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Valuing Community Benefits of Final Ecosystem Goods and Services: Human Health and Ethnographic Approaches as Complements to Economic Valuation

SHC PROJECT 2.61

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by

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Notice/Disclaimer Statement

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Abstract

As part of the Sustainable and Healthy Communities Research Program, the National and Community Benefits of Final Ecosystem Goods and Services Task is focused on translating the provisioning of final ecosystem goods and services (FEGS) into community health and well-being. As stated by the EPA Science Advisory Board, “The science of sustainability must emphasize the interrelated aspects of human actions and [human] well-being and the functions of human altered and natural supporting ecosystems”. While other tasks in the SHC Research Program are centered on assessing the economic valuation of FEGS, the Benefits task will create a complementary link to indicators of human health and well-being, providing a more comprehensive accounting of the benefits that ecosystems provide.

Task objectives are being met through literature synthesis and case studies across the country. This report provides a summary of three of our research projects: 1) an evaluation of the quality of scientific evidence associating green spaces with health benefits, along with ensuing research in San Juan, Puerto Rico; 2) a Health Impact Assessment of a Long Island sewering pilot program in Suffolk County, NY that revealed health benefits associated with control of sewage- and effluent-related ecosystem goods and services; and 3) a Great Lakes community case study that used ethnographic methods to characterize how a community values FEGS affected by aquatic ecosystem remediation and restoration. Each chapter is written as a standalone section with a narrative synthesis. Each study represents the experiences of social, public health, and environmental scientists recruited to ongoing interdisciplinary research projects at the Agency.

This report covers a period from October 2016 to May 2017 and work was completed as of June 2017.

Foreword

The U.S. Environmental Protection Agency (EPA) is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. To meet this mandate, EPA's research program is providing data and technical support for solving environmental problems today and building a science knowledge base necessary to manage our ecological resources wisely, understand how pollutants affect our health, and prevent or reduce environmental risks in the future.

The National Exposure Research Laboratory (NERL) within the Office of Research and Development (ORD) supports EPA's mission to protect human health and the environment by developing and applying innovations in exposure science. Exposure science sets the context for understanding and solving real-world problems and is used to help answer three fundamental questions:

- Is there a risk?
- If so, how do we reduce/mitigate/prevent the risk?
- Have our actions been successful in reducing risk?

NERL collaborates with both public and private sector partners and is internationally recognized as the leader in environmental exposure science. Our multidisciplinary expertise enables the laboratory to bring cutting-edge research and technology to the field of exposure science to address the Agency's priority environmental problems.

This report is a product provided by the Community and National Benefits of Final Ecosystem Goods and Services Task 2.61.4 of the Sustainable and Healthy Communities National Research Program.

Dr. Andrew Gillespie, interim Director

Computational Exposure Division

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Acronyms and Abbreviations

AOC	Area of Concern
BACI	Before After Control Impact
BUI	Beneficial Use Impairment
CAV	Citizen Advisory Council
CCS	Coordinated Case Study
CDC	Center for Disease Control
CICES	Common International Classification of Ecosystem Services
CVD	Cardiovascular Disease
DSRP	Distinctions-Systems-Relationships-Perspectives Model
EGS	Ecosystem Goods and Services
EPA	U.S. Environmental Protection Agency
ES	Ecosystem Services
FEGS	Final Ecosystem Goods and Services
FEGS-CS	FEGS Classification System
FEMA	Federal Emergency Management Agency
GI	Gastrointestinal
GIS	Geographic Information System
GLNPO	Great Lakes National Program Office
GLWQA	Great Lakes Water Quality Agreement
HIA	Health Impact Assessment
HSRRO	Human Subject Research Review Official
ICR	Information Collection Request
IRB	Institutional Review Board
NEP	National Estuary Program
OMB	Office of Management and Budget
ORD	Office of Research and Development
OSDS	Onsite Sewage Disposal System
PAC	Public Advisory Council
PII	Personally Identifiable Information
PRA	Paperwork Reduction Act
RAP	Remedial Action Plan
R2R2R	Remediation to Restoration to Revitalization
SAB	Science Advisory Board
SHC	Sustainable and Healthy Communities National Research Program
SJBE	San Juan Bay Estuary
SSC	Student Services Contractor
TEV	Total Economic Value
WTP	Willingness to Pay

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Executive Summary

As part of the Sustainable and Healthy Communities Research Program, the National and Community Benefits of Final Ecosystem Goods and Services Task is focused on translating the provisioning of final ecosystem goods and services (FEGS) into community health and well-being. This report provides a summary of three research projects: 1) an evaluation of the quality of scientific evidence associating green spaces with health benefits, along with ensuing research in San Juan, Puerto Rico; 2) a Health Impact Assessment of a Long Island sewering pilot program in Suffolk County, NY that revealed health benefits associated with control of sewage- and effluent-related EGS; and 3) a Great Lakes community case study that used ethnographic methods to characterize how a community values FEGS affected by aquatic ecosystem remediation and restoration. Whereas there is broad scientific consensus that ecosystems provide a wide diversity of benefits to the public, there is not broad consensus among researchers regarding the best way to determine the value of these benefits. In each of these studies, multidisciplinary approaches to non-monetary FEGS valuation are explored, successful aspects of these approaches are considered, areas where the approach can be improved are identified, and important future research areas are discussed.

In the first study, the quality of scientific evidence regarding the associations between green space and human health are considered, making the important connection between ecosystem services and well-being. For communities to be successful managing green space for public benefit, stakeholders should be informed of the underlying processes linking green spaces to health, as well as the methods available both for estimating future health outcomes and for post-restoration monitoring effectiveness. Broadly, it was found that the evidence linking EGS to human health mainly supports intermediate steps, and very few published studies address the entire pathway from ecosystem quality to disease. Specifically, multiple research needs were identified regarding ecosystem-health linkages between green space and health. These needs include evaluating the association between green spaces and either gastrointestinal disease or asthma, defining the predominant mechanism linking green spaces and cardiovascular benefits (in particular, physical activity versus air pollution removal), and improving our understanding of the factors that determine if green spaces promote or prevent respiratory illness. Studies evaluating ecosystem-health linkages should take into consideration other aspects closely tied to human health and captured in conceptual models such as the FEGS framework (e.g., socio-economic factors), the interdisciplinary nature of eco-health research, and the importance of aligning research objectives with the decision context. An example is provided demonstrating how a multidisciplinary team of scientists collaborated with local stakeholders in the San Juan Bay Estuary, PR to better inform non-monetary valuation of FEGS in this case study community.

In the second study, a Health Impact Assessment (HIA) was used to evaluate how proposed municipal code changes regarding onsite sewage disposal systems (OSDS) in Suffolk County, New York might affect human health. By connecting elements of a decision or project that affect local ecosystems to potential impacts on human health and well-being, HIA can provide a linkage between FEGS and community-level benefits. Suffolk County is considering changes to their Sanitary Code regarding OSDS to address the growing environmental issues they face related to nitrogen loading from old, failing, and densely packed systems. It was found that OSDS and cesspool systems are a major contributor to nitrogen pollution in Suffolk County's surface and groundwater. Numerous benefits associated with upgrading OSDS to innovative or alternative systems were further identified, including reduction of the number of harmful algal blooms in local estuaries, reduction of the risk of illness from sewage contamination to private drinking water wells, and improvement in community economics as a result of cleaner surface waters. It is concluded that while HIA is not a research tool, it was possible to

use HIA to identify FEGS and health impacts that were of interest and concern to the community. Further, this experience confirmed that of others, namely, that a HIA can be used by researchers conducting community-level EGS studies as a tool for building mutual trust and understanding with the community.

Finally, a community case study is presented in which the researchers sought to understand how citizens, community groups, and a municipality (City of Duluth, Minnesota) value FEGS. Of particular interest were the FEGS affected by improved ecosystem services and neighborhood revitalization associated with ongoing sediment remediation and habitat restoration. This concept is called remediation to restoration to revitalization, or R2R2R. Because the benefits of restoration are context-dependent and based on personal and professional experiences, it is paramount to find methods that relate the values of ecosystem services to the values of other actors or organizations. Ethnographic methods were used to create a conceptual map of a neighborhood to identify and characterize the different values placed on an ecosystem and its services. This community model includes and defines many of the components that individuals, organizations, and local governments may discuss or make decisions about in the context of their neighborhood or community. FEGS are embedded throughout the framework. It is concluded that stakeholders and decision makers recognize and appreciate nature based on their relationships with it and usually in context. Accordingly, how citizens, local governments, and natural resource managers value the benefits of FEGS varies among these groups. The community model is a tool to facilitate translation of goals and values between resource agencies and communities.

Collectively, the three approaches yield insight into how to conduct studies that address the link between FEGS and their value to communities. First, FEGS valuation requires a multidisciplinary team. However, researchers need to be aware that perspectives and language grounded in specific disciplines can impede communication and lead to related challenges managing and analyzing multidisciplinary data. As such, researchers should be aware of differing lexicons and the application of conceptual models. Second, each study demonstrated promise in its own right. Researchers identified a variety of community benefits related to human health and well-being associated with changes in FEGS. Where these benefits were identified in concert with environmental decisions, the valuation of these benefits had the potential to inform community decision making. Nevertheless, because these studies must be interdisciplinary and require practitioners of social, economic, human health and ecological sciences, integration must be designed into the research and development process.

1. Introduction

1.1. Background

The EPA Scientific Advisory Board (SAB) stated that using a wide range of valuation methods could allow EPA to "capture the full range of contributions stemming from ecosystem protection and multiple sources of value derived from ecosystem sources" (U.S. EPA 2009: 23). Similarly, Costanza et al. (2016) called for alternative measures of ecosystem and human well-being that incorporate ideas from ecology and psychology to describe how the natural, social, human, and built dimensions of the environment contribute to well-being. The greatest challenges in the ability to both value ecosystem goods and services (EGS) and include them in the decision-making process are the effectiveness of valuation approaches, and strong (direct and indirect) evidence connecting EGS to human health and well-being.

Whereas there is broad scientific consensus that ecosystems provide many diverse benefits to the public, researchers still face challenges in determining appropriate methods to assess the value of these benefits. Generally, valuation methods are used to convey the importance of ecosystems in a manner that can be readily understood by the general public and decision makers. To address these challenges, the EPA Office of Research and Development (ORD) has developed or implemented tools and strategies to identify more comprehensive approaches to characterize the contribution EGS to human health and well-being. This report outlines a number of non-monetary approaches, frameworks, and tools that can be used to make better decisions that include consideration of ecosystem services and connections to human health and well-being.

1.2. Approaches for Studying Non-Monetary Benefits of Ecosystem Services

In addition to monetary valuation approaches, researchers at ORD have been employing alternative ways of assessing benefits from EGS and values associated with EGS. Non-monetary valuations rank and evaluate preferences based on socio-cultural values using qualitative methodologies that provide social context and other salient details that may not be captured within a monetary valuation. Non-monetary valuations capture greater detail on the type and range of community preferences and values than monetary valuations, including relative weighting and potential tradeoffs, and therefore are not able to perform with the same methodological consistency (i.e., not as straightforward) than the use of a monetary valuation may provide (Kelemen et al. 2016). However, a focus on dollar values can have unintended consequences because it overemphasizes the value of market goods, oversimplifies the full complement of benefits and values associated with EGS, and largely excludes those benefits that are not easily monetized (i.e., those for which publicly traded markets do not exist). Although dollars are an accepted, universal standard of comparison, valuable information regarding what matters to communities is lost when reducing value to a purely economic endpoint. As an example, omission of cultural and spiritual values of EGS and their manifold benefits to human health and well-being in a benefit/cost analysis can lead to natural resource depletion in the near term. This report examines three types of non-monetary approaches to addressing benefits from EGS looking at ecosystem, societal, and human health elements: causal criteria analyses, impact assessments, and ethnographic assessments (Figure 1.1).

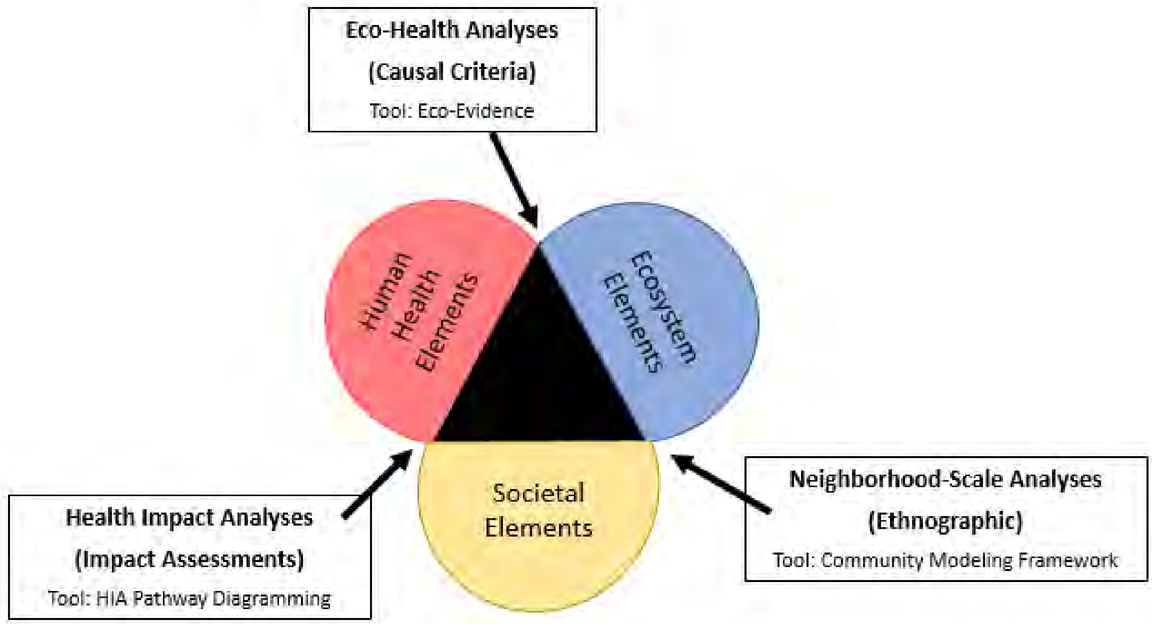

Figure 1.1 Examining the benefits from EGS to human health and well-being among ecosystem, societal, and human health elements. Three different analytical approaches, and the tools examined in this report, are described in the text boxes.

Causal criteria approaches examine the lines of evidence connecting direct and indirect linkages between two or more items in a hypothesized relationship. The current knowledge base linking EGS to human health (termed eco-health linkages) has been compiled by the U.S. EPA's Eco-Health browser[1] (Eco-Health Relationship browser; accessed 20, July 2017). The browser describes the cause and effect mechanisms linking ecosystems to health and disease through "health promotional" EGS (e.g., physical activity, engagement with nature) and "buffering" EGS (e.g., clean air, clean water, weather hazard mitigation; Jackson et al. 2013). It not only provides a comprehensive inventory of the best available science, but also a visualization interface that allows users to better understand the complex relationships between different ecosystems and aspects of human well-being. While certain eco-health linkages have been studied by hundreds of research articles, others just have one or two supporting studies, raising questions about which linkages have enough evidence to be used as a basis for management decisions and which should be regarded as working hypotheses in need of further research. Recently, ORD researchers have conducted a causal criteria analysis of the available scientific base supporting eco-health linkages (de Jesus Crespo and Fulford 2017). This approach consists of evaluating the weight of evidence towards causality in terms of: 1) probabilistic evidence (i.e., consistent cause-

[1] Examples of other data-derived models to examine health consequences from ecosystem services are presented in Appendix 2.

effect association); and 2) mechanistic evidence (i.e., logical explanation of how the causal association occurs) (Russo and Williamson 2007).

Impact assessment approaches examine the potential effects of a decision on the recipients of a decision. Heath Impact Assessments (HIA) is “a means of assessing the health impacts of policies, plans, and projects in diverse economic sectors using quantitative, qualitative, and participatory techniques” (World Health Organization 2017) and can be used to examine linkages between EGS and community-level benefits. HIAs examine the potential effects of a management decision on community and human health by connecting elements of a decision or project that affect nature and local ecosystems to potential impacts on human health and well-being using a tool called pathway diagramming. Health Impact Assessments are an iterative stakeholder engagement process giving researchers insight into the relative values that the community places on ecosystem goods and services and the health benefits they provide.

Ethnographic approaches. Qualitative researchers use a variety of methods to collect and analyze data. In this study, an exploratory case study (Yin 2013) was utilized because of the contextual nature of ecosystem services. In qualitative research, case studies are used to answer how and why questions (i.e., how do communities value ecosystem services) when the researcher lacks control over events, and it is difficult to separate the object of study from its context (Creswell 2013, Yin 2013). Ethnographic data collection methods, like participant observation and document analysis, facilitate the identification of lived experiences, or day-to-day practices that might be taken for granted, through the participation in events or collection of materials that were created for a purpose important to the organizers or authors (de Volo and Schatz 2004). Ethnographic approaches to research are an alternative to the dominant approaches to ecosystem service valuation (i.e., stated or revealed preference approaches), which rely on discrete choice experiments or other survey instruments. Ethnographic research enables the identification and characterization of the different values placed on an ecosystem and its services – and is useful because those services may be different than what the researcher expects. This report presents a tool that was created as a result of an ethnographic study of ecosystem services in R2R2R.

1.3. Conceptual Modeling for Developing Analytical Frameworks

Conceptual model building is a valuable approach to develop analytical frameworks to describe a system, problem, or decision under consideration. Conceptual models are a communication vehicle that presents a clear picture of what is understood about a system, problem, or decision and often connect the knowledge and expertise of the relevant stakeholders for a given system, problem, or decision (ASTM 2009, Fulford et al. 2016a, U.S. EPA 1998, Yee et al. 2011). There are many approaches to building conceptual models, including influence diagrams, concept mapping, and pathway diagrams (Fulford et al. 2016b). The underlying premise involves analytical frameworks that diagram (i.e., capture, visualize, and organize) cause and effect relationships that are important to the system, problem, or decision under consideration (Fulford et al. 2016a, Joffe and Mindell 2006, Knol et al. 2010, Yee et al. 2011). This report presents several conceptual models used in developing analytical frameworks such as the Eco-Health Pathways Model (Figure 2.1), the Health Impact Assessment Pathway (Figure 3.2), and the Neighborhood Model (Figure 4.1).

The Final Ecosystem Goods and Services (FEGS) Framework. This report uses a Final Ecosystem Good and Services (FEGS) framework (model in Figure 2.2) to identify key factors that may influence health outcomes (Fulford et al. 2016a). Final ecosystem goods and services are defined as the components of nature directly enjoyed, consumed, or used to yield human well-being. The FEGS is a biophysical quality or feature and needs minimal translation for relevance to human well-being (Boyd and Banzhaf 2007), while benefits provided by ecosystems are defined as a good, service, or attribute of a good or service that promotes or enhances the well-being of an individual, an organization, or natural system such as more food, better hiking, less flooding (Fisher and Turner 2008, Harwell et al. 2017). For example, coral reef ecosystems provide a habitat for a variety of species, which is considered a FEGS. However, the benefits to humans are the raw materials that can be consumed or extracted from a reef such as fish harvest, or the recreational benefits from snorkeling or boating along the reef.

The elements of the FEGS conceptual framework (e.g., stakeholder engagement/decision context, intermediate and final ecosystem goods and services, ecological production functions, and measures of benefit) represent efforts to support community-level decision making that incorporates quantitative information on the production and delivery of ecosystem goods and services for the benefits of human health and well-being (Fulford et al. 2016a, Harwell et al. 2017, Yee et al. 2011). The human benefits perspective of the FEGS model includes four key components: ecosystem state metrics, EGS indicators, health benefit indicators, and socio-economic factors (highlighted in Figure 2.2). Place-based studies provide an opportunity to explore the application of this conceptual model.

1.4. Case Studies

A case study is typically defined as a place-based study that is connected to unique aspects of the location of the work, most often associated with a target community, components of a watershed, or other physical feature of the place (Fulford et al. 2016a). Case studies allow for examining the causes and effects of human stress on the environment, and the reciprocal, namely how changes to the environment (here, the production and delivery of ecosystem services) may affect human health and well-being. A classic EPA application of the case-study approach is one that approaches a practical problem. This report provides a summary of research from three selected case studies in the Sustainable and Healthy Communities (SHC) National Research Program, relating ecosystem services to human health benefits as a narrative synthesis. These case studies include ORD research in San Juan, Puerto Rico, Suffolk County, Long Island, and the St. Louis River Area of Concern in Minnesota.

The **San Juan Bay Estuary** (SJBE) watershed, Puerto Rico, is part of the U.S. National Estuary Program (NEP) and the U.S. EPA’s Coordinated Case Study (CCS) communities of the Sustainable and Healthy Communities program. Within the SJBE, a number of priority health outcomes have been identified as key concerns of the local community, including vector borne diseases, gastrointestinal diseases, heat morbidities, and respiratory conditions like asthma (Sheffield et al 2014, Méndez-Lázaro et al. 2015). These diseases have been associated with environmental stressors such as the deterioration of clean air and water, and the magnitude and frequency of weather hazard events. Green spaces within cities can help mitigate these environmental hazards through buffering ecosystem services. To inform management decisions, including creation, restoration, and preservation of green spaces, a key research need is to understand the regional influence of green space cover on health outcomes associated with environmental hazards in the SJBE and potentially other areas of Puerto Rico.

Suffolk County, Long Island, NY, was greatly impacted by Tropical Storm Sandy in October of 2012. In the wake of this storm, a collaborative effort was initiated to examine how to increase community resilience to coastal storms in the future. This work involves modeling, community engagement, and is a collaboration between the state of NY, EPA Region 2, and EPA ORD (Fulford et al. 2016a). Suffolk County has an estimated 360,000 residences that use on-site sewage disposal systems (OSDS), representing 74 percent of residential buildings (Figure 3.3) (Suffolk County Government 2014a). Almost 60 percent (approximately 209,000) of those are located in areas designated by the county as environmentally sensitive. Approximately 252,000 of the un-sewered residences were built before 1973, when new sewer code changes mandated the addition of septic tanks. These residences are served by cesspool systems (Figure 3.3). Septic systems and cesspools provide little to no nitrogen removal and are a significant source of nitrogen in the local groundwater (Hansen and Schoonen 1999). Excess nitrogen is a severe problem with Suffolk County surface waters, leading to harmful algal blooms (Hattenrath et al. 2010, Nuzzi and Waters 2004), hypoxia and anoxia in embayments (Anderson and Taylor 2001), and loss of aquatic life (LaRoche et al. 1997). Suffolk County is exploring options to change to their Sanitary Code regarding OSDS to address the growing environmental issues they face related to nitrogen loading from old, failing OSDS and areas with high concentrations of OSDS (Suffolk County Government 2014b).

The **St. Louis River Area of Concern[2] (AOC)**, is one of 43 geographic areas that was designated by the U.S. and Canada where "significant impairment of beneficial uses has occurred as a result of human activities at the local level" (Governments of Canada and United States 2012). Historically, the AOC program has been focused on remediating and restoring beneficial uses in the aquatic and riparian areas of the Great Lakes. ORD and the Great Lakes National Program Office (GLNPO) are interested in the steps between contaminated sediment remediation, habitat restoration, and community revitalization, or R2R2R. The City of Duluth, Minnesota provides an illustrative case study to understand the dynamics of R2R2R, because the City's revitalization strategy is focused on the neighborhoods adjacent to AOC remediation and restoration projects. Furthermore, the City of Duluth's revitalization of the St. Louis Corridor is based on environmental restoration, improving neighborhood quality of life, and attracting new homeowners, while also creating a new visitor destination and stimulating development (City of Duluth 2017). The focus of this study is how to relate the views of citizens to the objectives of city officials and natural resource managers, which appear to diverge. Restoring beneficial uses of the ecosystem in the AOC and in the City of Duluth will provide final ecosystem goods and services that contribute to human well-being, like fish for sustenance and recreation, wild rice for habitat and spiritual connection, scenic views, and increased access to natural areas.

1.5. Report Structure

The following chapters in this report present the application of each approach (Human Health – Causal Inference Approaches; Human Health – Health Impact Assessment Approaches; Ethnographic Approaches) to understand community level benefits related to health and human well-being derived from EGS. Development of the tools for each of these approaches are presented, along with an application (testing) in place-based case studies. Recognizing that decisions at the local level can impact ecosystem services, and in turn human health and well-being, each section on the application of the case studies presents the methods approach that incorporated ESS and FEGS, the outcome yielded by the case study results, and lessons-learned and research design considerations as part of a discussion on how to apply these frameworks and tools elsewhere. Each Chapter is summed up with a section on conclusions and future research needs. More details on the approaches and case applications are presented in the Appendices.

[2] Area of Concern were designated in the 1987 Protocol to the 1978 Great Lakes Water Quality Agreement as "geographic areas that fail to meet the general or specific objectives of the Agreement" (International Joint Commission 1987).

2. Human Health Approaches – Causal Inference

2.1. Causal Criteria Analysis

In epidemiology, observed associations between human health and environmental, social, or behavioral variables are applied to inform causal inference about potential drivers of disease (Merrill et al. 2008). The principles of causal inference, consistency, strength of association, temporality, biological plausibility, and specificity[3] (Merrill et al. 2008), need to be met in order for cause-effect relationships to be supported. Causal criteria analysis applies these principles to determine the weight of evidence towards causal connections in terms of: 1) probabilistic evidence (i.e., consistent cause-effect association); and 2) mechanistic evidence (i.e., logical explanation of how the causal association occurs) (Russo and Williamson 2007). A classic example of the application of this approach is the Surgeon General's 1964 report on smoking and health, which has become a landmark of how science can be effectively applied in decision making for the benefit of human health (Parascandola et al. 2006).

Regarding ecosystem services, U.S. EPA's Eco-Health browser provides a comprehensive inventory of the best available science supporting the complex relationships between different ecosystems, human health and well-being. This tool provides a starting point to construct a causal criteria analysis on this context and better understand which linkages have enough evidence to be used as a basis for management applications and which should be regarded as working hypotheses in need of more research.

2.2. Application of Causal Criteria Analysis to Evaluate the Role of Green Space EGS on Human Health

Building on U.S. EPA's Eco-Health browser, a causal criteria analysis was conducted using Eco Evidence an open source software tool that incorporates causal inference principles (Eco-Evidence tool; accessed 20, July 2017) (Norris et al. 2011). The focus of this analysis were linkages between diseases and the buffering EGS provided by green spaces (de Jesus Crespo and Fulford 2017; Figure 2.1). Buffering EGS refers to the ecosystem's capacity to buffer against health impacts by removing pollutants from air and water, and mitigating heat and water hazards (Jackson et al. 2013). The term green space refers to any vegetation within a human dominated environment (Kabisch and Haase 2013). This includes urban trees, green roofs, and natural or constructed wetlands, all of which provide EGS that influence health (GI – gastrointestinal, CVD - cardiovascular disease). Green spaces intercept water,

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[3] Consistency: the association has been replicated by different research projects; Strength of association: the association is not due to bias or confounding factors, and is statistically significant; Temporality: exposure to a suspected cause precedes the disease; Biological plausibility: a logical biological mechanism for the association exists; Specificity: the exposure and disease are specific to one another (this condition is not always needed in order to support causality) (Merrill et al. 2008).

promote infiltration, and serve as barriers to storm surges, leading to water hazard mitigation (Brody and Highfield 2013, Costanza et al. 2008). Mitigation of water hazards reduces exposure risk to polluted flood waters and GI disease (Wade et al. 2004). It also reduces the risk of post-flood household dampness, which could lead to mold growth and asthma (Chew et al. 2006). Green spaces also promote clean water by immobilizing and absorbing infectious and toxic pollutants (Karim et al. 2004, Silva et al. 1990) and reducing the risk of GI disease from contact or consumption (Araya et al. 2004, Katukiza et al. 2014). In addition, green spaces filter air pollutants (Räsänen et al. 2013) that cause respiratory illness and cardiovascular disease (Brook et al. 2004, Peters et al. 1997). They also provide shade and evapotranspiration, lowering the risk of heat wave induced morbidities (Bouchama and Knochel 2002).

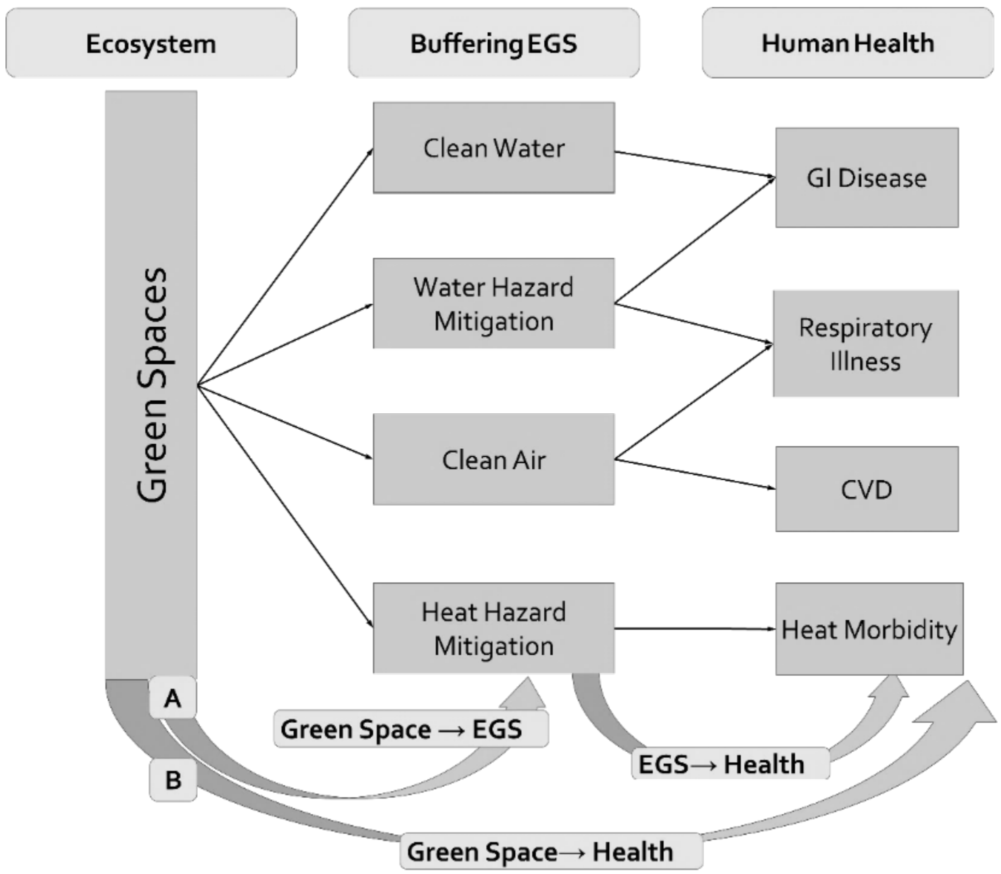

Figure 2.1 Eco-health pathways connecting the ecosystem attribute, green spaces, to human health endpoints through indirect ("A"; buffering EGS) and direct ("B"; human health) pathways. Figure from de Jesus Crespo and Fulford (2017).

While all these linkages are mechanistically plausible, our results showed that the weight of evidence supporting each of them varies as shown in Table 2.1. Notably, most of the current eco-health literature supports findings of intermediate steps (e.g., ecosystem to buffering EGS and buffering EGS to human health), but there is limited support for direct linkages from ecosystem (green spaces) to human health (disease endpoints) (Table 2.1). For example, while there is sufficient evidence supporting water pollution removal by vegetation, and sufficient evidence supporting a connection between certain water pollutants and GI disease, there is insufficient evidence supporting a direct connection between vegetation and GI disease (Table 8.3). Studies including all the components of the causal relationships are much needed as they would help provide clear management recommendations, such as the effectiveness of different plant species, relationships to the built environment and expected effect sizes of restoration initiatives. For more details of these results and the methods used see Appendix 3, and de

Jesus Crespo and Fulford (2017).

Table 2.1 Results of causal criteria analysis of eco-health linkages. (For more details, see Appendix 3; adapted from de Jesus Crespo and Fulford 2017).

Linkage	Total Studies Found	Total Studies Reviewed	Weight of Evidence in Favor	Weight of Evidence not in Favor	Conclusion
Green Spaces and Buffering EGS					
Green Spaces-Clean Water	60	44	166	16	Support for Hypothesis
Green Spaces-Water Hazard Mitigation	28	19	106	16	Support for Hypothesis
Green Spaces-Clean Air	44	22	105	16	Support for Hypothesis
Green Spaces-Heat Hazard Mitigation	31	19	117	3	Support for Hypothesis
Buffering EGS and Human Health					
Clean Water-GI Disease	11	6	35	0	Support for Hypothesis
Water Hazard Mitigation-GI Disease	9	7	41	7	Support for Hypothesis
Water Hazard Mitigation-Respiratory Illness	4	4	16	5	Insufficient Evidence
Clean Air-Respiratory Illness	37	28	247	178	Inconsistent Evidence*
Clean Air-Cardiovascular Disease (CVD)	27	23	206	143	Inconsistent Evidence*
Heat Hazard Mitigation-Heat Morbidities	22	18	114	2	Support for Hypothesis
Green Spaces and Human Health-Direct					
Green Spaces-GI Disease	0	0	0	0	Insufficient Evidence
Green Spaces-Respiratory Illness	9	7	28	27	Inconsistent Evidence*
Green Spaces-CVD	9	3	27	0	Support for Hypothesis
Green Spaces-Heat Morbidities	10	4	35	0	Support for Hypothesis

* Note: the finding of “inconsistent evidence” may indicate potential confounding factors that play a mediating role, or highlight the role that context and the types of indicators used could play in detecting a given cause and effect relationship. See Nichols et al. (2011) for more details on interpreting this and other conclusions derived using this approach.

2.3. Empirical Approaches for Eco-Health Research

Causal criteria analysis allowed identifying a research agenda (Appendix 3) to advance our understanding of eco-health linkages. Conceptual models, such as the Final Ecosystem Goods and Services framework (Figure 2.2), have been developed to guide research on this topic, and may be applied to address research needs. The FEGS framework includes four key components: Ecosystem state metrics, EGS indicators, Health benefit indicators, and Socio-economic factors, which are essential to fully characterize eco-health relationship pathways.

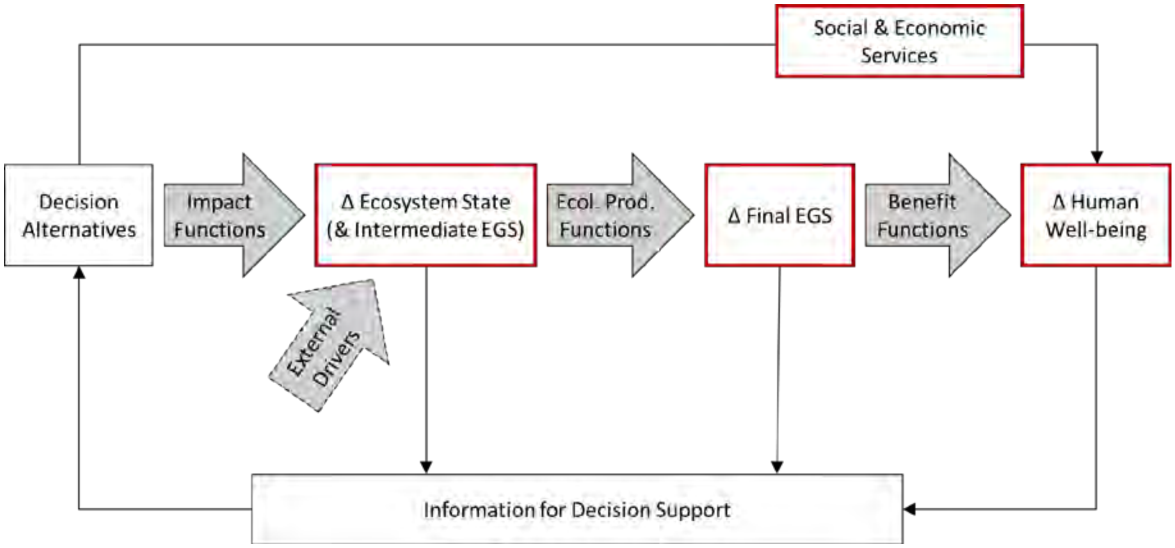

Figure 2.2 Conceptual Model for measuring Final Ecosystem Goods and Services. Areas measured through studies linking ecosystem services to health and well-being outcomes are highlighted in red.

Conducting spatially explicit correlation analyses is a logical first step towards testing eco-health conceptual models such as FEGS. Mapping platforms provide a way to test the spatial relationship between EGS and disease, contingent on the existence of suitable datasets to characterize the extent and quality of ecosystem services, to understand the socio-economic context, and to locate disease hotspots. Appendix 4 explores issues of data accessibility and granularity in mapping human health outcomes for spatially explicit correlation analyses approaches in eco-health studies.

For indicators that help map EGS, useful approaches include (but are not limited to) habitat suitability assessments, locations of trails or other recreational facilities, and modeling natural viewscapes. Angradi et al. (2016) mapped EGS in the Great Lakes region; the study provides a useful example of how to use existing datasets for EGS mapping, incorporating factors such as data uncertainty and tradeoffs into the analysis. Available sources for mapping EGS include the U.S. Geological Survey's National Gap Analysis Program, which helps estimate the distribution of species and ecosystems of interest, and the U.S. EPA EnviroAtlas (EnviroAtlas; accessed 20, July 2017) (Jackson et al. 2013), which helps visualize the extent of ecosystem services, among others.

Defining the spatial distribution of EGS is only the first step to modeling eco-health linkages. Socio-economic factors may exacerbate or decrease vulnerability to EGS loss and certain communities may be protected from the impacts of degrading EGS due to behavioral adaptations, technological adaptations, or access to EGS from other regions (Figure 2.3). These factors have been termed insulating layers (Myers et al. 2013), and are generally associated with wealth and access to information. Incorporating socio-economic indicators that reflect the potential for certain communities to benefit more than others from EGS provision (e.g., U.S. Census datasets) should be an essential part of studies assessing eco-health linkages.

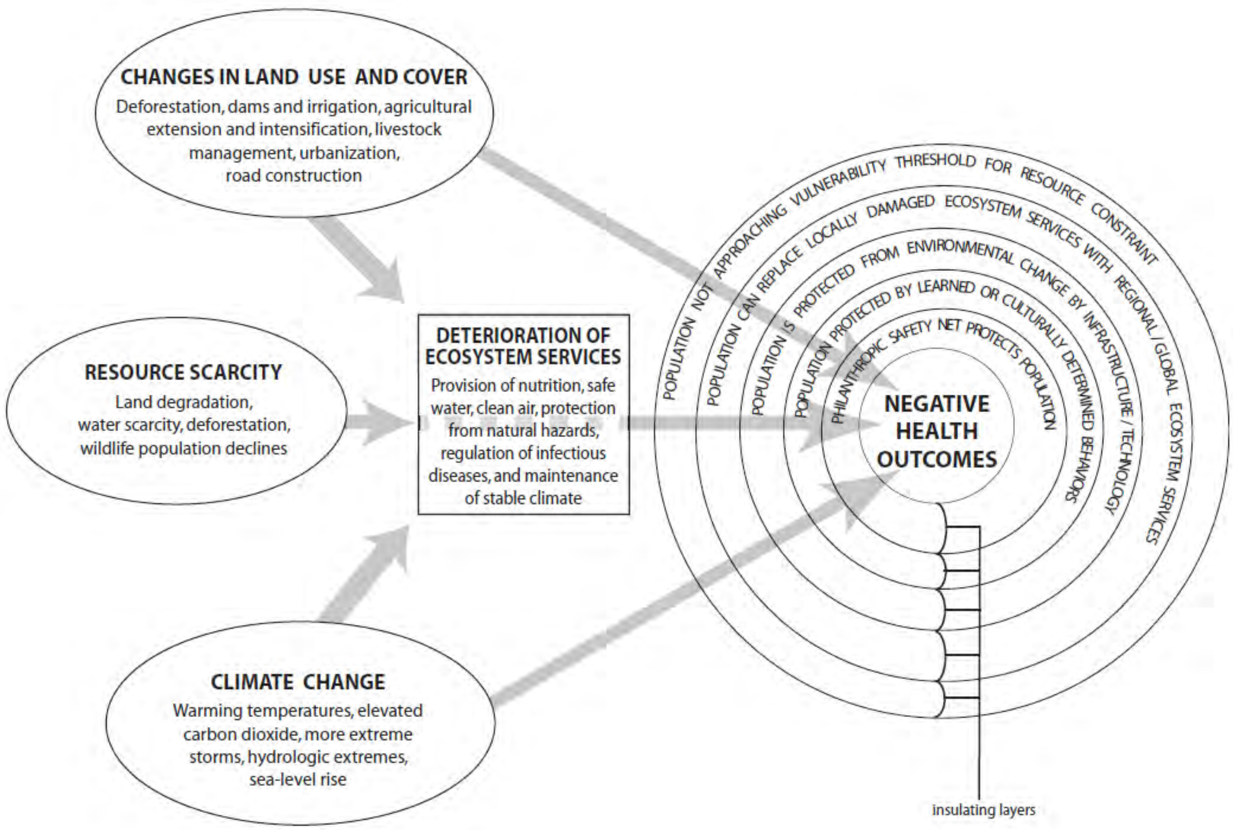

Figure 2.3 Schematic of the complex relationships between altered environmental conditions and human health. The impact of ecosystem goods and services loss is modified by socio-economic factors, termed insulating layers, which can ameliorate potential negative outcomes. Adapted from Myers et al. (2013).

Aside from health benefits, there are other human benefits associated with ecosystem services, such as safety, culture, and living standards. EPA's Human Well-Being Index (HWBI) provides a conceptual framework for mapping well-being at multiple scales in the United States (Smith et al. 2012, Smith et al. 2014), as well as forecasting changes due to loss of EGS (Summers et al. 2016). The HWBI is a tool that can be used to complement Eco-Health studies for a more general understanding of EGS benefits at the county and state levels.

Similar to economic benefit valuation (Figure 2.4; Wainger and Mazzotta 2011), research approaches for assessing health benefits could fall within a gradient of complexity, from the empirical analysis of conceptual models, as we propose here, to the use of simulation tools that predict loss of benefit from changes in EGS. Most conceptual models that describe eco-health linkages need more empirical evidence to develop quantitative relationships. Therefore, the use of simulation models is limited in this context to the few associations that have been studied extensively. A discussion of the use of data-derived models for simulating eco-health benefits is presented in Appendix 2.

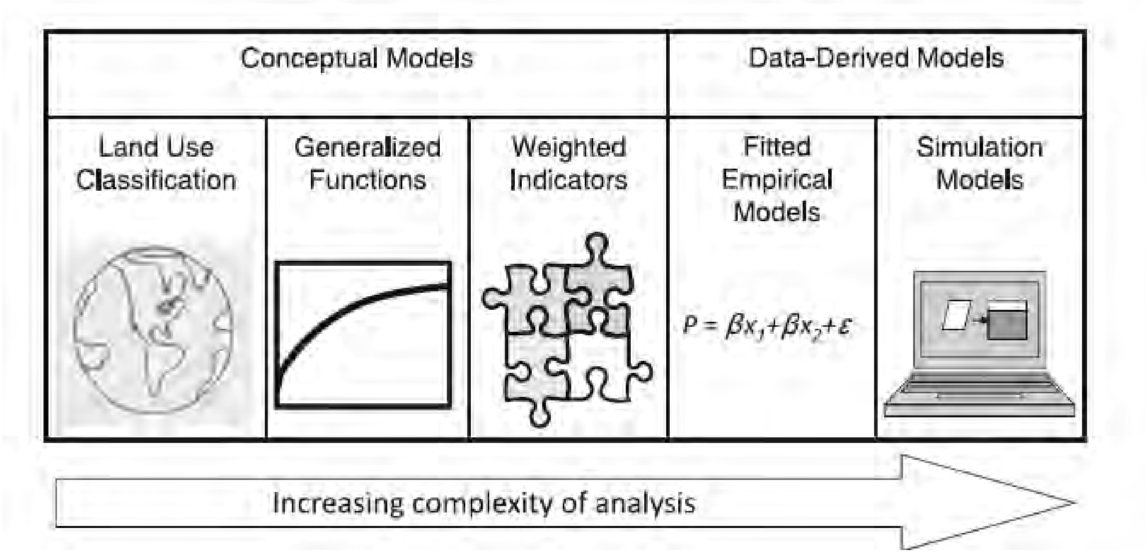

Figure 2.4 The gradient of modeling complexity shows different types of analysis used to generate the functional relations that estimate benefits of ecosystem goods and services management. From Wainger and Mazzotta (2011).

2.4. Upcoming Application of Empirical Approaches for Eco-Health Research in the San Juan Bay Estuary, PR

The communities in the SJBE, have identified many key health concerns associated with environmental stressors (Sheffield et al. 2014, Méndez-Lázaro et al. 2015). To help mitigate these stressors, the restoration of green spaces has been suggested a potential management strategy to improve health and well-being for SJBE residents (SJEB Management Plan 2017; accessed 26, July 2017). However, more studies are need to address the expected effectiveness of these practices. This case study seeks to quantify health outcomes associated with green space cover and buffering EGS using the FEGS framework (Figure 2.2) as a conceptual model. Using this approach entails identifying key ecosystems, ecosystem services, and socio-economic variables that are likely to influence health outcomes in the SJBE (Table 2.2), and then using statistical approaches to establish whether there is quantitative evidence for relationships between these key variables. Existing publicly available data sources could serve as indicators for each of these elements, in order to address the complex relationships in a cost-effective manner.

Some challenges to consider include disparate spatial scales of datasets to be included in the model, and restrictions on the availability of fine-scale human health information due to privacy considerations. Mechanisms to access detailed health data include establishing collaborations with health organizations, purchasing licenses to insurance claims or hospital data, or collecting information directly through surveys. All of these processes require consideration of PII and IRB restrictions. Appendix 5 presents a discussion on the challenges of collecting these types of data. To address limitations on the use of restricted health data, the SJBE case study will leverage collaborations with laboratories that have a health focus and the expertise in epidemiological research. This would not only allow access to data, but also foster cross-disciplinary dialogue to better inform the design and interpretation of a multidisciplinary topic such as eco-health linkages.

Table 2.2 Variables within the FEGS framework to evaluate Eco-Health linkages for the SJBE between green spaces or coastal wetlands and heat morbidities, GI disease, and Dengue fever.

ECOSYSTEM STATE		**ECOSYSTEM GOODS AND SERVICES**		**Δ HUMAN HEALTH BENEFITS**		**SOCIO-ECONOMIC FACTORS**	
NAME	Indicator	Name	Indicator	Name	Indicator	Name	Indicator
GREEN SPACES	% Green Space Cover	Heat Hazard mitigation	Surface temperature derived from satellite images (Landsat 8); Heat Wave Event time period	Heat Morbidities	Medicare Claims for heat related morbidities:	Wealth (influences air conditioning use, housing quality)	Median Income
COASTAL WETLANDS	% Wetland cover	Water Hazard Mitigation	FEMA[1] Flood Claims, Rainfall, Extreme flood event time period	Gastro-Intestinal Disease	Medicare Claims data for gastro-intestinal diseases	Infrastructure (influences storm water management effectiveness)	Sewage density
COASTAL WETLANDS	% Wetland cover	Habitat for Species (i.e., Biological Control)	Vertebrate Species Richness (Gould et al. 2008)	Dengue fever	Dengue prevalence (CDC[2])	Wealth (influences air conditioning use, housing quality)	Median Income
		Clean Water	Nitrogen Concentration (SJBE 2015)			Demographics (influences susceptibility to disease)	%Teenagers
		Heat Hazard mitigation	Surface temperature derived from satellite images (Landsat 8)			Infrastructure (influences vector habitat availability)	Sewage and road density

[1]FEMA: Federal Emergency Management Agency
[2]CDC: Center for Disease Control

As an example, ongoing studies in the SJBE are evaluating the role of wetland ecosystem services (e.g., biological control, clean water, and heat hazard mitigation) on Dengue fever (Figure 2.5). Heat hazard mitigation EGS may help reduce mosquito biting, ovi-position rate, and viral load; clean surface water provides habitat for wildlife and healthier ecosystems, favoring bio-control of mosquitoes (Araujo et al. 2015, Ibarra et al. 2013, Cox et al. 2007, Morin et al. 2015). Preliminary findings suggest that wetlands are negatively associated to Dengue cases even after controlling for potentially confounding variables (Table 2.2). They were also found to help reduce temperature (Figure 2.6), which is an environmental driver of Dengue transmission (Morin et al. 2015). These findings help support a connection between an important ecosystem in the SJBE, and an ecosystem service that directly influences human health. In the future, this and other eco-health research may help inform predictive models to estimate changes in health benefits under different decision scenarios.

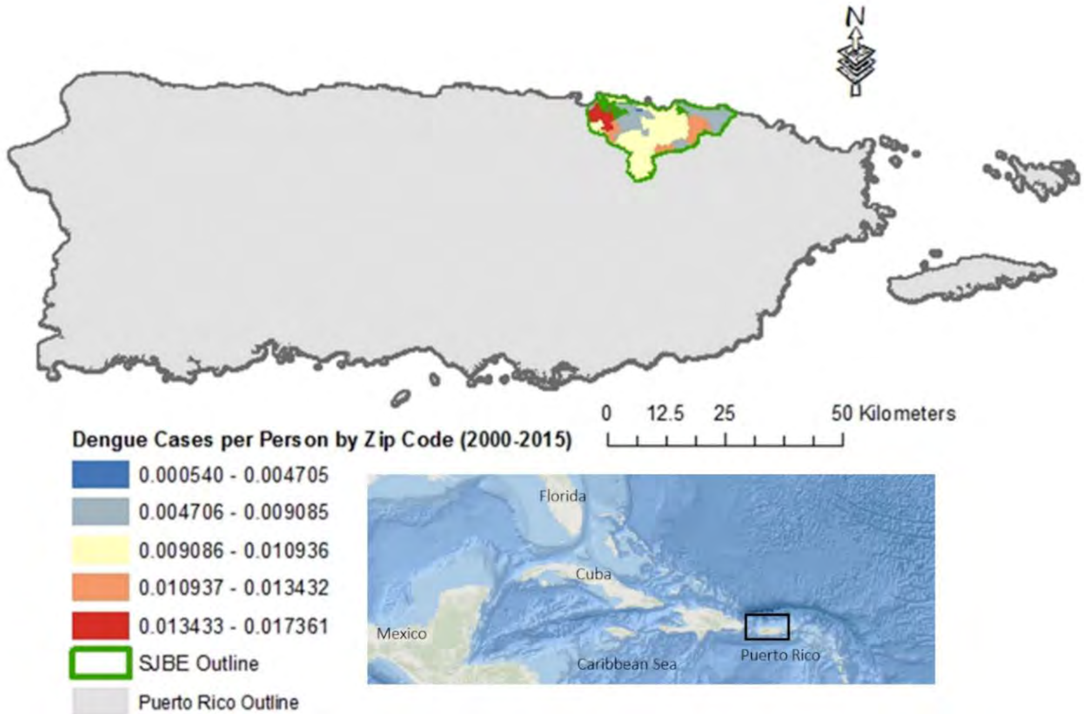

Figure 2.5 Dengue cases per person by zip code in the SJBE. Dengue data was provided by the CDC Dengue branch; Puerto Rico outline (United States Postal Service); Caribbean Map (DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS community).

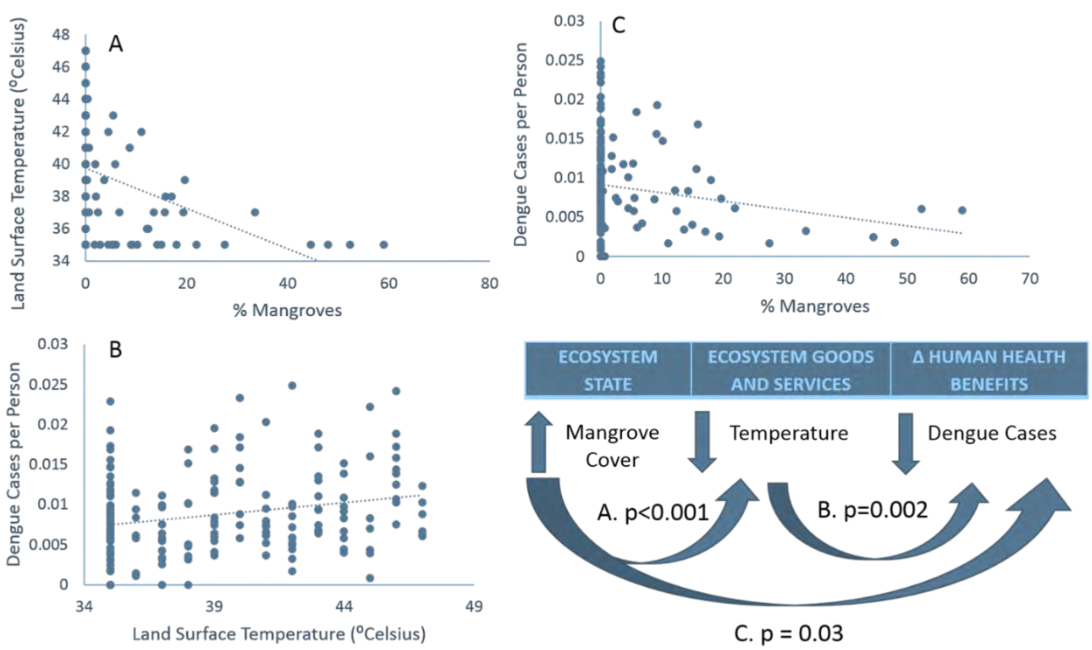

Figure 2.6 Preliminary findings of our study linking Dengue cases to wetland ecosystem services in the San Juan Bay Estuary (de Jesus Crespo et al. 2017). The p values for the linkages described in panel A and C were derived from Beta-binomial regressions including socio-economic confounding factors (Table 2.7). The p values from the link between mangroves and temperature were derived from simple linear regressions.

Work in the SJBE case study will link eco-health research to a decision context, which is the monitoring and management scenarios already proposed by the National Estuary Program (NEP). Aligning research objectives with those of the NEP will facilitate working with volunteers to collect data efficiently, promote educational opportunities, and improve the likelihood that the accumulating body of eco-health evidence (Table 2.2) is relevant and useful for decision makers.

2.5. Conclusions and Future Research Needs

Causal inference approaches allow researchers to use the best available science to inform evidence base decisions making. The principles of causal inference were applied to evaluate the weight of evidence linking green space EGS to human health and identify research needs. Results revealed that the evidence linking EGS to human health mainly supports intermediate steps, and very few published studies link the full pathways from ecosystem to disease. Establishing these linkages would be necessary to provide accurate non-monetary valuation of FEGS for community-based decision making. Specific research needs identified for the context of green space ecosystem services are summarized in Appendix 4 and include:

- Evaluating the association between green spaces on diseases such as GI disease and asthma by means of water hazard mitigation and clean water EGS;
- Defining the predominant mechanism driving the link between green spaces and cardiovascular benefits (i.e., physical activity or recreation versus air pollution removal);
- Better understanding the factors that determine if green spaces promote or prevent respiratory illness considering factors such as plant allergens, and re-circulation of pollutants trapped by foliage, among others.

For additional information on eco-health research needs involving ecosystems and health outcomes not discussed here, see Lee and Maheswaran (2011), Myers et al. (2013), Hartig et al. (2014), Hough (2014), and Sandifer and Sutton Grier (2014).

Addressing identified research needs could be facilitated by the application of conceptual models and using spatially explicit methods to empirically test these conceptual models. Studies evaluating eco-health linkages should take into consideration: 1) other aspects closely tied to human health and captured in conceptual models such as the FEGS framework; 2) the multidisciplinary nature of eco-health research; and 3) the importance of aligning research objectives to a decision context. In addition, issues of data accessibility and granularity in mapping human health outcomes as part of eco-health studies should also be considered (Appendix 4).

Examples were provided of the approach to incorporate these insights as part of ongoing research in the San Juan Bay Estuary, PR. Collaborating with local stakeholders and researchers across disciplines has facilitated progress in terms of identifying secondary data sources and defining priority questions to better inform non-monetary valuation of FEGS in this case study community.

3. Health Impact Assessment Approaches

Health Impact Assessments (HIAs) can provide a linkage between EGS and community-level benefits, which connects elements of a decision or project that affect nature and local ecosystems to potential impacts on human health and well-being. Regular meetings with stakeholders, decision makers, and researchers conducting the assessment are the cornerstone of HIAs (World Health Organization 2017). It is intended as a democratic process that solicits meaningful input from community members at all steps, to make sure the concerns of affected people are at the forefront of discussion and to foster a sense of ownership in the assessment results. The HIA approach is a recursive six-step process (Figure 3.1), and participants are encouraged to revisit earlier steps at any point in the HIA process as the project progresses. This typically occurs during stakeholder meetings. For example, when recommendations are delivered, it is often a good idea to revisit the Scoping and Assessment steps as a group to identify health impacts that may have been overlooked originally. Soliciting stakeholder input throughout the process gives researchers insight into the relative values that the community places on ecosystem goods and services and the health benefits they provide. While the focus of an HIA is to provide decision support, HIAs can also be used to highlight the services that the local environment provides for the community.

Figure 3.1 The six steps of the Health Impact Assessment process (Source: Mecklenburg County, North Carolina Health Department).

Pathway diagramming is a valuable tool used in the HIA process. The typical output of assessment HIA is a report subdivided into Impact Pathways that illustrate the flow of impact from decisions to affected systems, and ultimately well-being (Figure 3.2). In the case of pathways that affect natural systems, the flow of impact goes from decisions, to ecosystem characteristics, to (in some cases) intermediate EGS, and subsequently impacts community and human health.

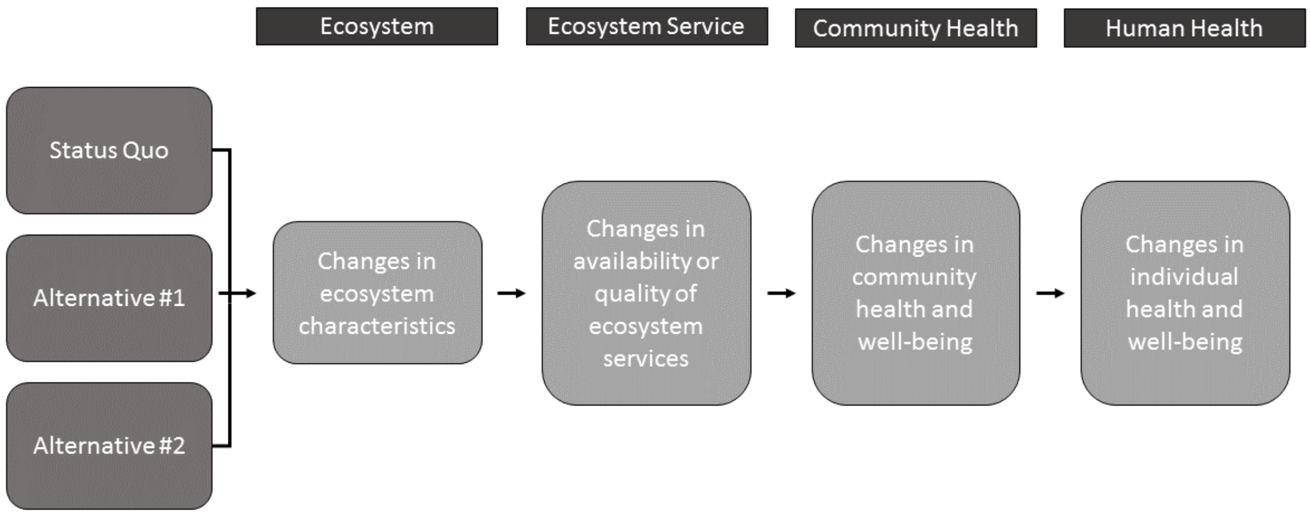

Figure 3.2 Health Impact Assessment Impact Pathway diagram.

3.1. Application in Long Island Sound

An HIA of a proposed municipal sewer code change in Suffolk County, New York, USA was conducted to determine the decision's potential effects on community and human health. The HIA process was to evaluate how a proposed municipal code changes regarding onsite sewage disposal systems (OSDS) in Suffolk County, New York might affect human health. Figure 3.3 shows the density of un-sewered parcels near recreational beaches in Suffolk County.

The County is considering changes to their Sanitary Code regarding OSDS to address the growing environmental issues they face related to nitrogen loading from old, failing OSDS and areas with high concentrations of OSDS (Suffolk County Government 2014b). The decision alternatives considered (Table 3.1) included no change, an upgrade to conform all OSDS to current standards, a mandate to upgrade old-style cesspool OSDS to a modern design in two proposed zones, and a mandate to upgrade all OSDS to one of several innovative/alternative designs that minimize nitrogen and pathogen pollution (Appendix 6).

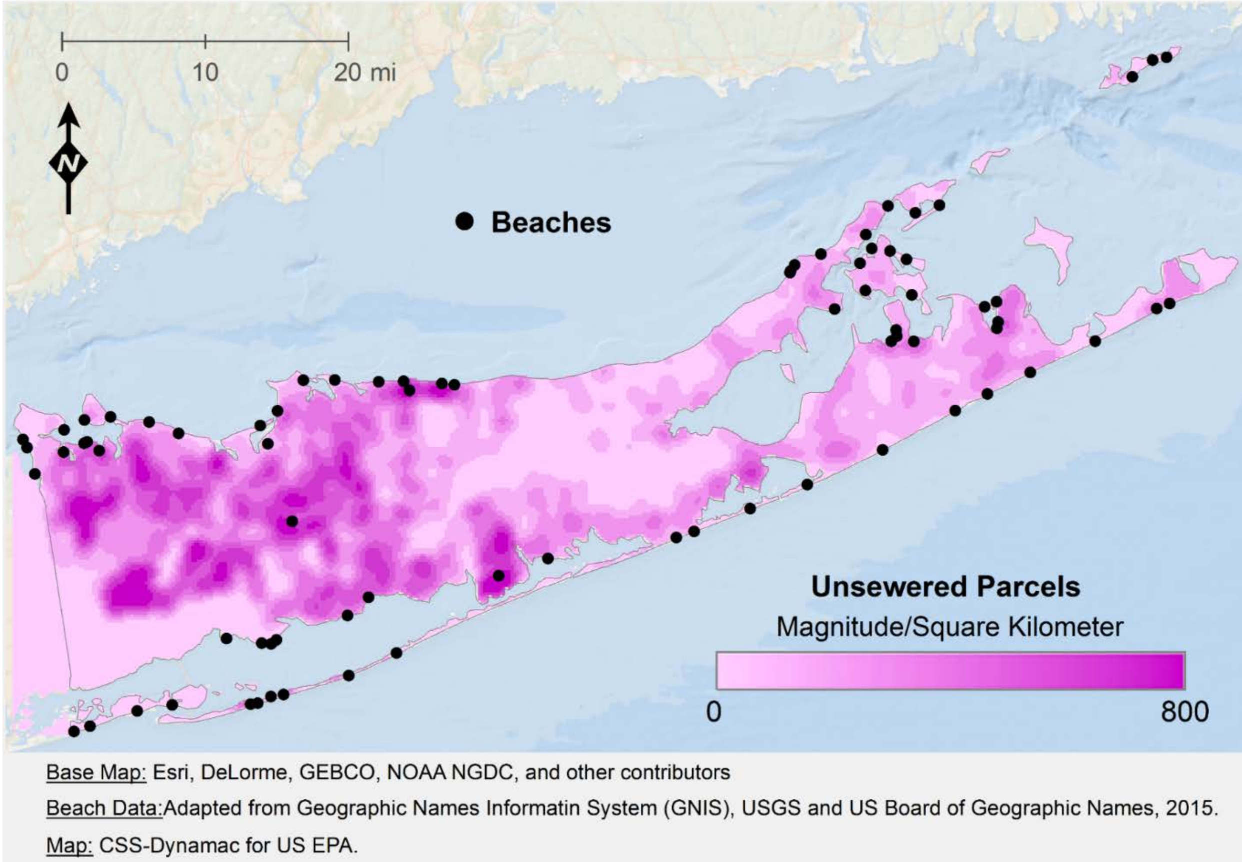

Figure 3.3 Density of un-sewered parcels in Suffolk County. There is a high density of un-sewered parcels near recreational beaches in the County.

Table 3.1 Decision impacts on policies for Suffolk County Department of Health Services (SCDHS) regarding onsite sewage disposal systems. From Suffolk County Health Impact Assessment Report, unpublished.

Decision Scenarios	Potential Change(s) in Policies
Baseline	• SCDHS operates under existing policies and procedures (i.e., "business as usual"). • Homeowners have autonomy with the management of their individual sewerage system.
Alternative I **All existing OSDS must be upgraded to conform to current County Sanitary Code and standards.**	• All existing individual sewerage system upgrade waivers will be rendered defunct. • Cesspool/septic system service professionals will be required to report systems needing upgraded to SCDHS. • SCDHS will assign a fixed schedule for each region in which property owners must upgrade the sewerage system. • In the event of a property sale, the seller will be required to obtain a certificate from SCDHS verifying the existing OSDS conforms to current codes and standards.

Decision Scenarios	Potential Change(s) in Policies
Alternative II **All existing OSDS in the high priority areas must be upgraded to conform to current County Sanitary Code and standards.**	• Those residences in high priority areas holding waivers under Memo #12 will rendered defunct. (Homeowners outside the high priority areas will maintain autonomy with the management of their individual sewerage system.) • Cesspool/septic system service professionals will be required to report systems needing upgraded to SCDHS. • SCDHS will assign a fixed schedule in which property owners must upgrade the sewerage system. • In the event of a property sale, the seller will be required to obtain a certificate from SCDHS verifying the existing OSDS conforms to current codes and standards.
Alternative III **All existing OSDS and C-OWTS in the high priority areas must be upgraded to an innovative / alternative system design.**	• Suffolk County Standards for Approval of Plans and Construction of Sewage Disposal Systems for Single-family Residences must be amended to permit alternative system designs approved by SCDHS for sites that meet requisite conditions (code change proposed in 2016). • Those residences in high priority areas holding waivers under Memo #12 will rendered defunct. (Homeowners outside the high priority areas will maintain autonomy with the management of their individual sewerage system.) • Cesspool/septic system service professionals will be required to report systems needing upgraded to SCDHS. • SCDHS will assign a fixed schedule in which property owners must upgrade the sewerage system. • In the event of a property sale, the seller will be required to obtain a certificate from SCDHS verifying the existing OSDS conforms to current codes and standards.

3.1.1. Approach (EGS/FEGS Involved)

HIA Impact Pathways initially were developed based on literature review and expert opinion. They were further refined by rounds of stakeholder input on priorities, resulting in a finalized subset of five Impact Pathways and benefits: Individual Sewerage System Performance/Failure; Water Quality; Community and Household Economics; Vector Control; and Resiliency to Natural Disaster. Resiliency to Natural Disaster was of interest in this area because of the 2012 Superstorm Sandy in Long Island. There was widespread damage to local infrastructure and the county received significant funding for projects increasing disaster resilience (Suffolk County Executive 2016).

Stakeholder engagement scoping workshops that asked attendees what health impacts concerned them provided a window into identifying ecosystem value (and EGS), by connecting health benefits to the ecosystems that provide them. For example, because of discussions regarding the particular concern placed on coastal resilience to flooding and storm surge, wave energy attenuation by coastal wetlands and vegetation were identified as an ecosystem service of value to stakeholders.

Because time and funding constraints limited the collection of new data, it was important to collect existing data to inform predictions of how the proposed decision alternatives would impact the chosen pathways (Table 3.2). Obtaining county-level data not available in national or state datasets, such as the density of OSDS and statistics about harmful algal blooms in the area, was particularly important, and involved collaboration with the Suffolk County government and the State University of New York. In general, HIAs usually do not involve a quantitative measurement of impact, instead employing expert opinion and literature review to come to an informed conclusion regarding decision impacts. This enabled researchers to work around deficiencies in data sources more easily than if conducting a quantitative empirical model-based assessment. In Suffolk County, because of absent information on changes in groundwater nitrogen from replacing OSDS, estimations of a specific reduction in nitrogen from the adoption of alternative OSDS options we were not available. The HIA noted that a reduction in nitrogen was probable based on other evidence for the OSDS technology being tested (New York State Center for Clean Water Technology 2016) and the hydrography of Suffolk County.

Table 3.2 Example data sources at national, state, and county levels.

Dataset Extent	Examples of Data Sources
National	• National Land Cover Database • U.S. Census • National Wetlands Inventory
State	• New York State GIS Clearinghouse (New York State GIS Program Office 2017) • New York State Department of Health
Local	• Suffolk County Government GIS Repository (Suffolk County Government 2014c) • Suffolk County Division of Planning and Environment • Suffolk County Arthropod-Borne Disease Laboratory

Data collection began with evaluation of national-level datasets. Several sets, including the MRLC National Land Cover Database, the U.S. Census, and the U.S. FWS National Wetlands Inventory, represented the highest-resolution data available. Often, high-resolution data are not collected on a state or local level, or if collected, they are unavailable publicly. For those datasets collected at a state scale, the New York Geographic Information System (GIS) Clearinghouse (New York State GIS Program Office 2017), a collection of state-created and aggregated spatial files, provided an invaluable source. At the county level, Suffolk County maintains a GIS repository and cartography website (Suffolk County Government 2014c) with districting maps, census data, information from the County Division of Planning and Environment, and more. Publicly-available data were found from a wide variety of internet sources including the Peconic Estuary Program, Centers for Disease Control, New York State Department of Health, and the U.S. Geological Survey.

Solicitation of data from local sources was performed in batches, to avoid alienating sources with repetitive and excessive data requests. Lists of data needed were aggregated from each researcher to complete their pathway analysis, and results then brought to local contacts in planning meetings. Stakeholders were then able to direct researchers to needed data sources. In the case of data from a known source, such as a county government agency or a local university, a single point of contact helped establish a consistent "face" for project data tasks. A designated liaison for contacting local researchers and data custodians helped avoid confusion and double-requesting.

3.1.2. Outcome

Onsite Sewage Disposal Systems and cesspool systems are a major contributor to nitrogen pollution in Suffolk County's surface and groundwater. The HIA identified that changing the sanitary code to mandate improvements in OSDS would reduce nitrogen discharge and mitigate the impact of nitrogen pollution in the county. Estimates on specific reductions in nitrogen to groundwater from decision alternatives were unable to be provided because onsite testing of OSDS technology is still underway. Over 50 percent of the total nitrogen loading in the Great South Bay area, the largest estuary on the Long Island south shore, stems from wastewater (Kinney and Valiela 2011). Resilience to natural disaster was a major focus of the report, with the 2012 impact of Superstorm Sandy increasing local concern. The natural hazards that most threaten Suffolk County are severe storms, hurricanes, and Nor'easters, along with the coastal erosion and flooding that they cause (Suffolk County Department of Fire, Rescue, and Emergency Services 2014). Coastal wetlands increase resiliency to storms, and risks to wetlands are considered under the purview of New York State programs to increase coastal resiliency (NYS 2100 Commission 2013). Wave height can be reduced by up to 80 percent by traveling through a 50-meter wetland buffer (Ysebaert et al. 2011), and wave energy is reduced by over 50 percent in the first three meters (Knutson et al. 1982). Suffolk County's wetlands have been in decline, however, with 18-36% reductions in cover in the Great South Bay from 1974-2001 because of factors including excess nitrogen entering the watershed (NYSDEC 2014). Other factors leading to a loss of wetlands, including sea level rise and ocean warming (Wigand et al. 2014), likely had a larger effect on wetland loss than the input of nitrogen in Suffolk County. With that in mind, the HIA assessment concluded that changing OSDS sanitary codes would likely not have a major effect on increasing the county's resilience to storms.

Suffolk County draws its water from a sole-source aquifer, meaning that most drinking water is drawn from a single aquifer and no reasonable alternative sources exist. The water table is very high, and all drinking water in the county is drawn from precipitation-derived groundwater from shallow aquifers. The protection of water quality is of paramount importance to maintain the provisioning of safe potable water. Nitrogen contamination can cause harmful algal blooms (Paerl et al. 2001), and OSDS can spread enteric pathogens to surrounding waters, causing illness in swimmers and consumers of shellfish (Cahoon et al. 2006). The presence of organic nitrogen in groundwater can affect water quality by increasing acidity, reducing dissolved oxygen, and inducing residual chloramines from the water disinfection process (U.S. EPA 2002). Nitrogen levels in Suffolk County groundwater are well below both EPA and New York State standards for drinking water quality, but the concentration of nitrate has steadily increased in monitored wells since 1987 (Suffolk County Department of Environmental Quality 2015). The HIA analysis found that upgrading OSDS to innovative/alternative systems (Table 3.1, Option III) would likely reduce the input of nitrogen to surface waters, and consequently reduce the number of harmful algal blooms in Suffolk County estuaries. Links between OSDS improvement and increases in public drinking water quality were not found, as the drinking water already meets standards. However, private drinking water wells are unmonitored by the county and do not necessarily meet the same standards. For this reason, the HIA analysis concluded that upgrading OSDS to innovative/alternative systems would likely reduce the risk of illness from sewage contamination to private drinking water wells.

Changing municipal codes influences household and community economics. The plans put forward by Suffolk County include providing tax waivers or grants to ease the cost of upgrading OSDS, but ultimately some cost would be borne by property owners. Suffolk County is relatively wealthy, with a median household income of $88,663 per year (U.S. Census Bureau 2015). For comparison, the median household income in the state of New York as a whole is $60,850. A living wage for a household with two adults and one child in Suffolk County is estimated at $56,554 (Massachusetts Institute of Technology 2017). The HIA analysis found that costs to homeowners would increase if OSDS upgrades were mandated, and that the cost would be especially burdensome to lower-income households; 7.6 percent of the county has earnings below the national poverty line, and 27.3 percent earn below $50,000 per year. Community economics would benefit as a result of cleaner surface waters from reductions in OSDS effluent, particularly through tourism. Tourism's total economic impact in Suffolk County was estimated at nearly $2.5 billion in 2010 (Tourism Economics 2010), with beaches and water recreation playing a major role.

3.1.3. Lessons Learned

The Suffolk County HIA identified several lessons that are applicable to any community-based scientific project [4]. First, although HIA is not commonly considered a research tool, its democratic, communication-driven process was successfully used to identify EGS and health impacts that were of interest and concern to the community. The HIA process helped researchers learn that EGS that are of initial interest to researchers are not necessarily the same as those valued by the community, and furthermore the reasons that EGS are valued may not be initially apparent to ecologically-minded researchers. Overall, HIAs can be used by researchers conducting community-level EGS studies as a tool for building mutual trust and understanding with the community by taking, considering, and acting upon input at multiple steps and showing that the study is focused on the well-being of community members.

The Suffolk County case study demonstrated the importance of identifying data needs and other requirements from local collaborators early in the process of conducting a place-based study to avoid overburdening data custodians and creating “request fatigue.” This helped expedite the study, avoiding a loss of momentum or, worse, a loss of stakeholder and community interest. Designating a data liaison at the beginning of a project creates a single assigned point-of-contact for local data custodians and may reduce project delays and thus help with retaining community involvement.

Third, HIAs are a powerful tool for scientific communication when applied to an amenable problem: one that has a clear impact on health and the environment, involves evaluating several well-defined alternative choices, and one in which the community is invested both emotionally and intellectually. For the Suffolk County case study, the decision between several explicit choices of OSDS upgrades had clear implications in terms of nitrogen release to groundwater, the ecological and health impacts of which are thoroughly documented in the scientific literature. A decision that involved more social or less easily quantified changes, or one that would not conceivably affect the environment or health, would be better served with a different assessment of its choices. Finally, the interests, biases, and motivations of stakeholders need to be balanced carefully when conducting a community level study. Maintaining interest and engagement with the project is paramount to the ability of a study to impact local decision making.

3.2. Conclusions and Future Research Needs

Though the HIA step of revisiting Suffolk County’s decision to evaluate the impact of the HIA process/recommendations has not yet occurred, initial conclusions about the utility of the method and how it was applied can be drawn. By using the HIA method, community planners and stakeholders were drawn into the decision-making process where a science-based perspective on each of the OSDS alternatives considered was presented. One of the major benefits of HIA is drawing decision makers and stakeholders into the process of how decisions are made, and in case studies participants frequently comment on “the importance of being involved rather than being just [a] report recipient” (Elliott and Francis 2005). Thus, the HIA approach provided participants with a window into the health and

[4] Refer to Appendix 9 for more information.

environmental considerations that are made for a county planning decision.

The immediate future research need is to complete the final monitoring and evaluation step of the HIA. In this step, researchers return to the community after the decision is made and evaluate how the recommendations of the HIA were used, what impact the process had on the decision, and what might be changed for future HIAs to make them more effective. For the Suffolk County HIA, this evaluation will look at whether citizen and stakeholder involvement in the decision process for the OSDS alternatives increased ecosystem services literacy, and if it provoked any conversations within county planning or community groups on how future decisions may impact ecosystem services and human health. This information will come from revisiting the county and interviewing the decision makers, stakeholders, and community members that participated in the earlier process, as well as independently evaluating the results of the HIA's recommendations.

4. Ethnographic Approaches

The EPA Scientific Advisory Board (SAB) stated that using a wide range of valuation methods could allow EPA to “capture the full range contributions stemming from ecosystem protection and multiple sources of value derived from ecosystem sources” (U.S. EPA 2009: 23). One of the challenges of utilizing a wide range of valuation methods is the differences in language, approaches and methods between disciplines (Lélé and Norgaard 2005). Generally, the dominant approach to ecosystem service valuation is stated or revealed preference, which relies on discrete choice experiments or other survey instruments. Economic approaches based on utility and individual rational choice may limit valuation to a narrow range of the human experience and may exclude consideration of services that are intrinsically or collectively valued (Wegner and Pascual 2011). Psychological contributions to well-being (including endogenous preference), altruism, and motivational pluralism all present challenges for conventional approaches to valuation (Paavola and Adger 2005, Wegner and Pascual 2011). Recognizing the need to identify and characterize the different values placed on an ecosystem and its services, a study was designed to capture ecosystem knowledge across disciplines and spheres of responsibility. Specifically, ethnographic approaches were used to collect data, like participant observation and document analysis, which are intended to identify and characterize lived experiences (de Volo and Schatz 2004). As a result, ORD scientists developed a neighborhood-scale community conceptual model to identify and describe how ecosystem and environmental elements contribute to well-being.

An exploratory case study was done on the process of contaminated sediment remediation to habitat restoration to community revitalization (R2R2R) in the St. Louis River Area of Concern (AOC). Participant observation was utilized and document analysis to identify how the public, community groups, and the City of Duluth officials value ecosystem goods and services (EGS) (Baum et al. 2006, Hoggart et al. 2002, Laurier 2006). This was done through a study of the revitalization of the western neighborhoods in Duluth, Minnesota.

The City of Duluth was interested in revitalizing the neighborhood through enhanced access to environmental resources. Citizens, however, felt the City of Duluth was ignoring their concerns about their neighborhoods, like housing conditions and neighborhood traffic. At the same time, natural resource managers were interested in what citizens care about, but focused on their individual projects. It became evident that additional effort was needed to translate across diverging spheres of experience and responsibility that shape perspectives about a resource (Figure 4.1) or lived personal and professional experience of city officials, natural resource managers, and local residents. Thus, a neighborhood-scale community model intended to relate different perspectives to each other through the application of framework was developed.

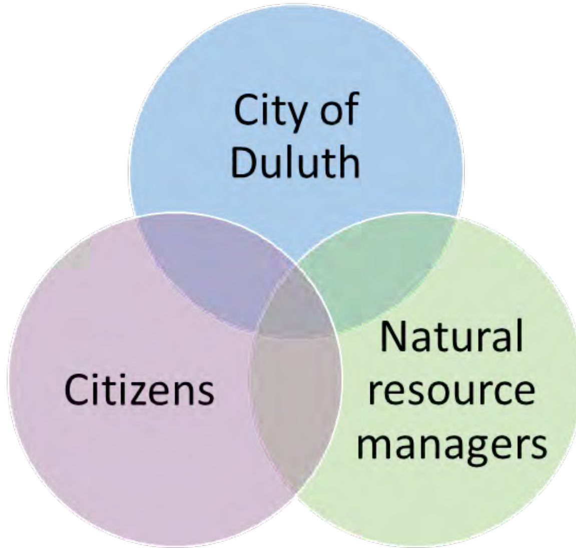

Figure 4.1 The interests of the City of Duluth, citizens, and state natural resource managers converge at the St. Louis River (center of the diagram). The interests diverge where city staff make decisions about the provision of city services including trail creation and maintenance; where natural resource managers make decisions about restoring aquatic habitat, including creating islands or reefs; and citizens make decisions about advocacy and engagement, including participation in city planning processes.

4.1. Application in Great Lakes

ORD scientists undertook an exploratory case study (Yin 2013) of the process of contaminated sediment remediation to habitat restoration to community revitalization, (R2R2R; see Appendix 7) in the St. Louis River AOC. Data were collected through ethnographic methods (i.e., participant observation and document analysis) and were utilized to identify and characterize the elements of different decision contexts where ecosystem services or human well-being might be discussed in relation to the AOC (Baum et al. 2006, Hoggart et al. 2002, Laurier 2006) including in technical or scientific, governmental, and community settings.[5] Through a study of the revitalization of the western neighborhoods in Duluth, Minnesota, it became apparent that perspectives and relationships were complicating discussions regarding EGS value, like the benefits that a trail alignment would provide (i.e., access to amenities versus scenic view of the river). For example, the City of Duluth was interested in revitalizing the

[5] The results of this section reflect the results of a multi-faceted study to identify the factors that shape different decisions, where data were collected in different contexts over an extended period of time. Themes that emerged in the study as forces that shape decisions include disconnected and isolated decision contexts, variable opportunities for citizen input, educational approaches to reducing conceptual barriers, and importance of boundary (i.e., the boundaries between science and policy) spanning. Because both tools and people are important for boundary spanning, the method presented here is a primary result of the study.

neighborhood through enhanced access to environmental resources. Citizens, however, felt the City of Duluth was ignoring their concerns about their neighborhoods, like housing conditions and neighborhood traffic. At the same time, natural resource managers were interested in what citizens cared about, but focused on their individual projects. It became evident that additional effort was needed to translate across diverging spheres of experience and responsibility that shape perspectives about a resource (Figure 4.1) or lived personal and professional experience of city officials, natural resource managers, and local residents.

The research team's goal was to identify the relative valuation of ecosystem services, meaning that it was important to identify which services were important relative to each other. More specifically, the research biologists were interested in determining what people cared about, as well as the physical elements of place. Because place attachment is emotional or affective (Brown 2015, Williams et al. 1992), the study goals became to identify what services were important. Thus, the social scientist chose a methodology based on observing behavior as expressed through participation and policy actions or documents to determine important goals and values. Following collection and analysis of background data and observation, a neighborhood-scale community model was developed to relate different perspectives to each other through the application of framework. The City of Duluth provides an illustrative case study application of the neighborhood-scale community model because the City's revitalization strategy is focused on the neighborhoods adjacent to AOC remediation and restoration projects. Further, the City of Duluth's revitalization of the St. Louis Corridor is based on environmental restoration, improving neighborhood quality of life, and attracting new homeowners, while also creating a new visitor destination and stimulating development (City of Duluth 2017). The purpose of the neighborhood-scale community model was to relate the views of citizens and objectives of city officials or natural resource managers.

4.1.1. Approach (EGS/FEGS Involved)

In the course of data collection and analysis, it became evident there was a disconnect between city officials and citizen visions for the St. Louis River Corridor. To better understand the nature of the differences between the City and citizen perspectives, perceptions related to a contentious trail were examined. The City was conducting planning processes for parks and trails throughout the western neighborhoods, including a trail connection that would complete the Cross City Trail, a city-wide trail that was to run parallel to the river (and AOC) and connect numerous western neighborhoods (Figure 4.2). The following section outlines an initial analysis and a proposed framework for analysis.

In January 2016, the City of Duluth held a public meeting to outline the project and their priorities, followed by a survey to inform their decisions about a connecting trail segment. The City's stated project purpose was to provide a "One of a kind, off-road trail for non-motorized trail users of all ages and abilities. The trail will provide a connection to the Munger State Trail to the Duluth Lakewalk, offer safe access to distinctive natural areas in West Duluth, present exceptional views of the St. Louis River Corridor and estuary, and fill a gap in a significant state trail route from central Minnesota to the North Shore of Lake Superior." Additional considerations for the City of Duluth are connecting community, ensuring a safe user experience, encourage economic development, and economically and technically feasible (City of Duluth 2017).

Figure 4.2 Map of City of Duluth St. Louis River Corridor community revitalization projects (Source: City of Duluth).

As part of the survey, the City of Duluth asked an open-ended question, “Do you have any comments on the project’s vision?” An analysis was conducted of the submitted answers to determine what citizens believe that the trail should provide (Hsieh and Shannon 2005). There were 173 responses (Figure 4.3). An analysis of the comments revealed that the respondents were most concerned about a dedicated off-road trail with the fewest road crossings (safety), felt the trail should connect to existing resources (Munger State Trail), and provide a unique and scenic experience (experience). Furthermore, several of the emergent themes reflected an attachment to multiple benefits or ecosystem services, especially aesthetics or “viewscapes” or “sounds and scents” but other comments indicate citizens appreciate that the trail connects communities, connects people to nature, and provides economic benefits. In other words, both the city and the survey respondents valued the trail alignment based on what the trail provided, and they valued different alignments based on their priorities.

The initial analysis provided an opportunity for critical examination. While citizen input was collected, and reflected in the plan’s recommendations, it was included with hints at the difficulty of implementation. The City’s explanation starts “the riverside portion of Segment II requires purchase of two railroad properties, an easement along the periphery of an industrial site, and coordination with an MPCA -led environmental restoration site” (Minnesota Pollution Control Agency; City of Duluth 2017, p. 22). The plan further described the challenges implementing the citizen-desired alignment owing to constraints facing the City, including complicated real estate negotiations, the need to create a route underneath an interstate, and perplexing engineering to avoid existing infrastructure (Table 4.1). This finding implies that citizen articulation of ecosystem benefits may not match the values, purpose, or realities of park or economic developers, and it may be difficult to incorporate citizen values into project-specific planning efforts.

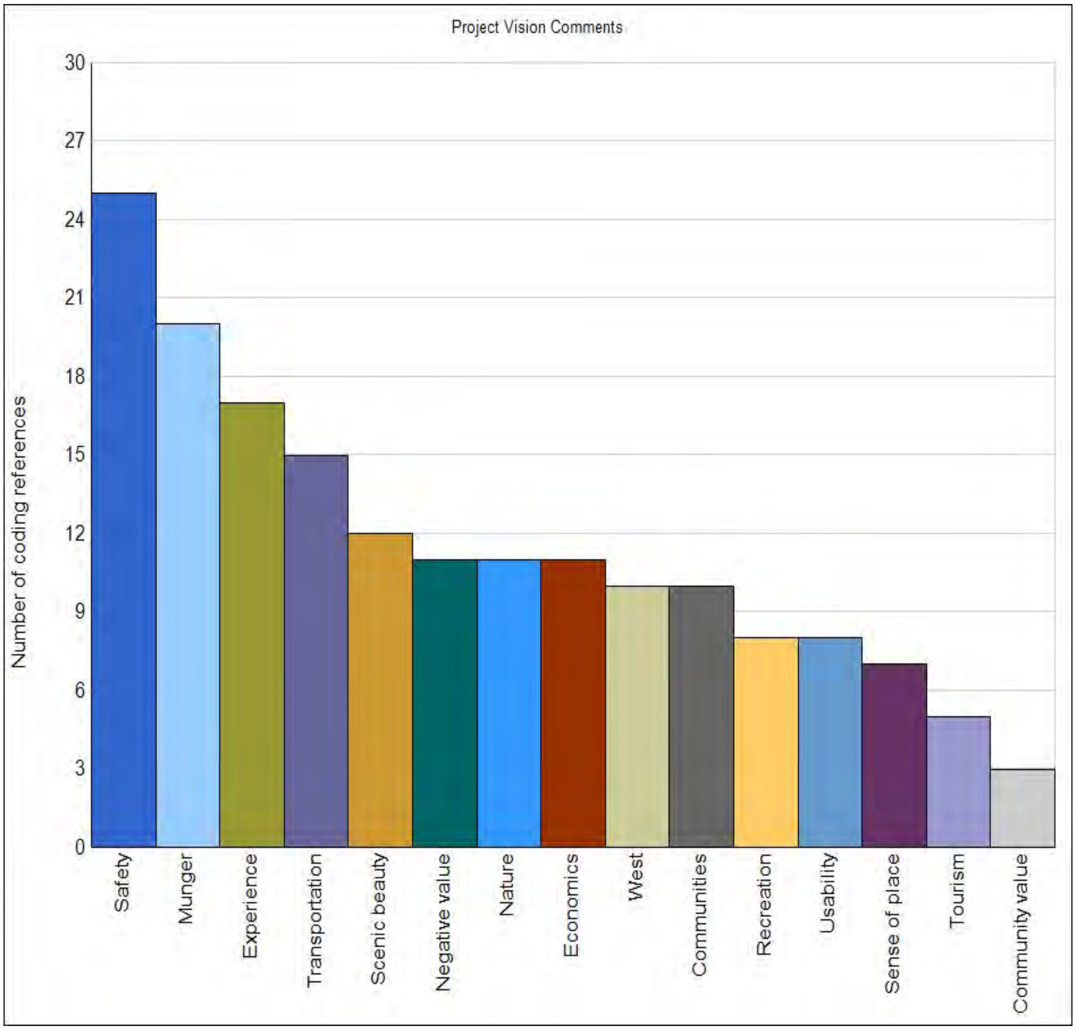

Figure 4.3 Safety, connections to existing resources, and experience were some of the most important components identified in open-ended responses to the question "Do you have any comments on the project's vision?" from a survey by the City of Duluth.

Table 4.1 Comparing the differences in priorities between City of Duluth officials and the public regarding the Cross City Trail.

City of Duluth priorities	Priorities from public input
Respond to demographic trends	Safety: fewest intersection crossings
Connect visitor resources and regional trail assets	Munger: connect to regional trail through neighborhood
Faces constraints in securing real estate for trail placement	Unique experience: embraces industrial nature of neighborhood

In this example, the benefits of environmental restoration were recognized by both citizens and city officials, but different definitions of benefits that related specifically to their organizational responsibilities or lived experiences resulted in disagreement that can be difficult to resolve.

4.1.2. Outcome

The results of the community group observation and analysis of the Cross City Trail survey results prompted a question: If the desires regarding a trail is a reflection of neighborhood and personal experiences for one group, but a resource and connection to amenities for another – how can the difference in perspective resolved? Both the emotional attachment to a place, as well as the professional obligation to create amenities that serve many purposes are valid, true and express different ideas about well-being. Recognizing how resources may provide variable contributions to well-being depending on an individual's or organization's relationship to it, a review was undertaken of the dimensions of community planning and human well-being that emerged in the entirety of the R2R2R study. The result is a conceptual model of a neighborhood or place, that can be used to translate values across perspectives and create opportunities to examine the relationships between actors (i.e., city officials and citizens) and the landscape (Figure 4.3).

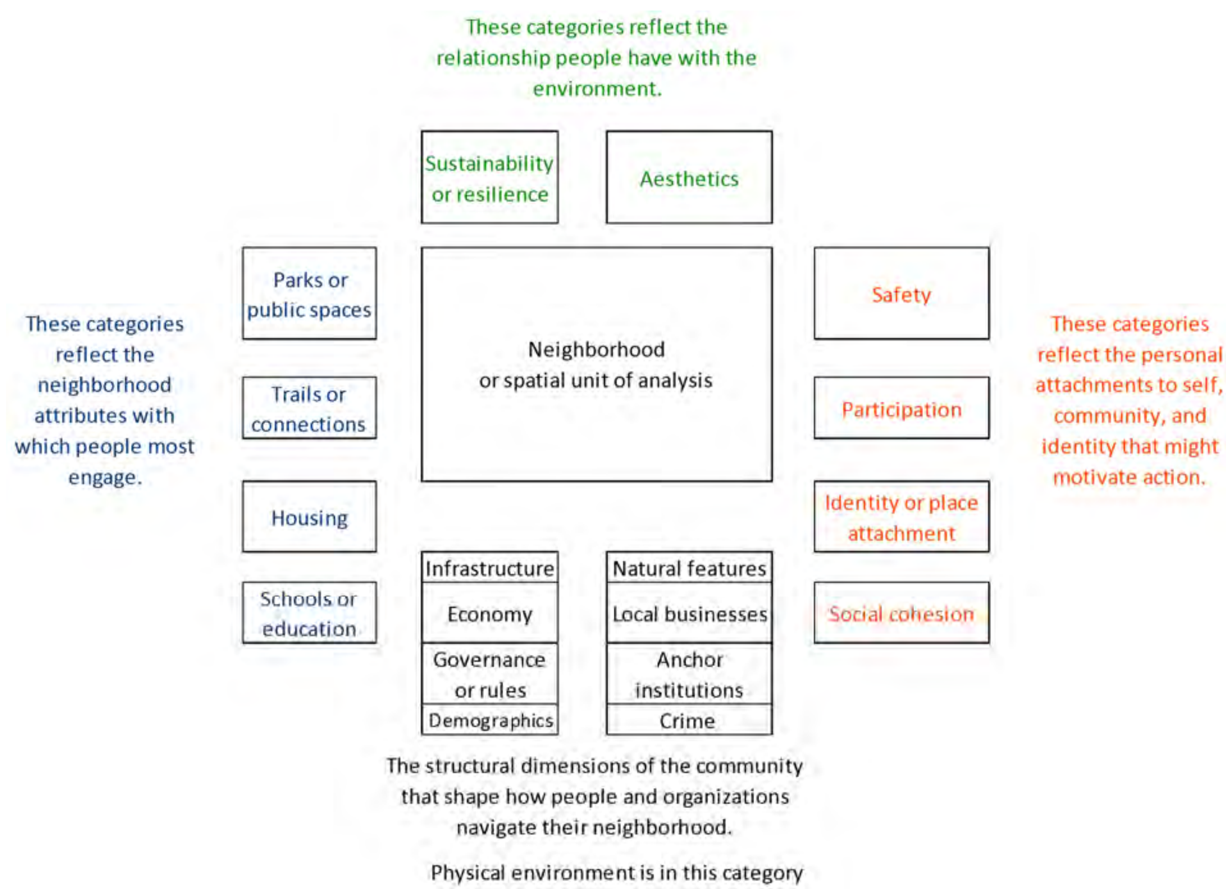

Figure 4.3 Neighborhood diagram. The colors represent how individuals might interact with individual attributes. **Blue attributes** are representative of the built environment, the reasons that individuals might choose their neighborhoods, or what cities plan to change. **Black attributes** are structural dimensions, or the important elements that are fixed, part of larger process, or expressed in statistics. **Orange characteristics** reflect personal attachments, values, or motivations of individuals. **Green attributes** represent human-environment relationships (Refer to Appendix 8 for more information).

The framework utilizes approaches from conflict resolution theory and systems thinking. The DSRP or Distinctions-Systems-Relationships-Perspectives heuristic (Cabrera et al. 2015) guided the development of the framework. The DSRP model explains how people think, more specifically that individuals each have their own perspectives, make distinctions, and identify part-whole relationships. Thus, a tool was created that could capture different perspectives, as well as identify and explain relationships. The model is specifically designed to capture the difficult to quantify elements in the environment that contribute to personal identity or organizational mission, safety and connection to place or professional ethic, thereby enabling researchers to compare perspectives and identify sources of disagreement.

The model is a tool that can be used as a coding strategy to sort and classify text-based or other qualitative data. Cheng et al. (2003) argued that the physical environment is “not an inert, physical entity ‘out there’… but a dynamic system of interconnected, meaning-laden places.” Examination of R2R2R provided an opportunity to examine how environments and communities are related. There were three distinct communities in this investigation: agencies, local governments and the public. While this study was based in Duluth, state agency, local government, and advocacy groups operate similarly in their own unique settings. Thus, the elements of the environment and community identified in this study (i.e., environment to be restored, rules that govern the process, emotional impulse to protect home) were treated as an addition problem and integrated into a mental map of a community, similar to other communities. The map (Figure 4.3) was refined through a literature review of the relationships between elements of the natural, structural, or built environments in order to be codified into a system as summarized in Table 4.2.

The community model identifies many of the components that individuals, organizations, and local governments may discuss or make decisions about in the context of their neighborhood or community. The characteristics in the model are a mix of built environment types, structural dimensions, personal experiences, and human-environment relationships. The assemblage of attributes functions like a framework. Definitions for each type of attribute is listed below. The model can be applied to a community or neighborhood of any size.

Table 4.2 Elements of a place that contribute to well-being. The descriptions below describe dimensions of the physical, built, and social environment.

Component	Explanation
Parks	People visit parks to relax, commune with nature, find peace, be with friends, play sports, or experience other recreation (Chiesura 2004). Parks are an integral part of a sustainable city. Access to quality parks and greenspace is often cited as a positive contributor to health, well-being, and quality of life.
Trails	Trails can connect neighborhoods to each other, as well as amenities and other destinations. Trails can be considered both linear parks and infrastructure for transportation. “The cities that are deemed most vibrant and alive are the ones where large numbers of people move around outside their cars in the public realm (Erickson 2006).”
Housing	Community advocates argue that overburdened neighborhoods are impacted by multiple environmental stressors (Morello-Forsch et al. 2011). Community leaders further contend that social factors including housing quality and neighborhood composition may impact long-term well-being.
Schools - Education	Schools are a critical community resource for learning, community cohesion and sometimes other basic needs. Schools are the place where children spend a lot of time – in class and in after-school activities. Additionally, schools can be important to the identity of the neighborhood, especially through sports. Scholars argue that the quality of schools is often linked to the quality of the neighborhood.
Infrastructure	Infrastructure shapes and facilitates how people move around their neighborhood. Examples of infrastructure include roads, sidewalks, utilities, street lights, interstate

Component	Explanation
	highways, ports, pipelines, which can enhance or detract from connectivity or quality of life in the neighborhood.
Natural features	The dominant natural features shape neighborhood layout, experience, and affect (or disaffect). Parks are often the access points to natural features like hills, grasslands, rivers and streams. Natural features include topography, water, vegetation, and climate. In Sustainable and Healthy Communities research, natural features may be an ecosystem service or an indicator of an ecosystem service.
Government or rules	Government might be local, state, tribal, or federal governments. These governmental entities might be impacting the neighborhood in positive and/or negative ways. Government may be repairing something in the landscape (road, park, water/sewer line, interstate highway), or creating plans (land use, site, neighborhood) for the neighborhoods or whole city.
Economy	Economy in the context of document analysis might include discussion of the macro-economy (national economy and how it impacts the neighborhood – such as the loss of large industrial manufacturers), local economy and local businesses; the purchasing behavior of residents; development of industrial sectors (like tourism, retail, agriculture, or manufacturing); and property values.
Anchor institutions (i.e., health care)	The presence of health care facilities and pharmacies in a neighborhood is an important indicator of access to care for families and the elderly (less mobile). At the same time, the presences of such facilities are considered assets. Place-based enterprises like universities, hospitals and cultural institutions are important foci of community redevelopment efforts.
Safety	In a neighborhood, there are any number of conditions that could cause harm, such as environmental conditions that promote the growth or movement of disease vectors; exposure to risk (e.g., air or water pollution); inadequate lighting; poorly maintained infrastructure; or hazardous traffic conditions. In many ways, "safety" questions are the conditions that cause residents or other stakeholders to contact governmental entities.
Participation or self-determination	Participation or participatory democracy is a method for improving environmental decisions that impact the public by giving residents a voice in the process. In short, often (not always) citizens want a voice in their own neighborhood's development. In fact, the outcome may not matter – a seat at the table and knowing they were heard is sometimes enough.
Identity and place attachment	Identity is a complex and can include the personal, political, social, or organizational. Identity is a function psychological processes, but might manifest themselves in a number of ways in neighborhoods or communities. Identity with a neighborhood or place can be affective, reactionary, and protective based on the type of connection to the place. Identity and place are also contested terms and reflect the conflicts that might exist in a space. For this investigation, identity will refer to how a group (neighborhood or otherwise) describes itself or origin; how the place is rooted in history; and how the group identifies the space they claim.
Local groups, organizations, churches	Local organizations, including service and advocacy groups, are important resources in a community. They are potential community assets, knowledge brokers, gatekeepers and collaborators. Religious communities, libraries, block groups, park organizations, cultural or neighborhood groups might all be reflections of collective action in the area.
Sustainability or resilience	Sustainability can be interpreted in the intergenerational equity sense, or might mean how the neighborhood can be sustained and less vulnerable to elements such as pollution, flooding, loss of jobs, or food insecurity. Sustainability in this model can refer to how a neighborhood enhances its own sustainability or builds resilience including neighborhood beautification, other placemaking activities, community gardens, or green infrastructure. Scholars debate sustainability, but many are beginning to recognize that sustainability is a *process* that is or should be inclusive, interdisciplinary, and intentional. Sustainability might be reflected in any strategy that attempts to improve well-being of both humans and the environment simultaneously.

Component	Explanation
Aesthetics	One definition of aesthetics is the governing principles that define an idea of beauty at a particular time or place (Aesthetics 2017). Furthermore, landscape ecologists have argued that what makes a landscape pleasing is context dependent and limited to the "human perceptual realm" (Gobster 2007).

Final ecosystem goods and services (FEGS-CS) (i.e., specific elements that contribute to human well-being) are embedded throughout the framework. For example, parks are an important pathway through which people experience nature or ecosystem services (Buchel and Frantzeskaki 2015, Landers and Nahlik 2013). Some of the FEGS experienced in parks include sights and sounds, fishing, learning, and existence. Similarly, aesthetics may be dependent on the physical components of the environment and social context. In Duluth, the scenic views of the river are not limited to the aquatic vegetation or the water, but include the ore docks that provide a sense of history and identity. Identity, place attachment, and social cohesion are important elements of human well-being, and are a function of the spaces available to experience them. (Smith et al. 2013). Thus, this framework helps organize articulations of value and relates them to specific domains of the ecosystem and well-being. Using FEGS-CS as a key facilitates the identification of the EGS (i.e., the fish, view, wild rice, or existence), the key beneficiaries (i.e., boaters, anglers, experiencers). At the same time, the HWBI provides means for describing other dimensions of environmental benefit – namely the connection to place and culture. Together, the tools woven together provide a means to analyze both the environmental and cultural dimensions of human well-being.

4.1.3. Lessons Learned

Throughout the study, it became evident that the "what" individuals and organizations cared about was attached to a "why," which was difficult for them to articulate, but was expressed as resistance to the City of Duluth's planning efforts. We found that the "what" people organized around or advocated for was attached to neighborhood identity, current use of parks and resources, or ideas of how they thought their neighborhoods should look. In other words, people advocated not for an object or resource, but for participation in the process, protection of the landscape features they use and appreciate, and a say over what happens in their neighborhood. In other words, the hopes and values of citizens could not be met with the normal procedures that many agencies follow to gather input – because that input was not necessarily relevant to the project at the risk of being discounted. Similarly, ecosystem goods and services and physical or social determinants of health are embedded in city planning documents and planning processes, but not necessarily in ways that are obvious to researchers investigating ecosystem services.

The envisioned steps to utilize the model are: 1) collect data[6] (text-based or other qualitative data); 2)

[6] There is no preconceived amount of data needed to apply the model. Data sets could be as small as a written note or photograph, or as large as a set of written comments from multiple audiences. The data could be collected at a single site, or many sites over time. The tool is meant to be flexible and transferable.

initially code the data according to the categories; 3) conduct content analysis on the data in each category. The model should reveal what is valued about each element. More details about how to apply the strategy can be found in Appendix 8.

To test the framework, an analysis of a neighborhood development plan developed by community organizations was analyzed through the framework. The results of the analysis demonstrate that the most important elements of the neighborhood as determined by the number of words coded in the document are parks, trails, infrastructure, and aesthetics (Figure 4.4). The categories are important, but an analysis of the contents of each category reveal important details that explains how each element contributes to the neighborhood's well-being. For example, parks are important to the Irving Neighborhood because they provide gathering spaces, year-round recreation, and an identifying feature. The plan states that the neighborhood groups and City of Duluth should, "undertake steps that improve Irving as a walkable residential neighborhood and highlights Irving Park as the key identifying feature." Understanding valued resources, like parks, in context is critical because it has the potential to shift the conversation from the abstract object, in this case, the park, to being able to describe what the park contributes to the well-being of the neighborhood. In this case, it is a gathering place and a signature feature – or elements that contribute to the social cohesion and identity.

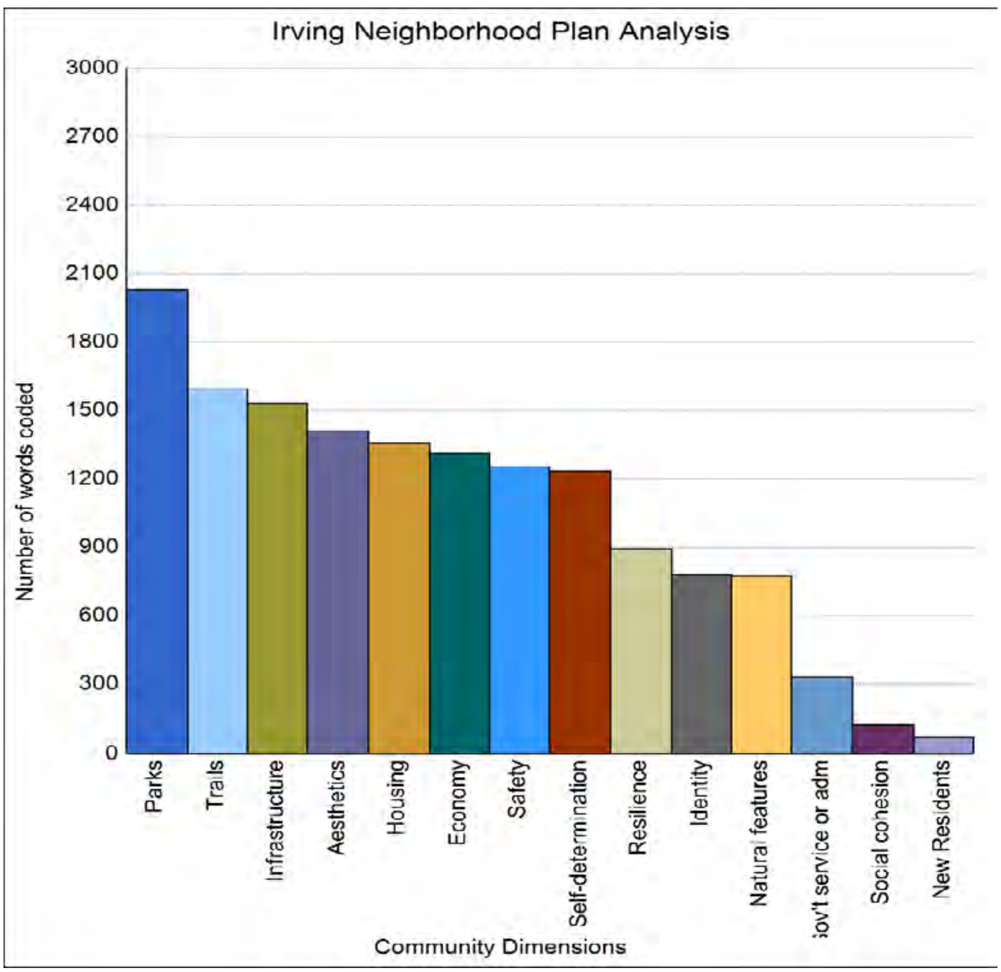

Figure 4.4 Analysis of Irving Sustainable Neighborhood Action Plan. Parks, trails, infrastructure, and aesthetics are among the most important elements to in the neighborhood.

4.2. Conclusions and Future Research Needs

Communities and individuals recognize and appreciate nature based on their relationships with it and usually in ways that challenge typical approaches to ecosystem service valuation (Wegner and Pascual 2011). The context for experiences with nature include the built environment, the physical environment (including infrastructure and natural features), and personal experiences. Childers et al. (2015: 3778) argued that “cities are habitat for people, so the urban design process should include city residents and integrate a social component into design objectives and actions.” It was found that such an endeavor is easier stated than implemented, because the values of benefits vary between stakeholder groups including citizens, local government, and natural resource managers.

This study utilized an exploratory case study approach to develop a method to characterize the roles of different actors, how ecosystem service values influence decision-making practices, and how citizens value environmental resources. While elements have been identified that influence R2R2R in Duluth and the St. Louis River AOC, comparisons of the revitalization process in other AOCs will provide opportunities to test and refine the findings. Furthermore, the programmatic relationship, wherein EPA, state agencies, and local governments must collaborate to implement environmental programs, is not unique. Comparing the AOC program to other types of EPA programs including Superfund, National Estuary Program, or other geographic programs will provide further insights about how different agencies and individuals who participate in the programs value ecosystem services.

5. Synthesis

This report is intended for community decision makers and those who support and participate in decision making at various levels of government. Within the report, three studies were presented that explore multidisciplinary approaches to non-monetary valuation of FEGS, particularly the use and application of non-monetary valuation in the context of community decision making. Although the approach presented in each study is distinct, a number of common findings emerged. First, ecosystem goods and services do factor into community decision making and are important to communities and states. Second, ecosystem goods and services contribute to human health and well-being in manifold ways, and characterizing the entire pathway between ecosystem state and health is important to aid decision making. However, to improve the application of ecological-health relationships in decision making, researchers need to address the whole pathway connecting FEGS to human health and well-being outcomes (whether directly or indirectly). Third, the ability to include and value FEGS in decision making can be improved by including approaches from the social and public health sciences. These approaches complement monetary valuation of FEGS and can be used now to incorporate a wide range of community values related to FEGS, as well as their connection to human health and well-being. The three place-based studies presented in this report demonstrate how FEGS, benefits, and community values were brought into the conversation successfully and practically – including what worked well and what could be improved in the future.

Each study demonstrates distinct benefits related to health or well-being from changes in FEGS that were in turn related to community-level environmental decisions (i.e., green space, onsite sewage disposal, and developing trail networks). The value of these benefits was affected by the relative certainty of the outcome, the policy alternative chosen, and who was assessing the benefits. In the first study, where evidence for the health benefits of green spaces was insufficient, the quality of information had a direct impact on the value of the green space. In the second study, whether the county chose an innovative or an alternative system for sewage disposal affected the benefit with respect to both harmful algae bloom reduction and risk of illness. And in the third study, how citizens, local governments, and natural resource managers value the benefits of FEGS varied. These findings emphasize the need to proceed with a decision-support framework built upon concepts of transparency and equity (such as the Health Impact Assessment) and to use a tool such as the community model (presented in the third study) that can facilitate translation of goals and values between the various stakeholders and decision makers. It was concluded that a thorough documentation and understanding of the causal pathways between the community decision, FEGS, and benefits, combined with an appropriate decision-support process, can contribute to decisions that result in healthier, more resilient communities. Public health and ethnographic methods and tools provide a variety of approaches to integrate human beings and their collective values into ecosystems, including urban and other developed systems.

Based on these studies, specific recommendations are offered regarding how to conduct future research that addresses the link between FEGS, their value, and their benefit to communities. First, FEGS valuation should be conducted by an interdisciplinary team, including those with expertise in social science, public health, and ecology. Notably, researchers need to be aware that perspectives and language grounded in different disciplines can impede communication. The research team should plan how to manage and analyze multidisciplinary data and establish a common terminology when working with conceptual models. Moreover, integration must be designed into both the research and decision support from the outset. Second, communities and states require access to and the active support of practitioners of social, economic, human health, and ecological sciences to make this a reality. These practitioners can build trust with stakeholders and decision makers by producing data with the community and using a decision-support process that is built upon concepts of transparency and equity. Expertise can be recruited from amongst community staff, from universities and non-profit organizations, from industry, and also from federal staff, but each discipline should be represented.

6. References

Aesthetics. (2017). Dictionary.com. Accessed 15, August 2017 from http://www.dictionary.com/browse/aesthetics.

Anderson, T.H. and G.T. Taylor. (2001). Nutrient pulses, plankton blooms, and seasonal hypoxia in western Long Island Sound. *Estuaries* 24(2):228-243.

Angradi, T.R., J.J. Launspach, D.W. Bolgrien, B.J. Bellinger, M.A. Starry, J.C. Hoffman, A.S. Trebitz, M.E. Sierszen, and T.P. Hollenhorst. (2016). Mapping ecosystem service indicators in a Great Lakes Estuarine Area of Concern. *Journal of Great Lakes Research* 42(3):717-727.

Araujo, R.V., M.R. Albertini, A.L. Costa-da-Silva, L. Suesdek, N.C.S. Franceschi, N.M. Bastos, G. Katz, V.A. Cardoso, B.C. Castro, M.L. Capurro, and V.L.A.C. Allegro. (2015). São Paulo urban heat islands have a higher incidence of dengue than other urban areas. *The Brazilian Journal of Infectious Diseases* 19(2):146-155.

Araya, M., M. Olivares, F. Pizarro, A. Llanos, G. Figueroa, and R. Uauy. (2004). Community-based randomized double-blind study of gastrointestinal effects and copper exposure in drinking water. *Environmental Health Perspectives* pp. 1068-1073.

American Society for Testing and Materials (ASTM). (2009). E-1689 Standard Guide for Developing Conceptual Site Models for Contaminated Sites. Annual Book of Standards. ASTM International, Conshohocken, PA.

Baum, F., C. MacDougall, and D. Smith. (2006). Participatory action research. *Journal of Epidemiology and Community Health* 60(10):854.

Bouchama, A. and J.P. Knochel. (2002). Heat stroke. *New England Journal of Medicine* 346(25):1978-1988.

Boyd, J.W. and S. Banzhaf. (2007). What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics* 63(2-3):616-626.

Bracht, N., J.R. Finnegan Jr., C. Rissel, R. Weisbrod, J. Gleason, J. Corbett, and S. Veblen-Mortenson. (1994). Community ownership and program continuation following a health demonstration project. *Health Education Research Theory & Practice* 9(2):243-255.

Brody, S.D. and W.E. Highfield. (2013). Open space protection and flood mitigation: A national study. *Land Use Policy* 32:89-95.

Brown, G., C.M. Raymond, and J. Corcoran. (2015). Mapping and measuring place attachment. *Applied Geography*, 57, 42-53.

Buchel, S. and N. Frantzeskaki. (2015). Citizens' voice: A case study about perceived ecosystem services by urban park users in Rotterdam, the Netherlands. *Ecosystem Services* 12:169-177.

Cabrera, D., L. Cabrera, and E. Powers. (2015). A unifying theory of systems thinking with psychosocial applications. *Systems Research and Behavioral Science* 32(5):534-545.

Cahoon, L.B., J.C. Hales, E.S. Carey, S. Loucaides, K.R. Rowland, and J.E. Nearhoof. (2006). Shellfishing closures in southwest Brunswick County, North Carolina: Septic tanks versus stormwater runoff as fecal coliform sources. *Journal of Coastal Research* 22(2):319-327.

Cheng, A.S., L.E. Kruger, and S.E. Daniels. (2003). " Place" as an integrating concept in natural resource politics: Propositions for a social science research agenda. *Society & Natural Resources* 16(2):87-104.

Chew, G.L., J. Wilson, F.A. Rabito, F. Grimsley, S. Iqbal, T. Reponen, M.L. Muilenberg, P.S. Thorne, D.G. Dearborn, and R.L. Morley. (2006). Mold and endotoxin levels in the aftermath of Hurricane Katrina: A pilot project of homes in New Orleans undergoing renovation. *Environmental Health Perspectives* pp. 1883-1889.

Chiesura, A. (2004). The role of urban parks for the sustainable city. *Landscape and Urban Planning* 68(1):129-138.

Childers, D.L., M.L. Cadenasso, J.M. Grove, V. Marshall, B. McGrath, and S.T. Pickett. (2015). An ecology for cities: A transformational nexus of design and ecology to advance climate change resilience and urban sustainability. *Sustainability* 7(4):3774-3791.

City of Duluth. (2017). Cross City Trail Mini Master Plan. Accessed 4, April 2017 from http://www.duluthmn.gov/media/542221/cross-city-trail-mmp-final-high-res.pdf.

Costanza, R., L. Fioramonti, and I. Kubiszewski. (2016). The UN sustainable development goals and the dynamics of well-being. *Frontiers in Ecology and the Environment* 14(2):59.

Costanza, R., O. Pérez-Maqueo, M.L. Martinez, P. Sutton, S.J. Anderson, and K. Mulder. (2008). The value of coastal wetlands for hurricane protection. *AMBIO: A Journal of the Human Environment* 37(4):241-248.

Cox, J., M.E. Grillet, O.M. Ramos, M. Amador, and R. Barrera. (2007). Habitat segregation of dengue vectors along an urban environmental gradient. *The American Journal of Tropical Medicine and Hygiene* 76(5):820-826.

Creswell, J.W. (2013). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

de Jesus Crespo, R. and R. Fulford. (2017). Eco-Health linkages: Assessing the role of ecosystem goods and services on human health using causal criteria analysis. *International Journal of Public Health*, doi: 10.1007/s000 38-017-1020-3.

Delfino, R.J., N. Staimer, T. Tjoa, D.L. Gillen, J.J. Schauer, and M.M. Shafer. (2013). Airway inflammation and oxidative potential of air pollutant particles in a pediatric asthma panel. *Journal of Exposure Science and Environmental Epidemiology* 23(5):466-473.

de Volo, L.B. and E. Schatz. (2004). From the inside out: Ethnographic methods in political research. *Political Science and Politics* 37(02):267-271.

Elliott, E. and S. Francis. (2005). Making effective links to decision-making: Key challenges for health impact assessment. *Environmental Impact Assessment Review* 25(7-8):747-757.

Erickson, D. (2006). MetroGreen: Connecting Open Space in North American Cities. Island Press.

Fisher, B. and R.K. Turner. (2008). Ecosystem services: Classification for valuation. *Biological Conservation* 141(5):1167-1169.

Fulford, R., R. Bruins, T. Canfield, J. Handy, J.M. Johnston, P. Ringold, M. Russell, N. Seeteram, K. Winters, and S. Yee. (2016a). Lessons Learned in Applying Ecosystem Goods and Services to Community Decision Making. U.S. Environmental Protection Agency, Gulf Breeze, FL, EPA/600/R-16/136.

Fulford, R.S., M. Russell, J. Harvey, and M.C. Harwell. (2016b) Sustainability at the Community Level: Searching for Common Ground as Part of a National Strategy for Decision Support. U.S. Environmental Protection Agency, Gulf Breeze, FL, EPA/600/R-16/178.

Gobster, P.H., J.I. Nassauer, T.C. Daniel, and G. Fry. (2007). The shared landscape: What does aesthetics have to do with ecology? *Landscape Ecology* 22(7):959-972.

Gould, W.A., C. Alarcón, B. Fevold, M.E. Jiménez, S. Martinuzzi, G. Potts, M. Quiñones, M. Solórzano, and E. Ventosa. (2008). The Puerto Rico Gap Analysis Project. Volume 1: Land Cover, Vertebrate Species Distributions, and Land Stewardship. Gen. Tech. Rep. IITF-GTR-39. Río Piedras, PR: U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry. 165 p.

Government of Canada and the Government of the United States of America. (2012). Great Lakes Water Quality Agreement. Accessed 10, August 2017 from at https://binational.net//wp-content/uploads/2014/05/1094_Canada-USA-GLWQA-_e.pdf.

Hansen, G.N. and M. Schoonen. (1999). A geochemical study of the effects of land use on nitrate contamination in the Long Island Aquifer system. Stony Brook: Department of Geosciences, SUNY.

Hartig, T., R. Mitchell, S. De Vries, and H. Frumkin. (2014). Nature and health. *Annual Review of Public Health* 35:207-228.

Harwell, M.C., C. Jackson, and J. Molleda. (2017). Managed Vocabulary for use of Ecosystem Goods and Services in Decision-Making. U.S. Environmental Protection Agency, Gulf Breeze, FL, EPA/600/X-17/168.

Hattenrath, T.K., D.M. Anderson, and C.J. Gobler. (2010). The influence of anthropogenic nitrogen loading and meteorological conditions on the dynamics and toxicity of Alexandrium fundyense blooms in a New York (USA) estuary. *Harmful Algae* 9(4):402-412.

Hoggart, K., L. Lees, A. Davies, and A. Davies. (2002). Researching Human Geography. Arnold, Hodder Headline Group, London, UK.

Hough, R.L. (2014). Biodiversity and human health: Evidence for causality? *Biodiversity and Conservation* 23(2):267-288.

Hsieh, H.F. and S.E. Shannon. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research* 15(9):1277-1288.

Ibarra, A.M.S., S.J. Ryan, E. Beltrán, R. Mejía, M. Silva, and A. Muñoz. (2013). Dengue vector dynamics (*Aedes aegypti*) influenced by climate and social factors in Ecuador: Implications for targeted control. *PloS one* 8(11):e78263.

International Joint Commission. (1978, 1987). Great Lakes Water Quality Agreement of 1978. Accessed 16, March 2015 from http://binational.net/glwqa-aqegl/.

Jackson, L.E., J. Daniel, B. McCorkle, A. Sears, and K.F. Bush. (2013). Linking ecosystem services and human health: The Eco-Health Relationship Browser. *International Journal of Public Health* 58(5):747-755.

Joffe, M. and J. Mindell. (2006). Complex causal process diagrams for analyzing the health impacts of policy interventions. *American Journal of Public Health* 96:473–479.

Kabisch, N. and D. Haase. (2013). Green spaces of European cities revisited for 1990–2006. *Landscape and Urban Planning* 110:113-122.

Karim, M.R., F.D. Manshadi, M.M. Karpiscak, and C.P. Gerba. (2004). The persistence and removal of enteric pathogens in constructed wetlands. *Water Research* 38(7):1831-1837.

Katukiza, A.Y., M. Ronteltap, P. Steen, J.W.A. Foppen, and P.N.L. Lens. (2014). Quantification of microbial risks to human health caused by waterborne viruses and bacteria in an urban slum. *Journal of Applied Microbiology* 116(2):447-463.

Kelemen, E., M. García-Llorente, G. Pataki, B. Martín-López, E. and Gómez-Baggethun. (2016). Non-monetary techniques for the valuation of ecosystem services. In: Potschin, M. and Jax, K. (eds): *OpenNESS Ecosystem Services References Book*. EC FP7 Grant Agreement no. 308428.

Kinney, E.L. and I. Valiela. (2011). Nitrogen loading to Great South Bay: Land use, sources, retention, and transport from land to bay. *Journal of Coastal Research* 27(4):672-686.

Knol, A.B., D.J. Briggs, and E. Lebret. (2010). Assessment of complex environmental health problems: Framing the structures and structuring the frameworks. *Science of the Total Environment* 408:2785-2794.

Knutson, P.L., R.A. Brochu, W.N. Seelig, and M. Inskeep. (1982). Wave damping in *Spartina alterniflora* marshes. *Wetlands* 2(1):87-104.

Krantzberg, G. (2012). First off the List: The Collingwood Harbour Story. In Grover, Velma I., and Gail Krantzberg, eds. *Great Lakes: Lessons in participatory governance*. CRC Press, 2012.

Landers, D. and A. Nahlik. (2013). Final Ecosystem Goods and Services Classification System (FEGS-CS). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-13/ORD-004914.

LaRoche, J.L., R. Nuzzi, R. Waters, K. Wyman, P.G. Falkowski, and D.W.R. Wallace. (1997). Brown tide blooms in Long Island's coastal waters linked to interannual variability in groundwater flow. *Global Change Biology* 3:397-410.

Laurier, E. (2006). Participant Observation. In: Clifford, N., Valentine, G. (eds) Key Methods in Geography, First edition, Sage Publications Ltd. Thousand Oaks, London, UK. pp. 133-148.

Lee, A.C. and R. Maheswaran. (2011). The health benefits of urban green spaces: A review of the evidence. *Journal of Public Health* 33(2):212-222.

Lélé, S. and R.B. Norgaard. (2005). Practicing interdisciplinarity. *BioScience* 55(11):967-975.

Lim, S.S., T. Vos, A.D. Flaxman, G. Danaei, K. Shibuya, H. Adair-Rohani, M.A. AlMazroa, M. Amann, H.R. Anderson, K.G. Andrews, and M. Aryee. (2013). A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: A systematic analysis for the Global Burden of Disease Study 2010. *The Lancet* 380(9859):2224-2260.

Lovasi, G.S., J.P. O'Neil-Dunne, J.W. Lu, D. Sheehan, M.S. Perzanowski, S.W. MacFaden, K.L. King, T. Matte, R.L. Miller, L.A. Hoepner, and F.P. Perera. (2013). Urban tree canopy and asthma, wheeze, rhinitis, and allergic sensitization to tree pollen in a New York City birth cohort. *Environmental Health Perspectives* 121(4):494.

MacMynowski, D. (2007). Pausing at the brink of interdisciplinarity: Power and knowledge at the meeting of social and biophysical science. *Ecology and Society* 12(1).

Massachusetts Institute of Technology. (2017). Living Wage Calculator. Accessed 7, July 2017 from http://livingwage.mit.edu/.

McDonough, K., S. Hutchinson, T. Moore, and J.M. Shawn Hutchinson. (2017). Analysis of publication trends in ecosystem services research. *Ecosystem Services* 25:82-88.

Méndez-Lázaro, P., O. Martínez-Sánchez, R. Méndez-Tejeda, E. Rodríguez, E. Morales, and N. Schmitt-Cortijo. (2015). Extreme heat events in San Juan Puerto Rico: Trends and variability of unusual hot weather and its possible effects on ecology and society. *Journal of Climatology & Weather Forecasting* 3:135.

Miller, J.R., M.G. Turner, E.A. Smithwick, C.L. Dent, and E.H. Stanley. (2004). Spatial extrapolation: The science of predicting ecological patterns and processes. *BioScience* 54(4):310-320.

Merrill, Ray M. (2008). Environmental Epidemiology: Principles and Methods. Jones & Bartlett Learning.

Morello-Frosch, R., M. Zuk, M. Jerrett, B. Shamasunder, and A.D. Kyle. (2011). Understanding the cumulative impacts of inequalities in environmental health: Implications for policy. *Health Affairs* 30(5):879-887.

Morin, C.W., A.J. Monaghan, M.H. Hayden, R. Barrera, and K. Ernst. (2015). Meteorologically driven simulations of dengue epidemics in San Juan, PR. *PLOS Neglected Tropical Diseases* 9(8):e0004002.

Mumby, P.J., A.J. Edwards, J.E. Arias-González, K.C. Lindeman, P.G. Blackwell, A. Gall, M.I. Gorczynska, A.R. Harborne, C.L. Pescod, H. Renken, and C.C. Wabnitz. (2004). Mangroves enhance the biomass of coral reef fish communities in the Caribbean. *Nature* 427(6974):533-536.

Munns, W.R., A.W. Rea, M.J. Mazzotta, L.A. Wainger, and K. Saterson. (2015). Toward a standard lexicon for ecosystem services. *Integrated Environmental Assessment and Management* 11(4):666-673.

Myers, S.S., L. Gaffikin, C.D. Golden, R.S. Ostfeld, K.H. Redford, T.H. Ricketts, W.R. Turner, and S.A. Osofsky. (2013). Human health impacts of ecosystem alteration. *Proceedings of the National Academy of Sciences* 110(47):18753-18760.

New York State (NYS) 2100 Commission. (2013). Recommendations to Improve the Strength and Resilience of the Empire State's Infrastructure. New York City, NY.

New York State Center for Clean Water Technology. (2016). Nitrogen Removing Biofilters for Onsite Wastewater Treatment on Long Island: Current and Future Prospects. Stony Brook University, Stony Brook, NY.

New York State GIS Program Office. (2017). NYS GIS Clearinghouse. Accessed 7, July 2017 from http://gis.ny.gov.

Nichols, S., A. Webb, R. Norris, and M. Stewardson. (2011). Eco Evidence Analysis Methods Manual: A Systematic Approach to Evaluate Causality in Environmental Science. eWater Cooperative Research Centre, Canberra.

Norris, R.H., J.A. Webb, S.J. Nichols, M.J. Stewardson, and E.T. Harrison. (2011). Analyzing cause and effect in environmental assessments: Using weighted evidence from the literature. *Freshwater Science* 31(1):5-21.

Nuzzi, R. and R.A. Waters. (2004). Long-term perspective on the dynamics of brown tide blooms in Long Island coastal bays. *Harmful Algae* 3(4):279-293.

New York State Department of Environmental Conservation (NYSDEC). (2014). Nitrogen Pollution and Adverse Impacts on Resilient Tidal Marshlands: NYSDEC Technical Briefing Summary. New York State Department of Environmental Conservation, Albany, NY.

Oosterbroek, B., J. de Kraker, M.M. Huynen, and P. Martens. (2016). Assessing ecosystem impacts on health: A tool review. *Ecosystem Services* 17:237-254.

Paavola, J. and W.N. Adger. (2005). Institutional ecological economics. *Ecological Economics* 53(3):353-368.

Paerl, H.W., R.S. Fulton, P.H. Moisander, and J. Dyble. (2001). Harmful freshwater algal blooms, with an emphasis on cyanobacteria. *Scientific World Journal* 1:76-113.

Parascandola, M., D.L. Weed, and A. Dasgupta. (2006). Two Surgeon General's reports on smoking and cancer: A historical investigation of the practice of causal inference. *Emerging Themes in Epidemiology* 3(1):1.

Pascual, U., R. Muradian, L. Brander, E. Gomez-Baggethun, B. Martin-Lopez, M. Verma, P. Armsworth, M. Christie, H. Cornelissen, F. Eppink, and J. Farley. (2010). The Economics of Valuing Ecosystem Services and Biodiversity. TEEB-Ecological and Economic Foundation.

Peters, A., A. Döring, H.E. Wichmann, and W. Koenig. (1997). Increased plasma viscosity during an air pollution episode: A link to mortality? *The Lancet* 349(9065):1582-1587.

Räsänen, J.V., T. Holopainen, J. Joutsensaari, C. Ndam, P. Pasanen, A. Rinnan, and M. Kivimäenpää. (2013). Effects of species-specific leaf characteristics and reduced water availability on fine particle capture efficiency of trees. *Environmental pollution* 183:64-70.

Reef Resilience Network. (2016). Resilient MPA Design: Connectivity. Accessed 26, May 2017 from http://www.reefresilience.org/coral-reefs/resilient-mpa-design/connectivity/.

Richardson, E.A., J. Pearce, R. Mitchell, and S. Kingham. (2013). Role of physical activity in the relationship between urban green space and health. *Public Health* 127(4):318-324.

Russo, F. and J. Williamson. (2007). Interpreting causality in the health sciences. *International Studies in the Philosophy of Science* 21(2):157-170.

Safety. (2017). Merriam-Webster Dictionary. Accessed 15, August 2017 from https://www.merriam-webster.com/dictionary/safety.

San Juan Bay Estuary (SJBE). (2015). Area cientifica: Datos de monitoreo. Accessed 30, January 2017 from http://www.estuario.org/index.php/datos/ciencia?limitstart=0.

Sandifer, P.A. and A.E. Sutton-Grier. (2014). Connecting stressors, ocean ecosystem services, and human health. *Natural Resources Forum* 38(3):157-167.

Sheffield PE, Agu DP, Rowe M, Fischer K, Pérez AE, Rodríguez LN, Avilés KR. 2014. Health Impact Assessment of the Proposed Environmental Restoration of Caño Martín Peña. San Juan, Puerto Rico.

Silva, C.A.R., L.D. Lacerda, and C.E. Rezende. (1990). Metals reservoir in a red mangrove forest. *Biotropica* pp. 339-345.

Smith, L.M., J.L. Case, H.M. Smith, L.C. Harwell, and J.K. Summers. (2013). Relating ecoystem services to domains of human well-being: Foundation for a U.S. index. *Ecological Indicators* 28:79-90.

Smith, L.M., H.M. Smith, J.L. Case, L.C. Harwell, J.K. Summers, C. Wade. (2012). Indicators and Methods for Constructing a U.S. Human Well-Being Index (HWBI) for Ecosystem Services Research. U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-12/023

Smith, L.M., L. Harwell, J.K. Summers, H.M. Smith, C.M. Wade, K.R. Straub, and J.L. Case. (2014). A U.S. Human Well-Being Index (HWBI) for Multiple Scales: Linking Service Provisioning to Human Well-Being Endpoints (2000-2010). U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-14/223.

Suffolk County Department of Fire, Rescue, and Emergency Services. (2014). Multi-jurisdictional Hazard Mitigation Plan Update. Suffolk County Government, Yaphank, NY.

Suffolk County Department of Health Services. (2000). General Guidance Memorandum #12: Guidelines for Issuing Approval of Sewage Disposal Systems and Water Supplies for Existing Residences. Division of Environmental Quality, Yaphank, NY.

Suffolk County Department of Environmental Quality. (2015). Comprehensive Water Resources Management Plan. Suffolk County, Hauppage, NY.

Suffolk County Executive. (2016). Coastal Resiliency Projects. Accessed 7, July 2017 from http://suffolkcountyny.gov/Portals/0/countyexecutive/PDF/Resiliency%20FAQs%20FINAL.pdf.

Suffolk County Government. (2014a). Suffolk County Water Quality and Coastal Resiliency Action Plan. Municipal Officials Conference: Managing Cesspools and Septic Systems to Protest Long Island's Waters, March 25, 2014 (p. PowerPoint). Suffolk County Department of Health Services.

Suffolk County Government. (2014b). Proposed Sanitary Code Policy Changes for Upgrading Existing OSDSs, Rev. 2. Suffolk County Department of Health Services.

Suffolk County Government. (2014c). Suffolk County GIS Portal. Accessed 7, July 2017 from https://gisportal.suffolkcountyny.gov/gis/home/.

Summers, J.K. and L.M. Smith. (2014). The role of social and intergenerational equity in making changes in human well-being sustainable. *Ambio* 43(6):718-728.

Summers, J.K., L.C. Harwell, and L.M. Smith. (2016). A model for change: An approach for forecasting well-being from service-based decisions. *Ecological Indicators* 69:295-309.

Tourism Economics. (2010). The Economic Impact of Tourism in New York, Long Island Focus. Oxford Economics, Philadelphia, PA.

U.S. Environmental Protection Agency (U.S. EPA). (1998). Guidelines for Ecological Risk Assessment. U.S. Environmental Protection Agency, Washington, DC, EPA/630/R-95/002F.

U.S. EPA. (2002). Nitrification. U.S. Environmental Protection Agency, Office of Groundwater and Drinking Water, Washington, DC.

U.S. EPA. (2009). Valuing the Protection of Ecological Systems and Services: A report of the EPA Science Advisory Board. U.S. Environmental Protection Agency, Washington, DC, EPA-SAB-09-012.

U.S. EPA and Environment and Climate Change Canada. (2012). Great Lakes Water Quality Agreement, Great Lakes Areas of Concern, Annex 1. Accessed 24, March 2017 from https://binational.net/annexes/a1/.

U.S. Census Bureau. (2015). Suffolk County, NY. Accessed 7, July 2017 from https://www.census.gov/quickfacts/table/HCN010212/36103.

Wade, T.J., S.K. Sandhu, D. Levy, S. Lee, M.W. LeChevallier, L. Katz, and J.M. Colford. (2004). Did a severe flood in the Midwest cause an increase in the incidence of gastrointestinal symptoms? *American Journal of Epidemiology* 159(4):398-405.

Wainger, L. and M. Mazzotta. (2011). Realizing the potential of ecosystem services: A framework for relating ecological changes to economic benefits. *Environmental management* 48(4):710

Wania, A., M. Bruse, N. Blond, and C. Weber. (2012). Analyzing the influence of different street vegetation on traffic-induced particle dispersion using microscale simulations. *Journal of Environmental Management* 94(1):91-101.

Wegner, G. and U. Pascual. (2011). Cost-benefit analysis in the context of ecosystem services for human well-being: A multidisciplinary critique. *Global Environmental Change* 21(2):492-504.

Wigand, C., C. Roman, R. Davey, M. Stolt, R. Johnson, A. Hanson, and P. Rafferty. (2014). Below the disappearing marshes of an urban estuary: Historic nitrogen trends and soil structure. *Ecological Applications* 24(4):952-963.

Williams, D. R., M.E. Patterson, and J.W. Roggenbuck. (1992). Beyond the commodity metaphor: Examining emotional and symbolic attachment to place. *Leisure Sciences*, 14, 29-46.

Williams, K.C., J.C. Hoffman. 2017. Remediation to Restoration to Revitalization – A Path Forward for AOCs? US Environmental Protection Agency. EPA/600/R-17/119.

World Health Organization. (2017). Health Impact Assessment (HIA). Accessed 7, July 2017 from http://www.who.int/hia/en/.

Yin, R.K. (2013). Case Study Research: Design and Methods. Sage publications.

Yee, S.H., J.E. Rogers, J. Harvey, W. Fisher, M. Russell, and P. Bradley. (2011). Concept Mapping Ecosystem Goods and Services. In: Applied Concept Mapping: Capturing, Analyzing, and Organizing Knowledge, Moon, B.M., R.R. Hoffman, J.D. Novak, and A.J. Canals (eds.). CRC Press, Boca Raton, FL, pp. 193-214.

Ysebaert, T., S.L. Yang, L. Zhang, Q. He, T.J. Bourma, and P.M. Herman. (2011). Wave attenuation by two contrasting ecosystem engineering salt marsh macrophytes in the intertidal pioneer zone. *Wetlands* 31(6):1043-1054.

7. Glossary

Glossary definitions were obtained from:

Harwell, M.C., C. Jackson, and J. Molleda. (2017). Managed Vocabulary for use of Ecosystem Goods and Services in Decision-Making. U.S. Environmental Protection Agency, Gulf Breeze, FL, EPA/600/X-17/168.

Area of Concern: Geographic areas within the Great Lakes where significant impairment of beneficial uses has occurred as a result of human activities at the local level.

Benefits: A good, service, or attribute of a good or service that promotes or enhances the well-being of an individual, an organization, or a natural system.

Buffering ecosystem services: "Regulating" ecosystem services that buffer from pollution and environmental hazards (e.g., water filtration or heat hazard mitigation).

Classification system: A method to group individual elements or features into collections similar in type, function, affiliation, behavior, response, or ontogeny.

Conceptual model: A written description and/or visual representation of known or hypothesized relationships among variables in a system (e.g., human or ecological entities), often representing causes and effects, environmental stressors, and/or potential management strategies.

Decision context: The environment in which a decision is made, and the environment that will prevail when the effects of the decision are brought to bear, including the set of values, preferences, constraints, policies, and regulations that will affect both the decision makers and those identified as the ultimate beneficiaries.

Decision maker: Individual(s) or groups of people responsible for making choices or determining policies that impact the functions, processes, and conditions of ecological systems. Decisions may be local, regional, or national in scale.

Eco-health: Linkages between human health and ecosystem services.

Ecosystem goods and services: Outputs of ecological processes that directly ("final ecosystem service") or indirectly ("intermediate ecosystem service") contribute to social welfare. Some outputs may be bought and sold, but most are not marketed. Often abbreviated as ecosystem services, a common descriptor for non-technical audiences when describing ecosystem goods and services.

Final ecosystem goods and services: Components of nature, directly enjoyed, consumed, or used to yield human well-being. The final ecosystem goods or services is a biophysical quality or feature and needs minimal translation for relevance to human well-being. Furthermore, a final ecosystem good or service is the last step in an ecological production function before the user interacts with the ecosystem, either by enjoying, consuming, or using the good or service, or using it as an input in the human economy.

Health impact assessment: A means of assessing the health impacts of policies, plans and projects in diverse economic sectors using quantitative, qualitative, and participatory techniques.

Human well-being: A multidimensional description of the state of people's lives, which encompasses personal relationships, strong and inclusive communities, meeting basic human needs, good health, financial and personal security, access to education, adequate free time, connectedness to the natural environment, rewarding employment, and the ability to achieve personal goals.

Human well-being index: An index of well-being for the U.S. based on indicators and metrics derived from existing measures of well-being.

Intermediate ecosystem goods and services: Attributes of ecological structure or processes (including functions, characteristics, and interactions) that influence the quantity and/or quality of ecosystem services but do not themselves quantify as final ecosystem goods and services (because they are not directly enjoyed, consumed, or used by beneficiaries).

Nonuse value: The value people hold for an ecosystem attribute or service that they do not use in any tangible way. Sometimes referred to as "passive use value."

Place-based study: A research project focused on a specific geographic location or geographic type.

Revealed preference: Preference revealed through buying behavior.

Stakeholder engagement: A process through which stakeholders influence and share control over initiatives and the decision and resources which affect them.

Stated preference: Preferences revealed from surveys or otherwise asking people directly how much they prefer or value something.

Total economic value: The concept of total economic value involves measuring the value of the sum of all flows -present or future- of natural capital provisioned by an ecosystem, including both use and nonuse values.

Use value: The value of a good or service derived from its direct or indirect use (as opposed to nonuse value). This includes direct and indirect values.

Weight of evidence: The process for characterizing the extent to which the available data support a hypothesis that an agent causes a particular effect.

8. Appendices

Appendix 1. Total Economic Valuation Overview

Monetary valuations provide values for various components of ecosystems, or provide proxy values for the value of an ecosystem, using dollar values as the common currency. Methods for monetary valuation can be divided into revealed or stated preferences. Revealed preferences methods seek to “reveal” the implied values through an individual’s choice by examining how environmental quality factors into housing values (hedonic pricing), and distance traveled and amount spent for a recreational experience (travel cost method). Stated preferences methods, including contingent valuation and choice experiments, ask respondents through surveys to directly indicate their willingness to pay (WTP) for quantities of ecosystem goods and services. Regardless of the chosen valuation method, all economic valuation methods disaggregate the totality of ecoservices provided by an ecosystem. As such, valuation efforts do not capture the total economic value (TEV) of an ecosystem (Figure 8.1). The concept of TEV involves measuring the value of the sum of all flows - present or future - of natural capital provisioned by an ecosystem, including both use and non-use values (Figure 8.1). Use values refer to benefits gained from ecosystems, in such a way that beneficiaries use them. Use values include both consumptive (raw materials, fisheries, livestock, etc.) and non-consumptive goods (recreation, spiritual, etc.), as well as indirect uses, which include regulating and supporting ecosystem services (water purification, pollination, etc.). Non-use values include bequest or existence values, in which a person derives utility from the knowledge that future generations will have access to the ecosystem or that the ecosystem will continue to exist, respectively (Pascual et al. 2010).

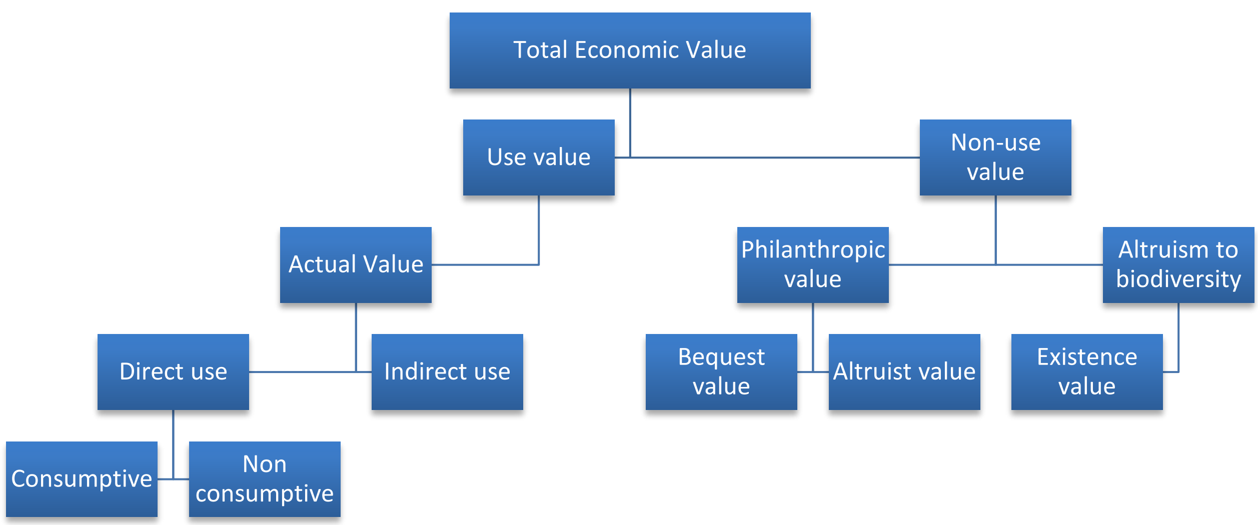

Figure 8.1 Ecosystem goods and services values typology within a TEV framework. Adapted from Pascual et al. (2010).

The TEV framework provides an approach for conceptualizing FEGS to encompass all possible values, but also inherently poses a challenge to valuation efforts- specifically monetization efforts. Uncertainties within TEV assessments stem from: (1) the inability to identify all beneficiaries for a given FEGS or to correctly address attribution between ecosystems; (2) the previously described challenges to quantify non-use values; and (3) uncertainties related to valuation methodologies based on human subjects and their ability (or lack thereof) to understand/assign value to FEGS. Further, siloed academic discipline-based perspectives and methods present a challenge both for discussing ecosystem service valuation within multidisciplinary research teams and, more broadly, producing valuation information with stakeholders and decision makers.

Mapping the flow of EGS within an ecosystem is an important step to determine TEV. However, ecoservices flow between both adjacent and distant ecosystems, and these flows are critical for ecosystem heath and resilience. For example, coastal ecosystems such as mangroves, seagrass beds, and coral reefs are interconnected in a myriad of ways (Figure 8.2). If one of the fish species depicted in Figure 8.2 is a commercially harvested species fished from the coral reef, which ecosystem would the provision of the raw material (food source) be attributed to if the species in question requires the presence of all three ecosystems for various stages of its ontogenetic development? This question is representative of just one of the problems in determining a boundary for the flow of ecoservices among ecosystems, which is essential to determine the TEV of a single ecosystem. Ecosystem goods and services classification systems, including EPA's Final Ecosystem Goods and Services (FEGS-CS; accessed 20, July 2017) and the European Environment Agency's Common International Classification of Ecosystem Services (CICES; accessed 20, July 2017), focus primarily on the FEGS that an ecosystem provides, and do not address these attribution considerations. An assessment of TEV requires precise boundary settings of the ecosystem under scrutiny to avoid double-counting, or errors in service attribution.

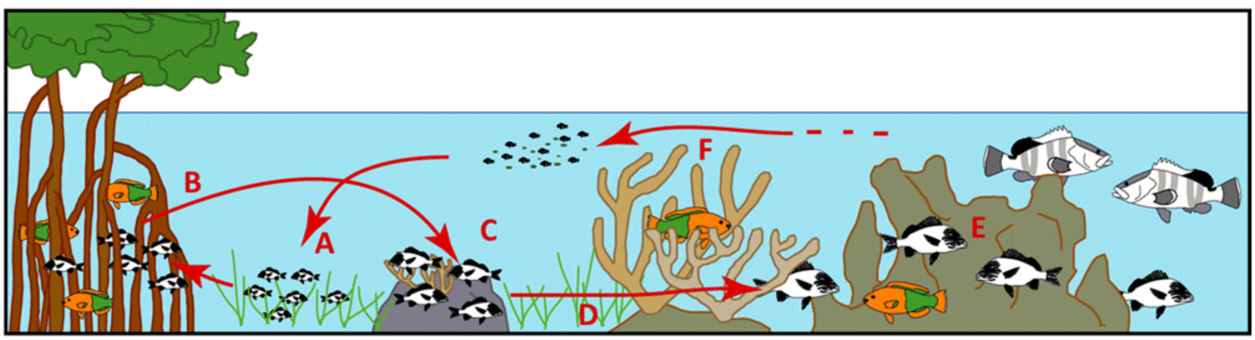

Figure 8.2 Illustrating the challenge of identifying where (ecosystem type) and when (different life stages denoted by letters A-G) to value an ecosystem goods and services component (fish) in complex ecosystems. Adapted from Mumby et al. (2004) and Reef Resilience Network (accessed 26, May 2017).

Non-use values also present a challenge for assessing the TEV of an ecosystem. Non-use values are passive benefits that people ascribe to the environment; for example, a person might obtain psychological well-being from knowing that an ecosystem exists (existence value). Current monetization methods do not sufficiently account for these values; certain monetization methods aim to assess a market value that can reveal values associated with a desired ecosystem good or service, while others aim to estimate marginal values for specific ecological or social attributes. However, it is not possible to assess whether an individual would be willing to pay for a marginal increase within an existence value because the unit is undefined. Further, some stakeholders and decision makers believe the monetization of non-use values is inappropriate because they believe that spiritual, cultural, and other abstract values that contribute to well-being cannot, or should not, be converted into a currency value. Finally, assessing the whole of the beneficiary landscape is difficult because beneficiaries may not necessarily live near an ecosystem they value and derive utility from its existence. For example, the Everglades in Florida provide many ES primarily to residents of Florida and visitors. However, parts of the Everglades are a

U.S. National Park, a World Heritage Site, and a UNESCO/Ramsar Wetland of International Importance. Accordingly, the Everglades have beneficiaries worldwide who value its existence despite never visiting the ecosystem.

Given the challenges associated with TEV, it is important to bridge the gap between how different disciplines define and assess goals surrounding TEV. That is, in a multidisciplinary context, it is necessary to recognize that each member of the team will perceive, construct, and approach economic valuation research questions grounded within their respective discipline, and this discipline-specific view will determine how each team member understands the ultimate goals for a project. Further, it is important for the research team, stakeholders, and decision makers to understand the different approaches that project partners use to conceptualize the study goals and plans to approach valuation research questions. Doing so in an intentional manner can help build consensus on appropriate study goals, how to reach those goals, and the appropriate interpretation of the findings across disciplines.

From a systems-thinking perspective, TEV may be an appealing approach to value FEGS. A systems-level perspective of economic valuation attempts to outline all the various ways humans may derive value from an ecosystem; this perspective may resemble the TEV model shown in Figure 8.1. From an economist's perspective, it is important to acknowledge the challenges inherent within monetizing all values identified in a TEV framework. For example, discrete choice experiments remain the most state-of-the-art method that economists use to estimate monetary values for various ecological and social attributes associated with an ecosystem; however, as a marginal analysis, it cannot effectively measure non-use values. From a decision maker's perspective, it is important to understand whether information from different disciplines represented among members of an interdisciplinary valuation team create a disparity in understanding that will cause scientists to talk past one another (Lélé and Norgaard 2005). This is important in an ecoservices context because valuing benefits will require natural scientists, health scientists, and social scientists to effectively communicate among each other. To address this challenge, when measuring and valuing ecoservices in a multidisciplinary team, an important starting point is establishing a common lexicon among team members and disciplines (e.g., Harwell et al. 2017, Munns et al. 2015, McDonough et al. 2017). Interdisciplinary teamwork models focusing on cooperation and mutual identification of communication, models, and approaches can be used to improve the efficacy of conducting integrated, interdisciplinary research (MacMynowski 2007). By increasing communication among team members and emphasizing the importance of not regarding the knowledge from any one team member's discipline as superior or proprietary, researchers can cultivate a space in which researchers feel comfortable exchanging ideas to develop interdisciplinary research solutions.

Appendix 2. Simulating Eco-Health Benefits Using Data-Derived Models

For eco-health linkages that have been studied extensively, it is possible to apply functions based on land cover classifications to estimate the current and future health benefits associated to EGS. Reduction of respiratory disease, water and heat hazard vulnerability, and overall mortality are examples of benefits that may be estimated through existing modeling tools (Table 8.1). These modeling approaches vary in level of complexity and generally require some level of calibration using locally-collected data.

There are, however, very few health outcomes that can currently be modeled using available tools, which reflects the current state of knowledge regarding eco-health linkages. Being able to estimate the changes in a wider range of health benefits from a loss of EGS would require more primary research studies that quantify these associations in a variety of contexts and multiple spatial scales.

Table 8.1 Available computer based modeling tools for estimating health consequences of Ecosystem Services. Qualitative assessment of relative technical difficulty is based on data input requirements, software requirements, and the availability of user guides and training tools. Adapted from Oosterbroek et al. (2016).

Modeling Tool	*EGS-Health Linkage*	*Technical Difficulty*	*Reference*
Enviro-Atlas	Clean Air-Respiratory Disease	Low	EnviroAtlas Interactive Map (Accessed 16, August 2017)
Green Infrastructure Valuation Toolkit	Engagement with Nature-Mortality	Moderate/Low	Green Infrastructure Valuation Toolkit (Accessed 16, August 2017)
i-tree Eco	Clean Air-Respiratory Illness	Moderate/High	i-Tree Eco (Accessed 16, August 2017)
InVEST	Water Hazard Mitigation-Vulnerability to Coastal Storms	Moderate/High	Natural Capital Project - InVEST (Accessed 16, August 2017)
MIMES	Heat Hazard Mitigation-Heat Morbidity/Mortality	High	Affordable Futures - MIMES (Accessed 16, August 2017)

Appendix 3. Causal Criteria Analysis of Direct and Indirect Linkages Between Green Spaces and Human Health Endpoints

An empirical causality assessment of these pathways between green spaces and human health endpoints, specifically diseases linked to buffering EGS provided by green spaces, was conducted using the Eco Evidence Analysis Software tool (Norris et al. 2011). A total of 2,756 publications were screened regarding potential eco-health linkages following the systematic framework outlined in the Eco Evidence Analysis Software (Figure 8.3). Selected papers providing empirical evidence on one or more of the intermediate or direct linkages (or both) were classified using the weights described in Table 8.2. (see de Jesus Crespo and Fulford 2017 for more details).

Figure 8.3 Screenshot of the Eco Evidence Analysis Software overview page.

Table 8.2 Factors considered and weight of evidence scores for causal criteria analysis (modified from Norris et al. 2011). A score of 20 was the threshold value for rejecting or supporting the causal linkage. This threshold means that at least three high quality studies are needed for evidence of causality (Norris et al. 2011).

Factors Considered	Weight Applied	
I. Study Design		
Before After Control Impact (BACI)	4	
Gradient Response Model	3	
Before v. After	2	
Control/Reference v. Impact	2	
After Impact Only	1	
II. Number of Control Locations		
0	0	
1	2	
1+	3	
III. Number of Independent Impact Locations		
1	0	
2	2	
2+	3	
IV. Locations for Gradient Response Model		
3	0	
4	2	
5	4	
5+	6	
Possible Outcomes*		
Score in Favor	*Score Not in Favor*	*Conclusion*
≥ 20	<20	Sufficient Evidence in Favor
<20	≥ 20	Sufficient Evidence not in Favor
<20	<20	Insufficient Evidence
≥ 20	≥ 20	Inconsistent Evidence

*The scores are a result of summing the weights for each category. Factors categorized here as II and III are applied to all design types except "gradient response". Category IV is only applied to "gradient response" designs.

Sufficient evidence was found showing green spaces help promote clean water and provide water hazard mitigation, and that these EGS are causally related to GI disease (Table 2.2; de Jesus Crespo and Fulford

2017). However, no studies were found directly linking green spaces to GI disease. This may be an important area for future research because of its potential significant management implications. Studies linking green spaces to GI disease should include considerations of exposure mechanisms, primary sources of pathogens and whether it is feasible to use green space EGS for pathogen removal or exposure prevention (Table 8.3).

Table 8.3 Considerations for developing a research agenda addressing the direct link between green spaces and gastrointestinal (GI) disease, an area of limited empirical evidence but strong background support and important management implications.

Sources of Pathogenic Microbes
Poor wastewater management Leaky sewage Combined sewage
Environmental Exposure Pathways
Consumption Drinking water Irrigated crops Polluted fisheries
Recreation Swimming Wading Fishing Boating
Water Hazards Contact with flood water Contact with items affected by flood
Potential Role of Green Spaces
Constructed/Natural wetlands for wastewater management Constructed/Natural wetlands for storm surge mitigation Landscape level wetland/green space cover for runoff filtration Landscape level wetland/green space cover for flood mitigation
Examples of hypotheses to be tested
The use of constructed wetlands should help reduce waste water pollution, improve irrigation water quality and consequently lower GI disease prevalence in rural areas.
Landscape level green space cover should help mitigate flood exposure and consequently GI disease prevalence in urban areas.
Fishing communities characterized by large extents of coastal wetlands and/or riparian buffers should have healthier fisheries and consequently lower GI disease prevalence.
Estuaries with protected wetlands are likely associated to cleaner beach water, and consequently lower GI disease prevalence among swimmers.
Potential Confounding Factors
Unknown waste water inputs Impacted water flow (damming, clogging) Unmapped sewage infrastructure

There was sufficient evidence linking green spaces to clean air and green spaces directly to cardiovascular disease (CVD) (Table 2.2; de Jesus Crespo and Fulford 2017). There was inconsistent evidence found linking CVD to the EGS of clean air. This inconsistency may be due to the relatively large number of studies evaluating this link (N=27), with a large variety of contexts and indicators (e.g., blood pressure, hospital admissions, blood clot formation, etc.) (Table 2.2). Identifying which physiological responses associated to CVD are more sensitive to air pollution, and under which circumstance this cause-effect relationship is observed could be the subject of future research (Table 8.4). Aside from clean air, alternative pathways linking green spaces to CVD include promotion of physical activity and stress reduction. These factors were not assessed in this study, but they have been shown to be key at moderating CVD risk (Lim et al. 2013) and have been associated to green space cover (Richardson et al. 2013).

Table 8.4 Priority questions for a research agenda to evaluate the role of ecosystem goods and services provided by green spaces on human health (GI – gastrointestinal, CVD – cardiovascular disease).

ECO-HEALTH LINKAGES	PRIORITY QUESTIONS
GREEN SPACES-CLEAN WATER/POLLUTED WATER-GI DISEASE	Is GI disease prevalence related to green space measures (presence, % cover, etc.) in areas exposed to water pollution? (see also Table 3)
GREEN SPACES-WATER HAZARD MITIGATION/WATER HAZARDS-GI DISEASE	Is GI disease prevalence related to green space measures (presence, % cover, etc.) in flood prone areas? (see also Table 3)
GREEN SPACES-WATER HAZARD MITIGATION/WATER HAZARDS-RESPIRATORY ILLNESS	Is mold more common in houses prone to natural flooding? Does household mold correlate to asthma?
GREEN SPACES-CLEAN AIR /POLLUTED AIR RESPIRATORY ILLNESS	What are the best indicators to detect the impact of air quality on respiratory illnesses (e.g., oxidative potential vs pollutant mass)? Are there consistent confounding factors (demographics, seasonality) determining the impact of air pollutants? Could we define transferable green space restoration guidelines to enhance pollution removal and reduce allergen potential? How can we incorporate flow dynamic principles into the design of green space restoration to deal with the issue of re-circulation?
GREEN SPACES-CLEAN AIR/POLLUTED AIR-CVD	What are the best indicators to detect the impact of air quality on CVD (e.g., inflammatory response, coagulation, CVD prevalence)? Are there consistent confounding factors (demographics, seasonality) determining the impact of air pollutants on CVD? What is the main mediator between green spaces and CVD-physical activity or clean air?

There was inconsistent evidence linking green spaces to respiratory illness (de Jesus Crespo and Fulford 2017). This is in part because certain types of vegetation act as a source of allergens (e.g., pollen; Lovasi et al. 2013), and because, depending on tree and building configuration, particles trapped by trees may be re-circulated, exposing nearby communities (Wania et al. 2012). There were also inconsistencies regarding the intermediate pathway linking clean air to respiratory illness. The types of clean air indicators used may help explain this inconsistency. Traits such as oxidative potential, which strongly influence inflammatory response (Delfino et al. 2013), may better correlate to respiratory illness than mass of air pollutants, which is the most commonly-used indicator. Future studies may focus on oxidative potential and the role of green spaces at mitigating this impact.

Insufficient evidence was found to support the link between water hazard mitigation and respiratory illness (de Jesus Crespo and Fulford 2017). No study has looked at the direct connection between green spaces and respiratory illness through this eco-health pathway so this potential linkage cannot be validated.

The best supported linkage was between green spaces and prevention of heat morbidities. This eco-health linkage may be prioritized for management action related to efforts to protect vulnerable communities such as the elderly, especially within cities affected by urban heat islands.

Overall, most of the current eco-health literature supports findings of intermediate steps (e.g., ecosystem to buffering EGS and buffering EGS to human health), but there is limited support for direct linkages from ecosystem (green spaces) to human health (disease endpoints). Few studies have involved measures for each step of the eco-health relationship pathway. Determining whether green space management delivers human health benefits through buffering EGS is still an area of research in need of development. Based on these results, priority questions are outlined in Table 8.4 to help guide future research on this topic.

Appendix 4. Issues of Data Accessibility and Granularity in Mapping Human Health Outcomes as Part of Eco-Health Studies

In mapping human health outcomes as part of eco-health studies, there is a tradeoff between data accessibility and granularity. At large scales (e.g., state, metropolitan area, and county level), data are accessible generally without restrictions or the need to request approval from the organization/agency's Institutional Review Board (IRB). In addition, behaviors that can pose health risks, access to healthcare and certain self-reported health outcomes are estimated at the census-tract level for selected metropolitan areas across the United States (e.g., Center for Disease Control's 500 Cities project). Some examples of these available datasets are included in Table 8.5.

Table 8.5 Examples of available human health datasets.

Dataset	*Finest Scale*	*EGS related health outcomes*	*Source*
CDC Wonder (Mortality by Cause, Cancer Diagnoses, TB cases, STD morbidity)	County; Metro Area	Causes of Death-ICD-10 codes	CDC Wonder - Mortality by Cause (Accessed 16, August 2017)
Morbidity and Mortality Weekly Report (National Notifiable Diseases)	State	Notifiable diseases such as cholera, malaria, yellow fever, vibriosis, among others.	CDC Wonder - Morbidity and Mortality Weekly Report (Accessed 16, August 2017)
Community Health Status Indicators (health profiles, risk behavior, access to health care)	County	Stroke, diabetes, cancer, heart disease, chronic lower respiratory disease, asthma, kidney disease, obesity, physical inactivity, depression.	CDC Community Health Status Indicators (Accessed 16, August 2017)
Health, USA (disease, health insurance, risk factors, etc.)	National, Geographic Region (North, South, East West)	Mental health, cancer, infectious diseases, obesity, hypertension, diabetes, age adjusted death rates, physical activity, notifiable diseases.	CDC - Health (Accessed 16, August 2017)
USGS Disease Maps (zoonotic diseases)	County	West Nile Virus, Dengue Fever, Chikungunya, Eastern/Western Equine Encephalitis, La Crosse Encephalitis	USGS Disease Maps (Accessed 16, August 2017)

Dataset	Finest Scale	EGS related health outcomes	Source
500 cities project (risk factors, health outcomes)	Census tract (for select cities)	Asthma, blood pressure, cholesterol, heart disease, chronic obstructive pulmonary disease, kidney disease, mental health, stroke, diabetes, obesity, mental health, physical activity	CDC - 500 Cities Project (Accessed 16, August 2017)

These datasets however, have limited applicability for assessing the role of EGS on health. Most are summarized at large spatial scales, which provides an incomplete understanding of the level of exposure to environmental hazards and key EGS. The 500 Cities Project (500 Cities Project; accessed 20, July 2017) is useful in this sense, but it provides estimates on only a subset of health indicators, which may not relate to the EGS of interest. Another limitation is that data are generally aggregated on an annual basis or longer timespans making it difficult to establish associations to events of interests such as heat waves and floods and hazard mitigation services. For gathering empirical evidence associating health and environmental factors that vary in time and space, the level of detail offered by readily accessible datasets is often not enough.

Acquiring finer-scale health data may require the collection of primary data through field work or establishing collaborations with health providers or local health agencies that may have access to non-public datasets. Often these datasets come with restrictions associated to personally identifiable information (PII) and require IRB approval prior for their use in analysis. Certain datasets may be acquired through the purchase of licenses for specific timeframes. An example of this is the use of Medicare Claims data, which is common in research because it is standardized across the nation, and allows associating disease occurrence with specific time intervals and therefore hazard events of interest. Medicare Claims Data can be acquired through services such as University of Minnesota's Research Data Assistance Center (Research Data Assistance Center; accessed 20, July 2017), among others.

The following is a list of considerations to help guide studies focusing on Eco-Health linkages:

- Interdisciplinary aspects: Health and environmental scientists may have different analytical perspectives and are trained to address common challenges such as confounding factors, controls, and replicates using different methodologies and terminologies. Ideally, Eco-Health studies should be developed as collaborative, multidisciplinary projects between, for example, ecologists, epidemiologists, and social scientists to ensure rigorous design and execution. This may not always be possible, in which case, researchers are advised to at least become familiarized with these differences and acknowledge the potential limitations and biases.
- Temporal and spatial differences: Researchers may have high-quality, fine-grain health data for a study, but only poorly-defined environmental and EGS datasets to establish comparisons, or vice versa. This is a source of error and uncertainty that must also be acknowledged. Researchers should adhere to principles of extrapolating data to different scales (e.g., Miller et al. 2004) and report such approaches to promote consistency and transparency. Medical coding: Acquiring health data requires gaining familiarity with the International Statistical Classification of Diseases and Related Health Problems (ICD; accessed 17 August, 2017) coding system, which has several versions, with specific codes for each medical diagnosis. Different sources may use different versions of the classifications (ICD-9, vs ICD-10), and codes vary based on the level of specificity (e.g. ICD 9 code, Intestinal infection due to other organisms: 008; Intestinal infection due to entero-pathogenic

E. coli: 008.01). This is especially relevant for accessing insurance claims data and hospital admissions data.

- Big data: Studies that include health benefits may use data from hospital records and insurance claims, often available on a daily basis. These data are generally analyzed within large timeframes to account for disease seasonality or lag times between exposure and disease occurrence. The resulting datasets may therefore include thousands of entries that may present storage and manipulation challenges especially when combined with similarly large long term environmental information. Strategies for synthesizing, analyzing and storing this information should be considered during the planning process.

Appendix 5. Limitations to Current Social Science Research at ORD

In EPA's ORD, barriers to conducting social science research include the lack of an Institutional Review Board (IRB) within ORD and challenges in obtaining an Information Collection Request (ICR) from the Office of Management and Budget (OMB).

The IRB is an administrative body within a research institution that aims to protect human participants within scientific studies. Researchers using human subjects within their studies design protocols to safeguard confidentiality, collect informed consent, convey all the risks associated with the study, and other measures designed to ensure the fair treatment of all subjects and protection of their rights. Social science studies generally pose minimal risk to participants as they primarily include surveys and interviews. However, an approval by the IRB is still needed to proceed with this type of research before data collection begins. The lack of a transparent and predictable process surrounding how a social science researcher within ORD who does not have a university-affiliated researcher on their team to obtain an IRB approval may discourage researchers to pursue more rigorous social science methods in favor of less generalizable methods that fall outside the purview of the IRB.

In addition to obtaining IRB approval, researchers within the federal government must also prepare an ICR for OMB approval as part of the Paperwork Reduction Act (PRA; accessed 20, July 2017). The OMB must approve an ICR before any federal agency begins information collection— through surveys or questionnaires— from 10 or more members of the public. The process for ICR approval takes approximately six to nine months and includes two periods for public comment and two separate review periods. Studies that warrant an ICR include primary data collection methods within the social sciences and create an additional burden on government and government-affiliated researchers in meeting this requirement. As part of the ICR, draft materials, such as survey instruments and supporting documentation, will need to have already been completed in the event that members of the public request the materials as part of the public review/comment periods. Drafting a survey instrument can take between six months to a year, and the survey might still need further refinement through focus groups and expert consultation. Although the six to nine-month period could be used to further develop a survey instrument, significant effort will have already been needed to design the survey, which further elongates the timeline towards project completion. Finally, EPA researchers must also receive approval from the Human Subject Research Review Official (HSRRO; accessed 20, July 2017), in addition to the IRB and the ICR. The HSRRO is charged with ensuring that all human subject research conducted within EPA are subject to EPA regulations. The HSRRO requires that an IRB approved research protocol must be in place before their approval is granted.

Conducting research within EPA that aims to understand how human populations value or consume benefits derived from the environment inherently results in social-science challenges. In addition to the burdensome operational requirements in the form of obtaining three separate approvals (IRB, HSRRO, and ICR), the lack of a clearly defined process that outlines how researchers should complete these approval processes with the necessary documentation at each step further complicates how researchers obtain these approvals. Developing a streamlined process that integrates the requirements for all approvals, and a clearinghouse for information about these processes, would be beneficial to researchers and provide more clarity on how to initiate these studies.

There are, however, many ways in which researchers interested in using social science methods can pursue conducting ecosystem services valuation research. First, researchers can choose to limit their investigations to nine people or less to avoid the need for an ICR. Second, for researchers who opt for 10 or more participants in their study, they can utilize a few generic OMB clearances, such as the Citizen Science and Crowdsourcing Projects (accessed 20, July 2017) initiative or the Focus Groups as Used by

EPA for Economics Projects (accessed 20, July 2017), to streamline a portion of the research approvals process. However, researchers must carefully consider the limitations of each generic clearance and design around these challenges, as they may limit data collection methods or statistical extrapolation. Finally, researchers can try to utilize existing data to fill in data gaps. Public meetings and local meetings held by relevant stakeholder groups can provide a wealth of knowledge on community priorities and values, along with opportunities to speak to the public in an informal manner. Data and information from public reports and social media also represent opportunities to understand how the public is interacting with ecosystems, and which ecosystem goods and services are valued.

Appendix 6. Innovative/Alternative OSDS Under Consideration

Suffolk County Chooses Four Vendors for Round One of Demonstration of Innovative Alternative Onsite Wastewater Treatment Systems: 2-4-2015

Suffolk County has selected four firms with proprietary nitrogen removal technology– BUSSE Green Technologies, Hydro-Action Industries, Norweco and Orenco Systems – to participate in Round One of the Suffolk County's demonstration of innovative/alternative OSDS program.

The selection followed a thorough review conducted by the selection committee consisting of representatives from the County Departments of Economic Development and Planning, Health Services, and Public Works. As part of the evaluation, the selection team looked at the applicants' system approvals on national and state level, financials, treatment process, effluent testing data, performance in comparable climate conditions, as well as the costs of the installed system and annual maintenance. All of the selected vendors previously demonstrated average effluent concentrations of total nitrogen equal to or below 19 mg/l (i.e., nitrogen reduction of 50% or more).

Three vendors (BUSSE, Hydro-Action, and Norweco) have been recommended for demonstration of their systems on private residential properties. The fourth vendor (Orenco) was recommended for demonstration of its systems on county municipal property. The self-reported costs of advanced treatment systems proposed by three firms ranged from $5,000 to $16,500 installed; the cost of a system proposed by the fourth firm was $23,000 installed. The annual maintenance cost for all systems ranged from $200 to $600 per year. In addition, one non-proprietary treatment technology ─ constructed wetlands – has been added to the demonstration program and is expected to be tested on select county parkland residencies and town park settings. Additional information about four selected vendors is provided below.

- BUSSE technology has been installed in Maine and Massachusetts. It was also approved in Maryland and New Jersey. **BUSSE MF**, the system proposed for demonstration, utilizes Membrane Bio Reactor (MBR) treatment process. MBR technology combines biological treatment with a membrane filtration into one unit process and, as such, requires smaller footprint.
- Hydro-Action technology has been installed in Illinois and Ohio (n = 7,700 systems in IL and 5,600 systems in OH) and several other states, according to the firm. **Hydro-Action AN Series**, the system proposed for demonstration, uses extended aeration activated sludge process in which microorganisms that treat wastewater remain in the treatment process for a longer period of time (more than 24 hrs.).
- Norweco technology has been approved and installed in Massachusetts (n = 140 systems), Maryland, Ohio, and Rhode Island. **Norweco Singulair TNT** and **Hydro-Kinetic** are two systems proposed for demonstration project; both systems use extended aeration activated sludge process.

Orenco technology has been approved and installed in Massachusetts (56 systems), Maryland, Rhode Island, and several other states. According to the firm, more than 20,000 Orenco systems have been installed in the U.S. and Canada. Two systems proposed for the demonstration, **Orenco Advantex AX-RT** and **Advantex AX**, use attached growth packed bed reactor process where microorganisms responsible for biological treatment are attached to textile media.

Appendix 7: Contaminated Site Remediation to Habitat Restoration to Community Revitalization (R2R2R) in the Great Lakes' Areas of Concern (AOC)

In many ways, the progression of community revitalization in Areas of Concerns (AOCs) represents the next evolution of advancement in AOCs in environmental restoration. The City of Duluth, Minnesota is located adjacent to the St. Louis River, one of the 42 AOCs in the United States and Canada identified in the Great Lakes Water Quality Agreement (GLWQA). Areas of Concern are geographic areas "designated by the Parties where significant impairment of beneficial uses has occurred as a result of human activities at the local level (U.S. EPA and Environment and Climate Change Canada 2012)." In other words, many of the beneficial uses of the ecosystem (in essence, ecosystem goods and services) are impaired. Fish and wildlife populations, benthos health, water for drinking, beach-going, safe fish consumption, and aesthetics are among the beneficial uses of the environment that could be impaired because of the compromised water, sediment, and habitat quality. Restoring beneficial uses of the ecosystem will provide final ecosystem goods and services that contribute to human well-being, like fish for sustenance and recreation, wild rice for habitat and spiritual connection, and scenic views.

To restore the Beneficial Use Impairments (BUI), state agencies and Public or Citizen Advisory Councils (PAC) have developed Remedial Action Plans (RAP) to identify the problems in each AOC, as well as the actions needed to remove the BUIs. It is important to note that nearly all of the attention to improving water quality in the Great Lakes through GLWQA-related actions have been focused on the aquatic ecosystem. But, stakeholders throughout the region, the EPA Great Lakes National Program Office, and EPA Office of Research and Development scientists are starting to recognize aspects of development in the communities adjacent to AOCs and ask how contaminated sediment remediation and aquatic habitat restoration are related to community revitalization (Angradi et al. 2016, Williams and Hoffman 2017).

There are community examples where one of the mechanisms used to clean-up AOCs, the Great Lakes Legacy Act, has been utilized to transform degraded waterfront by removing contaminated sediments and restoring aquatic habitat. A new resort and marina facilities in Sheboygan, Wisconsin, and a brewpub and adjacent business revitalization in Milwaukee, Wisconsin, demonstrate the potential for reclaiming and utilizing formerly degraded waterways. The EPA Great Lakes National Program Office, which is responsible for cleaning-up AOCs, uses the term "R2R2R" or "R3" to characterize this process of remediating contaminated sediments and restoring aquatic habitat to help revitalize coastal communities.

It is not yet clear exactly how sediment remediation and habitat restoration can help spur community revitalization, especially in the context of AOC delisting. One of the complications is that the AOC delisting process involves multiple layers of program and funding interactions. For example, sediment remediation and habitat restoration activities are often the responsibility of state agencies who solicit and manage federal funding from the EPA and other agencies, but also must coordinate efforts of cooperating federal, state, and local organizations. Furthermore, another complicating factor in R2R2R implementation is the difficulty in communicating and aligning remediation, restoration and revitalization goals among federal and state agencies, tribal governments, local government entities, nonprofit organizations, and citizens. Another complicating factor is that because the AOC program is an aquatic program, AOC boundaries are most often at the shoreline. On the other hand, community redevelopment or revitalization, including brownfields reclamation, often unfolds simultaneously in the communities next to the AOC. More often than not, these processes occur in parallel to each other – separate and not intersecting.

Because the benefits of restoration are defined for organizations and individuals based on their personal and professional experiences and responsibilities, it is paramount to find methods to relate the values articulated by actors to each other. Early successes from the AOC program demonstrate that federal and state remediation and restoration projects to remove impairments and restore EGS can achieve stated goals if the activities engage citizens, leverage ongoing community redevelopment (revitalization) objectives, and aligned with community values (Krantzberg 2012). Given the importance of aligning AOC goals for the aquatic ecosystem with the community vision for waterfront neighborhoods, it is likely that both the change in EGS related to a R2R2R project and the R2R2R process that restores EGS are equally important to improving community well-being.

Appendix 8: Neighborhood Model Tool: Mapping the Human Ecosystem for a Place

Overview

The neighborhood model is an interpretive or translational tool designed to help identify how elements of the environment (built, social, or natural) contribute to well-being. In this case, the environment may consist of more than the biophysical elements.

> "Furthermore, engaging in environmental restoration work may provide benefits to workers beyond simple employment, including exposure to and interactions with nature, which is a limited "commodity" in many urban locations. In short, *cities are habitat for people*, so the urban design process should *include city residents and integrate a social component* into design objectives and actions."
>
> (Childers et al. 2015: 3778; emphasis added)

The neighborhood model is an organizational tool to sort and classify data collected through inductive research methods like document or archive analysis or participant observation (Figure 8.4). Inductive methods facilitate the identification of lived experiences, or day-to-day practices that might be taken for granted, through the participation in events or collection of materials that were created for a purpose important to the organizers or authors. Cheng et al. (2003, p. 96) argued that the physical environment is "not an inert, physical entity 'out there'…but a dynamic system of interconnected, meaning-laden places." The tool is meant to disentangle and classify some of the place meanings in order to better understand how the environment influences (positively or negatively) community life and how environmental attributes might be valued.

<u>Attribute definitions</u>

The neighborhood model tool identifies many neighborhood components that individuals, organizations, local governments may discuss in the context of their community. The characteristics are a mix of built environment types, structural dimensions, personal experiences, and human-environment relationships. The assemblage of attributes functions like a framework and can be broken into four broad categories. Definitions for each type of attribute are listed in the Methodology section.

<u>Role of critical questions</u>

Critical questions are guiding questions meant to direct the analyst's attention toward the reasons that a particular item might have been included in a document (i.e., they have particular meaning for the neighborhood, organization, document author or other entity in question). Recognition and documentation of such details in environmental research might be a way to integrate local knowledge into inquiry. The application of the framework is meant to shift the discussion away from residents want "x," to why "x" is important for residents. Changing the direction of the conversation is important because "x" is often context dependent – as in the context of the neighborhood or geographic area. The item in question is attached to something else that is an essential element to how "x" is perceived to be important for residents. A set of critical questions for each attribute are listed in the Methodology section.

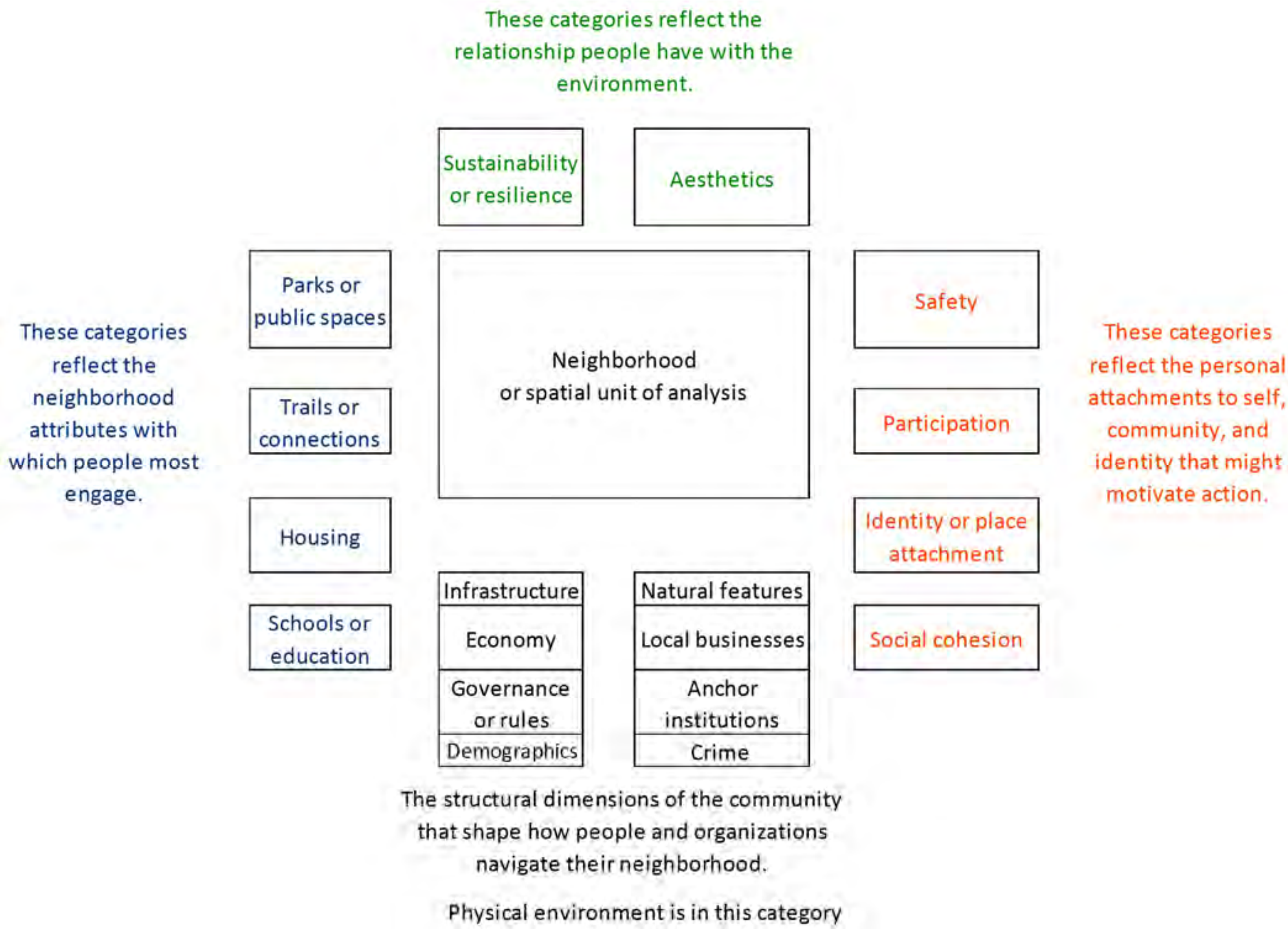

Figure 8.4 Neighborhood diagram. The different colors of text represent how individuals might interact with individual attributes. **Blue text** attributes are representative of the built environment, the reasons that individuals might choose their neighborhoods, or what cities plan to change. **Black text** attributes are structural dimensions, or the important elements that are fixed, part of larger process, or expressed in statistics. **Orange text** characteristics reflect personal attachments, values, or motivations of individuals. Finally, the **green text** attributes represent human-environment relationships.

Methodology

A two-step process can be used to guide in the coding of text-based data:

1. Decide to which broad category, and the subsequent attributes, a piece of text data belongs: (1) engaging attributes (parks, trails, housing, schools); (2) physical environment attributes (infrastructure, economy, anchor institutions, governance (or rules, politics, program requirements), natural features, demographics, crime); (3) personal attachment attributes (safety, identity, self-determination or participation, identity or character, or social cohesion); or (4) relationship with the environment attributes (sustainability, aesthetics).
2. Conduct a content analysis on the answers to the critical questions for each category. The pattern that emerges reflects what the identified element contributes to well-being as defined by the source of the text data.

ENGAGING ATTRIBUTES

Parks

People visit parks to relax, commune with nature, find peace, be with friends, play sports, or experience other recreation (Chiesura 2004). Parks are an integral part of a sustainable city. Access to quality parks and greenspace is often cited as a positive contributor to health and well-being.

<u>Critical questions:</u>

- What do residents/the authors/document say about the parks?
    - Are they a place to gather?
    - A place to avoid?
    - A place for events?
- What do people do in the parks?
    - Both positive and negative

Trails or Connections

Trails can connect neighborhoods to each other, as well as amenities and other destinations. Trails can be considered both linear parks and infrastructure for transportation. “The cities that are deemed most vibrant and alive are the ones where large numbers of people move around outside their cars in the public realm (Erickson 2006, p. 139).”

<u>Critical questions:</u>

- What do residents/the authors/document say about the trails?
    - Are they for transportation?
    - Do they link the neighborhood to important things?
        - Businesses
        - Features or points of interest
        - Important resources (water, scenic places)
        - Cultural resources
    - Something to avoid?
        - Go by dangerous/undesirable sites
        - Not enough lights
        - Trash, debris, industry (smells bad)
        - No
- Important for visitors
    - Both positive and negative
    - From the suburbs or somewhere else nearby
    - From far away (tourist destination)

Housing

Community advocates argue that overburdened neighborhoods are impacted by multiple environmental stressors (Morello-Forsch et al. 2011). Community leaders further contend that social factors including *housing quality* and neighborhood composition may impact long-term well-being. “We conclude that current environmental policy…should be broadened to take into account the cumulative impact of exposures and vulnerabilities encounter by people who live in neighborhoods consisting of largely racial or ethnic minorities or people of low socio-economic status (Morello-Forsch et al. 2011, 879/abstract).”

Critical questions:

- What do residents/the authors/document say about housing?
    - Is the housing adequate?
    - Does the document refer to the demographics of the residents?
    - Talk about foreclosures/tear-downs?
- Does the document mention vacant lots?
- Opportunities for building?
- Substantial repair?
- What is the voice of the document?
    - Protective of the neighborhood?
    - A need to change or improve the neighborhood?

Schools/Education

Schools are a critical community resource for learning, community cohesion and sometimes other basic needs. Schools are the place where children spend a lot of time – in class and in after-school activities. Additionally, schools can be important to the identity of the neighborhood, especially through sports. Scholars argue that the quality of schools is often linked to the quality of the neighborhood.

Critical questions:

- What do residents/the authors/document say about the schools?
    - Are they a place to gather?
    - A place to avoid?
    - A place for events?
    - A place to learn?
    - A place to access services?
- What do people do in the schools?
    - Both positive and negative
- Do they (the source of the documents or notes) mention intergenerational programming?
- Are the schools a source of pride?
- Is there a neighborhood school or is the school somewhere else?

PHYSICAL ENVIRONMENT ATTRIBUTES

Infrastructure

Infrastructure shapes and facilitates how people move around their neighborhood. Roads, sidewalks, water/sewer, street lights, interstates, ports, pipelines can enhance or detract from connectivity and/or quality of life in the neighborhood – including public transportation.

Critical questions:

- What do residents/the authors/document say about infrastructure?
    - It is in good/bad repair?
    - It works well/does not?
    - It enhances/detracts from the neighborhood?
    - Infrastructure serves…residents? Industry?
    - It directs users to or away from the neighborhood?

Natural Features
The dominant natural features shape neighborhood layout, experience, and affect (or disaffect). Parks are often the access points to natural features like hills, grasslands, rivers and streams. Natural features include topography, water, vegetation, and climate. In Sustainable and Healthy Communities research, natural features may be an ecosystem service or an indicator of an ecosystem service.

Critical questions:

- What do residents/the authors/document say about natural features?
  - Water bodies, rivers/streams, rocks (including bedrock), mountains, soil
- Do they mention natural features?
- Does the neighborhood have access or do they want it?
- Is the natural feature a positive feature?
- Is it or has it been a hazard?
- Why was it mentioned?
- What do they want to do with it?

Government (any level) or Rules
Government might be local, state, or federal governments. These governmental entities might be impacting the neighborhood in positive and/or negative ways. Government may be repairing something in the landscape (e.g., road, park, water/sewer line, interstate highway), creating plans (e.g., land use, site, neighborhood) for the neighborhoods or whole city. A short hand for knowing whether government is the right category is if there is something wrong – is there an office that someone might call to get the problem resolved?

Critical questions:

- What do residents/the authors/document say about natural features?
  - Water bodies, rivers/streams, rocks (including bedrock), mountains, soil
- Do they mention natural features?
- Does the neighborhood have access or do they want it?
- Is the natural feature a positive feature?
- Is it or has it been a hazard?
- Why was it mentioned?
- What do they want to do with it?

Demographics & Crime
Demographics and crime (i.e., statistics, numbers, or objective data) are generally large datasets that summarize the characteristics that can be counted and aggregated for a geographic area. The most common source of demographic data is the U.S. Census Bureau. The Pew Research Trust, the Centers for Disease Control, and the National Oceanic and Atmospheric Administration, and local governmental entities, have all analyzed the data to produce demographic-base products (i.e., the Social Vulnerability Index).

Critical questions:

- What do residents/the authors/document say about demographics or crime?
  - It is in good/bad for the neighborhood or geographic area?
  - It enhances/detracts from the neighborhood?

    - It directs visitors or residents to or away from the neighborhood?
- Why was it mentioned?

Economy
Economy in the context of document analysis might include: discussion of the macro-economy (e.g., national economy and how it impacts the neighborhood – like the loss of large industrial manufacturers); local economy and local businesses; the purchasing behavior of residents; development of industrial sectors (e.g., tourism, retail, agriculture, or manufacturing); and/or property values.

<u>Critical questions:</u>

- Do residents/the authors/document discuss any economic indicators?
    - Discussed as a positive or negative for the neighborhood or geographic area?
    - It enhances/detracts from the neighborhood?
    - It directs visitors or residents to or away from the neighborhood?

Health Care and/or Facilities (Anchor Institutions)
The presence of health care facilities and pharmacies in a neighborhood is an important indicator of access to care for families and the elderly (less mobile). At the same time, the presence of such facilities is considered assets. Place-based enterprises like universities, hospitals and cultural institutions are important foci of community redevelopment efforts.

<u>Critical questions:</u>

- What do residents/the authors/document say about health care facilities?
    - It is in good/bad for the neighborhood or geographic area?
    - It enhances/detracts from the neighborhood?
    - It directs visitors or residents to or away from the neighborhood?
- Why was it mentioned?

PERSONAL ATTACHMENT ATTRIBUTES

Safety (lighting, traffic, etc.)
Safety, a rather large concept, is "the condition of being safe from undergoing or causing hurt, injury, or loss (Safety 2017)" In a neighborhood, there are any number of conditions that could cause harm: environmental conditions that promote the growth or movement of disease vectors; exposure to risk (e.g., air or water pollution); inadequate lighting; poorly maintained infrastructure; hazardous traffic conditions. In many ways, safety issues are the conditions that cause residents or other stakeholders to contact governmental entities. If crime is mentioned and coded in this section, it means the author/speaker feels that their personal safety is threatened by perceived crime.

<u>Critical questions:</u>

- What do residents/the authors/document say about safety?
    - It is in good/bad for the neighborhood or geographic area?
    - It enhances/detracts from the neighborhood?
    - It directs visitors or residents to or away from the neighborhood?
- Why was it mentioned?

Participation (desire to/opportunity for/capacity to)
Participation or participatory democracy is often held up as a method for improving environmental

decisions that impact the public by giving residents a voice in the process. In short, citizens often (not always) want a voice in their own neighborhood's development. In fact, the outcome may not matter – a seat at the table and knowing they were heard is sometimes enough.

<u>Critical questions</u>

- Do residents/the authors/document mention a desire to participate?
- If so, why?
- Are they asking for any particular thing or are they asking to be part of the process?

Identity and Place Attachment/Character

Identity is complex and can include the personal, political, social, or organizational. Identity is a function psychological processes, but might manifest themselves in a number of ways in neighborhoods or communities. Identity with a neighborhood or place can be affective, reactionary, and protective based on the type of connection to the place.

Identity and place are also contested terms and might result in competing definitions of the potential value of a place. For the purpose of this guide, identity will refer to how a group (neighborhood or otherwise) describes itself or origin; how the place is rooted in history; and/or how the group identifies the space they claim.

<u>Critical questions</u>

- How residents/the authors/document describe themselves?
  - Do they articulate a claim for a particular place (e.g., this neighborhood is…)?
  - How/do they describe history?
  - What do the residents/authors/document want to protect?

Social Cohesion (Local Groups, Organizations, Churches)

Local organizations, including service and advocacy groups, are important resources in a community. They are potential community assets, knowledge brokers, gatekeepers and collaborators. Religious communities, libraries, block groups, park organizations, cultural or neighborhood groups might all be reflections of collective action in the area.

<u>Critical questions</u>

- Are local organizations mentioned by residents/authors/document?
- Are these groups considered stakeholders?
- How are they described? What are their roles?

RELATIONSHIP WITH THE ENVIRONMENT ATTRIBUTES

Sustainability

Sustainability could mean sustainability in the intergenerational equity sense (Summers and Smith 2014), or might mean how the neighborhood can be sustained and less vulnerable to elements like pollution, flooding, loss of jobs or food insecurity. Sustainability can refer to how a neighborhood enhances its own sustainability or builds resilience including neighborhood beautification, other placemaking activities, community gardens, or green infrastructure.

Scholars debate sustainability, but many are beginning to recognize that sustainability is a process that is or should be inclusive, interdisciplinary, and intentional. Sustainability might be reflected in any strategy that attempts to improve well-being of both humans and the environment simultaneously.

Critical potential indicators (not an exhaustive list):

- Food security or community gardens
- Green infrastructure
- Floodplain enhancement
- Trees/shade/temperature control
- Targeted plantings
- Improving ecological function for the human population

Aesthetics (i.e., how the neighborhood should look)
One definition of aesthetics is the governing principles that define an idea of beauty at a particular time or place (Aesthetics 2017). Furthermore, landscape ecologists have argued that what makes a landscape pleasing is context dependent and limited to the "human perceptual realm" (Gobster et al. 2007).

Critical questions

- Do residents/the authors/document mention changing the landscape to change their experience with some element in the neighborhood?
  - It could be positive…want to enhance views of a feature
  - It could be negative and framed as a buffer to some element that detracts from the neighborhood experience, (e.g., a buffer for noise, sound, smells)
- If so, do they describe why the enhancement would be important?

> "The environment is not an inert, physical entity "out there" with trees, water, animals, and the like, but a *dynamic system of interconnected, meaning-laden places*. Biophysical attributes may be the most obvious features of places; however, those attributes are constantly altered by social and political processes (e.g., *personal experiences, community uses, regional economic production, national conservation policies*) and vary greatly in their social and cultural significance."
>
> (Cheng et al. 2003, 96; emphasis added)

Example
As an example, a set of comments from a neighborhood planning exercise were sorted according to the model. All comments regarding how participants felt the neighborhood should look were coded as "aesthetics", one attribute within the broader category of human-environment relationships. The source of comments is provided at the end of each comment.

Aesthetics
Cohesion and design

- Consult local organization/urban design student plans for reuse site. (Stakeholders)
- Major arterial road lacks the presence of businesses that provide "cues" to the proximity of the nearby trail system. (Technical advisors)
- Major arterial road needs an "amenity plan" that extends from the business area down to the recreational hubs further to the west. E.g., banners. (Technical advisors)
- Entrance to arterial highway has blight and lots of scrub vegetation…. if this were cut down and cleaned up, it would make a more inviting entrance to the regional recreation

area. (Conservation organization)

Buffers, mitigation, and hazards

- Neighbors have voiced desire for a buffer between railroad and back alley on truck route. (Stakeholders)
- Green-up the area along interstate/near the former school — to mitigate air pollution from the interstate and paper mill. Questions paper mill's odor monitoring; references treatment plant's program that ties monitoring with permitting. (Technical advisors)
- Jake Braking: still happens in spite of signage prohibiting such. (Businesses)
- There should be clear aesthetic buffers between residential and industrial areas. (Businesses)
- Absentee landlords that don't ensure yards/homes are maintained hurts the neighborhood (especially single family rentals). (Parents group)

Analyzing all of the comments coded as aesthetics reveals that there were two broad themes – desired changes and mitigating less-desired features. Further analysis reveals that the Parents group identified a unique hazard that diminishes the quality of life. This highlights the fact that yards are a source of green space that contributes to well-being.

Appendix 9: Additional Suffolk County HIA Lessons Learned

The HIA process is built upon iterative collaboration between the researchers conducting the assessment, decision makers who have an impact on the choice being considered, and the stakeholders who will be impacted by the decision. Because of the many rounds of feedback and revision, it is often impossible to know in advance what aspects of the decision will end up being emphasized and which ecosystem benefits will be of importance to stakeholders. Because of this uncertainty, the HIA team may include members from a broad range of disciplines and knowledge bases as identified throughout the process.

Multidisciplinary collaboration was necessary to provide thorough subject-area knowledge and expert opinion on the Impact Pathways. Ecology, public health science, municipal planning, economics, epidemiology, and hydrology provide a partial example of the expertise represented by the team behind the HIA. The HIA team was geographically dispersed, and primarily communicated through planning team meetings to guide the development of the report and technical team meetings for discussion of scientific and technical matters. Small teams wrote each pathway chapter of the report separately with frequent check-ins with the planning team to guide the work progress and provide advice on draft products. It was particularly helpful to have a technical editor as part of the team, who helped to unite the disparate elements of the five pathway documents and resulted in a report with a consistent tone, flow, and voice despite its constituent parts being written by a large group. Researchers on the pathways were able to send drafts to the technical editor throughout the process of writing, which allowed the technical to serve as a central guiding influence for the paper's composition.

The separation of the technical group from planning was key in avoiding bog-down in meetings about the broad direction of the report. The planning group was responsible for making decisions about report formatting, which sections would ultimately be included in the final report, recruiting public input, and speaking to stakeholders among other broad duties. This freed time in the technical calls for discussing the details of how impacts should be estimated, the scope of the literature review, refinement of Impact Pathways, and similar narrow concerns. As with any project involving decision making, timing is crucial to the HIA process. While keeping everyone involved in the project informed and up-to-date is important, it can be necessary to limit debate on details of analysis to those who are involved so that the project sticks to schedule. The choice of organizational structure allowed each team to save time by working in parallel.

HIA is meant to improve local decision making by allowing the researchers to act as a conduit for democratic and equitable input from community members and stakeholders to decision makers. The health impacts under evaluation are chosen by asking members of the community what they are concerned about, and at each step of the evaluation process stakeholders are consulted. This allows the final product, a report detailing potential health impacts of the decision alternatives at hand, to reflect the concerns and wishes of the community. Local control of the decisions that affect people's lives is the central aim of a HIA. The decision context of this study was particularly amenable to the HIA process. The decision at hand, involving changes in requirements for OSDS wastewater treatment, had direct and measurable impacts on environmental quality and human well-being. Since HIA involves forecasting the effects of a decision on future community health, it is important that the mechanisms of impact are well-understood and ample scientific literature is available to justify the researchers' conclusions. Decisions involving less well-studied mechanisms can suffer from poor strength of evidence. The main mechanism of effect, discharge of nitrogen to groundwater, is a well-publicized and widely shared concern in Suffolk County. This allowed the difficult task of informing the public about the issue to be bypassed. The decision context involved multiple tiers of intervention, with increased costs and benefits associated with higher tiers. The alternatives that mandated that more residents upgrade their OSDS or switch to costlier innovative or alternative systems resulted in greater benefits to community health. This allowed examination of the human and ecological health results of proposed decisions on a scale, comparing the relative merits of the various choices. The decentralized nature of OSDS, in that most residents have one on their property, encourages personal participation in the decision. When community members feel that the decision will affect them directly, the HIA is bolstered by increased interest.

Obtaining data at the scale of individual towns was difficult, especially for the pathways that involved economic information (monetary value). It was found in the study area, which is a high-net-worth, high-population county east of New York City, that local data custodians were reluctant to share datasets that reveal property characteristics or commercial value. Licenses to access cadastral data are often sold by counties to various bodies in the real estate industry. The data that was needed were eventually obtained to examine the economic impacts of the decision, but it was a time-consuming process that resulted in a major delay. Communication between the researchers who needed the data, the project managers who were authorized to sign documents on behalf of EPA and disburse payment for datasets, and the local offices that license data were often complex. Requesting data from county or town-level departments may be best done in-person whenever possible. If requests must be done via phone or email, it should be conducted by one designated contact on the team who is vested with the necessary authorizations to make payments or sign documents as needed. This avoids a time-consuming back and forth of obtaining permissions, which may prove frustrating for stakeholders and local collaborators.

There was trouble engaging the local community in the study: while the initial meetings in 2014 and 2015 had a good level of participation, the final round of community participation meetings in 2016 had no attendees. The 2014 meeting was a planning and kickoff meeting and many of the future planning committee members were in attendance, along with the local stakeholders and decision makers. The 2015 community meeting attendees consisted of stakeholders representing local organizations including The Nature Conservancy, Long Island Sound Study of the New York Department of Environmental Conservation, Suffolk County Water Authority, and local county legislators, among others. While the 2015 meetings had over a dozen attendees, the 2016 meetings went unnoticed. There were several differences between these meetings that may have contributed to the disparity.

The 2016 meetings, in contrast to 2015, had no invited attendees from representatives of stakeholder organizations. They were meant to be information sessions for the general public. Since no members of the project group reside in the study area, it was difficult to identify and engage a community leader to act as a local champion for the study and increase awareness. Librarians were recruited to put up posters in local libraries advertising the meetings, and sent around emails to citizen groups who may have been interested. However, it seemed that without an ambassador that could act as a messenger trusted by local people, there was little interest in the HIA meetings. The communities in Suffolk County seemed not to suffer from low civic engagement; there were many meetings and community symposia advertised on the bulletin boards where the flyers were posted. This may have contributed to the lack of participation as well: the meetings were scheduled during the late 2016 Presidential election season and happened to coincide with well-attended political meetings. The meeting would have been scheduled for another time if a local representative or if one of the project's group members had been able to go in-person to scout the area and put up flyers personally.

The decision in this study is a fairly polarizing one in Suffolk County; adoption of several of the decision alternatives would lead to the imposition of costly OSDS repair for homeowners in the area. These repairs would likely need to be done anyway, as the majority of OSDS in Suffolk were constructed prior to 1973. However, a government mandate to perform even a badly-needed repair is less appealing to a homeowner than arriving at the decision to repair the system themselves. Additionally, the project's stakeholders in local government had an interest in some decision alternatives explored in the study achieving a certain result, and expressed some dissatisfaction with the final report because sufficient evidence was not found to support that result.

These issues both serve to emphasize the importance of establishing stakeholder and community ownership of the HIA process. When decision makers and stakeholders feel that the final product of a community-based study is theirs, and they played a significant part in its creation, they are more likely to accept its recommendations (Bracht et al. 1994). The stakeholder engagement included multiple well-attended meetings and check-ins by phone throughout the project. One thing that could be improved was community engagement, possibly by designating a team member for public relations to seek local champions in community interest groups and acting as a liaison to distribute information. Creating a series of easy-to-understand progress reports in the form of posters, flyers, or pamphlets and designating a team member or local surrogate to present them in community meetings of existing area ecological and environmental groups could have improved local awareness and engagement.

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