic impacts associated with alternative water-related technologies and institutions; and expanded the scope to improve the scientific and practical understanding of the relationships between water resource and human systems, and how humans evaluate trade-offs and respond to incentives. Across various states, researchers participating in W4190 acquired external federal funding, developed workshops, created new collaborations, and published multiple papers to address its four objectives. This iteration expands the committee’s scope to contribute to the discussion of water resources as a national natural capital, an explicit consideration of DEI issues and environmental justice across objectives, and a specific goal to translate water-related economic science to broader audiences.

To identify active multistate projects that may be related to W5190, we conducted an advanced search in the NIMSS system with the keywords: water, climate, management, and economics. The search returned 42 results (see Appendix B for details). The most closely related multistate project is W5133. The core mission of that project is to contribute to advances in the theory and empirical application of economic valuation of nonmarket goods and services. The work they perform does inform water management decision makers at the policy level. This is clearly a related group as many of our members have led publications (cited in the W5133 project proposal) co-authored with members of W5133. This is a case of augmentation and not duplication of multistate projects, as we expect to continue benefiting from their advancements in valuation methods to be applied to the water management challenges that our multistate project addresses. Cross-project collaboration would be expected precisely because of the complementarity of the efforts.

Similar to W5133, S1069 aims to research and develop UAS-based remote sensing systems and methods to aid in the research and management of agricultural inputs and outputs as well as natural resources. Advances from this group could be exploited by researchers in W5190 and water management projects emerging from W5190 could serve as test beds for S1069 projects, particularly where it relates to field-level precision estimations of crop water use at larger scales.

Another multistate project with some similarity to W5190 is NC1190: Catalysts for Water Resources Protection and Restoration: Applied Social Science Research. The NC1190 project focuses on the water quality dimensions related to Gulf Hypoxia -- primarily nutrient losses from crop production in the Midwestern U.S. NC1190 researchers study the social processes that influence attitudes and beliefs, along with other (non-economic) social factors driving practice adoption behaviors. They also consider the roles of local actors such as soil and water conservation districts and other networks of conservation professionals in these social dynamics. Research from the NC1190 and W5190 projects would complement each other, potentially informing additional research on the intersection of social dynamics, policy incentives, and other economic drivers to evaluate management approaches.

W4190 Objective 1: Characterize water resource and human system response to climatic and anthropogenic perturbations. Participants in this group have made strides in understanding, addressing and communicating to stakeholders the challenges posed by climate change on water resources and agriculture. Significant interstate collaboration has produced studies that characterize climate change responses including work on climate databases, climate change impacts on water use, effects of policies on groundwater, effects of climate change on stream flows, impacts of climate change on stormwater management, uncertainty and risk analyses, and estimates of water yield (Gardner et al., 2021; Sampson et al., 2021; Gardner and Sampson, 2022; Ao et al., 2021; Obembe et al., 2023; Rohith et al., 2021; Warziniack et al., 2022; Heidari et al., 2021; Heidari et al., 2021). Members released The Water Assessment as part of the USFS’s Resource Planning Act Assessment (https://[www.fs.usda.gov/research/inventory/rpaa/2020).](http://www.fs.usda.gov/research/inventory/rpaa/2020))

W4190 Objective 2. Quantify water demand and value of water in competing and complementary water uses. Researchers provided insights into the management and valuation of water resources in agricultural and natural systems amid climate change, and evaluated the effectiveness of demand management programs and the economic outcomes of groundwater curtailment, alongside estimating agricultural water use and nutrient management across various landscapes. Work was done to enhance datasets on water use, integrating variables such as weather, crop choices, and water table elevations, supporting the development of more accurate and comprehensive models for water management (Suter et al., 2021; Tatlhego et al., 2022; Sampson et al., 2019; Perez-Quesada, 2022; Perez-Quesada et al., 2024; Edwards et al., 2024).

W4190 Objective 3. Evaluate and compare coordinated/integrated management of water sources and land use practices. Researchers examined the effects of land use change on water quantity and quality highlighting the need to evaluate the coordinated management of these resources. They explored the feasibility of alternative water sources and the adoption of efficient irrigation practices, analyzed integrated management practices of water sources and land use, focusing on sustainability and economic impact, researched the intersection of urban land, water quality, and biodiversity, and informed policy for sustainable water management amidst climate change challenges (Ricciardi et al., 2022, Chen et al., 2019, Ghane and Askar 2021, Shokrana and Ghane, 2021, O’Neill et al., 2023, Dialameh and Ghane 2022).

W4190 Objective 4. Evaluate and compare alternative water quantity and quality management strategies and institutions. Research by W4190 members has focused on the development and assessment of water management strategies and their economic implications. Regional modeling has been developed to evaluate groundwater management institutions and managed aquifer recharge. Efforts have also been made to integrate hydro-economic modeling with willingness-to-pay estimates to gauge the economic benefits of groundwater retirement programs and to assess the potential for conservation spillovers from retired wells. Other activities have been carried out to enhance the efficacy of payment programs for water- based ecosystem services and to address the information needs of watershed-based management programs (Hrozencik et al. 2022, Rouhi Rad et al. 2021, Manning et al. 2020).

# Objectives

1. Characterize the response of water resources and human systems to climatic and anthropogenic perturbations. Comments: Water resources and human systems are differentially affected by changes in climate and anthropogenic fluctuations. Research is needed to define and evaluate responses to current changes, as well as anticipate responses to future conditions. This work will provide insight on future management of water resources, and provide tools, data, and methods on how to plan for a changing water resources future.
2. Quantify the use, non-use, and natural capital (flows and stocks) value of water in different stages of the water cycle. Comments: Water plays a key role in economies. Quantifying the social, environmental, and economic value of water is a continual challenge. Data, measurement, and theoretical advances are needed to understand factors that affect the value of natural capital, to address uncertainty in valuation approaches, to assess value throughout the stages of the water cycle, and to expand existing empirical estimates from case studies to the entire nation. Results will assist policymakers in developing incentives for preserving water quality and supplies.
3. Evaluate and compare alternative strategies and institutions to manage water quantity and quality, and their relationship to ecosystem, communities, land, and energy uses.

Comments: Effective management solutions are essential to provide a framework for securing future water resources. Research is needed to explore the conditions under which policies and institutions lead to improvements in water storage, allocation, and quality with minimal adverse effects to all water users. Results will provide insights for researchers, policymakers, and stakeholders in designing better management of water resources.

# Methods

## Obj 1. Characterize the response of water resource and human systems to climatic and anthropogenic perturbations

Task 1.1 Evaluate the effects of short- and long-term water availability and shortages on natural and human systems under projected climatic conditions: Research will estimate the impact of climate change on the supply and demand for water, both regionally and nationally. Researchers will assess patterns, trends, and the future outlook for water availability, considering local and regional climate. Outputs will focus on daily, seasonal, and long-term patterns, and evaluate general shifts and extreme event responses. Results will show areas where water supplies are vulnerable to climate change and trends in population growth. By incorporating these models into simulations and/or evaluating current responses to policy, we will be able to assess which adaptation strategies may reduce vulnerability to climate change.

Researchers will measure technological adaptation to policy-induced groundwater use curtailments in a portion of the Kansas High Plains Aquifer. This project will develop a conceptual model of technological adaptation to water use curtailment and test the model using field-level data. Outcomes will include an assessment of producers’ willingness-to- experiment with novel biotechnologies, and will be evaluated in the context of individual risk attitudes, soil quality, and water allocations.

Task 1.2 Study the impact of hydro-climatic scenarios and shocks on water resource and human systems: Researchers will take various modeling approaches to evaluate hydrologic and water quality responses to future climate, providing information that will guide future water management, and estimating the impacts of drought on local economies across a wide range of sectors and regions. Results will apply to water quality modeling as well. For example, research will be conducted on measuring how temperature and climate change drive the formation of toxic algal blooms, and their impacts on the environment and the economy. Additional efforts to measure risks to watersheds throughout the United States will be conducted using machine learning tools, to gain better understanding of risk associated with development, agriculture, wildlife, and oil, gas, and mineral extraction.

Research on how climate change impacts irrigation withdrawals, under various climate projections will be conducted in the Great Lakes and High Plains regions, to assess how changes in risk, climate, and profitability will drive changes in water use. Researchers will assess outcomes for both water resource availability, agricultural productivity, and private profitability for producers. Using remotely sensed irrigation, evapotranspiration, and cropping data, assessments of current weather shocks can be identified at the field level, and discrete choice models can simulate changes in irrigation adoption and agricultural land use under climate projections.

Researchers will write a book proposal and draft to analyze how institutions are positioned to respond to physical and social changes in coastal regions around the world. This book follows on research on Hurricane Sandy and design solutions to shoreline hazards as well as an analysis of cases of retreat from sea shorelines around the world and in the United States.

Researchers will study the impact of woody plant encroachment on groundwater recharge into the Carrizo-Wilcox aquifer of Texas. This research will quantify the extent to which groundwater recharge may be reduced in the Post Oak Savanna using a combination of techniques including soil chloride mass balance, quantification of the water balance including detailed quantification of soil water dynamics and deep recharge, regional hydrological modeling, and remote sensing.

Task 1.3 Study Objective 1 through the lenses of (i) diversity, equity, and inclusion and (ii) environmental justice: Projects addressing DEI include investigating the distributional facets of legacy infrastructure, water services and rates, and contaminant exposure. These efforts will focus on water affordability and quality for low-income and historically disenfranchised groups.

Projects addressing environmental justice include research that will analyze how wildfire impacts to community drinking water systems correlate with social vulnerability characteristics of the communities that are served and how this has changed over time.

Task 1.4 Translational Economics: Researchers in W5190 will put forth efforts to experientially learn how to share the results of their research via a variety of mediums and outlets. These include extension publications, policy briefs, webpage outlets, presentations, grant proposals and other types of initiatives to support graduate and undergraduate training related to Objective 1.

For example, researchers will lead an effort to publish an edited handbook titled “Handbook on Climate Change and Agriculture”. Chapters in the book (around 40 chapters) will be solicited from members of W5190, but also from other researchers in Western and other parts of the USA where climate change affects agricultural production and farmers apply different kinds of adaptation measures to cope with climate change induced water scarcity.

Research on how climate change will impact irrigation development and water use in the Great Lakes Region, which will inform both revised irrigation investment calculator tools hosted by Extension outlets, and a variety of outreach publications and presentations.

At the proposal stage, members from the following states will be engaged in objective 1: California, Georgia, Illinois, Indiana, Kansas, Massachusetts, Michigan, Mississippi, Montana, Nebraska, Oklahoma, Tennessee, Texas, Washington, and Wyoming. The list of states is expected to expand with the multistate group membership.

## Obj 2. Quantify the use, non-use, and natural capital (flows and stocks) value of water in different stages of the water cycle

Water plays a key role in economies throughout the United States. Much of western agriculture relies entirely on irrigation, and many of the areas in the eastern US will need supplemental irrigation in face of a changing climate (Rosa et al., 2020). Power generation for communities throughout the U.S. relies on water withdrawals for cooling. Non-use values of water, many of which are defining features of western culture and recreation, include the support of ecosystems, provision of wildlife habitat, water- and snow-based recreational activities. Across the west, water is also important for and is allocated to indigenous communities and carries important cultural values. However, many of the major aquifers are being depleted rapidly, mainly due to the expansion of irrigated agriculture and growing western cities. Furthermore, while the quality of water across water bodies has, on average, increased since the passage of the Clean Water Act (Keiser and Shapiro, 2019), many local streams and aquifers continue to deal with issues related to pollution.

The literature has made significant leaps in estimating the value of ecosystem services, including the valuation of ecosystem services provided by streams and lakes (Rouhi Rad et al., 2021) and the value of groundwater for irrigation (Sampson et al. 2021, Suter et al. 2021, Fenichel et al. 2016). This work, however, has just scratched the surface of a vast field. These advances in ecosystem service and natural capital valuation will be particularly important in the face of the new Federal initiatives and programs on natural capital accounting that aim to include these values in the U.S. System of National Accounts (essentially the development of a “Green GDP”) (National Strategy to Develop Statistics for Environmental-Economic Decisions, 2023). More broadly, understanding and measuring the value that water resources provide to society is also important for better understanding the sustainability of water use. Within the weak sustainability framework (Neumayer, 2003), natural capital use and depletion would not be considered within a vacuum, but within a broader context accounting for investments in other forms of capital. The continuation of W4190 into W5190 supports the collaboration of researchers across multiple states, which will encourage conceptual and theoretical improvements in natural capital valuation, while also expanding the valuation of water resources (and their related services) to a broader region. The following tasks will be accomplished under this objective:

Task 2.1 Estimate the ecosystem service values of water resources, including the recreational, and amenity values: Hedonic valuation, producer and household surveys, benefits transfer, and eco-hydrological modeling are all important tools in ecosystem service valuation. These methods are used, and science advanced, at two different scales. First, revealed and stated preference methods, such as sectoral analysis, hedonic analysis, household surveys, and producer production functions are used to develop in-depth values of ecosystem services for use and non-use values of water.

Second, those values are used in integrated assessment and eco-hydrology models to value economy-wide impacts. Researchers will estimate the value of wetlands for improving water quality. Furthermore, research will explore the benefits of various aspects of the Clean Water Act. Also, researchers will study the value of water rights seniority within the prior appropriation doctrine of the American West. Researchers will also explore the effects of wildfires on water quality and ecosystem services provided. Finally, researchers will use econometric methods to estimate the spillovers of irrigation on livestock, agribusiness, and other economic sectors. These estimates quantify the value of irrigation water beyond just the crop sector.

Task 2.2 Estimate the natural capital value of water resources: Natural capital valuation often begins as the capitalization of the flows of ecosystem services from a landscape. While present value calculations are likely to be needed, very little understanding exists how financial valuation methods, especially around risk and portfolios of assets, can be applied to natural resources. This work, therefore, spans traditional economic valuation and financial economics. Often, these valuations are done across national scales and increasingly finer spatial and temporal resolution. Integrating remote sensing into economic valuation is also a method used at the forefront of this research. Projects under this task include: Assessing the value of drinking water from natural landscapes (forests and rangelands) and the role of natural landscapes in improving water quality; developing optimal investment models for conservation finance, building landscape scale integrated assessment models that incorporate risk (from wildfire, flooding, drought, etc.) and that can be used to guide conservation finance decisions; Estimating the value of snowpack; Developing new methods to estimate the value of groundwater stocks and understand how the value differs across different types of users; and valuing heterogeneous groundwater irrigation rights attributes using transaction-level farm sales data and the hedonic model.

Task 2.3 Environmental justice aspects of the service and natural capital value of water: Researchers in W5190 will put forth efforts to study Objective 2 through the lenses of environmental justice and DEI. Examples include: Investigating water use and valuation on tribal lands, including their exposure to climate change and drought impacts, or management of water resources in the Missouri River Basin and evaluating the provision of affordable and high-quality water to small water systems and individuals with domestic wells. Ensuring that equity, not just efficiency, enters all research conversations will be paramount.

Task 2.4 Translational Economics: Researchers will put forth efforts to experientially learn how to share the results of their research through many mediums and outlets. These include extension publications, policy briefs, webpage outlets, presentations, grant proposals and other types of initiatives to support graduate and undergraduate training related to Objective 2. For example, researchers will reformulate a county-level decision support tool assessing the value of irrigation as a risk management tool for agricultural producers in the Midwest under varying climate conditions, hosting the tool online and presenting the results to agricultural stakeholder groups.

At the proposal stage, members from the following states will be engaged in objective 2, but the list of states is expected to expand with the multistate group membership: California, Georgia, Kansas, Massachusetts, Minnesota, Mississippi, Missouri, Montana, Nebraska, South Carolina, Tennessee, Texas, and Washington.

## Obj 3. Evaluate and compare alternative strategies and institutions to manage water quantity and quality, and the relationship to ecosystem, communities, land, and energy uses

The common-pool nature of water resources creates economic incentives that promote the deterioration of water quality and water use beyond the recharge rate. Collective management solutions are essential in order to provide a framework for securing water resources in the future. However, all policy management solutions are not equal: centralized versus local management, water markets, quotas, prices, taxes, and other mechanisms have different levels of effectiveness under different contexts. More research is needed to explore the conditions under which policies and institutions lead to improvements in water storage, allocation, and quality with minimal adverse effects to all water users. Special attention should be paid to the distributional impacts of allocation and policy across historically underserved user groups.

Additionally, while current research has largely focused on tradeoffs between current and future human water users, less focus has been placed on balancing human and ecosystem needs and how successful policies come about. Results will provide important insights for researchers, policymakers, and stakeholders in designing better management of water resources, as well the impacts of these management strategies on others.

Task 3.1 Allocation mechanisms: In the western United States, property rights under the prior appropriation doctrine are the primary water allocation mechanism. Differences in initial allocations, state interpretations, rules related to transfers, surface versus groundwater, and environmental protections offer “natural experiments” researchers will utilize to answer policy relevant questions about how allocation, both initially and during shortfalls, affects economic well-being, water use choices, and water, environmental, and ecosystem quality.

The projects under this task include: evaluating how water transfers from agricultural to urban regions in the Arkansas River Valley of Colorado have impacted surface water quality and the costs that surface water quality impairments cause for agricultural water users in the region;

examining how characteristics of water rights, including seniority and transferability, are capitalized into agricultural land values; estimating the market value of tribal water rights, providing a policy relevant estimate of the gains from trade of reducing barriers to tribal water marketing; assessing how different allocation mechanisms are preferred by different types of users and the distributional consequences of alternative mechanisms; evaluating how policy changes in water withdrawal applications have impacted the distribution of agricultural water use; analyzing survey data of irrigators' preference for different amounts of allocated water under alternative methods of assigning the allocations across water rights. Insights from the analysis will give a greater understanding of heterogeneity in preferences and opportunities for compromise to increase support for collective management; utilizing detailed data on water rights and historical water use to simulate the distributional consequences of alternative allocation mechanisms.

Task 3.2 Collaborative management/collective action: Water management often takes place at small scales in collaborative organizations. Examples include drainage districts, irrigation districts, and groundwater management districts. How these organizations form, evolve, and provide incentives (or not) for efficient resource management remain open but important questions. For instance, irrigation districts control the majority of irrigation water in the western US and economic models of their incentives to engage in water transfers and conservation are limited. Projects under this task include: modeling the coordination problems faced by drainage management districts and levee districts, investigating how these problems are overcome, and estimating the capitalized value of these types of coordination institutions in ag land values; investigating the historical drivers of formation and success of irrigation districts; studying why there has been more support for collective management in some portions of the High Plains Aquifer than others and what types of characteristics of irrigators are major drivers of support; investigating novel strategies to adapt to a drier climate; studying the role of user and resource characteristics on support for collective groundwater management and irrigators' preference for collective groundwater management; and conducting a comparative analysis of local water management across western states.

Task 3.3 DEI and Environmental Justice: Researchers will study Objective 3 through the lenses of (i) diversity, equity and inclusion and (ii) environmental justice, making a conscious effort to incorporate DEI and environmental justice into initial stages of research projects, broadly addressing race, equity, and discrimination to water research related to this objective. Examples of topics addressing DEI and environmental justice include: inequitable access to potable water impacting institutions that manage water quantity or quality; welfare implications of water rights settlements to indigenous communities and Native American reservations; distributional impacts, affordability, and disparities in access to high quality water within historically marginalized or low-income communities; long-term social and health impacts associated with locating waste disposal sites near low-income communities and communities of color; groundwater access due to drying wells in underserved or predominantly minority communities; health-related outcomes in environmental justice communities as a result of water transfers and dust pollution; indigenous rights to water; impacts of racial discrimination and historical lending practices on current water infrastructure and water quality in schools; historical practices of ‘Redlining’ in the United States; PFAS bioaccumulation; and community and mental health impacts of flooding.

Task 3.4 Translational Economics: Researchers in W5190 will put forth efforts to experientially learn how to share the results of their research via a variety of mediums and outlets. These include extension publications, policy briefs, webpage outlets, presentations, grant proposals and other types of initiatives to support graduate and undergraduate training related to Objective 3.

At the proposal stage, members from the following states will be engaged in objective 3, but the list of states is expected to expand with the multistate group membership: California, Georgia, Illinois, Kansas, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, North Dakota, Oklahoma, South Carolina, Tennessee, Texas, Washington, and Wyoming.

# Measurement of Progress and Results

## Outputs

## Explore opportunities to co-author grant proposals that advance the objectives of W5190 project across state boundaries or benefit from the complementary skillsets of members;

develop raw data, databases, integrated models, decision support tools, methods, and tools to study the proposed objectives of W5190;

estimate the (non-market) value of the ecosystem services provided by water, such as regulating services, and the natural capital value of different aspects of water resources, such as groundwater stocks, and study the implications for water management;

estimate the effects of climate change on the demand for water and on water scarcity; estimate the effect of water scarcity on human and natural systems;

evaluate the adaptation and mitigation measures to climate change across the water sector;

estimate the environmental justice impacts of existing or proposed water policies and the distributional implications of water transfers and redistributions;

understand how hydrologic and human systems impact water quantity and water quality;

develop decision support tools for natural resource managers and policymakers; evaluate the effectiveness of different allocation mechanisms;

investigate the efficacy of collaborative management/collective action;

translate the outcomes of the research in the form of briefs, extension reports, fact sheets, field days, and other events to be more accessible to a broader public and stakeholders;

present findings at academic conferences, author and coauthor peer-reviewed publications, and presentations at academic conferences;

explore the creation of a website that will provide publicly available raw data, databases, integrated models, methods, and tools;

author and coauthor peer reviewed publications;

present findings at academic conferences, peer-reviewed publications, and presentations at academic conferences.

## Outcomes or Projected Impacts

* The members of W5190 will provide results, models, and datasets that will guide policymakers as they consider the design of water markets, pricing schemes, and other allocation mechanisms. Additionally, evidence on the effectiveness of water management strategies (e.g., increasing water use efficiency, voluntary cost-sharing programs, water markets, and water prices) will provide guidance for effective policy design.
* The proposed methodologies and approaches taken are interdisciplinary, providing tools for scientists, water managers, and policymakers to better understand how hydrologic and human systems interact.
* The methods, data and results produced will provide modelers and planners with a better understanding of how climate change affects coupled hydrologic and human systems resulting in effective policies and investments in appropriate infrastructure to adapt to a changing climate.
* Strategies developed to estimate the natural capital value of water will allow researchers and the various agencies that gather, analyze and distribute national level statistics to better align estimated impacts with the way national accounts are recorded.
* Finally, the work conducted by W5190 members will provide improved estimates of the value of water for human consumption, agricultural irrigation, and ecosystem services. By incorporating the stages of the water cycle into valuation methods, policymakers can better understand how the value of water varies across phase, time, and space.

## Milestones

(**2025**):An annual meeting will be organized to bring together members to present and discuss each of the tasks of W5190. Development of theoretical models, data collection, experimental design, implementation of experiments begins in the first year. Also, meetings with local stakeholders and policymakers will be held to gather background information, exchange ideas, and discuss potential implications of our research results. An annual meeting report and a proceeding from presentations at the meeting will be provided, detailing accomplishments.

(**2026**):An annual meeting will be organized to bring together members to present and discuss the models and approaches, data collection, and research across the tasks. Data collection on all objectives will continue into the second year. An annual meeting report along with a proceeding from presentations at the meeting will be provided, detailing accomplishments.

(**2027**):Data collection, experimental design, implementation of experiments completed. Meetings will be held with local stakeholders and policymakers to exchange ideas, and discuss practical implications of our research results. An annual meeting will be organized to present and discuss the models and approaches, experimental design, and the preliminary results of the research across the tasks. In this year, members will focus on the analysis of the results. An annual report will be provided detailing accomplishments.

(**2028**):Analysis of results from experimentation completed. Outcomes include: Evaluation and comparison of alternative water quantity and quality management strategies and institutions completed; estimating the value of water and the ecosystem services it provides; Estimate the effect of climate change and water scarcity on human water systems.

Members will disseminate results to a broader audience, including scholarly venues, workshops, stakeholder engagement events, and state and federal agency decision-makers. An annual meeting report along with a proceeding from presentations at the meeting will be provided detailing accomplishments.

(**2029**):Meetings will be held with local stakeholders and policymakers to discuss practical implications of our research results. Dissemination of results and preparation and submission of a final report will be undertaken. Several manuscripts will have been submitted and accepted for publication for each of the objectives and tasks. Many more will be in various stages of revision for publication. An annual meeting report along with a proceeding from presentations at the meeting will be provided, each detailing work-in-progress, accomplishments, and areas for further research.

# Outreach Plan

Members of W5190 will build on the rich tradition and success of the previous WX190 groups in reaching out to stakeholders and policymakers. Outreach to stakeholders will include publicly available web-based decision tools, one-page research fact-sheets, public symposiums, popular press articles, and reports targeted to stakeholder groups. Meetings may have different aspects to them. While some of the meetings will be to disseminate the results of the research from W5190, other meetings with local stakeholders and policymakers can provide background information, result in an exchange of ideas, and make clearer the practical implications of our research results. W5190 will also more explicitly take on the tasks of outreach by directly including translational economics as a part of each of the three objectives of the proposal.

Furthermore, the group will disseminate the results of the research to academic and professional audiences through peer reviewed journal articles and professional presentations. Many projects that will be defined and pursued under W5190 will involve training and mentoring postdocs, graduate students, and in some cases undergraduate students, which constitutes outreach to future water resource scientists and managers. W5190 members will continue to publish peer-reviewed articles in disciplinary and interdisciplinary journals. The group will also pursue opportunities for proposing special sessions at academic conferences, such as the Western Agricultural Economics Association, Southern Agricultural Economics Association, Agricultural and Applied Economics Association, the Northeastern Agricultural and Resource Economics Association, or multidisciplinary conferences such as the University Council on Water Resources or the American Geophysical Union.

# Organization/Governance

W5190 will be governed by an executive committee, which will consist of a Chair, Vice-Chair and Secretary. Each year, at the annual meeting, project participants will elect a new Secretary. The Secretary’s responsibilities will include: providing input about the proposed organization of the next annual meeting; corresponding with W5190 members about the meeting; soliciting state reports from members in the weeks leading up to the annual meeting; compiling state reports and providing an electronic copy to participants during the annual meeting; taking notes during the annual meeting; and providing input on the annual (or final) report after the annual meeting concludes. The Secretary will then be promoted to serve as Vice-Chair for one year. The Vice-Chair’s responsibilities will include helping the Chair organize and prepare for the annual meeting, and drafting the annual report for the executive committee to review. The Vice-Chair will then be promoted to serve as Chair for one year. The Chair is responsible for organizing the next annual meeting, and revising and submitting the annual (or final) report. At times, the executive committee may choose to organize ad-hoc sub committees for various purposes, such as proposal writing, special annual meeting events (e.g., field trips), etc.

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# Land Grant Participating States/Institutions

TX,NE,KS,MO,MS,CA,MA,GA,IN,WY,MN,TN,OK,WA,MT,IL,ND

# Non Land Grant Participating States/Institutions Participation

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Participant** | **Is Head** | **Station** | **Objective** | **Research** | | | | | | **Extension** | |
| **KA** | **SOI** | **FOS** | **SY** | **PY** | **TY** | **FTE** | **KA** |

Combined Participation

|  |  |  |  |
| --- | --- | --- | --- |
| **Combination of KA, SOI and FOS**  **Grand Total:** | **Total SY**  **6.40** | **Total PY**  **1.00** | **Total TY**  **0.00** |
| 111 | 0.1 | 0 | 0 |
| 111 | 0.08 | 0 | 0 |
| 605 | 0.08 | 0 | 0 |
| 111 | 0.05 | 0 | 0 |
| 605 | 0.05 | 0 | 0 |
| 111 | 0.1 | 0 | 0 |
| 111 | 0.1 | 0 | 0 |
| 111 | 0.05 | 0 | 0 |
| 601 | 0.05 | 0 | 0 |
| 111 | 0.5 | 0 | 0 |
| 111 | 0.5 | 0 | 0 |
| 111 | 0.1 | 0 | 0 |
| 112 | 0.1 | 0 | 0 |
| 111 | 0.2 | 0 | 0 |
| 112 | 0.2 | 0 | 0 |

|  |  |  |  |
| --- | --- | --- | --- |
| 112 | 0.17 | 0 | 0 |
| 132 | 0.17 | 0 | 0 |
| 133 | 0.17 | 0 | 0 |
| 111 | 0.2 | 1 | 0 |
| 111 | 0.2 | 1 | 0 |
| 123 | 0.2 | 1 | 0 |
| 131 | 0.2 | 1 | 0 |
| 132 | 0.2 | 1 | 0 |
| 104 | 0.05 | 0 | 0 |
| 112 | 0.05 | 0 | 0 |
| 605 | 0.1 | 0 | 0 |
| 0 | 0.05 | 0 | 0 |
| 111 | 0.05 | 0 | 0 |
| 111 | 0.25 | 0 | 0 |
| 111 | 0.38 | 0 | 0 |
| 112 | 0.38 | 0 | 0 |
| 111 | 0.1 | 0 | 0 |
| 111 | 0.1 | 0 | 0 |
| 111 | 0.03 | 0 | 0 |
| 112 | 0.03 | 0 | 0 |
| 131 | 0.03 | 0 | 0 |
| 605 | 0.03 | 0 | 0 |
| 112 | 0.05 | 0 | 0 |
| 112 | 0.05 | 0 | 0 |
| 111 | 0.1 | 0 | 0 |
| 605 | 0.1 | 0 | 0 |
| 111 | 0.2 | 0 | 0 |
| 605 | 0.35 | 0 | 0 |
| 111 | 0.1 | 0 | 0 |
| 111 | 0.1 | 0 | 0 |

|  |  |
| --- | --- |
| **Program/KA** | **Total FTE** |
| **Grand FTE Total:** | **1.15** |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 112 | 0.03 |
| 0 | 0 |
| 0 | 0 |
| 111 | 0.33 |
| 112 | 0.33 |
| 0 | 0 |
| 605 | 0.02 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |
| 0 | 0 |