**Publications**

**Objective 1: Evaluate Natural Resource Management Decisions and the Effects of Climate Change to Understand Associated Welfare Impacts**

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**Objective 2: Advance Economic Valuation Methods and Uses to Enhance Natural Resource Management, Policy, and Decision-Making**

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**Objective 3: Integrated Policy and Decision-Making**

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**2024 Annual Meeting Abstract**

**Session 1: Land Use Change, Protection, & Regulation**

**Title**: Payments and Penalties in Ecosystem Services Programs

**Authors**: Youngho Kim, Erik Lichtenberg, David A. Newburn

**Presenter**: Youngho Kim

**W5133** **Objective**: 1

**Abstract**: Payment for ecosystem services (PES) programs pay landowners to adopt land use or management activities that enhance environmental amenities. PES programs typically offer a combination of upfront and annual payments under long-term contracts (5-20 years) that specify terms of performance. Contract completion is crucial for long-term environmental benefits that depend on vegetation growth. Premature termination of PES contracts has been a persistent problem in US agricultural conservation programs (Wallander et al., 2019; Pathak et al., 2024).

The literature on PES contract designs has mainly focused on incentives for initial enrollment and criteria for cost-effective targeting (see Baylis et al., 2022; Claassen et al., 2008 for reviews). Little attention has been given to contract features that ensure performance after contracts have been signed, such as penalties for premature contract termination. The standard penalty for early contract termination in federal programs, like the Conservation Reserve Program, requires participants to pay back all payments received. Direct coupling of penalties and program payments is inefficient because any increase in payment simultaneously increases the penalty, attenuating the attractiveness of incentives and restricting flexibility in contract design.

This paper examines the optimal structure of penalties for contract non-completion for a population of heterogeneous agents. We begin with a theoretical model of how PES contracts should be structured to maximize environmental benefits net of programs costs for a long term contract that ensures voluntary enrollment. We then examine the principal’s decisions in selecting projects to maximize environmental benefits subject to a constraint on the program budget. Our theoretical analysis finds that the optimal non-completion penalty structure is fundamentally different from the standard penalty structure. The standard penalty is backward-looking and equal to the sum of total payments received until contract termination. In contrast, the optimal penalty level is forward-looking and equal to the government’s net future benefits lost due to the contract termination. Importantly, the optimal penalty structure decouples the penalty from the total program payments paid to the participant, increasing flexibility in contract design. As a result, project rankings in terms of benefit-cost ratios differ under optimal and standard contracts.

We then conduct a numerical policy simulation focusing on a heterogeneous set of agricultural landowners in the Chesapeake Bay region (N=7,223 geospatially identified parcels) to target PES contracts aimed at installing riparian buffers on cropland. We investigate the magnitudes of differences between the standard and optimal contract designs in terms of penalty schedule offered, rates of program participation and contract completion, water quality benefits, and program expenditures. Our simulation shows that optimal contracts outperform standard contracts, generating substantially greater environmental benefits for any given program budget. They do so by drastically reducing premature contract termination rates, making it desirable to enroll parcels offering large environmental benefits that also have high opportunity costs of participation.

To our knowledge, this paper is the first to examine the optimal non-completion penalty structure in PES programs and derive the qualitative differences from the standard penalty commonly used in USDA federal conservation programs and elsewhere globally. Our analysis suggests that decoupling penalties for early termination from participation incentives has the potential to improve PES program performance substantially.

**Title**: Land Tenure and Conservation in Agriculture: Evidence from Nationwide Farm-level Data

**Authors**: Mani Rouhi Rad

**Presenter**: Mani Rouhi Rad

**W5133 Objective**: 1

**Abstract**: Agricultural production creates a range of negative environmental externalities, including water pollution, soil erosion, and greenhouse gas (GHG) emissions. Most of the policy tools aimed at reducing the external costs of farming in the United States are programs that incentivize land retirement or the adoption of conservation practices on working lands. Multiple Farm bills have allocated significant amounts of funding to boost conservation among producers by offering financial and technical assistance for the adoption of environmentally friendly farming practices. Around 40% of all acres and 60% of cash grain acres in the U.S. are rented by operators who do not own them (Bigelow et al., 2016). Since the post-Dust Bowl era, several studies have pointed out that renters may not share the same incentives as landowners to adopt conservation practices. Specifically, it has been thought that the focus of renters is more on the crops rather than the soil, to gain the most profit possible from the land in the short term (McDonald, 1938). In this paper, we examine the differences in the adoption of conservation practices among three groups of operations based on their tenure status. These groups include producers who fully own the land they operate (full owners), those who own a portion of the operation and rent the rest (part-owners), and farmers who operate exclusively on rented lands (full tenants). We use the most complete profile of over two million repeated cross-section observations of operations and their practices across the U.S. from the Census of Agriculture to study how conservation choices, including tillage practices, cover crop planting, and enrollment in CRP differ across tenure categories. To achieve this, we incorporate the operation-level data from the 2012 and 2017 rounds of census into econometric models to estimate the adoption of conservation practices as a function of tenure and a range of operation-level characteristics that might impact farmers’ conservation decisions.

Our findings suggest that renters (both part-owners and full-tenants) may be just as likely as full-owners, and even exhibit a modestly higher propensity to adopt on-farm conservation practices like reduced tillage and cover crops. On the other hand, results show that full-owners are more likely to use no-till; however, this trend is insignificant in some production regions, and for producers with large operations. Regarding long-term land retirement programs like CRP, it is evident from our analysis that full-owners are the group most likely to participate at significantly higher rates compared to renters. We use the data on crop yields, production cost, land value, and government payments to provide potential explanation for the conservation trends observed across tenure categories. The findings of our study have important implications for the effectiveness and design of conservation programs, particularly those aimed at incentivizing the adoption of conservation tillage and cover crops in line with the GHG abatement goals of the Paris Accord.

**Title**: Consideration of new OMB guidance on benefit-cost analysis and valuation of ecosystem services in practice

**Authors**: Luanne Lohr

**Presenter**: Luanne Lohr

**W5133 Objective**: 1

**Abstract**: In 2023, the Office of Management and Budget (OMB) published an update to Circular A-4, which provides guidance to Federal agencies on the development of regulatory analysis. This version significantly expanded and updated much of the guidance around uncertainty, discounting, distributional analysis, and ecosystem services valuation. While the circular is targeted at regulatory analysis, it is adopted by reference into programmatic analysis for federal agencies under OMB Circular A-94. As a result, both regulations and programs will be subject to updated approaches in analysis and valuation. This presentation will look at possible implications of the new guidance on formulation of Forest Service regulations, investments, and programmatic decision making, using examples from activities of the Forest Service.

**Title**: Underserved Farmer Participation in Voluntary Conservation Markets: The Role of Access, Costs, and Preferences

**Authors**: Dale Manning, Yifan Peng, Amy Ando

**Presenter**: Dale Manning

**W5133 Objective**: 2

**Abstract**: US farms can manage soil and nutrient applications to remove carbon dioxide from the atmosphere and reduce nitrous oxide emissions. As a result, the US government includes agriculture in plans to reduce greenhouse gas (GHG) emissions nationwide. Alongside public initiatives, private voluntary carbon markets (VCMs) have emerged as a tool for allowing emitting firms to reach GHG abatement goals. VCMs give farmers the option to receive payment in exchange for adopting practices that reduce GHGs, but current initiatives target large commodity producers. In this research, we measure variation in carbon market participation rates among farms with different characteristics (e.g., size and crops grown) and among different farmer groups (e.g., women- or minority-owned). We then explore the extent to which differences occur because of transaction costs, other barriers to access, and/or farmer preference heterogeneity. If heterogeneous preferences exist, we test if heterogeneity is driven by the cost of practice changes and/or by farmer experiences or trust. Finally, we discuss the consequences of our results for efficiency and equity and weigh policies that increase VCM participation.

To address our research questions, we survey farmers across 7 Midwestern US states. To enhance statistical power when comparing across farm and farmer characteristics, we oversample small farms (<150 acres), minority-owned farms, and women-owned farms. We ask farmers about participation in VCMs along with other conservation and government programs (e.g., EQIP, crop insurance, etc.). For respondents that do not participate in VCMs, we ask the importance of a range of factors (e.g., cost of enrollment, additionality requirements, lack of information, size restrictions, or low trust), which we obtained from a literature review, conversations with farmers, and through structured interviews with companies participating in VCMs. Regression analysis reveals how participation rates and barriers differ by farm and farmer characteristics. Finally, we conduct a choice experiment to explore how preferences for VCMs differ by farm and farmer characteristics. Specifically, we quantify farmers’ willingness to accept (WTA) to enroll in a VCM while focusing on the type of organization that runs it (private vs public), the amount of historical data required to enroll (1- or 5-years’ worth), the provision of technical and business assistance (yes or no), and whether changes in soil carbon are verified by a third party. We also see if WTA changes when local environmental benefits are emphasized.

The survey was conducted in November and December of 2023, and preliminary data is due in late-January 2024. Therefore, preliminary analysis will be complete for the W5133 meeting at the beginning of March 2024.

**Session 2: Methodological Improvements**

**Title**: A Closed-Form Expression for a Common Kuhn-Tucker Model Based Upon the Lambert W Function

**Authors**: David F. Layton

**Presenter**: David F. Layton

**W5133 Objective**: 2

**Abstract**: Computing the standard quantities of interest in Kuhn-Tucker demand systems such as the Marshallian demands, Hicksian demands, indirect utility function, and the expenditure function are well known to be challenging as beyond the simplest utility functions the demands do not have closed-form expressions and so their computation entails some form of numerical method. Thus from their initial introduction to the field, the recreational demand literature has devoted considerable effort and ingenuity in developing reliable approaches that work quickly enough to be implementable for models with complexities such as unobservable heterogeneity and larger choice sets (e.g. Phaneuf *et al*. (2000) von Haefen and Phaneuf (2005) von Haefen *et al*. (2004), Lloyd-Smith (2018), Pinjari and Bhat (2021)). In order to further the range of available methods, we show that a commonly employed additively separable utility specification consisting of a sum of logarithmic functions of quantities of inside goods (sites) and a power function of the outside good (all other goods) while not expressible in closed-from using the standard set of functions, can be expressed as function of the relatively recently named Lambert W function. Thus we have a closed-form expression as long as one admits the Lambert W into the pantheon of accepted functions (which is increasingly common). The Lambert W function is defined such that W = W(z) is the solution of z = W(z)exp(W(z)) (Corless *et al*. (1996) and has seen increasing use across a wide range of fields. When the constraint of the consumer’s utility maximization or expenditure minimization problem can be written such that it involves an exponential or a natural log term it may be possible to reframe it such that a function of Lambert W is the solution (see Edwards (2020) for many examples of this process for a range of general functions). This is the case in the “log plus power function” additively separable expenditure minimization case. We can solve for Hicksian demand functions that are explicitly a function of the key economics parameters of prices and utility. Computationally, Lambert W is now programmed into Python, R, Matlab, Mathematica, and Julia. Noting that the computation of the Lambert W function itself involves a root finding algorithm (typically Halley’s method, e.g. Moler (2013)), we offer some additional refinements in the area of rooting finding for the Marshallian and Hicksian demands in additively separable models. The field has eschewed using the traditional Newton (a second order) approach and 3rd order approaches such as the Euler, Halley, and Chebyshev methods. We are not entirely sure as to why, but our conjecture is that there is a healthy degree of concern for methods that have the possibility of overshooting and not converging which the first order bisection algorithm avoids. Using standard results (e.g. Melman (1997)) we show that this type of concern need not apply in the additively separable functions that form the foundation of current Kuhn-Tucker approaches and thus *global* second order convergence is generally possible and in some cases *global* third order convergence is achievable.

**Title**: Reconceptualizing the Random Component Of Random Utility Models

**Authors**: Richard T. Carson, Derrick H. Sun, Yixiao Sun

**Presenter**: Richard T. Carson

**W5133 Objective**: 2

**Abstract**: At the core of almost all multinomial choice random utility models (RUM) used in applied work is an individual agent whose random component is assumed to follow a Type 1 largest extreme value (Gumbel) distribution. What if instead the random component follows its mirror image, the Type 1 smallest extreme value (Reverse Gumbel) distribution? We show the differences between these two specifications, closely tied to the skewness of the random component, can be quite profound. The two RUMs are equivalent when there are J=2 choice options, but progressively diverge as J increases. They result in different estimates for statistics like elasticities, average partial derivatives, elasticities, and market shares. Fitting the incorrect specification can lead to considerable bias. The Gumbel distribution imposes the well-known independence of irrelevant alternatives (IIA) substitution pattern, while the Reverse Gumbel does not. Instead, the choice probability for a particular option involves an enumeration of all subsets in which the option can appear. The model with Reverse Gumbel random components, while more complex to estimate than that based on the Gumbel, is shown to have a computationally tractable closed form solution.

Much of the paper is devoted to fully explicating the properties of this model and of exploring the implications of the random component’s skewness, which also yields new insights into the multinomial probit model’s properties that the conventional wisdom it is closely approximated by the multinomial logit when the correlation terms between alternatives are restricted. Conceptually, differences between models built on Gumbel and Reverse Gumbel distributions revolves around whether information known to the agent, but not the analyst, is more likely to increase or decrease the latent utility index based on an option’s observed attributes. The largest extreme value (LEVI) does the former and the smallest (SEVI) the latter. An immediate implication is, if choice is characterized by SEVI random components, then the observed choice and the one predicted most likely are more likely to correspond than if LEVI characterizes the choice context.

In a series of standard empirical examples taken from different areas including recreational fishing, we show the SEVI assumption uniformly dominates the standard LEVI one. The SEVI market share estimate for the most preferred alternative is larger, for the same preference parameter estimates, than the LEVI estimate. LEVI market share estimates for less popular alternatives can be over 100% larger than their SEVI market counterparts. The two models can produce quite different estimates of Hicksian measures of the economic value of adding or removing choice set alternatives.

The distinction between LEVI and SEVI errors is fundamentally different from the usual rationales for generalizing the LEVI model and show these generalizations do not appropriately account for that difference. We advance a latent class model allowing for a mixture of LEVI and SEVI error components and show both the mixing proportion and preference parameters can be consistently recovered. SEVI counterparts of latent class, nested, random (mixed) parameter, and scale heterogeneity logit models can be developed that address correlated alternatives and different types of heterogeneity.

**Title**: Thinking about the Third Option in Binary Choice: A Classification Analysis of “I Don’t Know” Responses

**Authors**: Gregory Howard, John C. Whitehead

**Presenter**: Gregory Howard

**W5133 Objective**: 2

**Abstract**: Stated preference elicitation is an important tool for estimating use and non-use values with environmental amenities. While these methods carry with them the potential for a variety of biases, it is argued that many of the strategic and incentive-compatibility issues related to these biases are minimized by the use of single referendum-style binary choice. Within this referendum-style binary choice design, it is common practice to provide an additional option that often takes the form of either “I don’t know” or “I prefer not to vote”. This design has been utilized in public opinion polls for years in the political science literature. There are potential sample selection issues with discarding these responses, so the most widespread convention in economics being to recode any “I don’t know” responses as “no” responses. The logic here is that the majority (perhaps the vast majority) of respondents who express uncertainty about their vote typically vote “no” in practice, a finding that mirrors post-hoc adjustment based on certainty follow-up questions.

The goal of this paper is to perform a more rigorous examination of these “I don’t know” responses in the hopes of finding a better, more data-informed procedure for classifying them. Using multiple data sets that include these third options in a binary choice framework, we utilize ordered logistic regressions to examine what factors influence respondent voting. In this analysis, “I don’t know” votes are coded to fall between “no” and “yes” votes, and we explore several recoding procedures where respondents who vote “I don’t know” are recoded based on estimated probability of voting “no” and “yes” from our model.

We compare the welfare estimates and model fit statistics of a binary logistic model that utilizes our “I don’t know” recoding methods with estimates from models that utilize the more common recoding heuristics, including omitting “I don’t know” responses and recoding them uniformly as “no” responses. We find that our new methods generate improved model fit statistics compared with conventional methods. We also find that our recoding procedures produce lower welfare estimates than approaches that discard “I don’t know” responses and are very similar to approaches that uniformly recode “I don’t know” responses to “no” responses.

**Title**: When and How Should Non-Market Valuation be Used? Understanding the Value of Value Estimates to Inform Decisions

**Authors**: David J. Pannell, Robert J. Johnston, Michael P. Burton, Sayed Iftekhar, Abbie Rogers, Cheryl Day

**Presenter**: Robert J. Johnston

**W5133 Objective**: 3

**Abstract**: Non-market valuation (NMV) is often motivated by an assertion that these studies are required to promote policy decisions that increase net benefits to society. Yet is this assertion accurate? There may be situations for which the expected value of information (VOI) provided by an NMV study might not outweigh the cost of conducting that study. Even in cases where NMV is used to inform decisions, the literature provides little evidence to support the claim that the expected VOI from a typical NMV study exceeds the cost. Evidence is also lacking to inform choices over which types of NMV should be applied in alternative policy contexts.

This paper develops a VOI framework and numerical model to provide guidance on the optimal use of NMV to inform decisions. Among other outputs, the model characterizes (1) situations under which NMV should be conducted, i.e., the anticipated VOI outweighs study cost, and (2) which type of NMV approach provides the greatest net VOI. VOI theory is grounded in the concept that decisions are made under uncertainty and that—by reducing this uncertainty—research studies enable decisions with greater net benefits to society. The VOI from an NMV study would reflect the change in the expected net benefits of one or more policy decisions made possible by the new information from that study.

The model is implemented for a case of a water-quality improvement program which may be implemented at different scales. Information on the accuracy (validity and reliability) of each valuation method is derived via a systematic expert-elicitation that provides anticipated likelihoods of alternative study outcomes conditional on a set of underlying true values. This information, combined with model inputs such as the scale of the project, prior information on benefits available to decision makers, the composition of total benefits (e.g., use values only versus both use and nonuse values), and the cost of alternative valuation methods allows VOI to be derived and guidance provided on which, if any, methods should be applied.

Results yield insight into the circumstances in which NMV should be applied and what methods should be used. There are many situations in which NMV studies produce substantial VOI for water quality projects of even modest size—with VOI often exceeding $1-2 million USD. Conditions that tend to produce high VOI for NMV include larger gross project benefits, smaller expected net benefits and diffuse priors on these benefits. However, there are also cases in which NMV studies have negligible value. Each type of NMV study is optimal under some circumstances, demonstrating that “one size does not fit all” with regard to optimal choices of valuation method. Even inaccurate and perhaps biased NMV methods (e.g., unit-value benefit transfers) can produce high VOI in some cases—often far exceeding study costs. Results also belie common narratives about the preferability of particular methods, suggesting that common wisdom (e.g., that RP methods are preferred) may be misguided. Results such as these demonstrate the important and sometimes unexpected insight that can be provided by more rigorous treatment of the VOI from NMV research, beyond the often-colloquial claims in the literature.

**Session 3: Conservation and Climate**

**Title**: Maple Syrup Producers' Willingness to Diversify Forests for Increased Resilience

**Authors**: Yizun Yan**,** Shadi S. Atallah

**Presenter**: Yizun Yan

**W5133 Objective**: 1

**Abstract**: Diversity in forest species composition can mitigate climate change risks by increasing a forest ecosystem’s resilience to extreme weather (Bauhus et al., 2017; Jactel et al., 2021). The U.S. tree syrup industry, heavily reliant on sugar maple, has a low socioecological resilience due to this monoculture practice (Bishop et al., 2015). Forest tree composition diversification is a strategy that can increase resilience by managing naturally occurring syrup-producing species such as beech, birch, and sycamore (Jactel et al., 2021; van den Berg et al., 2023). Given the private costs and wider ecological benefits of maple forest diversification, the privately optimal level of diversification may be lower than the social optimum.

We designed a choice experiment (CE) to gauge maple syrup producers’ willingness to adopt maple forest diversification. The CE includes seven attributes. The first is diversification intensity, defined as the ratio of non-maple to maple species. The second and third attributes represent the consequences of diversification: the annual maple syrup yield reduction due to competition (e.g., shading) and the increased forest resilience, reflected in a reduced likelihood of below-average yields resulting from extreme weather over 15 years. These two attributes capture a trade-off producers face: the immediate yield penalty versus the long-term benefits of enhanced resilience. We also include the neighbor’s adoption rates, whether new equipment is needed, diversification contract length, and the payment.

We used a Bayesian approach to generate the experimental design (Bliemer & Collins, 2016)[[1]](#footnote-1). We focus on two key interactions: first, the link between diversification intensity and yield reduction, examining if increased non-maple species competition deters producers from adopting diversity due to yield losses; second, the impact of neighboring producers' adoption rates on individual decisions in diversification intensity, exploring whether producers reduce their diversification efforts to leverage collective resilience benefits while minimizing yield losses from diversification on their farms.

We conducted a pilot survey in December 2023. Using conditional logit and mixed logit models, our preliminary results show that diversity intensity, yield reduction, and contract length significantly influence producers’ willingness to diversify. We find a nonlinear preference for diversification intensity, with a favored range of 25% to 50% non-maple species. This is consistent with ecological evidence of a non-linear link between biodiversity and ecosystem functionality (Baeten et al., 2019). In addition, we find that producers prefer a 15-year contract but are less likely to enroll in a 10-year contract, compared to a 5-year contract. This nonlinear preference diverges from findings of previous literature in conservation agriculture where farmers favor no or shorter contracts (Gramig & Widmar, 2018; Howard et al., 2023). The key reason lies in the long-term and slower maturation of environmental benefits for forest diversification (or perennialization of agricultural system), compared with typical annual agricultural contracts. This preference aligns with studies suggesting the optimality of longer contracts in such contexts (Ando & Chen, 2011; Lennox & Armsworth, 2011). Future analysis will focus on the motivations and barriers to adoption based on different information treatment and perception questions (Khan et al., 2022; Rapp et al., 2019).

**Title**: Optimal investments in upstream watersheds when ecosystem services are jointly produced: An application to mitigate impacts of wildfires on drinking water quality

**Authors**: Beth M. Haley, Sahan Dissanayake, Sonja H. Kolstoe, Anna T. Maher

**Presenter**: Beth M. Haley

**W5133 Objective**: 1, 3

**Abstract**: Safe drinking water is one of society’s most basic needs. In the United States, approximately 77% of surface water sources for drinking water originate on forested lands. Increases in large severe wildfires raise concerns about the quantity and quality of drinking water supplies, as wildfires can alter the vegetation and soils regulating runoff, streamflow, and physical and chemical water quality. Post-fire changes may challenge drinking water treatment processes, prompting water utilities to consider investment options to mitigate disruptions to service after a wildfire occurs and/or reduce the risk of wildfire in source watersheds. Investments may include actions taken at the facility itself with benefits solely related to drinking water quality, while other actions may leverage nature-based solutions upstream of water intakes. For example, water utilities may partner with landowners to make conservation investments in the watershed to improve source water quality that may also result in additional co-benefits (e.g., recreational opportunities, wildlife habitat, etc.). Wildfire risk reduction and mitigation practices also present opportunities that may yield co-benefits for other ecosystem services (e.g., improved water quality, wildlife habitat, etc.). While there is a large body of work that has explored optimal resource/conservation targeting to maximize benefits, previous work primarily focuses on single benefits (species richness, water quality etc.).

In this work we develop an integer programming-based optimal decision-making framework that combines the co-benefits of forest conservation, hydrological services, species conservation, and wildfire risk reduction. This framework can guide prioritization of possible actions, accounting for whether water utilities are able to partner with other landowners on the landscape. While water utilities that are unable to partner with other landowners may be limited to investment options at the facility, those able to partner may have additional landscape-scale investment options they may consider to mitigate water quality impacts from wildfire occurrences.

We will present the results of a stylized landscape optimization model to answer the question “What are the tradeoffs, including potential co-benefits, in investment options (e.g., at the facility itself vs. upstream) for water utilities looking to minimize impacts from wildfires?” We follow a standard conservation site selection approach for the creation of the spatially explicit optimization model that accounts for co-benefits on a stylized landscape. The model simulates a landscape divided into grid cells with a stylized stream and one water treatment plant. An agent is tasked with the goal of minimizing levels of surface water contaminants to reduce the likelihood concentrations exceed the facility’s capacity to treat the water. We will explore trade-offs of co-benefits under different water utility manager objective scenarios, to include maximizing water quality at the treatment plant and minimizing loss of water quality. This work, and future applications of this framework with empirical data, will provide water utilities with a decision-support tool to evaluate investment options.

**Title**: The Value of Information for Invasive Species Management

**Authors**: Matthew Sloggy, Sonia Bruck, Michelle Thompson

**Presenter**: Matthew Sloggy

**W5133 Objective**: 1, 3

**Abstract**: Economic damages from invasive species are estimated to be over $100 billion annually. In the United States, there are several major efforts currently underway to manage non-native invasive species. Dynamic optimization of bioeconomic models have been used to assign treatments for invasive pests. However, many invasive species programs spend considerable amounts of money on monitoring in order to resolve uncertainties related to the presence and magnitude of populations. In this study, we advance the bioeconomic modeling of invasive species management to consider state uncertainty and spatial information flows within a Partially Observable Markov Decision Process (POMDP). We then use the model to construct a decision support system for managing the Spongy Moth (Lymantria dispar), which is a non-native invasive pest introduced to the northeastern United States in 1869. We also use the model to value the information obtained through monitoring.

The Slow the Spread (STS) program aims to stop the advancement of Spongy Moth across the United States. STS was piloted in 1992, became fully implemented in 2000, and operates in 12 states from North Carolina to Minnesota. The program is managed by a non-profit foundation funded by The U.S. Forest Service and collaborates with the Animal and Plant Health Inspection Service to eradicate jump spread populations and treat quarantined areas. STS divides geographic regions into “action” and “monitoring” zones. The action and monitoring zones are where suppression activities and monitoring occur, respectively. Across STS zones, monitoring makes up 60% of total program costs.

We set up a model where the manager’s objective is to minimize the cost of spongy moth through the optimal allocation of monitoring and suppression activities. The manager does not have perfect information regarding the actual amount of spongy moth in an area; however, they have a belief about the spongy moth population level. Beliefs evolve via Bayesian updating. Parameterizing the cost function allows us to solve a continuous-state POMDP for spongy moth management. Monitoring and treatment costs were obtained through cost data supplied by the STS program. Costs of Spongy Moth infestations were obtained through previously published cost-benefit analyses.

The model returns the optimal management strategy at a given site, effectively delineating what sites should belong to what management zones. Importantly, by removing the spatial information flow from the model, we can determine the loss in efficiency from not considering conditions in neighboring areas. Analysis of project costs implies tradeoffs between treatments, with less effective mating disruption treatments having a lower per-acre cost than more effective but costlier chemical treatments.

There is a significant lack of information regarding the cost of additional monitoring and treatment for invasive species under uncertainty. Our model addresses this need by providing a benefit analysis for monitoring activities. Expected findings may assist managers who can better utilize and interpret biological monitoring information to treat different invasive species spread, including Spongy Moth.

**Title**: Prices, Substitution, and Complementarity in Change-in-Wealth Based Measures of Sustainable Development

**Authors**: Eli P. Fenichel and Carl Obst

**Presenter**: Eli P. Fenichel

**W5133 Objective**: 3

**Abstract**:

**Session 4: Climate Change**

**Title**: How Are Insurance Markets Adapting to Climate Change? Risk Selection and Regulation in the Market for Homeowners Insurance

**Authors**: Judson Boomhower, Meredith Fowlie, Jacob Gellman, Andrew Plantinga

**Presenter**: Jacob Gellman

**W5133 Objective**: 1

**Abstract**: In the face of escalating climate risk, property insurance markets have a critical role to play in helping households and firms reduce risk exposure and recover from natural disasters when they strike. To perform these functions efficiently, insurers need to access good information about disaster risk and set prices that are commensurate with the costs of insuring this risk. We use proprietary data on parcel-level wildfire risk, together with insurance premiums derived from regulatory rate filings, to investigate how insurance is being priced and provisioned in a large market for homeowners' insurance with high levels of wildfire risk exposure. We first calibrate an empirical benchmark for the fair price of wildfire risk, which includes the capital costs for risk loading and accounts for correlation of risk in an insurer’s portfolio of houses. We then compare this benchmark to an empirically estimated gradient between parcel-level insurance premia and catastrophe risk. We document striking variation in insurers' wildfire risk pricing strategies. Firms that rely on relatively coarse measures of wildfire risk depart from a fair pricing strategy and charge relatively high prices in high-risk market segments – or choose not to serve these areas. These patterns are consistent with binding price regulation or with theoretical predictions from adverse selection. In a Bertrand duopoly model of competition we estimate a large winner’s curse, where firms with less granular pricing strategies have 33 to 56% higher expected losses per parcel than the most sophisticated firm, and 6 to 18% lower revenue net of expected wildfire losses. We also quantify a value of risk information of approximately $150 to $260 per parcel for the most-informed firm. A theoretical model of a market for natural hazard insurance that incorporates both price regulation and asymmetries in information across insurers helps rationalize the empirical patterns we document. Our results highlight the underappreciated importance of the winner's curse as a driver of high prices and limited participation in insurance markets for large, hard-to-model risks.

**Title**: Climate change beliefs, yea-sayers, and valuation: The case of landscape level grassland restoration in the U.S.

**Authors**: Kaylee Wells, Amy Ando, Sahan Dissanayake, and Rich Iovanna

**Presenter**: Kaylee Wells

**W5133 Objective**: 1, 2

**Abstract**: Before European settlement, diverse, functioning grassland covered much of the major grassland regions in the midwestern and western parts of the U.S. Recent estimates suggest that nearly 80% of the historical extent of grasslands in this part of the country have been converted for agriculture and development and conversion continues today (Samson et al. 1998; Wright and Wimberly 2013; Lark et al. 2019; Berger et al. 2020). Grasslands are important for carbon sequestration, controlling soil erosion, and providing pollinator habitat (Zhao et al. 2020; Chang et al. 2021). USDA and other organizations know grassland restoration is valuable, but do not know how much people value their restoration at the landscape level. This research addresses this question for the Tallgrass, Mixed Grass, and Short Grass prairie regions using a nationally representative choice experiment survey of over 1,200 Americans. We focus on these prairie regions because over 76% of all acres enrolled in the USDA Conservation Reserve Program (CRP) in 2022 were located there, making these regions most likely to be the focus of a similar landscape-level restoration project. In the survey, we present each respondent with six choice tasks each including a program and status quo option. Program attributes include the size of the area restored to grassland, the quality of the restored grassland, the extent of public access on the restored land, and the annual cost of the program to each respondent’s household as an increase in federal taxes. This research also addresses two methodological questions relevant to the choice experiment literature. The first relates to the inclusion of factual but politically divisive information about climate change in the survey influences willingness to pay (WTP). The second explores whether including a follow-up question intended to help identify yea-sayers provides information in addition to more commonly used follow-up questions for hypothetical bias mitigation (e.g., consequentiality questions). We contracted with IPSOS to elicit responses to the survey from their Knowledge Panel. Data collection was completed in Fall 2023. We expect to have preliminary results to share at the meeting.

**Title**: Climate Change and Irrigation Electricity in US

**Authors**: Aaron Hrozencik, Mani Rouhi-Rad, Dilek Uz, Liqing Li

**Presenter**: Dilek Uz

**W5133 Objective**:

**Abstract**: Variations in weather patterns associated with climate change threaten many sectors of the economy (Hsiang et al., 2017). The agricultural sector is particularly vulnerable to the economic costs of climate change as farmers rely on stable precipitation and temperature patterns to grow food, forage, and fiber (Nelson et al., 2014). A growing economics literature aims to understand the economic costs of climate change within the agricultural sector (Mendelsohn et al., 1994; Schlenker et al., 2005; Schlenker and Roberts, 2009; Burke and Emerick, 2016; Deschenes and Greenstone, 2007). A related literature has examined the ways in which agricultural production responds to changing climate and environmental conditions through altered cropping patterns, technology adoption, insurance uptake, and other factors (Kurukulasuriya and Rosenthal, 2013; Annan and Schlenker, 2015; McCarl et al., 2016). However, the sector’s use of energy inputs in response to a changing climate, which has significance for projections of future emissions, is relatively unexplored.

A significant focus has been directed towards investigating the implications of climate change on energy consumption. Specifically, numerous studies in this realm have concentrated on residential electricity use (Auffhammer and Mansur, 2014; Auffhammer, 2022). Despite the attention given to residential electricity use, there is a notable gap in research when it comes to the role of energy use in the agricultural sector in response to climate change, especially in the context of irrigation. This oversight is important as a separate strain of literature demonstrates that the impacts of climate change (e.g., higher temperatures, drought, etc.) on agricultural outcomes (e.g., crop yields) are generally minimal in irrigated production systems compared to rain-fed systems (Siebert et al., 2017; Tack et al., 2017; Schauberger et al., 2017). This paper addresses this gap in the literature by investigating how the agricultural sector utilizes energy, specifically electricity use for irrigation pumping, in response to climate change.

Energy is a key input for agricultural production, powering the machinery used to plant, irrigate, harvest, and store crops (Pimentel, 2019). In more drought prone and arid regions, the availability of energy inputs to power irrigation pumps has been vital for agricultural and rural development (Rhodes and Wheeler, 1996). Much of the energy used to power irrigation pumps comes from electricity, which in rural regions of the U.S. is generally provided by rural electricity cooperatives (RECs). In 2018, nearly 75% of all irrigation pumps in the U.S. were powered by electricity (USDA-NASS, 2019). Between 1979 and 2018, the number of irrigation pumps in the U.S. increased by more than 30% with the majority of these new irrigation pumps powered by electricity.

The significant increase in irrigation pumps beckons further questions regarding how agricultural producer decision-making related to energy use for irrigation is responding to a changing climate. This paper addresses these questions by presenting the first empirical estimates characterizing how agricultural producers respond to changes in climate along the intensive (i.e., change in the energy consumption per customer) and extensive margins (i.e., change in the number of irrigation customers) of energy use for irrigation.

We leverage novel administrative data, collected by the USDA’s Rural Utilities Service (USDA-RUS), on annual utility-level electricity distribution to irrigation customers spanning the 1992 to 2019 time period. We merge these administrative data with data characterizing utility-level climate variables (e.g., temperature and precipitation) to estimate econometric models exploring how the intensive and extensive margins of irrigation electricity use respond to changing climate in the short- and long-run.

Modeling results suggest that producers respond to changing climate patterns, specifically increases in temperature, along both the intensive and extensive margins of irrigation electricity use. In the short-run, we find that an additional day with a maximum temperature above 30◦ Celsius is associated with approximately a 0.4 to 0.5% increase in megawatt hours (MWh) distributed per irrigation customer. Long-run results similarly suggest responsiveness to climatic changes along the intensive margin. Using a long differences specification, we find that an increase in one day with maximum temperature above 30◦ Celsius between the 1992-1996 and the 2015-2019 time periods is associated with an approximate 2% increase in MWh per irrigation customer (Burke and Emerick, 2016). In the long-run, we also find that increases in temperature prompt extensive margin changes in irrigation electricity use. A rise in the occurrence of days with a maximum temperature surpassing 30◦ between the periods of 1992-1996 and 2015-2019 is linked to a 2% increase in the number of irrigation customers. Our results build on past research examining electricity use by the irrigated agricultural sector and the economic development impacts of rural electrification. We contribute to past work on irrigation sector electricity demand, notably Maddigan et al. (1982) and Uri (1979), by demonstrating the role of climate in determining intensive and extensive margin irrigation electricity use. We advance the rural electrification literature, e.g., Kitchens and Fishback (2015) and Lewis and Severnini (2020), by illustrating how irrigation electricity use responds to climate change, potentially helping the sector mitigate some costs associated with a changing climate. Given that energy use for irrigation is a proxy for water use for irrigation, our results have significance for policymakers and resource managers interested in water conservation as modeling output suggests that continued climate change may increase the use of already scarce water stocks (Scanlon et al., 2012; Martindill et al., 2021). Finally, our results demonstrate a significant feedback loop potential between evolving climate conditions, energy use in the irrigation sector, and ensuing greenhouse gas emissions.

**Title**: Estimated Greenhouse Gas Abatement Costs and Mitigation from Working Lands Enrolled in USDA Conservation Programs

**Authors**: B.M. Gramig, M. Bowman, J.W. Burnett, A. Rosenberg, C. Sichko, D. Szmurlo

**Presenter**: B.M. Gramig

**W5133 Objective**: 1

**Abstract**: The Inflation Reduction Act of 2022 provides an additional $19.5 billion to be allocated over five years to support USDA NRCS programs that have climate change mitigation benefits. The vast majority of these funds are allocated between working lands conservation programs and Conservation Technical Assistance with a small share devoted to measuring, evaluating, and quantifying carbon sequestration and greenhouse gas (GHG) emission reductions from conservation investments. This preliminary research uses data on funded conservation contracts together with estimated net GHG flux by practice to estimate implied carbon dioxide-equivalent emissions abatement cost from U.S. cropland enrolled in the Environmental Quality Incentives Program (EQIP).

**Session 5: Revealed Preferences and Other Valuation Methods**

**Title**: Using cell phone location data to estimate the effect of congestion on the demand for visits to outdoor recreation sites

**Authors**: Stephen C. Newbold, David M. Massey, Jude Bayham

**Presenter**: Stephen C. Newbold

**W5133 Objective**: 2

**Abstract**: We propose a new approach for estimating the effect of congestion in outdoor recreation demand site choice models. The approach is inspired by but is distinct from the approach developed by Chris Timmins and coauthors, which uses observable attributes of nearby sites as an instrument for congestion at each target site in a second-state IV regression. Our proposed approach is designed to use data on trips from multiple origins (e.g., zip codes or census tracts) to each of multiple destinations (recreation sites), which can now be readily estimated using location data collected from personal mobile devices. Rather than using an IV estimator to identify the effect of congestion on visitation behavior, we propose a different strategy that involves exploiting the difference between the aggregate demand for trips on weekdays versus weekends. To the degree that congestion is a disamenity, people will sort across recreation sites such that visitation will approach site capacity at more sites on the weekends (when aggregate demand is higher). In contrast, congestion has less impact on weekdays (when aggregate demand is lower), resulting in a different distribution of visits. This means that the distribution of the shares of all visitors among the sites will be more homogenous on weekends than on weekdays. We conduct a Monte Carlo simulation experiment to examine the performance of our proposed estimator. Our simulation experiment confirms that our proposed approach produces consistent estimates of all model parameters, including the congestion coefficient, and shows how precise the estimator can be with datasets of realistic size.

**Title**: The Social Cost and Inequity of Nutrient Pollution in U.S. Freshwater Streams

**Authors**: David J. Smith, Charles Griffiths, Bryan Parthum

**Presenter**: Bryan Parthum

**W5133 Objective**: 3

**Abstract**: The social cost of nutrient pollution (SC-NP) is an estimate of the economic damages of an additional kilogram of nutrients, such nitrogen and phosphorus, released into a watershed. We develop an integrated assessment model to systematically estimate of a large set of SC-NPs at high resolution by bridging well-developed models that are commonly used by the U.S. Environmental Protection Agency for benefits assessment. This allows for a comparative assessment of the marginal benefits of water quality improvements across subbasins, nutrients, nutrient forms (e.g., organic nitrogen, ammonia), and across time. Because nutrient pollution is highly local, as compared to well-known and globally well-mixed pollutants such as greenhouse gases, we evaluate the local distribution of economic damages from excess nutrients across income groups in the Mid-Atlantic Region of the United States. We first summarize the environmental justice implications caused by nutrient pollution by mapping the demographics of the affected downstream communities to the relative levels of pollution. We then use differences in income and exposure to recover an equity weighted SC-NP.

Because of the highly integrated system of freshwater streams, we use a myriad of data sources to inform our model. Land use is a combination of National Land Cover Database (NLCD) and the Cropland Data Layer (CDL). Land management data is from the Conservation Effects Assessment Project (CEAP). Soils are from the State Soil Geographic (STATSGO) dataset. Stream is the National Hydrography Dataset (NHDPlus). Point source data comes from the SPAtially Referenced Regression On Watershed attributes (SPARROW). Population, demographic and income data are at the block or block-group and are from the 2010 U.S. Census. Subindex curves for the concentration parameters are those used in Cude (2001), and the willingness to pay is based on data used by EPA (2009, 2015).

The modeling system in this project integrates a hydrological and water quality system (HAWQS/SWAT) with an economic water quality benefits valuation model (BenSPLASH) (Corona et. al 2020). The baseline is set up using the EPA's Hydrologic and Water Quality System (HAWQS 2020), which employs the Soil and Water Assessment Tool (SWAT) as its core engine (Arnold at al. 2012). We systematically perturb SWAT for each combination of subbasins, nutrients, nutrient form, and year; and compare the changes in water quality concentrations to the baseline concentrations. This includes any impacts of nutrients on biological oxygen demand and resulting dissolved oxygen impacts. Changes in water quality are valued using a benefit transfer approach based on a meta-analysis of studies that estimate the willingness to pay for water quality changes in the U.S. (US EPA 2015). To estimate an equity weighted SC-NP the economic damages are weighted by marginal utility using Census block household median income (normalized to median U.S. household income).

The SC-NP has a large variation across space. This is due to four primary reasons. First, as a result of dilution, pulses of nutrients have larger water quality impacts in smaller streams than in larger ones. This results in smaller water quality impacts downstream because of the confluence of streams in a stream network. Second, the delivery of nutrients downstream is higher in subbasins with lower water residence time. Higher delivery ratios create larger water quality impacts downstream, increasing the number of subbasins and households affected. Third, the economic disbenefits of nutrient loadings depend on the number and location of downstream households. Subbasins located upstream from densely populated areas have higher SC-NPs than similar subbasins downstream. Fourth, the marginal willingness to pay per household for water quality improvements varies. For example, higher income households are willing to pay more for water quality improvements.

When we equity-weight the economic damages by household income this reduces the variation due to household income. Marginal willingness to pay is increasing in household income. Giving less weight to higher income households reduces the importance of higher income houses in the social cost. The equity-weighted SC-NP is then lower when the affected households are richer and higher when the affected households are poorer.

Using an integrated assessment model we estimate a large set of SC-NP for subbasins in a major watershed in the U.S. We also estimate an equity weighted SC-NP to evaluate the equitable distribution of the impact of nutrient pollutants. These estimates allow for a comparative assessment of the marginal benefits of water quality improvements. They also provide systemic insights into the methods used by the US EPA to value water quality in Clean Water Act regulations. This integrated system can be applied to watersheds throughout the continental U.S. Like the social cost of greenhouse gases, systematic estimates of the SC-NP could be useful for state government, Federal agencies, and academics to estimate the economic benefits of policies the impact water quality, without the need for complex economic modeling capabilities.

**Title**: Identifying mechanisms that lead to differences in preferences between residential housing market and voting venues

**Authors**: Corey Lang, Jarron VanCeylon

**Presenter**: Corey Lang

**W5133 Objective**: 2

**Abstract**: Research investigating the determinants of voter choice on environmental referendums often finds that political affiliation is a key factor – specifically, Democrats are much more likely to vote approve than Republicans (Coan and Holman 2008, Holian and Kahn 2015, Altonji et al. 2016, Burkhardt and Chan 2017, Lang and Pearson-Merkowitz 2022). These differences in approval have consequences, evidence suggests that Democratic leaning states hold and pass more referendums and raise more money per capita than politically mixed states, which in turn do more than Republican leaning states.

Yet, when it comes to residential location choice, Democrats and Republicans are equally likely to locate in close proximity to conserved land (VanCeylon 2023). Given the premium associated with proximity, both groups of partisans are revealing their positive and similar WTP for open space.

How do we reconcile the disparity between the partisan gap in vote choice and the similar preferences observed in the housing market? The broad agenda of this research is to understand mechanisms that lead to differences in expressed preferences across venues.

We will conduct a large, three-state survey that will be used to test multiple possible mechanisms of partisan preference disparities. A key aspect of our design is that we will survey registered voters whose residential location is known, and we will harness that knowledge to explore differences in voting behavior and revealed residential location preferences. Party affiliation could potentially be a cause of the disparity, but more likely it is correlated with other individual characteristics that cause the disparity. The survey aims to tease these apart. Key personal attributes that we hypothesize could drive preference disparities in the venue of voting are trust in local/state/federal government, risk tolerance, and individualism vs. collectivism identity.

We will use the Tailored Design Method formulated by Dillman et al. (2014) to design a web-push survey. We will use voter registration data to select potential respondents. We will conduct a stratified random sampling design and segment groups by partisan affiliation and proximity to conserved lands. Hence, we will have respondents that are Republicans living near conserved land, Republicans not living near conserved land, Democrats living near conserved land, and Democrats not living near conserved land. This representation is critical for testing hypotheses about mechanisms for differences in preferences for residential choice and voting choice.

We will distribute survey invitations to 15,000 people across three states, 5,000 per state. We will choose states based on 1) partisan leaning (one Republican-leaning state, one Democrat-leaning state, and one politically equal state) and 2) the availability of voter registration data. The survey will be confidential, but not anonymous, and we can use our knowledge of where they live to inform our analysis and comparisons of their residential choice and their preferences elicited through the survey.

The survey will simulate ballot referendums on multiple topics, including land conservation or other environmental priorities. These questions will allow us to assess whether the partisan gap in environmental voting is present for both people that live near conserved FFOSs land and those that do not. We will also include a contingent valuation question meant related to housing choices, in which the objective is to estimate WTP for proximity to conserved land. In addition, we will elicit information about key personal attributes: trust in local/state/federal government, risk tolerance, and individualism vs. collectivism identity. We hypothesize that each of these may be correlated with partisan affiliation and thus may be a mechanism for disparities in preferences.

**Title**: Causal inference, high-frequency data, and the recreational value of water quality

**Authors**: Andrew Earle, Hyunjung Kim

**Presenter**: Andrew Earle

**W5133 Objective**: 2

**Abstract**: In their recent best practices paper, Lupi, Phaneuf, and von Haefen (REEP 2020) emphasize that “researchers should seek out modern identification methodologies… to improve causal inference in recreation analysis.” Ji, Keiser, and Kling (JAERE 2020) echo these sentiments, writing that “future work that finds ways to improve estimates of the causal effect of water quality on recreation will be fruitful.” Motivated by these calls to combine causal inference and recreation demand analysis, this paper introduces a method that exploits high-frequency recreation data to apply panel data causal inference techniques within travel cost RUM models. Our method allows researchers to embed popular causal inference techniques, such as difference-in-differences, event study designs, and the synthetic control method, within a RUM framework. The method works in two steps. We estimate a daily panel of site mean utilities in a first stage maximum likelihood estimation, and in the second stage, we apply causal inference techniques to identify how a resource change affects the mean utility provided by a site.

We apply our approach to value the welfare impacts of beach closures at Lake St. Clair in southeast Michigan. Our visitation data contain the exact minute-of-entry for 740,000 visits to the Huron-Clinton Metroparks system between May and October 2022. For the 115,000 visitors that own annual park passes, we can track their visitation history across the entire season.

Using the synthetic control method within a travel cost RUM model, we estimate that the 2022 Lake St. Clair beach closures caused a total welfare loss of $68,000. The losses tend to be larger on weekends, hotter days, and days without precipitation. We also find evidence of a “stigma effect,” similar to Boudreaux and Lupi (Ecological Econ 2023), where closures impact recreators’ preferences even after the beach reopens.

We believe our approach will be broadly appealing for several reasons. For one, our method draws heavily on current practices in both the recreation demand and causal inference literatures. Our approach is also particularly useful for estimating the welfare impacts of abrupt, non-marginal resource changes (i.e., resource shocks), such as beach closures, bacterial warnings, wildfires, or harmful algal blooms. Finally, high-frequency datasets describing recreation and environmental quality are becoming increasingly common (e.g., cellphone mobility data and remotely sensed environmental quality data), making our approach feasible in many settings.

**Session 6: Marine and Coastal**

**Title**: AIDS Model for Recreation Demand: Application to Aggregate Beach Visitation

**Authors**: Craig E. Landry,Travis A. Smith

**Presenter**: Craig E. Landry

**W5133 Objective**: 1

**Abstract**: Most recent studies on the demand for recreation have focused on discrete choice models, but recreation site demand equations remain a viable option for many types of data that are readily collectable – intercept data, mail surveys, internet panels. The single-site model is the simplest formulation and theoretical restrictions necessary for welfare consistency with utility maximization can be minor if the associated incomplete demand system is carefully specified (Landry and Smith, 2024). When the analyst is interested in multiple recreation sites, they often must contend with corner solutions, necessitating fairly complicated models like the Kuhn-Tucker demand system of von Haefen and Phaneuf (2003, 2004, 2005). An alternative approach to multi-site demand equations is to aggregate to higher level of analysis (e.g., county or state) and assess demand for aggregated recreation services. This offers at least two advantages: 1) the preponderance of corner solutions can be minimized, and 2) site aggregation permit introduction of site characteristics into the pooled recreation demand model.

In this paper, we explore the Almost Ideal Demand System (AIDS – Deaton and Muellbauer 1980) applied to aggregate beach recreation in North Carolina. The survey data screen for potential beach users by identifying North Carolina households that had visited any beach in the world in the previous 36 months. Thus, our sample is focused on potential visitors to North Carolina beaches; in addition, while we inquire about trips to individual beaches along the NS coast, we aggregate trips to on overall measure of demand (using weighted averages of travel costs and site characteristics to describe aggregate demand (Landry, Shonkwiler, and Whitehead 2020)). In practice, this limits the number of corner solutions in our data. We utilize trips to Virginia (northern substitute site) and South Carolina (southern substitute) as the other commodities in our incomplete demand system. Since aggregate trips to these other sites are elicited in the survey, we ca include these equations in estimation. We utilize Mundlak panel regressions on our stacked revealed preference (RP)/ stated preference (SP) data, imposing and testing the theoretical restrictions derived by Deaton and Muellbauer (1980b), LaFrance (1990), and von Haefen (2002), and we explore alternative formulations for aggregate multi-site, stacked RP/SP demand analysis.

**Title**: Coastal Erosion Protection on the Oregon Coast

**Authors**: Emma A. Gjerdseth, Steven J. Dundas

**Presenter**: Emma A. Gjerdseth

**W5133 Objective**: 1

**Abstract**: Climate change is driving sea level rise and increasing erosion in populated coastal areas. To motivate climate adaptation and develop informed land-use plans it is important to understand how preferences related to risk, landscape features, and policy options capitalize into coastal housing markets. We investigate what landscape features and climate risks matter, and why, in a single housing market in the U.S. Pacific Northwest with significant variation across these elements. Landscape features can be viewed by housing market participants as either providing or reducing amenities and protection from risk. Prior work in this area has largely focused on barrier islands on the Mid-Atlantic and Southeastern coasts of the United States (e.g., Landry & Hindsley, Land Econ. 2011; Dundas, JEEM 2017; Qiu & Gopalakrishnan, JEEM 2018; Landry et al., AEPP 2022) with limited measurement of landscape features (i.e., beach width), and often a single policy option (beach replenishment). We use parcel-level observed and simulated geophysical measurements, relying on remote sensing data and lidar, to obtain precise values across coastal features for homebuyers. To model risk, we use information from a probabilistic climate emulator, based on total water level observations and predictions (Anderson et al. JGR Oceans 2019), to develop risk and safety metrics. A key advantage of our study is the use of high-resolution data that is temporally and spatially precise, which may translate to both new and improved hedonic estimates. To better leverage this rich variation, we are exploring machine learning methods to understand which features matter to homebuyers. Some of our preliminary results suggest risk and amenities capitalize differently across dune- or bluff-backed shorelines. We find evidence of variation across seasons and combinations of other coastal features (e.g., wide and narrow dunes) in the capitalization of beach width. The effect of dune height on housing prices is consistently positive, suggesting this feature is viewed as protective. The latter contrasts previous research on the East Coast of the U.S. where dune height has been found to capitalize negatively due to impaired viewshed (e.g., Dundas, JEEM 2017).

**Title**: Swimming against the crowd: congestion effects in beach demand and valuation

**Authors**: Andrew Earle, Frank Lupi, Caroline Tompson, and Roger von Haefen

**Presenter**: Caroline Tompson

**W5133 Objective**: 2

**Abstract**: The recreation demand literature has long recognized that recreation sites are a congestible good such that the welfare of site visits can be affected by the number of other visitors (Cesario 1980). In a multi-state research effort, we examine the impact of alternative levels of beach crowding on visitation in two distinct regions: (1) the Southeastern US coastal areas from Texas to Virginia and (2) Great Lakes beaches in Michigan. Using two internet surveys, congestion effects are elicited in both surveys using the same stated preference questions. Both surveys randomly assign respondents to choice experiments and contingent behavior questions, which are used to estimate the impact of congestion on site choices. We compare the estimated results across regions and across stated preference methods. The estimated congestion effects will ultimately be incorporated into multi-site beach demand models for each region (von Haefen and Lupi, 2020; Lupi, von Haefen and Cheng, 2020) and welfare measures that account for congestion will be compared to those that ignore congestion.

**Title**: Tsunami risk and information shocks: Evidence from the Oregon housing market

**Authors**: Amila Hadziomerspahic, Steven J. Dundas

**Presenter**: Amila Hadziomerspahic,

**W5133 Objective**: 1

**Abstract**: Estimating risk perceptions related to natural disasters is critical to understanding behavioral responses of individuals and adaptive capacity of communities. Developed coastlines experience hazard risk from sources with different frequency and intensity, such as flooding, erosion, and sea-level rise. In the Pacific Northwest, there is an additional high severity but very low frequency risk: the Cascadia Subduction Zone earthquake and tsunami. This paper examines the coastal Oregon housing market response to three sets of risk signals: 1) two exogenous events – the March 11, 2011 Tōhoku (Japan) earthquake and tsunami and the July 20, 2015 New Yorker article “The Really Big One”; 2) a hazard planning change – the release of new official tsunami evacuation maps in 2013 by the State of Oregon; and 3) visual cues of tsunami risk – the Tsunami Blue Line project, which has installed signage denoting the upper limit of the tsunami inundation zone in communities along the coast since 2016. We estimate the treatment effects of these tsunami risk signals in a series of hedonic pricing models using difference-in-differences (DID) and triple differences (DDD) research designs. Results suggest that a property inside the primary tsunami inundation zone sells for up to 8.5 percent less than a property outside of the zone after the 2011 Tōhoku tsunami, with this discount decaying within 2.5 years. Results are also suggestive of a positive spillover effect of the Tōhoku tsunami on prices of coastal properties outside of the primary tsunami inundation zone. We find evidence that the 2013 release of new tsunami inundation maps was capitalized into home values in only the most vulnerable new inundation zone. Results also suggest houses near roadway blue lines denoting boundaries of the tsunami hazard may be selling for 8 percent less compared to similar houses farther away. These estimates suggest that information shocks can be salient to coastal residents and may be useful policy tools to increase resilience to low frequency but high severity hazard events.

**Session 7: Stated Preference Methods**

**Title**: The unknown costs and benefits of addressing invasive annual grasses across the sagebrush biome

**Authors**: James R. Meldrum, Elizabeth K. Orning, Bryan C. Tarbox, Chris Huber, Catherine S. Jarnevich, Cameron L. Aldridge

**Presenter**: James R. Meldrum,

**W5133 Objective**: 1, 3

**Abstract**: Cheatgrass (Bromus tectorum L.) and other invasive annual grasses (IAG) continue to spread within the sagebrush biome of the western United States, degrading plant communities and wildlife habitat, decreasing forage for ranching livelihoods, and heightening wildfire risk. Effective management of IAGs requires long-term strategic planning and action across the sagebrush biome, but the economic implications of potential treatments and spatial prioritizations are not well understood.

Recently, a large collaboration advanced the “Sagebrush Conservation Design,” which argues for proactive management of IAG across this biome (Doherty et al., 2022). At the request of a related interagency working group, the USGS is conducting an economic assessment of this strategy. I will discuss our efforts in this data-poor environment and seek to highlight the information needs to this broader economics research community. Specifically, our preliminary modeling indicates the strategy will cost billions of dollars, yet despite demonstrated agency interest in the problem, we have limited information on the economic benefits of treatment strategies.

To estimate treatment costs, we have developed simple models of observed cost data in the Land Treatment Digital Library (https://ltdl.wr.usgs.gov/), which demonstrate the limitations of existing “calculators” and provide an ability to project expected costs to new contexts. To investigate the effects of the systems’ biophysical dynamics on long-run treatment costs, we incorporate these estimates, along with expert elicitation, into a detailed state-and-transition simulation model of the biological effects of different management strategies over time. In next steps, we seek to incorporate information on the nonmarket benefits associated with the alternative management scenarios. I will briefly discuss the (limited) availability of existing data for benefit transfer and will highlight areas where we believe more research could support more efficient management of the sagebrush biome.

**Title**: Testing for Differences in WTP Based on How Sample Selection Accounts for Partial Responses in the First Stage

**Authors**: Amila Hadziomerspahic, Sonja H. Kolstoe, Steven J. Dundas

**Presenter**: Sonja H. Kolstoe

**W5133 Objective**: 1, 2

**Abstract**: Surveys are increasingly administered online for both proprietary panels and address-based samples due to several advantages for researchers (e.g., lower costs). Concerns remain about sample representativeness, data quality and impacts on willingness to pay estimates when using online panels (e.g., Boyle et al., ERE, 2016; Campbell et al., JEM, 2018; Lindhjem and Navrud, IRERE, 2011; Penn et al., AEPP, 2023; Sandstrom-Mistry et al., AEPP, 2023). We investigate whether there are systematic differences in willingness to pay (WTP) estimates for a coastal erosion management policy between an address-based sample – a traditionally preferred but costly probability sample – with an opt-in online panel sample from Qualtrics – a less costly non-probability sampling alternative that may be subject to potential selection biases. We account for three factors across both sample frames in the contingent valuation (CV) question: 1) cleaning the data for bots and inconsistent respondent behavior (e.g., speeders, inattention to questions); 2) whether respondents viewed the survey as consequential; and 3) whether they attended to the attributes (i.e., attribute non-attendance (ANA)). We also investigate issues relating to sample selection in these two sample frames. Recent research is using ordered discrete choice models to account for the different levels of engagement respondents have with a survey instrument (Cameron and Kolstoe, Land Econ, 2022). Researchers traditionally treat response and non-response as a binary discrete choice, allowing for only two types of engagement with the survey instrument and other categories of partial responses are relegated to one category or the other. We investigate whether partial responses are systematically different using an ordered discrete choice in lieu of the traditional binary approach.

We find that accounting for problematic behavior in the exclusion criteria when cleaning the data prior to analysis matters. In the Qualtrics sample, a naive correction using the broadest exclusion criteria and without accounting for consequentiality and ANA yields MWTP estimates for safe recreation access hours that are not statistically significant. Accounting for these behaviors narrows the Qualtrics sample’s MWTP distribution, bounds it away from zero, and shifts it to have more overlap with the Address sample’s corrected MWTP distribution. Both samples have statistically significant MWTP for safe access hours and the status quo after applying corrections, but only the Address sample has a statistically significant MWTP for relaxing the existing armoring policy. This difference may be driven by when respondents saw the topic of the survey; Address invitees saw it before accessing the survey whereas Qualtrics invitees saw it after accepting to be on the online panel.

We are currently investigating whether differences exist in estimates based on how sample selection in the first stage accounts for different levels of engagement as well as response behaviors, namely ANA and consequentiality and will be presenting these results at the W5133 workshop. We hypothesize that differences may exist between respondents who complete the survey versus respondents who drop off and thus only complete a portion of it. We also hypothesize that partial responses are systematically different than non-responses from people who never started the survey.

**Title**: Tourists’ WTP to view sea otters in the North Pacific

**Authors**: Brian Vander Naald, Heidi C. Pearson

**Presenter**: Brian Vander Naald

**W5133 Objective**: 1, 2, 3

**Abstract**: The reintroduction of sea otters (Enhydra lutris) in Southeast Alaska has caused a human wildlife conflict. As an apex predator and keystone species, sea otters have an outsized impact on the food web and rely on the same resources as subsistence harvesters and commercial shellfisheries. While this issue has been a primary focus of the sea otter narrative in Southeast Alaska, there are potential untapped benefits associated with increased sea otter population abundance. Nonmarket benefits of sea otters have been estimated for the contiguous U.S. portion of the Pacific Coast (e.g., Loomis, 2006). However, this exercise has not been completed in the North Pacific, where both the natural and human systems are quite different. Using Qualtrics’ pre-screened panel, we conducted a discrete choice experiment of 1100 potential marine tour users in Southeast Alaska. In the mixed logit estimation, we find monotonically increasing willingness to pay (WTP) for increasing chances of seeing sea otters on a marine tour (25% chance = $106; 50% chance = $154; 75% chance = $171). Interestingly, we find WTP is higher among the subset of respondents who value whether marine tour operators are part of an organization encouraging responsible tour operations (25% chance = $252; 50% chance = $338; 75% chance = $361). The distributions of WTP estimates for all levels of sea otter chances are statistically different between the full sample and the subsample mentioned. In the latent class estimation, the CAIC and BIC criterion indicate the two-class model is preferred. The classes are separated by income, prior knowledge of sea otter dynamics, and interest in marine tour operators’ behavior on the water. WTP differs between the two classes, most dramatically along the margin of time on the water. Our estimates of the nonmarket benefits of the tourism value of sea otters adds to the fraught conversation around this recovering species in Alaska.

**Title**: Willingness to Pay for Grid Resiliency and Reliability

**Authors**: Alecia Evans, J. Scott Holladay, Charles Sims

**Presenter**: Alecia Evans

**W5133 Objective**: 1

**Abstract**: Power companies face trade-offs in meeting their mandate to provide inexpensive, reliable, and clean energy. Reliability, and also resiliency, is important from the consumers’ perspective. Reliability refers to the frequency of outages. A resilient grid ensures that customers do not suffer from lengthy power outages. However, both reliability and resiliency are threatened by events including high-impact but low-probability events. These types of events, such as natural disasters, have a low probability of occurring, but when they do, they have devastating consequences. Winter storm Uri left 4.5 million households without power in 2021, resulting in over $130 billion in damages in Texas (Busby et al. 2021). Likewise, winter storm Elliot caused widespread power outages in the TVA region in December 2022 (TVA 2023). For power companies to make investments in minimizing or preventing these occurrences, it is useful to understand what consumers are willing to pay to forego the discomfort of outages.

To date, the literature has primarily focused on customers’ willingness to pay (WTP) to prevent an outage of specified duration and specific time, for example, an outage for 2 days on a summer weekday versus a one-hour outage on a weekend in winter (Vallejo et al. 2022; Baik et al. 2020; Morrissey, Plater, and Dean 2018; Pepermans 2011; Carlsson and Martinsson 2007). We theorize that this may overestimate WTP for grid resiliency given that customers are thrown into a scenario where the undesirable event of an outage has already happened. WTP estimates may change if the situation of power outage is captured in the more realistic fashion of a low-probability event that imposes a high cost to the customer and society as a whole. An added dimension to this research is understanding the WTP for resiliency across various stakeholder groups (e.g., residential customers, industry customers, policy makers). While grid resiliency is important across these interest groups, to our knowledge, it has not been documented if there are differences in the valuation across each group. This is important from a policy perspective, as it will prevent power companies from over or under investing in resiliency measures. Therefore, in this study, we will survey various energy stakeholders in the TVA region to understand their willingness to pay to prevent probabilistic power outages under various policy options.

We focus on four main attributes: average electricity bills, carbon intensity, outage frequency, and outage duration. We use a conditional logit choice model to address questions including: (1) what is the WTP to reduce the risk of a power outage of varying duration, across the three populations? (2) what is the willingness to pay to reduce the duration of a power outage conditional on varying probabilities of an outage? (3) What attributes should power providers and consumers prioritize? Preliminary results show that stakeholders believe that utility companies should prioritize Valley economics, while customers should prioritize affordability.

**Session 8: Methods 2**

**Title**: Random Forests For Contingent Valuation

**Authors**: Klaus Moeltner

**Presenter**: Klaus Moeltner

**W5133 Objective**: 2, 3

**Abstract**: Traditional Contingent Valuation (CV) approaches are based on explicitly defined Indirect Utility Functions (IUF), and designed to estimate underlying preference parameters. These are then recombined to predict Willingness-To-Pay (WTP) for a specific policy intervention. In this work we relax any functional assumptions on IUF, other than additive separability of income. We illustrate how nonparametric Machine Learning tools, such as Random Forest (RF) can be employed to generate robust predictions of individual choice probabilities. These can be further processed to produce a nonparametric estimate of WTP. The framework can be extended to estimate the effect on choice and WTP of individual variables in robust / nonparametric fashion. This is especially useful when such variables are likely endogenous in an IUF or WTP function. We illustrate the approach using data on online map exploration, and how different aspects of map interaction affect choice. The application is with respect to water quality improvement over large spatial scale.

**Title**: Applications of Virtual Reality for Recreation and Valuation of Forest Amenities

**Authors**: José J. Sánchez, Matthew R. Sloggy, Francisco J. Escobedo, Mark Lindquist

**Presenter**: José J. Sánchez

**W5133 Objective**: 1, 2

**Abstract**: The US Forest Service (USFS) manages a vast range of resources and lands that hold immense amounts of recreational value for the public. However, these recreational resources typically require that individuals can physically access trails, some of which might be overly strenuous for some. At the same time, recreational forest lands might be inaccessible to underserved communities due to lack of transportation, limited resources, or other barriers. Due to these access barriers, the USFS might not be fulfilling its motto of “Caring for the Land and Serving People” as certain segments of the population are being excluded from visiting national forests and grasslands.

One possible solution to increase access to national forests is the use of virtual reality (VR) technology. As the use of 360-degree cameras and software has become more easily accessible in the recent years, it’s providing a wide range of VR opportunities to both researchers and recreationalists. Although a virtual representation is not the same as being in nature; it can however, provide opportunities to experience some of these benefits, particularly for individuals that cannot readily access national forests. This study explores VR as a research tool for non-market valuation of recreation amenities. Through generating a large collection of VR representations and contingencies of recreational amenities in national forests, we plan to investigate several research questions related to recreation. First, we want to investigate how individuals value access to virtual landscapes. Second, we want to investigate whether VR representations of recreational attributes (ecosystem structure metrics, water and landscape features, aesthetics) can improve the salience of choice experiments on these specific features. Next, we want to utilize the VR technology to allow survey participants to construct their own optimal landscapes and vistas as well as explore this tool to facilitate participatory and deliberative valuation processes.

The research team travelled to various national forests in southern California to record different trail sites at several point of interest using a 360-degree camera. To view the VR content, the 360-degree videos were converted to VR format that can be viewed using a headset. However, the content can be viewed without a headset as well. To ensure that the developed VR content is available to view by the public, the products will be uploaded to websites such as: USFS, recreation.gov, and other public facing websites.

The first study is using a choice experiment to value trail attributes. To identify which attributes are preferred by recreationists, a choice experiment will be implemented to understand the tradeoff recreationists make for selecting preferred trail attributes. The attributes of interest are trail distance, type of water resources (e.g., waterfall, river, lake, etc.), trail difficulty, vegetation type (e.g., chaparral, pine, etc.), site/facility amenities (e.g., restroom, grills, picnic tables, etc.). The results of the choice experiment survey will help inform improvements to campsites, points of interest, site amenities, and other USFS recreational assets. This work has potential to produce accessible public facing content for the Forest Service, and to explore the use of a new technology in economic valuation.

**Title**: Household’s Perceived and Objective Measures of Wildfire Risk and their Willingness to Pay to Wildfire Fuel Reduction Programs

**Authors**: José J. Sánchez, Liqing Li, John Loomis

**Presenter**: Liqing Li

**W5133 Objective**: 1

**Abstract**: According to the FEMA, wildfires have destroyed more than 90,000 structures from 2005-2020. Over the last decade State and Federal agencies have spent nearly a billion dollars forest fuel reduction treatments such as prescribed burning, forest thinning and fuel breaks. To induce household participation, cost share programs have been provided. However, it is important for managers to increase participation by understanding how does risk perception impacts program participation.

We conducted a choice experiment in Arizona to understand the relationship between perceived and objective fire risk for willingness to pay for fire mitigation programs. Three choice sets, each with three alternatives programs, were presented to respondents: (1) Public Fire Prevention; (2) Private Fire Prevention; (3) Do nothing additional. Each alternative program included chance of damage to respondent’s house, amount of monetary, and a onetime cost for implementing the selected ten-year program. Private actions were defensible space measures for homeowners to take on their own properties. Public programs were described in terms of prescribed burning and mechanical removal of vegetation.

We used a random digit dialing of households and followed by a mailed or online survey, and we obtained 219 complete surveys out of 600. A mixed multinomial logit model in WTP-space is utilized to estimate individuals' WTP for private and public fire prevention programs. We also explore how respondent’s actual and perceived fire risks around their homes are associated with their WTP for the fire mitigation programs. Three risk measurements are included in the analysis. First information on respondent’s perceived fire risk is derived directly from the answer to a survey question that asks them to describe the risk of their home being damaged by a wildfire as “low,” “medium,” or “high” (i.e., “perceived risk”). Second, we assess respondents' actual fire risk near their homes by asking a series of questions regarding the surrounding landscape (i.e., “respondent objective risk”). Third, we determine the fire risk respondents face by overlaying their home locations on the fire risk map provided by Arizona Department of Forestry and Fire Management (i.e., “professional risk assessment”).

The results show that people in Arizona are willing to pay, on average, around $800 per year for the public program. Moreover, people’s WTP for fire mitigation programs varies by their fire risk status. Compared to respondents with low perceived fire risk, those who *perceive* they live in high-risk areas are willing to pay almost $1000 more for both private and public programs. Respondents with high respondent objective fire risk are also willing to pay more for both types of fire mitigation programs. This suggests that people in Arizona may have the ability to accurately assess fire risk around their homes. However, we find that compared to those living in low-risk areas based on the professional fire risk assessment, people in what professional foresters consider high-risk assessment areas are not willing to pay more for either private or public programs. This may indicate that people's perceived and professional objective fire risks differ significantly from the risk assessed developed by fire experts. This discrepancy could pose a problem if the expert risk assessment does not accurately represent the objective risks households face.

**Title**: Defining and Testing Simul Methods to reduce Hypothetical Bias

**Authors**: Juyoung Yoo, Jerrod Penn, Matt Fannin, Wuyang Hu

**Presenter**: Jerrod Penn

**W5133 Objective**: 2

**Abstract**: Numerous studies have tested methods to mitigate Hypothetical Bias (HB), the difference between hypothetical and real elicitations, a major issue in stated preference methods. Commonly, these methods either occur before (ex-ante), (i.e. cheap talk or oaths), or after (ex-post) (i.e. certainty follow-up questions) the elicitation. Ex-ante and ex-post methods both require additional questions or time and show limited effectiveness depending on the technique used.

However, these groups fail to recognize a third category distinct from ex-ante and ex-post that we term ‘Simul’. Simul methods work to affecting behavior during the elicitation, having potential time savings for respondents and practitioners. While several simul techniques have existed for some time, such as providing a Don’t know option or other dissonance minimization responses, recognition of their differences has gone unnoticed. Others are more recent, such as default choices, reference price reminders, and opt-out reminders.

This study defines Simul methods of HB mitigation, several examples, and describes how each may be similar or dissimilar to ex-ante and ex-post methods. Within a DCE, we implement a split-sample experiment with six treatments: 1) hypothetical choice context, 2) real with actual payment, and four Simul-type HB mitigation methods3) defaulting the opt-out option, 4) opt-out reminder, 5) reference price, 6) don’t know option. This allows us to measure the effectiveness of each Simul to mitigate HB. Based on preliminary evidence, we find that ‘opt-in’ responses (i.e. purchase a kit) were significantly lower in the defaulting opt-out treatment compared to the hypothetical control group. However, the mixed logit model indicated that none of the simul methods had a significant effect in reducing ‘opt-in’ responses.

1. \* Presenter. The generation of Bayesian designs allows a *priori* the knowledge of the desired sample size needed to obtain statistically significant parameter estimates at the 95% confidence level. We used the pilot data at the 2023 International Maple Syrup Conference (n=114 choice observations) to get the priors. [↑](#footnote-ref-1)