NC DEQ

A Guide to NC Water Quality Economic Valuation

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Introduction

Environmental policy is the primary mechanism federal, state and local government can leverage to protect and improve natural resources and their associated benefits. In a perfect world this type of regulation would be unnecessary, however the social, industrial and cultural systems in which we operate as individuals and a collective each take tolls on the natural environment, altering the ecology of our world. Environmental policy is therefore requisite and crucial to sustain the natural ecosystems upon which we and all living things depend on for healthy life. The challenge of crafting environmental policy lies in determining how to make regulation effective in the objectives of preserving natural resources and producing the greatest net benefit to the communities that interact with them. Both these objectives present unique challenges involving multidisciplinary issues that require robust and thoughtful solutions. However, our current understanding and capabilities for resource preservation and restoration are far more developed than our tools and mechanisms to understand and quantify the impacts of environmental policy on communities and individuals. This guide seeks to enhance understanding of the current processes and resources policymakers, researchers, and institutions use to quantify and analyze the impact of environmental policy in water quality to inform future discussion, research and regulation in this context.

When attempting to understand the potential impacts to a community of an environmental policy option, researchers engage in cost benefit (CB) analysis. Broadly, CB policy analysis seeks to quantify the associated costs to stakeholders of implementing a policy option and the projected benefits created over a time horizon for the use of comparison. For a policy to be considered effective, the benefits incurred must be greater than or equal to the costs. The challenge in implementing this analysis tool in the context of environmental policy and specifically in the case of water quality is quantifying benefits of protecting or improving a natural resource. To understand what benefits a natural resource provides to those who use and interact with it, researchers break down resources into constituent pieces that contribute to human well being called ecosystem services. A resource's ecosystem services carry value based on the type, quantity, and importance of the benefits they deliver. Understanding, quantifying and compiling the economic value of these ecosystem services provides an estimate to the total benefit created by a resource. Therefore, to understand the economic value of a resource, it is first necessary to quantify and monetize the value of its ecosystem services.

In the case of water quality many of the ecosystem services provided by water bodies do not hold explicit dollar values. Ecosystem services are majority nonmarket goods, meaning they are not bought or sold within a marketplace, so their value is not conveyed through a price. For example, urban streams can serve as climate regulators, cooling air temperatures. This delivers a benefit to individuals and communities located around this resource that does not have to be explicitly purchased. In order to assess the value of these streams against the costs of a potential policy initiative to protect streams from pollution caused by stormwater runoff, for example, policymakers and researchers must relate the benefit value of climate regulation to a dollar price estimate. This is accomplished through analyzing individual's preferences in a process called economic valuation.

Economic valuation of ecosystem services is not an exact science. Its purpose is to generate value estimates that can inform decision making in policy analysis. As ecosystem services are nonmarket, there is no definitive method to assign prices to the benefits they provide. Additionally, many ecosystem services are public or nonrival goods. This means they are not limited to a single user and cannot be owned as property, but rather are broadly and commonly available and usable. Ecosystem services also possess a variety of purposes or uses that create different kinds of benefits. Economists distinguish these purposes as use and nonuse value, where use value describes benefits obtained through actively purposing or utilizing a given resource and nonuse value conveys implicit or passive value like natural beauty. These characteristics are important because establishing explicit dollar values for this type of good is very difficult and often involves subjective data and reasoning. Ecosystem services do not fit easily or nicely into boxes of traditional economic concepts like supply-and-demand-driven pricing. These distinctions, however, do not disqualify the credibility or utility of well-performed ecosystem service value estimates. Economic ecosystem service valuation provides price estimates that can serve as a starting point for understanding the benefits a natural resource provides to individuals and communities. Often, ecosystem service valuation does not entirely quantify the total benefits a natural resource provides, but instead seeks to monetize the most important or desirable benefits to the point that they are equal to the estimated costs of a proposed policy option. In other words, the objective for economic valuation of ecosystem services is to produce a lower bound dollar estimate for the benefits a natural resource provides.

There are many different methodologies economists and researchers utilize to derive value estimates. Each has different advantages and shortcomings and provides unique perspectives towards the value that resources and their ecosystem services hold. This paper will discuss three methodologies that, through review and analysis of published studies applicable to North Carolina watersheds, water bodies, and communities and in consultation with leading researchers, have been determined as the preeminent methods of economic ecosystem service valuation. Every ecosystem service valuation study is distinct and provides different information about the value of the type of resource it examines. The conclusions and results of these studies can, however, serve policy analysis in a variety of contexts if the information they contain is accurately understood and correctly applied. This paper seeks to enhance understanding of the processes and characteristics of Contingent Valuation Method (CVM), Hedonic Pricing Method (HPM) and Travel Cost Method (TCM) to inform application of water quality valuation studies utilizing these methodologies. This paper will provide examples of studies utilizing each of these methodologies and discuss the meanings and applications of their results. Additionally, this paper will include citations of all works and researchers consulted to inform this guide and will examine and explain economic concepts fundamental to economic valuation of ecosystem services to improve comfort and fluency in future conversations, research, and policymaking in this context.

Contingent Valuation Method (CVM)

Contingent valuation is one of the primary methodologies utilized by economists and researchers for ecosystem service valuation. It generates value estimates through analyzing stated preference data which is collected from a survey of a random sample of the target population. CVM assesses individuals' willingness to pay (WTP) for the use of a good or resource. Individuals' WTP preferences are assumed to be contingent on alternative goods available in a hypothetical market. In other words, CVM assumes individuals will consider all possible purposes for $X in the hypothetical market and the expected benefit return of spending $X on each of those options and then conclude which option is most desirable to them, indicating their personal value for that option. As CVM is dependent on survey response data, the foundational aspect of a CVM study is the stated preference survey or series of surveys that researchers distribute to a sample.

The design and execution of a CVM study's survey component can significantly influence the final determined valuation. A survey should be designed to produce data that can support the most accurate and representative valuation possible for the analysis. Posing questions in a dichotomous choice format eliminates ambivalent answers and provides specific stated preference results as it asks respondents to choose between two distinct options (i.e., yes or no). Most crucially, in order to yield effective data, surveys need to provide adequate information on the proposed policy options and their impacts for respondents to make informed decisions while being comprehendible to the survey sample. Lacking surveys are more susceptible to various economic and behavioral biases increasing the potential for inadequate data and conclusions. Effective CVM surveys are often highly involved and expensive to perform, but these efforts are necessary to produce legitimate, useful results.

To provide adequate context, CVM surveys need to include explanations of the essential pieces of CVM studies: the natural resource and ecosystem services being valued; the hypothetical market and its constituent pieces; and the payment vehicle for funding proposed policy options. This is necessary in order to maintain the methodology's fundamental assumptions and elicit quality response data. The natural resource should be described, identifying in layman's terms its associated benefits and ecosystem services. Encapsulating the related ecosystem services and their impacts on associated direct and passive uses of the subject resource resultant from a change in water quality in a single monetary value is at minimum highly difficult and arguably impossible. However, identifying a group of relevant, measurable, and representative ecosystem services that can also be related to direct and passive uses can provide a more robust and reliable valuation. The hypothetical market from which survey respondents select options must also be outlined including identification of who will provide and who will pay for the improvement or protection of the natural resource. The vehicle of payment should be designated which describes how the proposed policy option would be funded and should preferably be designed as a collective action, eliminating freeloader bias and apathy-driven non-preference response. Considerations towards the representativeness of the survey sample is also key to procuring quality data. In order to accurately represent the value preferences for water quality improvement in a water body, the survey sample must be representative of the demographic make-up of the target region.

Since CVM relies upon stated preferences to estimate a resource's value, if respondents are unfamiliar or apathetic towards the type of policy or type of resource in question, it can affect their stated preference responses. It is very difficult to describe the total benefits associated with improving a natural resource. Even if background educational information is provided within a CVM survey, it may not be fully grasped by respondents. Lack of familiarity therefore can seriously impact the validity of survey results. Additionally, since it is so critical to establish familiarity, robust CVM surveys are very costly (in time, money, and effort) to perform which acts as a barrier to researchers looking to perform studies.

Hedonic Pricing Method (HPM)

An alternative methodological approach utilized in natural resource valuation is the Hedonic Pricing Method. HPM assumes a good’s value internalizes the additional amenities associated with ownership or usage of the good. For example, the value of a house in a picturesque, clean neighborhood would be worth more than the same house in a noisy, polluted neighborhood. HPM begins by creating a value function which sets the value of a good equal to the internalized factors that contribute to a good’s value.

V(house)=F(architecture, school district, surrounding environmental quality, etc.)

From this function, economists calculate the willingness to pay for a marginal change to each of the internalized amenities (the constituent parts that form a good’s value), providing an implicit price for that amenity. These implicit prices can then be used to derive demand curves for each amenity, relating the quantity or quality levels of the amenity to values or prices. Compiling these individual demand curves produces a value estimate for the subject good.

Through this process, HPM is able to estimate individuals' WTP from revealed preference data which is collected from a surveyed sample. Revealed preference is determined through analyzing individuals' decision-making patterns and determining their preferences based on their behavior. Therefore, the survey tool utilized to collect respondents' choices must be structured to accommodate heterogenous choices but also produce final preferences. This approach seeks to avoid potential biases associated with stated preference and accommodate a greater range of interests, background education, and other factors that may influence decision making and responses.

Since HPM valuation is predicated on deriving a robust initial value function, HPM is massively data intensive. Data must be collected and analyzed on the internalized amenities, factors impacting those internalized amenities, the study region's demographic and spatial characteristics, and the policy option's effect on each of these areas before a study can begin eliciting survey responses. This can act as a barrier to researchers pursuing resource valuation estimates. Additionally, the quality of the initial value function can carry implications towards the validity of a study's final value estimates. A poorly constructed value function can under- or overestimate the impacts of internalized amenities, skewing final results. Internalized amenities can also have positive and negative impacts. For example, if a policy lowers Nitrogen concentration in urban streams, it can increase ecosystem health, improving a neighborhood's environment and property values but may limit lawn fertilization or size, possibly lowering perceived aesthetic beauty and property values. Dissonant impacts on amenities can produce conflicting results.

Travel Cost Method (TCM)

The Travel Cost Method takes the most narrow consideration for ecosystem service benefits of the three methodological approaches for natural resource valuation discussed in this guide. TCM concentrates solely on the recreation value that water bodies provide to individuals. TCM assumes individuals will make trips to a recreation site until the marginal cost of each trip is greater than or equal to the marginal utility derived from the recreation site. Marginal cost refers to the cost of each additional visit, which is calculated by averaging the net expenditures a sample of individuals undertake traveling to the targeted recreation site. TCM considers these travel costs as directly revealed preferences for recreation and indirectly revealed preferences for nature.

Within TCM, demand for recreational trips to a given water body is dependent on characteristics of the recreation site, income level of potential recreators, price of substitutes (alternative recreation sites), and most importantly trip cost and distance to travel. To establish trip costs in relation to distance, researchers elicit survey data from samples within increasingly distant radiuses. Surveys additionally collect frequency data of visits over a determined time horizon. This data can then be compiled into a demand curve using the average trip cost values and visit frequency from each distance strata. This demand function represents the current WTP of individuals to recreate at the subject water body. Given a policy initiative that would improve recreation value of a water body, the marginal utility of additional trips would change.

Economists can then estimate the corresponding effect on trip frequency. In this way, TCM can predict policy impacts on individuals and assess benefit generation.

The primary argument against TCM is the narrow scope of ecosystem services it values. Solely focusing on recreation leaves the majority of ecosystem service benefits out and excludes water bodies that do not support recreating. TCM studies can also have weak representativeness in their survey samples. Since travel costs and visit frequency are averaged for each distance strata, TCM assumes individuals' preferences in each of these strata are homogenous. Recreation is, however, a highly relatable quality which can make TCM valuations both compelling and more easily communicated.

Example Studies

Phaneuf, D. J., von Haefen, R. H., Mansfield, C., & Van Houtven, G. (2013). Measuring nutrient reduction benefits for policy analysis using linked non-market valuation and environmental assessment models, final report on stated preference surveys. *Report to the US EPA*.

This study utilizes contingent valuation approach to assess benefit value for reducing nutrient loads in lakes in Southeastern US. It considers recreation use value and water quality nonuse values of lakes in sample states and examines the impacts of a proposed policy objective to lower nutrient loads in a case study in Falls Lake. Its component parts include a water quality index relating qualitative descriptions of water body characteristics to measurable nutrient levels, surveying demographically representative samples utilizing the water quality index to assess WTP for qualitative improvements to targeted lakes, modeling based on survey data estimating value gain at varying levels of water quality improvement and a case study applying value modeling to Falls Lake.

The water quality index is designed to enhance survey data quality by directly relating quantitative ecosystem health measurements (e.g. ambient nitrogen, phosphorous) to qualitative descriptors on an alphabetic scale. It is derived through expert elicitation to ensure qualitative descriptors and impacts on use and nonuse values are correctly correlated with quantitative ecosystem measurements. The survey component incorporates this index by utilizing the established qualitative descriptors to support greater comprehension by respondents.

Following the data analysis and modeling component, the study finds that improved water quality and economic value are nonlinearly correlated. It shows the greatest value gains occur over low to middle water quality transitions as defined by the index criteria. This indicates improvement past this point has a decreasingly productive impact on perceived value to individuals. The case study component shows implementing the proposed policy option in Falls Lake would yield an annual value return of $13.76 million and $108.81 over a twenty-year period.

These results provide estimates of the perceived recreational use value and general nonuse value for water quality in lakes within the Southeast US. This study considers easily perceivable and measurable ecosystem service benefits, excluding more ill-definable benefits to provide a lower bound estimate of benefit generated by water quality improvement through a nutrient reduction policy. While it targets a specific water body type, its broad scope (Southeastern US) allows for more diverse application in analogous regions. Its survey methods yielded demonstrably robust data, reflecting a well-conducted CVM study.

Chamblee, J. F., Dehring, C. A., & Depken, C. A. (2009). Watershed development restrictions and land prices: Empirical evidence from southern Appalachia. *Regional Science and Urban Economics*, *39*(3), 287-296.

This study utilizes hedonic pricing to examine the impact of land use policies on property values imposed in Buncombe County in 1989. The policies in question prohibited parcel subdivision to fewer than 4 acres in parcels bordering the Ivy River to prevent nutrient offloads into the water body caused by development. It specifically studies the disparate impacts on parcels and landowners within and outside the Ivy River watershed region targeted by these policies. In this study, HPM is leveraged to calculate willingness to accept (WTA), rather than willingness to pay. WTA is a calculation of the compensation an individual expects to receive to part with a good or service.

To create a value function, the researchers collected transaction data for parcels affected by the land use regulations and those within neighboring areas. The data spanned time frames preceding and following implementation of the targeted policies. They analyzed how property values generally responded to the policy's implementation, particularly examining spatial influences.

The study finds the land use policies created heterogenous impacts across Buncombe County. Properties directly bordering the Ivy River and located within the watershed displayed negative value changes, while properties outside the watershed in Buncombe County showed limited to no growth. Most adversely impacted were parcels smaller than 4 acres which could no longer be subdivided. The total value loss was estimated at $13 million. The authors proposed landowners within the watershed should be compensated in order for the land use regulations to constitute effective public policy.

This study presents two interesting conclusions. The first is the properties located outside the watershed fail to reflect the benefits created by preventing further degradation of the Ivy River in their respective values. This might indicate local ecosystem health amenities did not contribute significantly to parcel value. Alternatively, it could suggest that while the land use policies limited further nutrient pollution of the Ivy River, it did not necessarily improve the overall quality of the resource, therefore not generating any additional ecosystem service value which was reflected by the consistent non-watershed property values. The second is the authors' discussion of effective policy and solution of compensation for parcel owner that experienced value loss. Environmental policy should aim at protecting and improving resources while also generating benefits to the individuals and communities that interact with them. While preventing further pollutive actions to the Ivy River does protect the resources ecosystem health, the value loss to the community can perceivably negate these positive ecological impacts.

HPM provides a way to discern not only how much we value resources, goods, or property but also where that value originates from. In this way it is helpful for designing policy that is able to maximize both ecological and economic effectiveness.

Whitehead, J. C., Haab, T. C., & Huang, J. C. (2000). Measuring recreation benefits of quality improvements with revealed and stated behavior data. *Resource and energy economics*, *22*(4), 339-354.

This study utilizes travel cost and trip frequency data to examine impacts on recreation levels of ecosystem quality improvement in the Albemarle and Pamlico sounds. The study poses a relevant policy option to improve ecosystem quality which would enhance recreation ability within both water bodies. Researchers collect stated and revealed preference data through eliciting survey responses from the general population. Surveys were distributed spatially across counties to both nonparticipants and participants to create a representative sample. The study analyzes this data to estimate WTP for increased resource quality in terms of additional trips and then relates these estimates to an increase in consumer surplus (CS) in dollars. CS reflects the difference between the price an individual pays and their WTP.

The study finds restoring the two sounds' ecosystem quality to pre-1981 levels yields a $25 million improvement in CS for the Pamlico sound and $31 million improvement in the Albemarle. The authors utilize the survey data to predict increased participation by previous participants as well as previous nonparticipants. They emphasize the necessity of including previous nonparticipants to avoid negatively biased CS valuations. These should still be considered lower bound estimates, they note, as participation in the surrounding 41 counties in the region is already demonstrably high without policy implementation. They argue with policy implementation, recreation will only increase with resource quality improvement and will continuously draw more participants.

This TCM study reflects this methodology's ability to provide compelling valuation data despite its narrow ecosystem service focus. With trip cost remaining consistent, the benefit generated by policy driven quality improvement in the two sounds increases trip frequency of current participants and entices previous nonparticipants to also recreate in the water bodies. The CS estimates the researchers generate display the direct value individuals will receive as a result of the higher quality ecosystems. While recreation is a specific use value of water resources, it is highly valued and as demonstrated can generate high benefit returns.

Challenges and Opportunities

Water quality valuation is an extremely useful tool to inform policy, advocate for better, more comprehensive regulation, encourage regional, municipality, and community scale participation, and engage stakeholders to be more effective environmental stewards. Economic valuation has the potential to communicate benefits of water quality protection and improvement very clearly and attractively. However, current academic and institutional discussion and literature on this topic is not approachable and has led and will continue to lead to misunderstandings of what the available data means and what it can be used for.

There is a need to establish informed discussion of economic water quality valuation through education to clarify among policymakers, regulatory commissions, municipalities, and private sector stakeholders what valuation data is actually saying and how it can be used. Additionally, while there are many valuation studies already available applicable to North Carolina, not all studies are created equal. Enhancing the level of dialogue on water quality valuation will enable policymakers and researchers to communicate more effectively about what data is needed and what criteria stakeholders are expecting in order to justify more robust environmental protection.

Increasing fluency in non-market economic valuation of water resources – and natural resources generally – will serve to benefit all stakeholders involved in drafting, implementing, enforcing, and following environmental policy. Valuation estimates can serve as compelling evidence for the benefits environmental policy can create beyond protecting and improving ecosystem health. Understanding the value of natural resources and the systems that rely upon them will ultimately benefit the effort to preserve and maintain them.

Annotated Bibliography

Measuring nutrient reduction benefits for policy analysis using linked non-market valuation and environmental assessment models, final report on stated preference surveys. Report to the US EPA. 2013. Phaneuf, D. J., von Haefen, R. H., Mansfield, C., & Van Houtven, G.
Analysis of two part survey collecting information on value of water quality regulation for lakes in Southeast US states. Considers use value for recreation and nonuse value for general water quality in sample states. Creates qualitative criteria for ranking water quality from measured nutrient pollution data and then relates that to economic valuation of increased regulation through analyzing survey respondent's WTP preferences. Finds enhanced quality and economic value as nonlinearly correlated, with greatest value coming from transitions from low (D,E) to middle (B,C) overall quality ranking as defined by its criteria. Applies models to Case Study of Falls Lake in North Carolina where it finds implementing proposed policy objective to yield annual value of $13.76 million and $108.81 million over 20 year period. I could use some more explanation of statistical analysis techniques used in environmental and economic models.

The Benefits of the Falls Lake Nutrient Management Strategy. 2013. Roger H. von Haefen
Describes study done on proposed policy measures for Neuse River Basin, specifically examining economic value generated through improved water quality in Falls Lake and the Eno River. Performs benefit-cost analysis of the $1.5 billion FLNMS, finding a baseline value creation of $686 million over a 25 year period. Advises benefits could range between $469 to $903 million depending on assumptions adjustments in presented economic and environmental models. Additionally, report focuses on benefit derived from recreation which accounts for an estimated half of total use and non use value generated, meaning range of total benefit of FLMNS could be doubled.

Estimating the Benefits of Stream Water Quality Improvements in Urbanizing Watersheds: An Ecological Production Function Approach. 2015 Proposal. Investigators: Roger von Haefen (lead PI); co-PIs: Laura Taylor, Daniel Obenour, George Van Houtven, Melissa Kenney; Michael Gerst
Outlines research proposal to determine use and non use values of water quality improvement in urban streams. Stated outputs composed of valuation function predicting WTP, ecological production function linking measured water quality data with qualitative ecological endpoints, and water quality modeling framework to provide probable assessments in streams with scarce sampling data. Addresses research questions relating to effect of spatial scale, scope, and geographic proximity on WTP and if valuation models are robust across watersheds. Includes case study on Upper Neuse watershed to demonstrate research efforts towards the accomplishing stated objective. Will provide regulators and legislators with tools to evaluate pollution control policy options in urban streams. Conducted at watershed scale. Spatial scale, scope, and geographic proximity analysis could provide insights into community scale decision making.

2005. **Applying Cost-Benefit to Past Decisions: Was Environmental Protection Ever a Good Idea?** Lisa Heinzerling-Georgetown University Law Center, heinzerl@law.georgetown.edu;
Frank Ackerman-Tufts University; Rachel Massey-Tufts University

Argues against using cost benefit analysis as primary means for evaluating environmental policy and regulations. Presents three studies wherein cost benefit analysis is shown to be susceptible to providing an inaccurate evaluation due to bias, inadequate information, or naivete. While argument against utilizing it as a tool for policy evaluation is at times compelling, more pertinent is the discussion of the potential biases that can exist within various places in cost benefit models. Understanding how assumptions, datasets, and definitions used in models may be influenced to provide skewed outcomes can inform building better and more sound models to perform more reliable evaluations.

A Comprehensive Review of the Evidence of the Impact of Surface Water Quality on Property Values. 2017. Sarah Nicholls, John Crompton.
Outlines 43 studies conducted between 1968 and 2017 examining connection between property value and water quality in various regions in the US and internationally. In concert to analysis of outcomes reached by these studies, this review also tracks and evaluates the evolution of methodologies used to examine property value metrics in relation to quantitative and qualitative changes in water quality. Finds that almost all studies show positive correlation between property values and improved water quality in at least one model. Additionally, over time methodologies improved, providing higher confidence analysis with more diverse application. Includes interesting point, "The authors concluded that variable selection "should be based on conceptually and theoretically sound logic" [28](p. 296), as well as reflective of public perception, and "not be based solely on the convenience ofavailable environmental data" [28] (p. 296).

The Value of Coastal Wetlands for Flood Damage Reduction in the Northeastern USA. 2017. Siddharth Narayan, Michael W. Beck, Paul Wilson, Christopher J. Thomas , Alexandra Guerrero, Christine C. Shepard, Borja G. Reguero, Guillermo Franco, Jane Carter Ingram & Dania Trespalacios.
Estimates value coastal wetlands provide through assessing avoided flood damages. Finds wetlands mitigate flooding in most cases and reduce overall costs of flood events. Examines the east coast from Maine to North Carolina following Hurricane Sandy and estimates coastal wetlands prevented $625 in flood damages. Advocates combining risk and conservation interests in coastal areas where wetlands have shown to be beneficial in reducing flood risks. Decreasing development around wetlands and flood prone areas would serve to increase wetlands' effectiveness and their overall ecosystem health.

Watershed development restrictions and land prices: Empirical evidence from southern Appalachia. Regional Science and Urban Economics, *39*(3), 287-296. 2009. Chamblee, J. F., Dehring, C. A., & Depken, C. A.

Studies effect of land use policies imposed following the WSWPA in Buncombe County in 1989. Takes transaction data on parcels located in unincorporated areas of Buncombe County and within the Ivy River Watershed. Finds following the regulations, parcels outside of the watershed experienced no change in value and received environmental benefits due to the improved water quality. Parcels in the watershed fell in value, costing a total $13 million. Most adversely affected were parcels less than 4 acres which could no longer be subdivided under the new regulations. Authors propose compensation for watershed property owners to constitute effective public policy. Interesting solution for policy that unevenly distributes costs and benefits. Hedonic pricing

Estimating Economic Values for Outdoor Recreation: A Synthesis of Three Review Papers. 2005. George Van Houtven, Kelly Jones and John Powers.
Analyzes two papers that utilized a meta-regression function to examine hundreds of recreation valuation studies. They also applied the meta-regression analysis as a benefit transfer function to predict average recreation values. BTF measures in recreation days created, using consumer surplus to place quantifiable value on recreation activities. Meta-regression function does not reflect change in quantitative measurements of environmental quality. Found value is characterized by type of recreation, type of site, and features of the study. BTF was found to generally overestimate recreation value but proved to be positively correlated and significant with national evaluations. Interesting potential for analysis at community level, not sure of BTF scale requirements. Author recommends BTF used as "second-best estimate," less preferable than site specific study.

Economics of Environmental Improvement. 2006. Joel Huber and W. Kip Viscusi.
Presents study of WTP for various policy options related to water quality improvement in lakes/rivers. Policy options presented at regional and national levels. Measures both use and nonuse benefits but use benefits focus primarily on recreation (swimming and fishing) and ecosystem health, does not consider effect on property value, drinking water etc. Finds demographics with higher value for water quality being, higher income/education, environmental org members, and users/visitors to water bodies. Also presents regression model for predicting WTP estimates and claims it is applicable for use for sub-populations and smaller areas as long as adjustments are made for demographics/characteristics of those areas and pops. Also finds WTP per percent increase in water quality depreciates with delay in policy results and with higher base levels of water quality.

Forest Conservation as A Nutrient Credit In The Jordan Lake Watershed. 2020**.** Charles C. Stillwell, Jeffrey P. Johnson, William F. Hunt
Outlines literature review of nutrient loads and concentrations at water shed scale. Explains and analyzes contributing factors and relates Jordan Lake TMDLs guidelines in mitigating future load increases. Analysis of forest conservation as means of nutrient load reduction found conservation as relatively ineffective but notes, revitalization of riparian buffers, forest conversion of agricultural land, and more comprehensive evaluation measures are opportunities to increase impacts of forest conservation. Interestingly notes Jordan Lake rules do not reduce baseline nutrient loads but seek to minimize future increases due to development, leaving agriculture to shoulder actual load reductions.

Low Impact Development in Western North Carolina - a policy fact sheet. 2008. NCSU Cooperative Extension. Christy Perrin. Patrick Beggs
Outlines strategies to promote and implement low impact development policy and projects. Outlines five goals/aspects of LID: conserve resources, minimize impact, optimize water infiltration, create areas for local storage and treatment, build capacity for maintenance. LID serves primarily as a mitigation strategy for impacts of stormwater runoff to water bodies. LID works by reducing area of impervious surfaces that speed stormwater and nutrient flow into surrounding water bodies and replacing them

with green stormwater infrastructure (BMPs), greenspace and other mechanisms that encourage infiltration, reducing flow and nutrient loads. In providing these water quality services, LID also reduces erosion, ecosystem loss, and flood risk. Many current regulations limit implementation of LID infrastructure and development strategies which prevents LID projects from reaching their full capacity or being accomplished at all. Provides resources for design/implementation, examples of current policies emphasizing and incentivizing LID in NC, and suggestions for community outreach and engagement for LID strategies.

Side note, curious about carbon sequestration benefits of LID?

Low Impact Development - an economic fact sheet. 2008. NCSU Cooperative Extension. Patrick Beggs. Christy Perrin.
Provides information regarding economic value in terms of avoided costs and increased benefits of LID strategies. Distinguishes LID from conservation development and cluster development, acknowledging they may have similar goals and delivered outcomes depending on setting and project characteristics but neither fully accomplishes the other. Advocates for cost benefit analysis over other evaluation techniques as the optimal method to fully consider the value of LID mechanisms and projects. Breaks down benefits to homeowner and local governments, describing higher property values, lower stormwater fees, temperature regulation, higher tax revenues, cost mitigation for expanding existing traditional infrastructure, less stormwater infiltration into sewage treatment facilities, and lower water quality regulatory costs. Additionally it proposes benefits for developers and communities, listing more buildable lots, fewer infrastructure costs, higher property values, enhanced ecosystem services (translating to avoided costs and contributing to property values), enhanced health/quality of life (results of clean water). Offers case studies to support benefit claims and discusses tradeoffs of LID, ultimately concluding LID is beneficial for all stakeholders.

Water Quality Benefits Software Platform and Regulatory Analysis. 2017. EPA STAR Grants Workshop Powerpoint.
Goal of establishing framework to model national water quality benefits in support of EPA regulation. Creating software tool that takes raw WQ data and generates WQI using an adjustable model and provides benefits estimations. Paper on study published in *Environmental and Resource Economics.*Software tool seems to have potential application for providing benefit estimates to localities within NC considering WQ policy – scope is adjustable down to county (I believe). Follow up with project leads/related published material seems advisable. Could run into issue assessing national vs local policy because study seems geared towards EPA regulation but there could be work around.

Paying for Nutrient Reduction and Management in Jordan Lake. 2019. Erin Riggs, Evan Kirk, and Jeff Hughes.
Report developed by UNC Enviro Finance Center evaluating water management strategies to implement in the Jordan Lake watershed. Provides 4 potential scenarios ranging from the existing management framework, an expanded framework, watershed fees and taxes, and an integrated regional watershed utility plan. These scenarios provide increasing levels of legislative and systemic modification and

increasing enhancement of projected effectiveness. It's key findings describe existing water management strategies that model potential outcomes of implementing the proposed scenarios. The Catawba-Wateree Water Management Group incorporates Duke Energy and 18 water supply entities in an integrated management strategy in which members pay fees for access to water resources and a governing board. The CWWMG produces a 5 year plan outlining projects to protect water quantity, quality, and address economic concerns for water resources in the region. It uses membership fees at a ratio of $1 in fees to $1.50 in work as well as outside grants to execute these project and provides oversight internally and in partnership with outside organizations. The Upper Neuse River Basin Association creates a cooperative water management group out of regional stakeholders to manage water resources to comply with the Falls Lake Rules administered by the NC DWR. Members pay dues which are adjusted based on size of individual draw on resources and area within the region that are purposed by the governing body towards water quality monitoring and previously outlined nutrient reduction credit practices. Both the CWWMG and UNRBA include participation incentives either through fee structure or consensus decision making protocol that encourage stakeholders to remain members, retaining both funding a cooperation for enhanced effectiveness of water management projects. Report outlines other possible management/financing measures for water quality improvement within NC and nationally. Program in Iowa saw 40% reduction in nitrogen loads in watershed after implementing rain garden educational program. Program in Minnesota utilizes sub-financing groups to fund projects particularly beneficial to specific regions, indicating group members may have higher WTP for WQ improvements effective in a closer vicinity. Discusses ancillary benefits of One Water management approach, highlighting SCM valuation tool CLASIC (Water Research Foundation) that calculates secondary benefits over lifetime of SCMs. Concludes that a single approach scenario isn't adequate to address management issues, however deviation from status quo towards the more robust scenarios (3 and 4) would be advantageous. Maximizing ancillary benefits through increasing revenues, governance capacity, and determining most effective spending opportunities would yield most optimal outcomes.

The Disparity Between Willingness to Accept and Willingness to Pay Measures of Value. 1987. Don L. Coursey, John L. Hovis and William D. Schulze
Describes study evaluating difference between WTP and WTA for a market good given varying conditions of certainty around goods market value (price). Addresses initial assumption that WTA>WTP and looks to determined general level/motivation of this disparity. Finds that when market price is unknown or undefined WTA-WTP disparity is greatest and as more value information is obtained by actors via education/experience preferences readjust to reflect more similarity between WTA, WTP. Proposes WTA could be initially overvalued due to psychological factors like wishful thinking as actors may believe they should be paid more due to socially instilled assumptions. The supposed effect of this is reduced the more knowledgeable actors become of the good's market, however while WTA and WTP are shown become more correlated over time, WTA still remains greater than WTP and is statistically distinct from WTP for the length of the study.

Why the WTA–WTP disparity matters. 1998. Thomas C. Brown, Robin Gregory.
Relates WTP-WTA disparity to environmental applications, explaining sources of disparity and implications to environmental issues and policy. Describes Income Effect, Transaction Costs, Implied Value, Endowment Effect, Legitimacy, Ambiguity and, Responsibility as contributing factors for WTP-WTA disparities in various environmental and resource issues. Outlines WTP is preeminent valuation method for CB analysis in enviro policy and why. Advocates for alternative valuation techniques to avoid

undervaluation from WTP based valuation models. Shows WTA's possible applications and provides examples of how WTP vs WTA framing for policy options can affect outcomes and conclusions.

Willingness To Pay And Willingness To Accept Are Probably Less Correlated Than You Think. 2017. Jonathan Chapman, Mark Dean, Pietro Ortoleva, Erik Snowberg, Colin Camerer.
Study on correlation between WTP and WTA, conducted surveys with demographically representative samples using theoretical lottery based questions. Found WTP and WTA minimally negatively correlated as a result of the endowment effect. Findings led authors to conclude WTP and WTA ask fundamentally different questions, a conclusion supported by analysis of data and methodology within study and of other outside research. Additional neuroscientific research identifying different brain triggers during buying and selling processes supports this conclusion. Authors recommend utilizing models that frame WTP and WTA in alternative methods other than buying and selling to avoid endowment effect bias.

The benefits and costs of riparian analysis habitat preservation: a willingness to accept/willingness to pay contingent valuation approach. 2002. Jean-Pierre Amigues , Catherine Boulatoff (Broadhead) , Brigitte Desaigues , Caroline Gauthier , John E. Keith
Report performs benefit cost analysis of biodiversity protection through establishing riparian buffers. Evaluates benefit with WTP using survey of representative sample of residents. Evaluates WTA through survey of land owners with property adjacent to river. WTA data is limited which handicaps conclusiveness of study. Has some interesting statistical analysis of nonresponse/0 responses for WTA. Not really how I was thinking of WTA but interesting to see it framed alongside WTP for CB analysis. Overall very, very French.