Human Dimensions Research for Informed Decisions About Aquatic Restoration In New Hampshire: Environmental Justice in Implementation of Compensatory Mitigation

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HUMAN DIMENSIONS RESEARCH FOR INFORMED DECISIONS
ABOUT AQUATIC RESTORATION IN NEW HAMPSHIRE:
ENVIRONMENTAL JUSTICE IN IMPLEMENTATION OF
COMPENSATORY MITIGATION

BY

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THESIS

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List of Acronyms

ARM = Aquatic Resource Mitigation
CWA = Clean Water Act
DES = Department of Environmental Services
ELI = Environmental Law Institute
EJ = Environmental Justice
EPA = Environmental Protection Agency
ESRI = Environmental Systems Research Institute
GIS = Geographic Information Science
HH = Household
ILF = In-Liu Fee
K-Wallis = Kruskal – Wallis (differences of medians)
N = Total Number
NH = New Hampshire
NHDES = New Hampshire Department of Environmental Services
OA = Environmental Protection Agency Office of Administration
PCB = Polychlorinated biphenyl
PRM = Permittee-responsible mitigation
PRRT = Penobscot River Restoration Project
STATA = General-purpose statistical software package
T-FERST = Tribal-Focused Environmental Risk and Sustainability Tool
TNC = The Nature Conservancy
UNH = University of New Hampshire
USACE = United States Army Corps of Engineers
USCB = United States Census Bureau
ABSTRACT

Human Dimensions Research for Informed Decisions About Aquatic Restoration In New Hampshire: Environmental Justice in Implementation of Compensatory Mitigation

by

Simone Chapman

University of New Hampshire, September 2020

New Hampshire’s aquatic resources provide many important ecosystem services and values, such as recreation, wildlife habitat, flood storage, nutrient reduction, community identity and aesthetic enjoyment. However, the many competing interests that seek to benefit from New Hampshire’s aquatic resources present challenges for efforts to steward public aquatic resources in the public interest. This thesis presents findings about the environmental justice outcomes of New Hampshire’s compensatory mitigation program, the Aquatic Resource Mitigation (ARM) fund, to inform aquatic restoration policy.

Previous studies have found evidence that aquatic restoration programs can lead to systemic resource relocation and patterns of inequality in outcomes. Using geospatial and statistical analyses, this research compares census-tract level socioeconomic data on specific demographic characteristics (minority population, low education, population density and income) with the spatial location of New Hampshire compensatory mitigation program sites. Census tracts are analyzed according to groupings at the state level and for two service areas with different population densities: the Merrimack and Middle Connecticut Service Areas. This research also applies a geospatial approach to recommend areas where outreach could be expanded to increase environmental justice communities’ participation in the ARM fund.
Consistent with previous compensatory mitigation and environmental justice literature, this research finds demographic characteristics are an important consideration for environmental justice. At the statewide census-tract level, I find that populations around mitigation sites are more likely to have a lower percentage of nonwhite populations, lower population density, and higher income, as compared to sites without mitigation sites. Populations around permit sites are also likely to have lower population densities. I also find that this level of analysis is important to recognize inequalities and inform natural resource management decisions. In contrast, to the statewide results, I find significant demographic differences within the relatively low population density Middle Connecticut region. For the Merrimack region, which is larger and more diverse, results are similar to the statewide analysis: I find that populations around mitigation sites are more likely to have a lower percentage of nonwhite populations. Unlike the statewide analysis, I find that populations around mitigation sites are more likely to have lower educational attainment and populations around permit sites are more likely to have higher incomes.

Then, I identified 26 environmental justice communities with aquatic restoration opportunities and found that almost half of these communities have participated in the ARM fund by submitting proposals to receive mitigation funding. Using an optimizing hot spot analysis and a heat map, I identified three environmental justice communities that have experienced significant wetland loss and to which the ARM Fund could target outreach: Manchester, Dover and Newington.

This thesis research is intended to provide guidance to state agencies, cities and towns, nongovernmental organizations, and others interested in advancing protection of New Hampshire’s aquatic resources. The analytic methods contribute to broader research into the human dimensions of water policy.
Chapter 1: Introduction

Recent crises, such as lead in water in Flint, Michigan (FWATF, 2016) and Washington, D.C. (Baehler, et al., 2020), have raised awareness of continued environmental injustice in implementation of water policy in the U.S. and the need for more research into the social impacts of water policy implementation, including compensatory mitigation programs, to ensure water policy does not disproportionately burden disadvantaged populations, does not deny fair access to environmental benefits, and does provide opportunities for realizing political capabilities (Malloy & Ashcraft, 2020). However, very few studies analyze the environmental justice impacts of how the Clean Water Act’s compensatory mitigation policy is implemented. My research contributes to the growing understanding of using Geographic Information Systems (GIS) for environmental justice analysis and applies geospatial research analysis to a relatively under-researched area of natural resource management, compensatory mitigation. A geospatial research approach refers to the study of geographic locations to understand spatial patterns, relationships and processes (Foster & Hipp, 2011). Geospatial analysis provides a lens through which to understand the world, events, and processes. It is about, "...what happens where, and makes use of geographic information that links features and phenomena on the Earth's surface to their locations" (de Smith et al., 2007, pg. 33). “A geographic information system (GIS) is a computer system used for capturing, storing, querying, analyzing, and displaying geospatial data” (Chang, 2013, pg. 1). Spatial data, or geospatial data, are spatial objects that range from points, lines, polygons, and rectangles that can also attach non-spatial attribute information, such as city names, project details and more (Samet, 1994).

1.1 Introduction to Environmental Justice and the Use of Geospatial Analysis
Black, indigenous, other people of color and low-income communities are disproportionately exposed and vulnerable to the cumulative, negative impacts of environmental threats, including pollution and degradation of water resources (Bullard, Mohai, Saha, & Wright, 2007). The environmental justice movement is a social justice movement that emerged in the 1970s, which aims to achieve meaningful involvement from a diverse group of people in public policy decisions that affect their quality of life and challenges systemic sources of injustice, such as the exclusive nature of environmental decision making (Vanderwarker, 2012; US EPA, n.d.-a). According to the Environmental Protection Agency (EPA), environmental justice is, “The fair treatment and meaningful involvement of all people regardless of race, color, sex, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies” (US,OA EPA, 2019).

Two events sparked the EJ movement in the United States (U.S.) and drew national attention. The Memphis Sanitation Strike and accompanying protest led by Dr. Martin Luther King Jr. and the Warren County Protest in North Carolina. The Memphis Sanitation strike, “…was the first time African Americans mobilized a national, broad-based group to oppose what they considered environmental injustices” (US EPA - EJ Timeline, n.d.). The Warren County Protest caught national attention for its nonviolent sit-in against a polychlorinated biphenyl (PCB) landfill that was located in the community and catalyzed the EJ movement (US EPA - EJ Timeline, n.d.). Since the 1980s, EJ networks, community-based groups, legal groups, and youth organizations have formed to address environmental and health issues that are impacting poor people and people of color (Bullard, et al., 1987). In 1994, President Clinton signed Executive Order (E.O) No. 12898: “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations”, which directs federal agencies to integrate
environmental justice (EJ) considerations into policy implementation to promote non-discrimination.

To comply with E.O. 12898 the EPA created several geospatial tools using Geographic Information Systems (GIS) to support EJ analysis, which are available to the public. Geospatial techniques in GIS programs are useful for informing decision making in communities and statewide policy implementation. GIS uses geospatial mapping programs that uses spatial coordinates and attribute data, like total population or average income, to understand relationships between the spatial and attribute data using geospatial tools and techniques (Chang, 2013). The geospatial tools and techniques are used for quantitative and qualitative analysis and are used to conduct geographic mapping of areas for analysis (Chang, 2013). One commonly used GIS program is ArcMap, an application that allows you to explore and display GIS datasets, to perform analysis, create maps for publication and manage databases (Esri, n.d.). The EPA’s geospatial tools are Tribal-Focused Environmental Risk and Sustainability Tool (T-FERST), EnviroAtlas, and EJSCREEN. T-FERST is a "tribal roadmap" used to identify priority issues and address risks for tribal communities (US EPA, 2016). The EnviroAtlas provides geospatial data, tools, and other resources related to ecosystem services, their stressors, and human health (US EPA, 2020). The EPA developed the EJ Screen Tool specifically for EJ research. “EJSCREEN is an environmental justice mapping and screening tool that provides EPA with a nationally consistent dataset and approach for combining environmental and demographic indicators. EJSCREEN users choose a geographic area; the tool then provides demographic and environmental information for that area” (US EPA - EJScreen, n.d.). EJSCREEN includes environmental factors, such as measures of air pollution and proximity to superfund sites, and demographic factors, such as percentages of the population that are minority, low-income, or
have lower than high school education. Kumar (2002) identifies a methodology for EPA to use the new mapping tool to “assist EPA programs in targeting resources and...raise staff awareness of EJ concerns by providing a tangible method for prioritizing EPA examination of a potentially contentious policy issue” (Kumar, 2002, pg. 10).

Geospatial techniques can also help with the selection of the study unit and size of groupings of units to identify environmental inequalities. Several analyses focus on the effect of researchers’ decisions on findings of inequality, specifically on the effects of the extent or boundary for research, such as an administrative unit (Noonan, 2018) (i.e. census unit, county, state) or biophysical boundary (Hill, Collins, & Vidon, 2018) (i.e. watershed, airshed) and the number of subareas (Kedron, 2016; Liu, 2000). For example, Hill et al. (2018) note that prior EJ research has reached conflicting results because the studies used different units of analysis and boundaries. An approach recommended by Hill et al. (2018) is to incorporate biophysical boundaries into EJ research, such as watershed boundaries, which can demonstrate the impact political decisions have on pollution, because Clean Water Act programs, such as compensatory mitigation, are implemented at the watershed level, and because the findings may, therefore, be useful to managers (Hill, Collins, & Vidon, 2018).

Geo-statistical tools can be useful for identifying study units where a variable of interest occurs at an increased likelihood (Rogerson, 2012). Geo-statistics is a branch of statistics that focuses on analyzing spatial data to identify patterns (Esri, n.d.), such as clusters with high negative impacts. Clusters are spatial groupings of high and low values of features of interest unlikely to have occurred by chance (Knox, 1989, as cited in Elliot, 1995). For example, Kedron (2016) uses local scan statistics to investigate clustering and finds, “Integrated with complementary quantitative and qualitative methodologies, local scan statistics have the
potential to improve our ability to identify and understand causes of environmental inequality” (Kedron, 2016, pg. 488). Local scan statistics are geostatistical tools that can be used to detect significant clusters and identify environmental inequality (Rogerson, 2012; Kedron, 2016).

1.2  Compensatory Mitigation and Environmental Justice

Compensatory Mitigation started in the United States in the late 1950s and spread quickly (Lave, 2018). According to federal and local wetland regulations, developers must first try to avoid any negative impacts to wetlands. When a development project, such as widening a road or expanding a building, causes *unavoidable* negative impacts that impair wetlands regulated under Section 404 of the Clean Water Act and their functions, the authorizing permit requires mitigation to compensate for the loss of wetland functions and values so the result is “no net loss” (Deland, 1992).

Mitigation can occur through 3 types of mechanisms. One mechanism is permittee-responsible mitigation (PRM), where the permit applicant responsible for the wetland impairment is required to mitigate. An in-lieu fund (ILF) is a second mechanism where the permit applicant responsible for the wetland impairment pays a fee into a fund that pools similar payments, which is then used to fund restoration by a third party, typically of projects with greater conservation value. Mitigation banking is a third mechanism, in which the permit applicant responsible for the wetland impairment buys credits from a third party (a bank) that has already enhanced wetland resources somewhere else (EPA & USACE, 2008).

The United States Army Corps of Engineers (USACE) and EPA provide guidance to states on how to implement mitigation programs. Based on earlier finding that compensatory mitigation failures could often be attributed to poor siting of projects (ELI & TNC, 2014),
USACE and EPA issued the 2008 Final Rule, which directs states to apply a watershed approach to implement compensatory mitigation and to prioritize the mitigation banking mechanism over the ILF mechanism and to prioritize both of these over the PRM mechanism (EPA & USACE, 2008). According to the Final Rule, 33 C.F.R. § 332.3(c)(2) (2008), “A watershed approach to compensatory mitigation considers the importance of landscape position and resource type of compensatory mitigation projects for the sustainability of aquatic resource functions within the watershed.” In practice, states vary significantly in how they implement compensatory mitigation policy to meet the requirements of the 2008 Final Rule. For example, across northeastern states, compensatory mitigation programs vary in the type of mitigation mechanism implemented (PRM, ILF, banking or none), the implementing organization(s), and the structure of the program. Appendix A provides an overview of different mitigation programs in use across the northeastern states and several other states.

The USACE’s regulatory analysis in preparation for the Final Rule did not anticipate negative impacts to communities. Specifically, the analysis of compliance with E.O. 12898 states (USACE, 2006), “The final rule is not expected to negatively impact any community, and therefore is not expected to cause any disproportionately high and adverse impacts to minority or low-income communities.” In fact, much of the evaluation of compensatory mitigation programs has focused on whether wetland mitigation programs are successful in achieving “no net loss” of ecological functions of wetlands (see, for example, (Race, 1996; Kihslinger, 2008; National Research Council 2001). However, the Environmental Law Institute and The Nature Conservancy’s Watershed Approach Handbook, developed to help resource managers improve the conservation outcomes of compensatory mitigation decisions and meet the requirements of
the 2008 Final Rule, makes clear that compensatory mitigation has social impacts and these should be evaluated (ELI & TNC, 2014).

The Watershed Approach Handbook recommends using the watershed approach to achieve watershed-level goals beyond the level of decisions about individual permits, including environmental protection goals, such as water quality or habitat protection goals, as well as economic, regulatory, and non-regulatory goals, such as recreational opportunities, increasing state and federal agency program transparency and efficiency, achieving goals shared by the community, and improving community quality of life. One element of implementing the watershed approach involves defining desired social outcomes, which could include fostering environmental justice, to inform decisions about mitigation projects (ELI & TNC, 2014). In a recent example illustrating how a compensatory mitigation process can provide an opportunity for an EJ community to effectively voice their wants and needs, the Penobscot River Restoration Project (PRRP) in Maine focused on social outcomes (Owen & Apse, 2014). So far, only a few notable research studies have analyzed the social impacts of compensatory mitigation programs, specifically environmental justice outcomes. The findings indicate implementation of compensatory mitigation policy can have negative impacts on communities.

Geospatial studies of compensatory mitigation programs in Florida, Maryland, Chicago, and North Carolina have found evidence of systemic resource relocation, in which wetland resources are shifted from more urban, whiter, more highly educated impact sites to more rural, less populated, and poorer mitigation sites with a higher percentage of minorities (Ruhl & Salzman, 2006; BenDor et al., 2007; BenDor & Stewart, 2011; Dernoga et al., 2015). However, these studies observed differences between program outcomes in different states, between different programs within a single state, and differences in income and racial make-up of
populations around impact and compensation sites. The methods and findings from these foundational studies are summarized in Appendix B. Given the scarcity of research on this topic, the following paragraphs describe these critical studies in depth with a focus on the methods used and the findings.

An early analysis of the social impacts of compensatory mitigation by J. B. Ruhl and James Salzman analyzed wetland mitigation banking in Florida. The researchers, “…generated the GIS location, represented as mapped polygon boundaries, for each project and bank, and gathered demographic data for the locations to allow comparison of human populations” (Ruhl & Salzman, 2006). Ruhl and Salzman found that wetland mitigation banking in Florida systematically moves wetland resources from urban areas to less densely populated, rural areas within the wetlands bank’s service areas. A possible explanation provided by the authors is that entrepreneurial bankers, motivated by profit, are likely to seek the least costly land that will produce credits.

BenDor et al. (2007) conducted one of the first analyses of demographic differences between compensatory mitigation impact and mitigation sites, focusing on Chicago, Illinois. BenDor et al. used geospatial techniques to map wetland relocation and conducted global and local cluster statistical analyses to identify groups of proximate wetlands with similar relocation distances. Using paired t-tests BenDor et al. found that, compared to mitigation sites, populations around impact sites generally have higher population densities, which is consistent with the findings for Florida from Ruhl and Salzman, higher percentages of Black and Hispanic populations, lower levels of homeownership, and lower average household incomes (BenDor, Brozović, & Pallathucheril, 2007).
In subsequent research, BenDor and Stewart (2011) investigated social equity issues and land use planning for wetland and stream mitigation programs in North Carolina. Using geospatial information, the researchers mapped impact and mitigation sites, joining socioeconomic data. Consistent with the two prior studies, the researchers observed significant patterns of wetland losses from urban areas and gains in rural areas. Using paired $t$-tests, BenDor and Stewart found populations around impact sites, as compared to populations around mitigation sites, generally have: (1) higher total populations and higher population densities, (2) higher percentages of whites and lower percentages of blacks and Hispanics (these results contrast with those from Chicago), and (3) higher levels of education, with lower percentages of individuals over the age of 25 having only a high-school degree or less and higher percentages of the population have completed ‘‘some college’’ or more. The authors also note that the spatial relocation of aquatic resources is not a clear case of loss and gain, as mitigation could create a disservice to communities near both impact and mitigation sites by depressing property values (BenDor & Stewart, 2011).

In a more recent study analyzing social outcomes, Dernoga et al. (2015) investigated the distribution of funds for Maryland’s mitigation programs, focusing on environmental justice impacts. The researchers looked at the sites where wetland impacts occurred, the sites created through Maryland’s ILF program, and PRM wetlands. The authors linked GIS files for the ILF sites to GIS watershed maps and added U.S. census tract data for % African American/Black in the area, % Hispanic, % non-white residents, and % persons in poverty. All wetland impacts were classified by the watershed map. The authors analyzed three categories: total area gained, total area lost, and net area gained. Dernoga et al. found that predominantly non-white areas received few to no mitigation projects, compared to predominantly white areas, which gained
most of the wetlands. Very few mitigation projects (18%) took place in census tracts where the population was more than 40% people of color (Dernoga et al., 2015, pg. 73). The 16.1% average percentage of non-whites for mitigation projects was much lower than Maryland’s overall 40% non-white population. The relationship between mitigation projects and poverty was not as strong as some areas with high poverty rates that did receive mitigation projects. However, the authors did compare the non-white and poverty maps and found that poor non-white areas received hardly any mitigation projects. For net watershed area gains, the authors found conflicting results for the impacts of race/ethnicity and poverty. The authors note,

Since the study looks at all projects and all watersheds, the fact that there are many more census tracts and watersheds with high percentages of white populations allows for some of these areas to receive zero resources and offset the more urban and compact areas with a high non-white population that also received close to zero resources. This means that population is not accounted for; a rural watershed with 5000 people that receives no funds counts the same in a statistical test as an urban watershed with 500,000 that receives no funds (Dernoga, Wilson, Jiang, & Tutman, 2015): p.73.

This could be an important consideration for EJ analysis of compensatory mitigation outcomes in other states with high numbers of rural census tracts with high percentages of white populations and low numbers of urban census tracts with relatively higher percentages of non-white populations, like New Hampshire (NH).
Chapter 2: Research Design and Methods

2.1 Research Design

This research presents the first analysis of environmental justice outcomes of compensatory mitigation policy in New Hampshire and in the New England region. The research analyzes socioeconomic differences between impact sites, where wetland ecosystem functions and values are lost, and mitigation sites, where wetland ecosystem functions and values are gained in New Hampshire. As already described, previous mitigation research analyzed compensatory mitigation programs in Florida, Chicago, North Carolina, and Maryland. These previous research studies took place in locations with higher populations, and very different socioeconomic demographics, as compared to New Hampshire. Based on data from the United States Census Bureau, New Hampshire’s population has comparatively higher educational attainment, higher median household income, and higher per capita income. New Hampshire also has a comparatively lower population density, minority populations, and lower total population (United States Census Bureau, 2019). Therefore, New Hampshire represents an interesting case study, in contrast to some better-studied and more densely settled regions, to analyze patterns of inequality in compensatory mitigation.

2.2 Introduction to New Hampshire’s Compensatory Mitigation Program

New Hampshire’s aquatic resources provide many important ecosystem services that benefit the state’s residents and visitors. New Hampshire’s roughly 1000 lakes, 17,000 miles of rivers and streams, and 238 miles of coastline (Rowden, 2011) are a source of enjoyment for residents and tourists alike, providing recreation and hydropower, and contributing to community identity and the economy. For example, New Hampshire’s hundreds of thousands of acres of
wetlands buffer stormwater, remove nutrients, and provide habitat for birds, amphibians, and other wildlife (NHDAMF, 2019; NHDES, 2008). However, like other New England states, New Hampshire’s aquatic resources are threatened, for example by land use change and pollution from stormwater, septic tanks, road salt, and acid rain (New Hampshire Department of Environmental Services, 2008).

Natural resource managers in New Hampshire strive to steward public waters in the public interest, which requires balancing tradeoffs between different uses, such as hydropower generation, recreation, and fish habitat (Diessner et al., 2020). For example, New Hampshire’s Department of Environmental Services (NHDES) Wetlands Bureau protects and preserves the ecosystem services provided by wetlands in accordance with RSA 482-A, the New Hampshire Fill and Dredge in Wetlands Act (the “Wetlands Act”):

It is found to be for the public good and welfare of this state to protect and preserve its submerged lands under tidal and fresh waters and its wetlands, (both salt water and fresh-water), as herein defined, from despoliation and unregulated alteration, because such despoliation or unregulated alteration will adversely affect the value of such areas as sources of nutrients for finfish, crustacea, shellfish and wildlife of significant value, will damage or destroy habitats and reproduction areas for plants, fish and wildlife of importance, will eliminate, depreciate or obstruct the commerce, recreation and aesthetic enjoyment of the public… (The Wetlands Act, RSA 482-A)

Also in accordance with RSA 482, the NHDES Dam Bureau regulates dams in the state to protect and preserve aquatic resources, while also supporting the state economy (New Hampshire Department of Environmental Services, n.d.). New Hampshire implements compensatory mitigation through an in lieu fee program, the Aquatic Resource Mitigation
(ARM) Fund, which is an important part of the State’s efforts to sustain and restore aquatic resources (NH Department of Environmental Services, 2018). Given the many competing interests in the state’s aquatic resources, information is needed to inform policy decisions to better steward public resources in the public interest, but little is known about the social impacts of New Hampshire’s wetlands policy and, in particular, its compensatory mitigation program. Evaluating whether there are environmental justice concerns resulting from the implementation of compensatory mitigation can provide information about whether the program is achieving its desired outcomes and can provide guidance for prioritizing future mitigation projects.

The ARM Fund’s primary goal is to “provide sustainable compensatory mitigation for functions of waters and wetlands of the U.S. that are lost due to authorized impacts” (NHDES & USACE, 2012). The ARM Fund, “Provides wetlands permit applicants with the option to contribute payments to this fund in lieu of implementation of several other possible and more traditional compensatory mitigation alternatives” (NHDES, 2012). The ARM Fund is administered by NHDES with oversight from the USACE. NHDES and USACE have developed guidelines, standards, and a comprehensive approach for selecting mitigation projects to fund through the ARM Fund and ensure compliance with the federal mitigation rule:

The NHDES mitigation program involves a strategic process of saving natural habitat by directing development away from sensitive areas and using ARM Fund payments in a targeted and effective way. This attempts to accomplish restoration, enhancement, and preservation on a watershed or landscape scale that would not otherwise happen (NHDES & USACE, 2012).

The ARM Fund divides New Hampshire into nine service areas, which are the units at which the program is implemented. Service areas can be a hydrological unit code 8 (HUC 8) watershed or a
modified HUC 8 watershed (NH Department of Environmental Services, 2018). Figure 2.1 shows a map of the nine service areas and the locations of impacts and mitigation sites. The program pools together funds from developers, who have caused negative impacts to aquatic resource functions and values at permit sites in an ARM Fund service area and distributes the funds to support mitigation projects in the same service area.

![ARM Regions](image)

**Figure 2.1:** Map displaying of the nine service areas through which the ARM Fund distributes funds.
Aquatic resource functions and values are specific to individual aquatic resources. They are essentially the natural processes of ecosystem services wetlands, streams, and vernal pools provide and the benefits, or ecosystem services, the natural processes provide to people. Therefore, a simple comparison of acres lost and gained does not present a full picture of the impacts on the resources. New Hampshire’s authorizing legislation, RSA 482-A, details fourteen functions, and values (NH Department of Environmental Services, 2020):

- ecological integrity
- educational/scientific value
- fish and shellfish/aquatic life habitat
- flood storage/flood flow alteration
- groundwater recharge/discharge
- noteworthiness (threatened and endangered species habitat)
- nutrient removal/trapping/retention and transformation
- production export (nutrient)
- scenic quality
- sediment/toxicant retention/trapping
- sediment/shoreline stabilization/shoreline anchoring
- uniqueness/heritage
- wetland-based recreation, and
- wildlife habitat.

Many of the functions and values incorporate social factors. For example, ecological integrity incorporates human modification of aquatic systems and scenic quality considers
aesthetic benefits. However, similar to other compensatory mitigation programs (ELI & TNC, 2014), New Hampshire’s ARM Fund does not explicitly consider EJ or other social impacts in decisions to prioritize compensation sites.

As of 2019, the ARM Fund program coordinators have selected and funded 106 mitigation projects across the nine service areas. The transportation sector is the sector that has paid the most into the ARM Fund. The distribution of the number of acres lost by the number of impacts in New Hampshire is shown in Appendix C (note: one permit can include multiple impacts). Appendix C shows that each of the impacts that have led to a payment into the ARM Fund has led to the loss of a wetland area under one-acre, which is the threshold that can trigger the need to apply for a federal permit. The most ILF permits and the highest amount of wetland loss and linear feet of stream impacts are located in the Merrimack service area, reflecting large transportation projects such as highway expansion (NH Department of Environmental Services, 2018).

2.3 Research Questions and Objectives

This research evaluates the environmental justice impacts of NH’s compensatory mitigation program and asks:

- Are there socioeconomic differences between the populations surrounding permit sites where wetlands and their associated ecosystem functions are lost, and in the populations surrounding mitigation sites where wetland ecosystem functions are gained, compared with the populations in other parts of in New Hampshire?
- How does the choice of spatial grouping affect the patterns of socioeconomic differences between permit and compensation sites?
• Do New Hampshire’s EJ communities participate in the ARM Fund?

2.4 Methods

The first step in testing for differences between the populations surrounding permit sites, or mitigation sites, and other New Hampshire locations requires comparisons at the census-tract level. The NH ARM Fund coordinators provided spatial data for each ARM Fund impact site and mitigation site from 2009-2019. “Geospatial data describe both the locations and characteristics of spatial features.” (Chang, 2013, P.2). The NH ARM Fund spatial data includes project details and the spatial location of each impact and permit site with coordinates. I used census tracts as the unit of analysis for this study to mirror previous studies of compensatory mitigation and EJ, described above. I also obtained a data layer, from NH GRANIT, that indicates how many census tracts are in New Hampshire and their spatial location (GRANIT Database Manager, n.d.). The socioeconomic data was obtained from the U.S. Census Bureau FactFinder database (USCB, n.d.). The ArcMap program can then display multiple features for comparison, and this was done with the data provided by NH GRANIT and ARM Fund coordinators. This research compares the spatial location of each ARM Fund permit and mitigation site and the USCB demographic information of the census tracts in New Hampshire in which the sites are located.

I then created a database in Excel linking census tract demographic information and compensatory mitigation data, which displays values for the demographic variables for each of New Hampshire’s census tracts and notes census tracts that have mitigation and permit sites. In the database census tracts are marked as having: (1) one or more permits (with the exact number specified), (2) one or more mitigation projects (with the exact number specified), (3) both, or (4) neither. A single permit can include multiple impacts. Consistent with other environmental
justice research into compensatory mitigation, the four socioeconomic variables (and metrics) I analyzed are minority populations (percent nonwhite), low educational attainment (percent of residents with an associate degree and below), population density, and median household income (200% of poverty level = $51,500). The Excel database displays the average values of the four demographic variables for each census tract and compares them with mitigation and permit site locations. Results are in tabular form comparing the demographics of census tracts that have permits, no permits, mitigation and no mitigation sites for the state and the service areas. Appendix E shows a screenshot of the Excel database.¹

Previous studies of EJ and compensatory mitigation compared the socioeconomic characteristics of census tracts around permit sites and mitigation sites. This type of comparison is only possible when the locations of permit sites can be directly linked to funded mitigation sites, which was not possible in this research because funds from all permits within a service area are pooled. The alternative methodology I developed, which compares (1) the demographics of census tracts around permit sites and the demographics of census tracts without permit sites, and (2) the demographics of census tracts around mitigation sites and the demographics of census tracts sites without mitigation sites, resolves the complication of how to consider census tracts with both permit and mitigation sites. Detailed, step-by-step methods used in the geospatial analysis are described in Appendix F.

To investigate the impact of degree of grouping on the analysis of EJ patterns, I analyzed socioeconomic variables for two different census tract groupings: The State of New Hampshire and focusing separately on the smaller regions defined by two ARM Fund service areas. The

¹ The full database will be made publicly available through the UNH Scholars Repository.
state-level analysis is consistent with statewide analyses in previous studies linking EJ and compensatory mitigation (Ruhl & Salzman, 2006; BenDor & Stewart, 2011; Dernoga, et al., 2015). A statewide analysis also makes sense because compensatory mitigation is administered as a statewide program. However, based on the 2008 Final Rule, the ARM Fund is implemented according to modified watersheds, the nine service areas. And, following from Hill et al. (2018), EJ research using spatial analysis should incorporate biophysical boundaries. For both these reasons, I also selected two service areas to analyze as a second way of grouping census tracts to analyze inequalities. I selected two service areas, Service Area Five (Merrimack Service Area) and Service Area Eight (Middle Connecticut Service Area), based on variation in population density, which previous studies have shown to be significant (Ruhl & Salzman, 2006; BenDor, et al., 2007; BenDor & Stewart, 2011). Merrimack Service Area is the largest service area in the state, the service area with the highest population density, and the service area with the most impacts to aquatic resources that require mitigation payments to the ARM Fund. In contrast, the Middle Connecticut Service Area has a relatively low population density, which allows for an assessment of how variation in population density affects the analysis across two service area groupings. Although other service areas have even lower population densities, the Middle Connecticut Service Area has experienced impacts to aquatic resources due to agricultural use and I expected the number of permits and impacts, while still relatively low, would be sufficient for analysis. The same steps used to find significant socioeconomic variables for the state, were applied to the two service area analyses and are detailed in Appendix F.

2.5 Statistical analysis

To conduct the statistical analysis, I created an Excel database with census tract demographic and ARM Fund project information, then ran statistical tests in STATA. “STATA
is a powerful statistical software that enables users to analyze, manage, and produce graphical visualizations of data (Hamilton, 2013).” Using STATA software, I tested for significant differences and trends in the demographic profiles of census tracts that have zero, one, and two or more permits. I also tested for differences and trends in the demographic profiles of census tracts that have zero, one, and two or more mitigation sites. In general, EJ theory suggests that environmental inequalities often are concentrated in places with comparatively poor, minority or otherwise less powerful populations. In the case of compensatory mitigation, environmental inequalities correspond to loss of aquatic resource functions and values, which causes already disadvantaged populations to become even more vulnerable. According to EJ theory, it is plausible to hypothesize that environmental restoration efforts, corresponding to mitigation projects, may be concentrated in relatively more privileged places. My analysis tests these hypotheses with regard to New Hampshire census tracts that contain permit or mitigation sites.

To evaluate these hypotheses, I ran a least-squares regression test for differences in means and a quantile regression test for differences in medians. I chose to conduct two kinds of statistical tests because population density and minority populations vary substantially throughout New Hampshire, and their distributions often contain outliers which can distort a statistical test using only means. Statistical tests based on means, such as analysis of variance (ANOVA) or least-squares regression, depend on assumptions of normality and equal variances that may not be realistic for these kinds of data. For example, the variability of population density itself varies considerably across the State of New Hampshire. Statistical tests based on means also are very sensitive to outliers. As a check on the robustness of statistical conclusions, I test for differences using both mean-based methods and outlier-resistant median-based methods.
(such as Kruskal-Wallis test or quantile regression) that make fewer assumptions. I also use box plots to visually compare distributions, highlighting the presence of any outliers.

The results from these statistical tests at the state level and for the two selected service areas provide a p-value, which indicates if the socioeconomic variable tested is significantly different at either a permit or mitigation site, at a specified confidence level. The tests also quantitatively summarize (with means and medians) characteristics of residents within a census tract that has had an impact or mitigation project. The means and median values for each of the three groups (0, 1, or 2 and more impacts or mitigation projects) allow me to compare values of locations that have no impacts and no mitigation projects (0 group) to those that do (1 and 2+ group). As mentioned above, this approach resolves the problem of census tracts that have both permit and mitigation sites within them. Using both differences of medians and means tests provides more robustness and confidence in the results.

2.6 Participation by EJ municipalities in the ARM Fund

Furthermore, locating EJ towns and cities in New Hampshire with aquatic restoration opportunities and a relatively high number of impact sites and no or few mitigation projects can help the ARM Fund administrators identify communities in which to prioritize outreach. To evaluate environmental justice communities’ participation in the ARM Fund, I conducted a series of geospatial techniques to first, identify EJ communities with potential aquatic restoration projects, second, evaluate their participation, and third, provide recommendations to the ARM Fund program to encourage future outreach.

As mentioned before, EPA has developed EJSCREEN, a national mapping and screening tool, which EPA Region 1 is using to prioritize actions in EJ communities, such as
increased public outreach, public hearings, and follow-up with communities (US EPA, 2013). Building on EJSCREEN, this study uses the tool to locate EJ communities in New Hampshire. I first used the EJ screen tool to identify towns and cities with populations with high state percentiles (75th and higher) for one of the three demographic indicators available: low income, below high school educational attainment, and high minority population. Figure 2.2 shows a screenshot of what the EJ Screen Tool looks like. The tool allows a user to select a demographic indicators category and then filter specific demographic variables. I focused on the three demographic indicators of interest to my research. Specifically, I took the top 85th state percentiles for low income, the top 85th state percentiles for below high school education indicators, and the top 75th percentile for minority populations (I used the 75th percentile so as to include more towns because the minority population in NH is low). In this research, a town or city is considered an EJ community if it falls into the upper quantile for at least one of these demographic indicators.

![Screenshot of the EPA EJ Screen Tool](Image)

**Figure 2.2:** Screenshot of the EPA EJ Screen Tool (Source: EJScreen, 2019)
After identifying a list of EJ communities, the next step is identifying how many EJ communities also have potential restoration opportunities. I identified the subset of EJ communities with potential restoration projects through two methods: (1) letters of deficiency dams issued by the NHDES Dam Bureau; and (2) the ARM Fund Mapper. Dam removal and modification projects are a type of aquatic restoration project that is eligible for ARM program funding and, in New Hampshire, the issuance of a letter of deficiency is a common catalyst for action on a dam (Diessner et al., 2020). I identified EJ towns and cities that have been issued a letter of deficiency for a dam in the last two years. The ARM Fund Mapper is a geospatial tool created by the ARM Fund to identify potential restoration projects in New Hampshire. The Mapper includes watershed characteristics and fish and wildlife habitat data. Using the ARM Fund Mapper, I identified EJ towns and cities that have aquatic systems with a low aquatic organism passage score (aquatic animals restricted from stream crossing) or a geomorphic compatibility score of mostly or fully incompatible (long-term compatibility of a stream crossing). Looking through the types of mitigation projects already funded (provided by ARM Fund coordinators), I noticed many of the projects are related to improving fish passage, restoring stream channels and floodplains, preserving and conserving acres of aquatic resources and more. The ARM Fund Mapper doesn’t have options for every kind of mitigation project funded, so I chose low aquatic organism passage score and a geomorphic compatibility score of mostly or fully incompatible as the criteria because they best fit with a majority of projects that can be funded.

By combining results from the EJ Screen Tool, the ARM Fund Mapper, and NHDES letters of deficiency, I identified 26 environmental justice communities in New Hampshire that have potential aquatic restoration projects (see Appendix D and Figure 2.2). This dataset helps
identify what kinds of aquatic restoration opportunities are available within New Hampshire’s 26 environmental justice communities. I then used data provided by the ARM Fund to identify which of these towns and municipalities have submitted proposals to the ARM Fund. Appendix D highlights municipalities that have participated in the ARM Fund and whether or not they received funding for mitigation projects. I interpreted submitting a proposal as evidence of participation because the town knew about the ARM Fund and had the capacity to submit a proposal, regardless of whether it was funded.

Figure 2.3: Location of the 26 environmental justice communities with aquatic restoration opportunities in New Hampshire
After providing a list of EJ communities with aquatic restoration opportunities, next I intended to provide recommendations to the ARM Fund for communities where program administrators could prioritize outreach, but where should the ARM Fund start with this targeted outreach? I used two geospatial techniques to identify locations where the ARM Fund should start prioritizing outreach. One technique I used was to create a heat map, located in Figure 2.4, which helps to find dense clusters of permits in the state. The heat map is a useful tool in this study because it helps find locations that experienced the most loss of aquatic resource functions and values, an environmental inequality, and geospatially determined the area with the highest permit clusters in the state. To run this tool, I chose to use the kernel density method and I input my permit sites as the point feature of interest. Only permits were used because I’m only interested in seeing where wetland functions and values have been lost. From this heat map, I found the “high permit cluster location” outlined in red in Figure 4.3.

Figure 2.4: Heat map with high permit cluster location.
The second method I used was conducting an “optimizing hot spot analysis”, which helped me find significant clusters that are unlikely to exist by chance, called hot spots. To run this test, I first included my input features, the spatial locations of each permit site within the high permit cluster. Only permits were used because the spatial locations of permits are represented as “points”, while mitigation projects are represented as “polygons” and polygon features are not compatible with this technique. Next, I used an optional feature called “incident data aggregation method”, which “averages the nearest neighbor distance (ANN) for all of the unique location points, excluding locational outliers, and is computed by summing the distance to each feature's nearest neighbor and dividing by the number of features (N) (Esri, n.d.).” This approach works well on smaller areas and can locate towns and municipalities with significant clustering of permit sites, as opposed to clustering resulting from chance. I assumed if I tried to find “hot spots” for the whole state, most of these hot spots would be in the high permit cluster location. I wanted to look within this cluster to see if EJ communities fall within locations where clusters are significant. Although the optimizing hot spot test could have been conducted for the entire state, this analysis focused on identifying significant clusters within the location with the most permit clusters to provide useful recommendations to the ARM Fund about specific EJ towns and cities for targeted outreach about the funding and restoration opportunities.
Chapter 3

The sections below present the results of the analyses of demographic factors and compensatory mitigation permit and mitigation sites. The section starts with the analysis of demographic factors around permit sites for the entire State of New Hampshire and then around mitigation sites for the State. Then, I present the analysis for the two selected service areas, again starting with demographic factors around permit sites, followed by the same analysis around mitigation sites. Last, I present the analysis of environmental justice towns and cities with aquatic restoration opportunities in the area of the state with the highest permit clusters.

3.1 EJ and compensatory mitigation analysis: The State of New Hampshire

Table 3.1 shows the racial makeup, population, median income, education and poverty levels of census tracts that have permit sites and no permit sites, mitigation sites and no mitigation site, and the demographics of all census tracts in New Hampshire. More people live around permit sites (total population: 512,769), as compared to around locations that have mitigations sites (total population: 356,028). The total population is lower around permit sites as compared to sites with no permits (total population: 819,079). The total population around mitigation sites is also lower, as compared to sites with no mitigation projects (total population: 975,820). In total, fewer people live around mitigation projects, as compared to around permit sites. Population density is somewhat higher around locations with permits (384.84), as compared to locations that have mitigation sites (374.47). However, based on observations, the population densities around permit and mitigation sites are more similar to one another, than when compared to population densities in locations with no permit sites (636.64) or mitigation sites (606.80). These findings could indicate wetlands are being impaired and restored in and
around more densely populated areas, as compared to the other areas of the state. The percentage of white populations is higher around permit sites (permit - white: 94.26%; mitigation - white: 95.61%), as compared to mitigation sites, which reflects a lower percentage of non-white populations around these sites (permit - nonwhite: 4.00%; mitigation - white: 2.74%). The percentages of the population having earned an Associate degree or below do not show many differences. Median household income is higher for populations around mitigation sites ($78,236), as compared to other sites, but median household income for populations around permit sites is also higher ($76,062), as compared to locations with no permits ($73,029). It appears that the median household income is higher and percentages of populations below the 200% poverty level are lower for populations around both places where wetland functions and values are being lost and restored.
Table 3.1: This table reflects socioeconomic profiles of NH census tracts, by whether they contain permit or mitigation sites. The socioeconomic data is separated into 3 categories: population, household income and education.

<table>
<thead>
<tr>
<th>In-Liu Fee (ILF) – New Hampshire</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permit Sites n = 186</td>
</tr>
<tr>
<td><strong>Population</strong></td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Population Density (Mean; Population/SqKm)</td>
</tr>
<tr>
<td>White (percent of total)</td>
</tr>
<tr>
<td>Non-White (percent of total)</td>
</tr>
<tr>
<td>American Indian</td>
</tr>
<tr>
<td>Asian</td>
</tr>
<tr>
<td>Black</td>
</tr>
<tr>
<td>Native Hawaiian</td>
</tr>
<tr>
<td>Some Other Race Alone</td>
</tr>
<tr>
<td><strong>Education (mean)</strong></td>
</tr>
<tr>
<td>Associates Degree and below</td>
</tr>
<tr>
<td>Bachelor’s degree and above</td>
</tr>
<tr>
<td><strong>Household Income</strong></td>
</tr>
<tr>
<td>Median Household Income</td>
</tr>
</tbody>
</table>
Table 3.2 compares the percent nonwhite and median household incomes of census tracts that have zero, one, and two or more permit sites. Both least-squares regression and quantile (median) regression results are shown with p-values to evaluate statistically significant differences. The p-value for the mean percent nonwhite variable is 0.11, which is close to significance at the 0.1 level, but the p-value for the median is 0.97. The difference between the two tests likely reflects many outliers that make mean-based tests or least-squares regression less trustworthy, as seen in the box and whisker plot in Figure 3.1 (techniques and statistical software described in Hamilton (2013)). As a result of the variable distribution, the mean may not be a good representation of the population within the census tract. Both analyses agree, however, that there is no trend in household income across number of permit sites. The mean and medians of the household income variable are relatively similar with very few outliers (Figure 3.2) and do not rise to the level of significance. Across all census tracts in the state, we find no significant differences between the percentage nonwhite populations or the median household incomes of permit and non-permit tracts.
Table 3.2: Comparison of percent nonwhite and household income, across New Hampshire census tracts with zero, one, and two or more permit sites.

<table>
<thead>
<tr>
<th># of Permit Sites</th>
<th>Mean % nonwhite</th>
<th>Median % nonwhite</th>
<th>Mean income ($1,000)</th>
<th>Median income ($1,000)</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4.94</td>
<td>2.77</td>
<td>74</td>
<td>71</td>
<td>186</td>
</tr>
<tr>
<td>1</td>
<td>3.11</td>
<td>1.98</td>
<td>76</td>
<td>74</td>
<td>57</td>
</tr>
<tr>
<td>2+</td>
<td>4.12</td>
<td>2.87</td>
<td>77</td>
<td>73</td>
<td>46</td>
</tr>
<tr>
<td>All</td>
<td>4.45</td>
<td>2.67</td>
<td>75</td>
<td>72</td>
<td>289</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.11</td>
<td>0.97</td>
<td>0.42</td>
<td>0.67</td>
<td></td>
</tr>
</tbody>
</table>

*p values from t tests in least-squares regression (means) or quantile regression (medians) of characteristics on number of sites.

*p < .10 **p < .05

Table 3.3 compares census tracts with zero, one, and two or more permit sites for percent of the population with low educational attainment (below an associate degree) and population density. Educational attainment shows no significant trends in means or medians. Looking at the numbers for the mean and median population density around permit sites in Table 3.3, there does
appear to be a trend with higher population densities around locations with no permit sites, lower population densities around locations with one permit site, and even lower population densities around locations with two or more permit sites. Mean population density shows a significant trend at the 0.05 level (p-value=0.03), and the median population density approaches significance (p=0.12). The larger differences among population density means (compared with medians) reflects the influence of many outliers that are visible in Figure 3.4. Both mean and median analyses agree that places with more permit sites nearby are likely to have lower population densities than places without permit sites.

Table 3.3: Comparison of percent low educational attainment and population density, across New Hampshire census tracts with zero, one, and two or more permit sites.

<table>
<thead>
<tr>
<th># of Permit Sites</th>
<th>Mean % low educational attainment</th>
<th>Median % low educational attainment</th>
<th>Mean population density (population per sq. km)</th>
<th>Median population density (population per sq. km)</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>49.97</td>
<td>46.17</td>
<td>631.33</td>
<td>160.09</td>
<td>189</td>
</tr>
<tr>
<td>1</td>
<td>54.70</td>
<td>53.41</td>
<td>478.98</td>
<td>146.15</td>
<td>57</td>
</tr>
<tr>
<td>2+</td>
<td>49.01</td>
<td>46.01</td>
<td>268.19</td>
<td>57.470</td>
<td>46</td>
</tr>
<tr>
<td>All</td>
<td>50.74</td>
<td>46.53</td>
<td>544.39</td>
<td>148.59</td>
<td>292</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.84</td>
<td>0.84</td>
<td>0.03**</td>
<td>0.12</td>
<td></td>
</tr>
</tbody>
</table>

*p values from t tests in least-squares regression (means) or quantile regression (medians) of characteristics on number of sites

*p < .10 **p < .05
Table 3.4 compares the percent nonwhite populations and median household income of census tracts with zero, one, and two or more mitigation sites. Mean percent nonwhite is significantly related to number of mitigation sites ($p=0.00$) and median percent nonwhite approaches significance ($p=0.15$). The difference between the two tests may be explained by the numerous outliers in the percent nonwhite population among areas without mitigation sites (Figure 3.5). In general, it appears that census tracts with no mitigation sites also have the highest percentage of nonwhites. This finding is consistent with environmental injustice concerns, which would expect areas with a whiter population to benefit more from aquatic restoration opportunities.

Mean and median household income varies significantly between census tracts with zero, one, and two or more mitigation sites ($p=0.08$ for both). Populations around mitigation sites tend to be wealthier than populations around areas without mitigation sites and the trend is consistent as the number of mitigation sites increases from one to two or more. This finding is also
consistent with environmental justice concerns, which would expect areas with a wealthier population to benefit more from aquatic restoration opportunities.

Table 3.4: Comparison of percent nonwhite and household income, across New Hampshire census tracts with zero, one, and two or more mitigation sites.

<table>
<thead>
<tr>
<th># of mitigation Sites</th>
<th>Mean % nonwhite</th>
<th>Median % nonwhite</th>
<th>Mean Income ($1,000)</th>
<th>Median income ($1,000)</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.01</td>
<td>2.84</td>
<td>74</td>
<td>70</td>
<td>220</td>
</tr>
<tr>
<td>1</td>
<td>2.81</td>
<td>1.55</td>
<td>77</td>
<td>75</td>
<td>52</td>
</tr>
<tr>
<td>2+</td>
<td>2.53</td>
<td>2.21</td>
<td>83</td>
<td>82</td>
<td>21</td>
</tr>
<tr>
<td>All</td>
<td>4.44</td>
<td>2.66</td>
<td>75</td>
<td>72</td>
<td>293</td>
</tr>
<tr>
<td><strong>P-Value</strong></td>
<td>0.00**</td>
<td>0.15</td>
<td>0.08*</td>
<td>0.08*</td>
<td></td>
</tr>
</tbody>
</table>

*p values from t tests in least-squares regression (means) or quantile regression (medians) of characteristics on number of sites

*p < .10 **p < .05

Figure 3.5: Box and Whisker plot of percent nonwhite population by the number of mitigation sites in New Hampshire

Figure 3.6: Box and Whisker plot of the median household income by the number of mitigation sites in the state of New Hampshire
Table 3.5 compares census tracts with zero, one, and two or more mitigation sites for percent low educational attainment (below associates degree) and population density. Although the mean and median percentages of the population with low educational attainment appear somewhat higher for populations around both one and two or more mitigation sites, as compared to areas without mitigation sites, the differences do not rise to the level of statistical significance (p=0.55 and p=0.80, respectively). The mean and median population densities around mitigation sites vary substantially, ranging from 548 people per square kilometer to 151 people per square kilometer, and their trends are significant at the 0.1 level (p=0.06 and p=0.05 respectively). There are many more areas without mitigation sites, as compared to areas with mitigation sites, and population density varies considerably in areas without mitigation sites (Figure 3.8). Population density around areas with one mitigation site is lower, as compared to areas without mitigation sites. Population densities around areas with two or more mitigation sites are even lower. Population density is not a factor typically included as an environmental justice consideration. However, the findings indicate aquatic restoration opportunities are more likely to benefit areas with lower population density in the state.
Table 3.5: Comparison of percent low educational attainment and population density, across New Hampshire census tracts with zero, one, and two or more mitigation sites.

<table>
<thead>
<tr>
<th># of Mitigation Sites</th>
<th>Mean % low educational attainment</th>
<th>Median % low educational attainment</th>
<th>Mean population density (population per sq. km)</th>
<th>Median population density (population per sq. km)</th>
<th>count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>50.10</td>
<td>46.18</td>
<td>604.12</td>
<td>175.75</td>
<td>220</td>
</tr>
<tr>
<td>1</td>
<td>53.08</td>
<td>49.46</td>
<td>458.36</td>
<td>110.87</td>
<td>52</td>
</tr>
<tr>
<td>2+</td>
<td>51.31</td>
<td>47.30</td>
<td>183.70</td>
<td>42.30</td>
<td>21</td>
</tr>
<tr>
<td>All</td>
<td>50.71</td>
<td>46.53</td>
<td>548.12</td>
<td>151.03</td>
<td>293</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.55</td>
<td>0.80</td>
<td>0.06*</td>
<td>0.05*</td>
<td></td>
</tr>
</tbody>
</table>

*p values from t tests in least-squares regression (means) or quantile regression (medians) of characteristics on number of sites

*p < .10 **p < .05

The sections below present results from our analyses of demographic factors and compensatory mitigation sites in two ARM Fund service areas with varying population densities:

Service Area Five, Merrimack and Service Area Eight, Middle Connecticut.
3.2 Merrimack Service Area (Service Area Five)

Tables 3.1-3.5 analyzed all census tracts in New Hampshire. In this section, we focus only on Service Area Five (Merrimack Service Area) to identify significant trends at the service area level, which is how the ARM Fund implements the mitigation program. Table 3.6 shows the demographic characteristics of populations in Merrimack Service Area around permit sites, places without permits, mitigation sites, places without mitigation sites and across all census tracts. Merrimack Service Area includes New Hampshire’s three most populous cities, Manchester, Concord, and Nashua. I selected this service area because of its relatively high population density. Therefore, unsurprisingly, compared to the demographics of the entire state, population density and median household income in Merrimack Service Area are higher for every type of location (with permit sites, without permits, with mitigation sites, without mitigation sites, and for all of the Merrimack Service Area).

Table 3.3 showed that, for the state as a whole, census tracts with more permit sites tend to have lower population density. Table 4.6 indicates this is true within the Merrimack Service Area, as well. Population density in this area is also lower around mitigation sites (721.34), as compared to places with no mitigation sites (846.09), consistent with statewide results in table 3.5. The total numbers of people living around either permit (202,901) or mitigation sites (118,554) are also lower than the number of people living around places without ARM Fund sites. A possible consequence could be that many people in the state are unfamiliar with ARM Fund projects. In the Merrimack Service Area, the average nonwhite population is highest for census tracts around permit locations (5.36%), where wetland functions are being lost due to development, and lowest for census tracts around mitigation sites (2.77%), where aquatic functions are being restored. In statewide data, I saw no relationship between number of permit
sites, and percent nonwhite. However, much of the state's nonwhite population resides in the Merrimack area, so the focused analysis in Table 4.6 could be more meaningful.

**Table 3.6:** This table reflects socioeconomic profiles of Service Area 5 (Merrimack) census tracts, by whether they contain permit or mitigation sites. The socioeconomic data are separated into 3 categories: population, household income and education.

<table>
<thead>
<tr>
<th>In-Liu Fee (ILF) – Service area 5 (Merrimack Service Area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permit sites  n = 57</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td><strong>Population</strong></td>
</tr>
<tr>
<td>Total</td>
</tr>
<tr>
<td>Population Density</td>
</tr>
<tr>
<td><strong>White (percent of total)</strong></td>
</tr>
<tr>
<td><strong>Non-White (percent of total)</strong></td>
</tr>
<tr>
<td>American Indian</td>
</tr>
<tr>
<td>Asian</td>
</tr>
<tr>
<td>Black</td>
</tr>
<tr>
<td>Native Hawaiian</td>
</tr>
<tr>
<td>Some Other Race Alone</td>
</tr>
<tr>
<td><strong>Education (mean)</strong></td>
</tr>
<tr>
<td>Associates Degree and below</td>
</tr>
<tr>
<td>Bachelor’s degree and above</td>
</tr>
<tr>
<td><strong>Household Income</strong></td>
</tr>
<tr>
<td>Median Household Income</td>
</tr>
<tr>
<td>Permit Sites below 200% Poverty Level (n = 4)</td>
</tr>
</tbody>
</table>
The results in Table 3.7 show results from statistical tests of demographic differences in Merrimack Service Area for percent nonwhite populations and median household income in census tracts with zero, one, and two or more permit sites. The mean and median nonwhite populations are not significant (p=0.92 and p=0.78, respectively). The mean for median income is significant between permit groupings at the 0.1 level (p=0.06), suggesting income may be higher in areas with one or more permit sites. However, the median test for median income is not (p=0.24) significant. The difference between the two tests may be explained by the greater variation in median income around areas without permits or the presence of an outlier (Figure 3.10).
Table 3.7: Comparison of percent nonwhite and household income, across Service Area 5 census tracts with zero, one, and two or more permit sites.

<table>
<thead>
<tr>
<th># of Permit Sites</th>
<th>Mean % nonwhite</th>
<th>Median % nonwhite</th>
<th>Mean income ($1,000)</th>
<th>Median income ($1,000)</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.65</td>
<td>3.31</td>
<td>80</td>
<td>79</td>
<td>117</td>
</tr>
<tr>
<td>1</td>
<td>4.80</td>
<td>3.26</td>
<td>83</td>
<td>83</td>
<td>26</td>
</tr>
<tr>
<td>2+</td>
<td>6.29</td>
<td>4.18</td>
<td>97</td>
<td>94</td>
<td>10</td>
</tr>
<tr>
<td>All</td>
<td>5.55</td>
<td>3.31</td>
<td>81</td>
<td>82</td>
<td>153</td>
</tr>
</tbody>
</table>

P-Value: 0.92 0.78 0.06* 0.24

*p values from t tests in least-squares regression (means) or quantile regression (medians) of characteristics on number of sites.

*p < .10 **p < .05

Figure 3.9: Box and Whisker plot of percent nonwhite population by the number of permit sites in Service Area 5.

Figure 3.10: Box and Whisker plot of the median household income by the number of permit sites in Service Area 5.
Table 3.8 compares demographic characteristics for census tracts with zero, one, and two or more permit sites for percent of the population with low educational attainment (below associates degree) and population density. Differences in means and medians for educational attainment between the different types of sites do not rise to significance (p=0.64 and p=0.84, respectively). Sites with at least one permit site appear to have lower population density, but the differences in population densities between the different types of sites do not rise to significance (p=0.42 and p=0.57, respectively).

Table 3.8: Comparison of percent low educational attainment and population density, across Service Area 5 census tracts with zero, one, and two or more permit sites.

<table>
<thead>
<tr>
<th># of Permit Sites</th>
<th>Mean % educational attainment</th>
<th>Median % educational attainment</th>
<th>Mean population density (population per sq. km)</th>
<th>Median population density (population per sq. km)</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>39.93</td>
<td>41.36</td>
<td>861.87</td>
<td>233.54</td>
<td>117</td>
</tr>
<tr>
<td>1</td>
<td>41.51</td>
<td>42.15</td>
<td>712.65</td>
<td>304.32</td>
<td>26</td>
</tr>
<tr>
<td>2+</td>
<td>36.29</td>
<td>33.75</td>
<td>558.06</td>
<td>311.17</td>
<td>10</td>
</tr>
<tr>
<td>All</td>
<td>39.97</td>
<td>41.45</td>
<td>817.24</td>
<td>245.53</td>
<td>153</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.64</td>
<td>0.84</td>
<td>0.42</td>
<td>0.57</td>
<td></td>
</tr>
</tbody>
</table>

*p values from t tests in least-squares regression (means) or quantile regression (medians) of characteristics on number of sites

*p < .10 **p < .05
Table 3.9 compares the demographic characteristics of census tracts with zero, one, and two or more mitigation sites for percent nonwhite populations and median household income. The mean percent nonwhite population is significant for mitigation sites (p=0.01), but the median percent nonwhite population is not (p=0.26). Figure 3.13 shows a box and whisker plot displaying the outliers and the ranges between the zero, one and two or more groups for the nonwhite group. Consistent with the mean statistical analysis, Figure 3.13 shows lower percentages of nonwhite populations around places with at least one mitigation project and an even lower percentage of nonwhite populations around two more mitigation projects. These results are also consistent with what would be expected if environmental justice concerns are a factor. Mean and median tests of the differences in median household income are not significant (p=0.29 and p=0.21, respectively).
Table 3.9: Comparison of percent nonwhite and household income, across Service Area 5 census tracts with zero, one, and two or more mitigation sites.

<table>
<thead>
<tr>
<th># of mitigation Sites</th>
<th>Mean % nonwhite</th>
<th>Median % nonwhite</th>
<th>Mean income ($1,000)</th>
<th>Median income ($1,000)</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>6.14</td>
<td>3.48</td>
<td>80</td>
<td>80</td>
<td>129</td>
</tr>
<tr>
<td>1</td>
<td>2.65</td>
<td>2.07</td>
<td>85</td>
<td>87</td>
<td>18</td>
</tr>
<tr>
<td>2+</td>
<td>2.59</td>
<td>2.29</td>
<td>87</td>
<td>92</td>
<td>8</td>
</tr>
<tr>
<td>All</td>
<td>5.55</td>
<td>3.32</td>
<td>81</td>
<td>82</td>
<td>155</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.01**</td>
<td>0.26</td>
<td>0.29</td>
<td>0.21</td>
<td></td>
</tr>
</tbody>
</table>

*p values from t tests in least-squares regression (means) or quantile regression (medians) of characteristics on number of sites.

*p < .10 **p < .05

Table 3.10 compares the demographic characteristics of census tracts with zero, one, and two or more mitigation sites for percent of the population with low educational attainment and population density. Differences in the mean percent low education attainment just reach a level of significance (p=0.1), but the test of the median percent low educational attainment does not
(p=0.52). The box and whisker plots do not show a clear relationship between the types of places either. Differences in mean and median population densities at the different sites are not significant (p=0.30 and p=0.55, respectively), but they do follow a rough pattern I have seen before: census tracts with more mitigation sites tend to have lower population densities.

Table 3.10: Comparison of percent low educational attainment and population density, across Service Area 5 census tracts with zero, one, and two or more mitigation sites.

<table>
<thead>
<tr>
<th># of mitigation Sites</th>
<th>Mean % low educational attainment</th>
<th>Median % low educational attainment</th>
<th>Mean population density (population per sq. km)</th>
<th>Median population density (population per sq. km)</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>39.42</td>
<td>41.32</td>
<td>851.90</td>
<td>276.16</td>
<td>129</td>
</tr>
<tr>
<td>1</td>
<td>42.15</td>
<td>43.32</td>
<td>821.49</td>
<td>219.63</td>
<td>18</td>
</tr>
<tr>
<td>2+</td>
<td>43.95</td>
<td>42.67</td>
<td>248.72</td>
<td>106.50</td>
<td>8</td>
</tr>
<tr>
<td>All</td>
<td>39.97</td>
<td>41.45</td>
<td>817.24</td>
<td>245.53</td>
<td>155</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.10*</td>
<td>0.52</td>
<td>0.30</td>
<td>0.55</td>
<td></td>
</tr>
</tbody>
</table>

p values from t tests in least-squares regression (means) or quantile regression (medians) of characteristics on number of sites

*p < .10 **p < .05
3.3 Middle Connecticut Service Area (Service Area Eight)

Tables 3.6-3.10 analyzed all census tracts in Merrimack Service Area. In this section, I focus only on Service Area Eight (Middle Connecticut Service Area) to identify significant trends in a less densely populated service area. I selected the Middle Connecticut Service Area because of its relatively low population density, and population density seems to be a significant variable for the entire state and Merrimack Service Area. Therefore, unsurprisingly, as compared to the state, Middle Connecticut has a lower total population and lower population density. Table 3.11 shows the demographic characteristics of populations in census tracts with permit sites, without permit sites, with mitigation sites, without mitigation sites, and all census tracts in the Middle Connecticut Service Area.

In contrast to the patterns observed for the state and for Merrimack Service Area, population density is higher around both permit sites (20.56) and mitigation sites (20.47), as compared to places without permits (12.88) and places without mitigation projects (14.46). On average, fewer non-white people live in census tracts with permit sites (2.60%), as compared to
places without permits (8.34%). On average, fewer nonwhite people live in census tracts around the eight mitigation projects in the service area (2.70%), as compared to places without mitigation projects (7.24%). Higher percentages of people with low educational attainment live in census tracts around permit sites (26.17%), as compared to all other sites. Median household income is highest in census tracts around mitigation projects ($83,003). No census tracts with mitigation projects have populations below 200% of New Hampshire’s poverty level.

| Table 3.11: This table reflects socioeconomic profiles of Service Area 8 (Middle Connecticut)) census tracts, by whether they contain permit or mitigation sites. The socioeconomic data are separated into 3 categories: population, household income and education. |
|---|---|---|---|---|---|
| **ILF - Service area 8 (Middle Connecticut Service Area)** | Permit sites n = 17 | No Permit n = 8 | Mitigation sites n = 8 | No Mitigation n = 10 | All Middle Connecticut n = 15 |
| **Population** | | | | | |
| Total | 28,010 | 36,017 | 19,929 | 44,098 | 64,027 |
| Population Density (Mean;Population/SqKm) | 20.56 | 12.88 | 20.47 | 14.46 | 16.47 |
| White (percent of total) | 95.89% | 89.55% | 95.36% | 90.96% | 92.33% |
| Non-White (percent of total) | 2.60% | 8.34% | 2.70% | 7.24% | 5.83% |
| **American Indian** | 23.35% | 7.69% | 20.04% | 9.18% | 10.75% |
| **Asian** | 54.26% | 67.37% | 66.23% | 64.57% | 64.81% |
| **Black** | 20.33% | 18.98% | 9.46% | 20.90% | 19.24% |
| **Native Hawaiian** | <1% | <1% | <1% | <1% | <1% |
| **Some Other Race Alone** | 1.65% | 5.03% | 3.71% | 4.48% | 4.37% |
| **Education (mean)** | | | | | |
| Associates Degree and below | 43.07% | 36.99% | 37.13% | 41.17% | 39.85% |
| Bachelor’s degree and above | 26.17% | 28.91% | 32.95% | 24.98% | 27.63% |
### Household Income

<table>
<thead>
<tr>
<th>Median Household Income</th>
<th>Permit sites below 200% Poverty Level (n = 2)</th>
<th>Non-permit sites below 200% Poverty Level (n = 2)</th>
<th>Mitigation Sites below 200% Poverty Level (n = 0)</th>
<th>Non-mitigation sites below 200% Poverty Level (n = 4)</th>
<th>All Middle Connecticut census tracts below 200% Poverty Level (n= 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$67,476</td>
<td>$69,453</td>
<td>$83,003</td>
<td>$61,294</td>
<td>68,530</td>
<td></td>
</tr>
</tbody>
</table>

| % of Total Site Type | 13.3% | 25% | 0% | 40% | 26.7% |

^a Percentage represents the amount of people that fall below 200% of the poverty line ($51,500)

Table 3.12 compares the demographic characteristics of census tracts with zero, one, and two or more mitigation sites for percentage nonwhite population and median household income. Statistical tests of the mean and median percent nonwhite population do not rise to the level of significance (p=0.20 and p=0.83, respectively). Mean and median tests of differences in median income also do not rise to the level of significance (p=0.46 and p=0.77, respectively).

### Table 3.12: Comparison of percent nonwhite and household income, across Service Area 8 census tracts with zero, one, and two or more permit sites.

<table>
<thead>
<tr>
<th># of Permit Sites</th>
<th>Mean % nonwhite</th>
<th>Median % nonwhite</th>
<th>Mean income ($1,000)</th>
<th>Median income ($1,000)</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.82</td>
<td>2.63</td>
<td>70</td>
<td>58</td>
<td>8</td>
</tr>
<tr>
<td>1</td>
<td>5.41</td>
<td>5.41</td>
<td>100</td>
<td>100</td>
<td>2</td>
</tr>
<tr>
<td>2+</td>
<td>2.01</td>
<td>1.79</td>
<td>54</td>
<td>54</td>
<td>5</td>
</tr>
<tr>
<td>All</td>
<td>4.50</td>
<td>2.62</td>
<td>68</td>
<td>59</td>
<td>15</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.20</td>
<td>0.83</td>
<td>0.46</td>
<td>0.77</td>
<td></td>
</tr>
</tbody>
</table>
$p$ values from $t$ tests in least-squares regression (means) or quantile regression (medians) of characteristics on number of sites.

* $p < .10$  ** $p < .05$

Table 3.13 compares the demographic characteristics of census tracts with zero, one, and two or more permit sites for percent low educational attainment and population density. Statistical tests of the mean and median percent of the population with low educational attainment do not rise to the level of significance ($p=0.19$ and $p=0.33$, respectively). Although mean and median population densities appear to be lower in sites without permits, the tests of differences in population densities do not rise to the level of significance ($p=0.38$ for the mean and $p=0.42$ for the median).
Table 3.13: Comparison of percent low educational attainment and population density, across Service Area 8 census tracts with zero, one, and two or more permit sites.

<table>
<thead>
<tr>
<th># of Permit Sites</th>
<th>Mean % low educational attainment</th>
<th>Median % low educational attainment</th>
<th>Mean population density (population per sq. km)</th>
<th>Median population density (population per sq. km)</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>36.97</td>
<td>41.32</td>
<td>12.88</td>
<td>9.08</td>
<td>8</td>
</tr>
<tr>
<td>1</td>
<td>29.98</td>
<td>29.98</td>
<td>24.46</td>
<td>24.46</td>
<td>2</td>
</tr>
<tr>
<td>2+</td>
<td>48.30</td>
<td>49.11</td>
<td>19.01</td>
<td>18.44</td>
<td>5</td>
</tr>
<tr>
<td>All</td>
<td>39.83</td>
<td>44.78</td>
<td>16.47</td>
<td>10.14</td>
<td>15</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.19</td>
<td>0.33</td>
<td>0.38</td>
<td>0.42</td>
<td></td>
</tr>
</tbody>
</table>

p values from t tests in least-squares regression (means) or quantile regression (medians) of characteristics on number of sites

*p < .10  **p < .05

---

Table 3.14 compares the demographic characteristics of census tracts with zero, one, and two or more mitigation sites for percent nonwhite populations and median household income.
Statistical tests of the mean and median percent nonwhite population do not rise to the level of significance (p=0.40 and p=0.99, respectively). Mean and median tests of differences in median income also do not rise to the level of significance (p=0.42 and p=0.54, respectively).

Table 3.14: Comparison of percent nonwhite and household income, across Service Area 8 census tracts with zero, one, and two or more mitigation sites.

<table>
<thead>
<tr>
<th># of mitigation Sites</th>
<th>Mean % nonwhite</th>
<th>Median % nonwhite</th>
<th>Mean income ($1,000)</th>
<th>Median income ($1,000)</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.16</td>
<td>2.38</td>
<td>61</td>
<td>54</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>3.76</td>
<td>2.78</td>
<td>90</td>
<td>80</td>
<td>4</td>
</tr>
<tr>
<td>2+</td>
<td>0.77</td>
<td>0.77</td>
<td>54</td>
<td>54</td>
<td>1</td>
</tr>
<tr>
<td>All</td>
<td>4.50</td>
<td>2.62</td>
<td>69</td>
<td>59</td>
<td>15</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.40</td>
<td>0.99</td>
<td>0.42</td>
<td>0.54</td>
<td></td>
</tr>
</tbody>
</table>

*p values from t tests in least-squares regression (means) or quantile regression (medians) of characteristics on number of sites.

*p < .10 **p < .05

**Figure 3.21:** Box and Whisker plot of percent nonwhite population by the number of mitigation sites in Service Area 8.

**Figure 3.22:** Box and Whisker plot of median household income by the number of mitigation sites in Service Area 8.
Table 3.15 compares the demographic characteristics of census tracts with zero, one, and two or more mitigation sites for percent low educational attainment and population density. Statistical tests of the mean and median percent of the population with low educational attainment do not rise to the level of significance (p=0.81 and p=0.78, respectively). Although the population density of the one census tract with two or more mitigation sites is higher than the other places, the mean and median tests of differences in population density do not rise to the level of significance (p=0.14 and p=0.17, respectively), and little can be inferred from a single census tract.

Table 3.15: Comparison of percent low educational attainment and population density, across Service Area 8 census tracts with zero, one, and two or more mitigation sites.

<table>
<thead>
<tr>
<th># of mitigation Sites</th>
<th>Mean % educational attainment</th>
<th>Median % educational attainment</th>
<th>Mean population density (population per sq. km)</th>
<th>Median population density (population per sq. km)</th>
<th>Count</th>
</tr>
</thead>
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<tr>
<td>0</td>
<td>41.17</td>
<td>46.48</td>
<td>14.46</td>
<td>9.72</td>
<td>10</td>
</tr>
<tr>
<td>1</td>
<td>35.22</td>
<td>37.23</td>
<td>15.02</td>
<td>13.59</td>
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<tr>
<td>2+</td>
<td>44.78</td>
<td>44.78</td>
<td>42.30</td>
<td>42.30</td>
<td>1</td>
</tr>
<tr>
<td>All</td>
<td>39.83</td>
<td>44.78</td>
<td>16.47</td>
<td>10.14</td>
<td>15</td>
</tr>
<tr>
<td>P-Value</td>
<td>0.81</td>
<td>0.78</td>
<td>0.14</td>
<td>0.17</td>
<td></td>
</tr>
</tbody>
</table>

*p values from t tests in least-squares regression (means) or quantile regression (medians) of characteristics on number of sites.*
3.4 Evaluating ARM Fund Participation by EJ Communities

After evaluating demographic differences between census tracts with 0, 1 or 2+ permit sites, and between tracts with 0, 1 or 2+ mitigation sites for the state as a whole, and within two sub-areas (Merrimack and Middle Connecticut Service Areas), I evaluated participation of environmental justice communities in the ARM Fund program. From the 26 EJ communities with potential aquatic restoration projects in New Hampshire, I used data provided by the Arm Fund coordinators to identify which municipalities in New Hampshire have already submitted proposals for mitigation project funding. Of the 26 EJ communities, 12 communities have submitted proposals and received funding, three communities have submitted proposals but not receive funding and 11 communities have never submitted proposals for mitigation project funding. Almost half of the EJ communities have submitted proposals and most of those have been funded, but the other half of the EJ communities still have not submitted proposals, so the arm fund could consider outreach to these communities.

3.5 Highest Permit Cluster Location

![Figure 3.23: Box and Whisker plot of low educational attainment by the number of mitigation sites in Service Area 8.](image1)

![Figure 3.24: Box and Whisker plot of population density by the number of mitigation sites in Service Area 8.](image2)
Next, I want to recommend environmental justice towns and municipalities with restoration opportunities, that have experienced substantial loss of wetlands for the ARM Fund administrators to prioritize outreach. Using the clustering approach from Kedron (2016), I identified significant clusters of areas in New Hampshire that have been exposed to the most wetland loss. Using the ArcMap geospatial program (Esri, n.d.), I identified the highest and lowest clusters of permit locations throughout the state, creating a heat map showing two highly clustered locations of permit sites in southeastern New Hampshire (Figure 3.25). Using geospatial tools, I then clipped a polygon that includes the two high cluster locations in southeastern NH (outlined in red in Figure 3.25).
Figure 3.25: Heat map (kernel method) showing density of permit sites throughout New Hampshire.

Using this clip, I then created a smaller map (Figure 3.26), which maps the permit and mitigation sites within this high permit cluster area and the environmental justice towns and cities with aquatic restoration opportunities.

Figure 3.26: Highest clusters of permit sites in New Hampshire showing environmental justice communities with aquatic restoration opportunities.

To identify statistically significant permit clusters within the highest cluster region, I used the optimizing hot spots GIS statistical tool. Clusters of significance or “hot spots” are shown in Figure 3.27. No significant cold spots were identified in the area selected.
Figure 3.27: Optimizing hot spot test results within the selected highest cluster area

Within the identified significant hot spots of permits, I identified three EJ communities with aquatic restoration opportunities (with a 95% confidence interval): Manchester, Dover, and Newington (Figure 3.28). As of 2019, there have been three mitigation projects in Manchester, two in Dover and one in Newington, indicating the communities are able to successfully participate in the ARM Fund program. In 2019, the Arm Fund focused on mitigation projects from only the Merrimack Service Area, reflecting significant payments into the Fund from this region. Using an EJ lens, within the Merrimack Service Area, Manchester should be prioritized for outreach to foster successful mitigation projects.
Figure 3.28: Results from optimizing hot spots of permits and identifying EJ communities with potential mitigation projects.

I then compared the significant hot spots with the four demographic variables of interest (Figure 3.29). Compared to the state, Manchester and Dover have slightly higher population densities, higher nonwhite populations, and lower educational attainment. In contrast to the state, permits in these two EJ towns have lower population density. This reiterates the finding that the selection of groupings of census tracts, at the state, service area, or municipality/town level, can lead to different results when analyzing inequalities. Newington also has a relatively high population with low educational attainment. The median household income in Manchester is
much lower than the statewide average and much of the City’s median income falls below two hundred percent of New Hampshire’s poverty level ($51,500).

Figure 3.29: Population density, low educational attainment, percentage of nonwhite population, and median household income surrounding the three hot spot environmental justice communities with mitigation opportunities.

Manchester, Dover, and Newington are EJ communities that have experienced significant losses of aquatic functions and values (high numbers of permits), which also have aquatic
restoration opportunities. This methodology presents a potential future application of GIS using an EJ lens to develop policy recommendations.

Out of the nine environmental justice communities within the high impact cluster location, only two communities have not submitted proposals nor received any mitigation funds. The ARM Fund has already received proposals from 78% of the EJ communities within the part of the state experiencing the most negative impacts. Based on my findings, the ARM Fund could, for example, prioritize outreach efforts to support development of future mitigation projects by these EJ communities, when funds are made available within the service area.
Chapter 4: Discussion

4.1 EJ Patterns and Compensatory Mitigation Policy

A summary of the significant findings from the analyses of demographic characteristics around permit and mitigation sites is provided in Table 4.1. At the statewide grouping, the finding that population densities are lower around both permit sites and around mitigation sites is surprising. Among other ranking criteria, ARM Fund mitigation projects are more competitive if they are near other conservation lands or unfragmented land parcels, which may explain the tendency for mitigation projects to be located in less densely populated areas. The large number of transportation projects paying into the ARM Fund for road widening and expansion may be taking place in less densely populated census tracts, which may explain the tendency for permit sites to also be located in less densely populated areas.

If the restoration of aquatic resources is considered a net benefit, then the finding that populations around mitigation sites are more likely to have higher percentages of white and higher-income populations is consistent with concerns about environmental justice. Areas with people who have more privilege and resources are able to successfully compete for new restoration projects to enhance local aquatic functions and values, such as aesthetics, flood risk management, and recreational benefits. Areas with people with less privilege and resources have fewer restoration projects.
Table 4.1: Summary of statistically significant demographic variables around permit and mitigation sites for the state, Service Area Five and Service Area Eight.

<table>
<thead>
<tr>
<th>Site type</th>
<th>% Nonwhite population</th>
<th>Population density</th>
<th>% Low educational attainment</th>
<th>Median household income</th>
</tr>
</thead>
</table>
| New Hampshire
| Permit | No significant differences | Populations around permit sites more likely to have lower population densities (mean test) | No significant differences | No significant differences |
| Mitigation | Populations around mitigation sites more likely to have lower % nonwhite population (mean test) | Populations around mitigation sites more likely to have lower population densities (mean and median tests) | No significant differences | Populations around mitigation sites more likely to have higher income (mean and median tests) |
| Merrimack Service Area
| Permit | No significant differences | No significant differences | No significant differences | No significant differences |
| Mitigation | Populations around mitigation sites more likely to have lower % nonwhite population (mean test) | No significant differences | Populations around mitigation sites more likely to have higher % low educational attainment population (mean test) | No significant differences |
| Middle Connecticut
| Permit | No significant differences | No significant differences | No significant differences | No significant differences |
In contrast, in the more densely populated Merrimack Service Area, populations around permit sites were more likely to have higher incomes. However, like the state grouping, in this service area populations around mitigation sites were more likely to have higher percentages of white populations. These populations were also more likely to have lower educational attainment, which conflicts with expectations for EJ concerns. In the less densely populated Middle Connecticut Service Area, no significant demographic patterns were observed.

Some of the findings in New Hampshire contrast with findings from previous literature. However, the statistical approach I applied may also make it difficult to compare some findings. I did not directly compare census tracts with permit sites to census tracts with mitigation sites. Instead, I resolved the difficulty of analyzing census tracts that have both permit and mitigation sites by comparing census tracts without permits to tracts with one and two or more permits. Similarly, I compared census tracts without mitigation projects to tracts with one and two or more mitigation projects. In New Hampshire, the finding that census tracts with mitigation sites are more likely to have lower population densities than census tracts without mitigation sites is consistent with the findings from Florida, Chicago, and North Carolina, that show relocation of aquatic functions from more densely populated areas to less densely populated areas (BenDor et al., 2007; BenDor & Stewart, 2011; Ruhl & Salzman, 2006). However, in New Hampshire, I also find that populations around permit sites are more likely to have lower population densities, as compared to populations around areas without permit sites. While population density seems to be a significant factor in the implementation of compensatory mitigation programs, my analysis
suggests differences exist for both areas where aquatic functions and values are lost and gained, as compared to areas without either permit or mitigation sites. The results from New Hampshire suggest compensatory mitigation activities of both kinds tend to occur in areas with lower population densities.

The statewide finding for New Hampshire that populations around mitigation sites are more likely to have lower percentages of nonwhite populations and higher percentages of white populations is consistent with findings from North Carolina and Maryland that mitigation restores aquatic functions and values in areas with higher percentages of white people. This consistency across statewide findings is interesting considering that New Hampshire has a much whiter overall population, as compared to North Carolina and Maryland (BenDor & Stewart, 2011; Dernoga, 2015). As a result, compensatory mitigation programs may want to pay particular attention to engaging areas with higher nonwhite populations in fostering aquatic restoration opportunities.

4.2 Effect of Different Levels of Groupings on Patterns of Inequality

The statewide pattern of significant differences for population density is not replicated within either service area level. In New Hampshire, the Merrimack Service Area accounts for almost half of the statewide census tracts. Neither the Merrimack nor the Middle Connecticut Service Areas show significant differences for population density between populations in census tracts around permit sites and tracts without permit sites and between populations in census tracts with mitigation projects and without mitigation. The analysis for the Middle Connecticut Service Area is based on only one census tract with two or more mitigation projects, four tracts with one mitigation project, and 10 census tracts without mitigation projects. For this service area, the low number of census tracts renders a statistical analysis based on the unit of policy implementation
less powerful. While the lack of observed differences in population density in the Middle Connecticut Service Area census tracts may be explained by the much lower variability of the mean and median population densities in census tracts around permit and mitigation sites, as compared to the statewide data, this is not true for the Merrimack Service Area. In the Merrimack Service Area, there are fewer outliers in the population density around census tracts with one or two or more permit sites and census tracts with one or more mitigation projects, which may explain the lack of significance at this service area grouping. According to Dernoga et al. (2015) statewide statistical analyses of demographics with high variability across census tracts and watersheds can obscure inequalities. In New Hampshire, the lower variability in population densities and fewer outliers at the service areas suggest the service area-level analyses provide a more representative picture of what census tracts look like, as compared to the statewide degree of grouping.

Consistent with findings from Chicago (BenDor et al., 2007), census tracts around mitigation projects in the Merrimack Service Area are more likely to have higher percentages of white people. The Merrimack Service Area is the more densely populated of the two selected services areas, includes major urban areas and, for New Hampshire, is home to a relatively higher percentage of non-white people. The more sparsely populated Middle Connecticut Service Area with lower percentages of nonwhites did not show any significant demographic differences. In contrast to Chicago where populations around permit sites are more likely to have lower-incomes, census tracts in the Merrimack Service Area with permit sites are more likely to have higher incomes. Based on these findings, the choice of the geographic level at which to group census tracts is an important consideration for EJ analysis.
Given the consistency of findings from previous literature (Ruhl & Salzman, 2006; BenDor et al., 2007; BenDor & Stewart 2011) for differences in population density, it is important to analyze whether patterns of inequality are replicated across different groupings of census tracts with varying population densities. Population density and percent nonwhite population, in particular, present analytical challenges in New Hampshire because these distributions contain many high outliers (tracts with high density, or high (for NH) percent nonwhite), which tend to pull subgroup means up, relative to medians. Consequently, the mean-based analyses are less stable with these variables. In some instances, however, the more resistant median-based analysis showed trends in the same direction, whether or not these reach thresholds for statistical significance. Findings consistent with both analytical methods are considered most trustworthy. And, although matching the grouping of census tracts to management units (service areas in New Hampshire), can be useful for providing policy insights to decision-makers, caution should be exercised when this leads to units of analysis with few observations, such as for the Middle Connecticut Service Area, which can complicate the detection of any patterns.

4.3 Recommendations from Geospatial analysis

Because of the findings mentioned in the previous section, I recommend the ARM Fund prioritize outreach to EJ communities and areas that have higher nonwhite populations to support these communities in the development of proposals for mitigation projects and to successfully compete for mitigation funds available within their service area. The EJSCREEN, ARM Fund Mapper, optimizing hot spot analysis and the creation of a heat map helped with identifying 26 environmental justice communities and areas that have had significant wetland acreage loss. These spatial mapping and screening techniques contribute to previous research findings about
using geospatial technology to help in environmental inequality and environmental justice research. Adopting GIS applications using an EJ lens to find inequalities, can ultimately lead to the development of policy recommendations to better achieve desired social outcomes of compensatory mitigation policy.

4.4 Limitations

This research does not attempt to weigh the overall benefits and costs of compensatory mitigation and generally considers the impairment of aquatic resources as a loss and the restoration of aquatic resources as a gain. However, as BenDor and Stewart point out (2011), mitigation may depress local property values by removing land from a town’s tax base, which is critically important in a state, like New Hampshire, where local taxes fund most local services. Although the net benefit of the development may be a benefit to a community, this research focuses only on the demographic characteristics of places where aquatic functions and values are impaired (loss) and restored (gain).

The compensatory mitigation programs across New England and the United States are highly variable. New Hampshire is one of the only New England states, along with Massachusetts, where a state agency administers the compensatory mitigation program under its mandate to steward public resources in the public interest. In other New England states, non-profit nongovernmental organizations collaborate with state and federal agencies to implement compensatory mitigation, while in Rhode Island mitigation is allowed only in unusual circumstances. It is not known how generalizable the findings are from New Hampshire given the variety of compensatory mitigation programs across the region and previous findings that patterns of inequality can vary even across different programs within states (BenDor et al., 2007).
4.5 Methodological Contributions

The methods and findings from this research aim to contribute to the ongoing research on socioeconomic considerations in aquatic restoration and natural resource management, more broadly. First, I advance geospatial methods for incorporating evaluation of environmental justice into the implementation of U.S. water policy and expand the analysis to a previously under-researched geographic area, New England. Second, my findings apply consideration of the geographic level at which to group census tracts to compare findings. Third, I used GIS through an EJ lens to provide policy recommendations to decision makers. Specifically, coupling the optimizing hot spot analysis with the EJ Screen Tool, the ARM Fund Mapper and an existing data set about dams with letters of deficiencies identifies specific towns and cities to prioritize outreach about restoration funding opportunities.

4.6 Potential Future Research

This research lays a foundation for more in-depth research to engage EJ towns and cities with aquatic restoration opportunities. It would be interesting to learn more how much EJ communities know about the ARM Fund, and about barriers that limit their participation in funding opportunities, as well as opportunities that facilitate their participation. Results from surveys or interviews could inform the scope of future ARM Fund outreach to EJ communities with aquatic restoration opportunities.
Chapter 5

This research began with my interest in learning more about how water policy is implemented to further positive social outcomes and foster environmental justice. Underrepresented communities are disproportionately exposed and vulnerable to the cumulative, negative impacts of environmental threats, including pollution and degradation of water resources. Achieving environmental justice means realizing the fair treatment and meaningful involvement of all people with respect to the development and enforcement of environmental policy.

I trace my passion for environmental policy, justice, and civil service to an observation I made to my father as a 10-year old playing in the Anacostia Park in Washington D.C., “I thought the water was supposed to be blue.” From what I’d seen in movies, books, and pictures I didn’t think the color should be green. I now know the Anacostia River is notorious across D.C. for its green pigmentation and for submerged trash, such as an ATM machine, bicycles, and tires. Raw sewage turned the river green. I now also know the reason I mostly saw people of color in the neglected Anacostia Park is because the community around the Park and River in Southeast D.C. is predominantly low-income and African American. In contrast, nearby Rock Creek Park is home to a much wealthier community. I didn’t understand then, and still don’t, why keeping the Anacostia Park and River isn’t more of a priority. Where is the leadership to spearhead action to ensure all communities have equal access to the benefits of our water systems and a healthy environment? These questions continue to drive my passion to apply research to address injustice, to demonstrate by example to children in low income communities and communities of
color why our representation in STEM research matters, and to lead through engagement in public service.

Through my MS research I have advanced my skills in geospatial and statistical analysis to better understand the human dimensions of water policy in New Hampshire. I applied geospatial and statistical analyses to identify patterns of inequality in New Hampshire’s compensatory mitigation program. Overall, population density is an important factor in determining who benefits from restoration opportunities, but race and ethnicity, educational attainment, and income can also be factors. As the ARM Fund continues to collect in lieu fee payments and fund restoration projects, it will be important to continue asking whether EJ consideration are being integrated into policy implementation to promote nondiscrimination, consistent with Executive Order 12898. It is imperative for researchers and program administrators to consider EJ outcomes and analyze the data to investigate patterns in order to foster justice for vulnerable communities.

Through my research on statewide public knowledge and preferences about dam removal (Appendix G), I used STATA to test how different demographic and socioeconomic characteristics affect residents’ opinions about dam removals. What people know affects people’s preferences for dam removal. Understanding how important dam decisions are for state resources, ecosystems, communities and public safety, there is a clear need for more public awareness and media attention to the issue of dam removal to inform the public.
<table>
<thead>
<tr>
<th>State</th>
<th>Name of the state’s compensatory mitigation program (note: 3 types of mitigation mechanisms: Wetland mitigation banking, in-lieu fee mitigation, permittee-responsible mitigation)</th>
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<th>Contact Info</th>
<th>Structure and data sources</th>
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<td>Connecticut</td>
<td>Connecticut Wetland In-Lieu Fee (ILF) Program</td>
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|           | • New England District  
• Corps of Engineers  
• Audubon Connecticut |
|           | U.S. Army Corps of Engineers, New England District, Regulatory, Division B (ATTN: Taylor Bell)  
phone 978-318-8723  
Taylor.M.Bell@usace.army.mil |
|           | After the applicant avoids and minimizes the impacts to the extent possible, USACE may approve the use of the ILF by the applicant. USACE determines the number of credits the applicant will need to purchase. The fees for the ILF credits are paid by the permittee to Audubon Connecticut and tracked by service area.  
• https://www.nae.usace.army.mil/Missions/Regulatory/Mitigation/In-Lieu-Fee-Programs/CT/  
• http://ct.audubon.org/conservation/in-lieu-fee-program  
Maine

In Lieu Fee Compensation Program (ILFP) - regulatory program
- Maine Natural Resource Conservation Program (MNRCP) - allocate funds collected
- U.S. Army Corps of Engineers
- Maine Department of Environmental Protection (DEP)
- The Nature Conservancy (TNC)

Dawn Hallowell - Maine DEP:
dawn.hallowell@maine.gov
Alex Mas - The Nature Conservancy in Maine:
maineresources@tnc.org

Program provides compensatory mitigation to offset in-stream impacts to aquatic resources. Mitigation projects have a focus on providing recovery and conservation measures for the Atlantic salmon in accordance to the Endangered Species Act (ESA).

- https://www.nae.usace.army.mil/Missions/Regulatory/Mitigation/In-Lieu-Fee-Programs/ME/ASRCP/

Fees collected by the Department through the ILF Program are allocated through the MNRCP. The MNRCP is a cooperative program between Maine DEP and the US Army Corps of Engineers and is administered by The Nature Conservancy in Maine. The MNRCP helps compensate for unavoidable impacts to protected natural resources in Maine by funding the restoration, enhancement, preservation, and creation of similar resources to maintain ecological benefits.

- https://www.nae.usace.army.mil/Missions/Regulatory/Mitigation/In-Lieu-Fee
- http://mnrcp.org/
| Massachusetts | In-Lieu Program (ILFP) | Department of Fish and Game (DFG) | Aisling O'Shea  
In Lieu Fee (ILF) Program Administrator  
Department of Fish and Game  
Phone: (617) 626-1605  
Aisling.O'Shea@state.ma.us | The ILFP affords Corps permittees the new option of paying an in-lieu fee to DFG's ILFP as mitigation for their project impacts to federally regulated aquatic resources. DFG, in turn, will aggregate ILFP fees to implement larger-scale mitigation projects. The Corps’ Mitigation Rule gives preference to in-lieu fee mitigation over permittee-responsible mitigation due to the increased likelihood of success with larger-scale mitigation projects and long-term monitoring by the in-lieu fee sponsor.  
If approved, Corps permits will be conditioned to require an ILF payment to DFG. No work may be performed under the permit until receipt of written verification that the required ILF payment has been received by DFG and DFG accepts responsibility for providing compensation mitigation in accordance with its ILF Program Instrument. |

- [https://www.nae.usace.army.mil/Missions/Regulatory/Mitigation/In-Lieu-Fee-Programs/MA/](https://www.nae.usace.army.mil/Missions/Regulatory/Mitigation/In-Lieu-Fee-Programs/MA/)
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<th>State</th>
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<th>Contact Information</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>New Hampshire</td>
<td>NH ARM</td>
<td>Mitigation Coordinator, Lori Sommer&lt;br&gt;NHDES Wetlands Bureau&lt;br&gt;(603) 271-4059&lt;br&gt;<a href="mailto:lori.sommer@des.nh.gov">lori.sommer@des.nh.gov</a></td>
<td>The NHDES holds the funds collected in an interest-bearing account to earn interest while maximizing the safety and preservation of the funds in the account. All interest earned on these accounts is used for purposes of compensatory mitigation. The accounts are maintained by NHDES and funds are only used for program administration and the selection, design, acquisition, implementation and management of compensatory mitigation projects.</td>
</tr>
<tr>
<td>New York</td>
<td>Ducks Unlimited New York In-Lieu Fee Program (DU-NY-ILF)</td>
<td>Patrick A. Raney, Ph.D.&lt;br&gt;Manager of Conservation Services - Mitigation&lt;br&gt;Mobile: 315-708-9614&lt;br&gt;Office: 315-453-8025&lt;br&gt;<a href="mailto:praney@ducks.org">praney@ducks.org</a></td>
<td>Sells wetland and stream mitigation credits for permitted impacts in 11 watersheds in New York state. By accepting payment to the ILF program, DU assumes responsibility for delivering compensatory mitigation projects. DU-NY-ILF projects will offer greater ecological benefits than isolated permittee responsible projects because ILF payments finance larger projects that will contribute to watershed level conservation goals.</td>
</tr>
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</table>


https://www4.des.state.nh.us/armfund/


https://ribits.usace.army.mil/ribits_apex/f
<table>
<thead>
<tr>
<th>State</th>
<th>Program Name</th>
<th>Contact Information</th>
<th>Details</th>
</tr>
</thead>
</table>
| Ohio       | Ohio Stream and Wetland In-Lieu Fee Mitigation Program (OMP) | - The Nature Conservancy  
- Ohio EPA  
- Ohio Water Development Authority  
- U.S. Army Corps of Engineers | This trust is an In-Lieu fee program that sells mitigation credits for permitted wetland impacts throughout NY.  
- https://ribits.usace.army.mil/ribits_apex/f
| Pennsylvania | Pennsylvania Wetland Replacement Project                  | - National Fish and Wildlife Foundation  
- The Dept. of Environmental Protection  
- PennDOT | Contributions or payments made by permit applicants, permittees or other parties, as approved by the Corps and Ohio EPA, will be organized by impact type and according to the 8-digit HUC where the impact occurred. The funds will be deposited into interest-bearing accounts (the “Accounts”) managed by the Ohio Water Development Authority.  
- Contributions or payments made by permit applicants, permittees or other parties, as approved by the Corps and Ohio EPA, will be organized by impact type and according to the 8-digit HUC where the impact occurred. The funds will be deposited into interest-bearing accounts (the “Accounts”) managed by the Ohio Water Development Authority. | Districts are responsible for preparing and executing wetland mitigation plans. PennDOT’s Environmental Policy and Development Section (EPDS) performs quality assurance for new wetland banks established under PUMBI. |
<table>
<thead>
<tr>
<th>State</th>
<th>Program</th>
<th>Contact Person</th>
<th>Information</th>
</tr>
</thead>
</table>
| Rhode Island | RI dept of Environmental Management  
  RI Coastal Resources Management Council | Carolyn Murphy (Freshwater Wetlands) RI Department of Environmental Management  
  Office of Water Resources 235  
  (401) 222-4700 x 7208  
  Carol.murphy@dem.ri.gov | RI Dept of Environmental Management does not have formal guidelines on compensatory mitigation for freshwater wetlands, as they only allow mitigation under unusual circumstances. Functional criteria for this discretionary mitigation work focus on the nature and values of the wetland, as well as the area of the replacement wetland. |
| Vermont     | Ducks Unlimited–Vermont In-lieu fee Program (DU-VT-ILF)  
  U.S. Army Corps of Engineers  
  USACE-New England District | Patrick A. Raney, Ph.D.  
  Manager of Conservation Services – Mitigation  
  Mobile: 315-708-9614  
  Office: 315-453-8025  
  praney@ducks.org | Provides a flexible compensation alternative to permittee-responsible compensatory mitigation for impacts to waters of the United States in the State of Vermont. The state-wide program sells credits in four separate service areas: The Connecticut River, St. Francois, Richelieu, and Upper Hudson watersheds. By aggregating funds from multiple permitted impacts, the ILF program can deliver projects that offer greater ecological benefits than permittee responsible mitigation and contribute to watershed level conservation goals. |
|             |                                                                         |                          | http://www.nae.usace.army.mil/Missions/Regulatory/Mitigation/In-Lieu-Fee-Programs/VT/  
  http://ribits.usace.army.mil/ribits_apex/?p=107:100:3809167239261::NO::P100_PROGRAM_ID:301 |
## Previous literature: compensatory mitigation mechanisms, methods and findings

<table>
<thead>
<tr>
<th>Reference</th>
<th>Study Location</th>
<th>Wetland Mitigation Type</th>
<th>Methods</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>BenDor and Stewart (2011)</td>
<td>North Carolina</td>
<td>Mitigation banking</td>
<td>Focused on the relationship between urban development and mitigation</td>
<td>Compared to mitigation sites, populations around impact sites generally have:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Compared socioeconomic characteristics (population, education level, poverty, income and housing) of census tracts surrounding impact sites to those around mitigation sites</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Compared mitigation and impacts with growth and development rates in watersheds</td>
<td>• Higher total populations and higher population densities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Higher percentages of whites and lower percentages of blacks and Hispanics</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Higher levels of education, with lower percentages of individuals over the age of 25 having only a high-school degree or less</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Higher percentages of the population have completed “some college” or more</td>
</tr>
<tr>
<td>Ruhl and Salzman (2006)</td>
<td>Florida</td>
<td>Mitigation banking</td>
<td>• Used GIS to generate locations of each project and bank using polygon boundaries and gathered demographic data to compare populations</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Collected information concerning all of Florida’s wetland banks and all the land development projects that purchased credits</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Compared to mitigation sites, populations around impact sites generally have:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Higher population densities</td>
</tr>
</tbody>
</table>
| BenDor, Brozovic, et al. (2007) | Chicago, IL | In-lieu fee (ILF): 2 programs  
Mitigation Banking  
Permittee-Responsible Mitigation (PRM) | - Used GIS to map mitigation banks and ILF sites  
- Conducted a set of paired t tests to compare differences in population density and demographic characteristics of the surrounding impact sites and mitigation sites |
|---|---|---|---|
| | | Overall, compared to mitigation sites, populations around impact sites generally have:  
- Higher population densities  
- Higher percentages of Black and Hispanic populations  
- Lower levels of home ownership  
- Lower average household income  
- Mitigation banking: lower unemployment, lower poverty levels, lower Black and higher Hispanic populations  
PRM: Higher non-white populations  
ILF(1): higher percentages of Blacks and Hispanics; lower incomes, housing values, and educational levels; and higher poverty and unemployment rates.  
ILF(2): lower percentages of Hispanic, higher income, educational levels and housing values, lower poverty and unemployment rate |
| Dernoga, Wilson, et al. (2015) | Maryland | In-lieu fee (ILF) Permittee-Responsible Mitigation (PRM) | 319(h) projects were linked to the 8-digit watershed GIS maps and overlaid with 2010 census data at the census tract level to create maps with socioeconomic data Kendall’s Tau test for statistical significance | Predominantly non-white areas received few to no wetland’s projects, while predominantly white areas gained most of the wetlands. Of the 75 wetlands projects performed, only three took place in census tracts where greater than 50% of the population was made up of people of color |
### Appendix D: Aquatic restoration opportunities for 26 environmental justice communities

<table>
<thead>
<tr>
<th>Town</th>
<th>Aquatic Organism Passage Score</th>
<th>Geomorph Compatiblity Score</th>
<th>EJ Communities with potential ARM Fund project opportunities</th>
<th>ARM Fund Service Area</th>
<th>Town percentage compared to the state (percentile)</th>
<th>Town percentage compared nationally (percentile)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>% Minority</td>
<td>% Low Income Population</td>
<td>Less than HS education</td>
</tr>
<tr>
<td>Almaden</td>
<td>No Passage</td>
<td>Mostly incompatible</td>
<td>3 - Pompano-St-Winnipesaukee</td>
<td>95</td>
<td>87</td>
<td>52</td>
</tr>
<tr>
<td>Belleville</td>
<td>No Passage</td>
<td>Mostly incompatible</td>
<td>3 - Pompano-St-Winnipesaukee</td>
<td>95</td>
<td>88</td>
<td>56</td>
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<td>3 - Pompano-St-Winnipesaukee</td>
<td>95</td>
<td>87</td>
<td>52</td>
</tr>
<tr>
<td>Berlin</td>
<td>No Passage</td>
<td>Mostly incompatible</td>
<td>3 - Pompano-St-Winnipesaukee</td>
<td>95</td>
<td>87</td>
<td>52</td>
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<td>Coldbrook</td>
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<td>95</td>
<td>86</td>
<td>50</td>
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<td>95</td>
<td>86</td>
<td>50</td>
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<tr>
<td>Danville</td>
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<td>9 - Upper Connecticut</td>
<td>95</td>
<td>86</td>
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<td>Dover</td>
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<td>95</td>
<td>86</td>
<td>50</td>
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</table>

*ARM Fund project proposals can include three different types: Restoration project, preservation, and a combination of preservation and restoration. Columns B and C provide a simplified screening approach to identify potential project opportunities. Additional analysis would be needed to evaluate whether the EJ towns contain projects that meet the ARM Fund scoring criteria. Even if an EJ town contains a potential preservation/restoration site, mitigation funds may contribute only a small fraction of the overall project cost.*
<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
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</table>
Appendix F: Steps for creating Excel database for analysis

Explanation of ILF New Hampshire Table Data (Table 3.1):

I organized the data into 3 categories: population, household income and education.

- **Population**
  - Total population:
    - Permit sites: Added up the total population that have permits sites by block group
    - Mitigation sites: Added up the total population that have mitigation sites by block group
      - Percent: \(\frac{\text{total population surrounding permit or mitigation site}}{\text{total population of state}} \times 100\)
      - This percentage says how many people are living near permit sites or mitigation sites, compared to the entire state
    - Total Mean difference: \(\frac{\text{total population of Permits} - \text{total population of mitigation sites}}{\text{total population of state}}\)
    - % Mean difference: \(\frac{\% \text{ total population of Permits} - \% \text{ total population of mitigation sites}}{\text{total population of state}}\)
  - Population density:
    - Data was only given by census tract*
    - Used pop density formula (convert area of land and water by sqmi, into sqkm)
      - Used the average population density of census tracts (where permits are located)
      - Used the average population density of census tracts (where mitigation sites are located)
  - Separated the populations by racial demographics, and took average
    - White Population:
      - Used total number of white populations that have permits sites by block group
        - Percent: \(\frac{\text{total white population surrounding permit sites}}{\text{total population within block group}} \times 100\)
      - Used total number of white populations that have mitigation sites by block group
        - Percent: \(\frac{\text{total white population surrounding mitigation sites}}{\text{total population within block group}} \times 100\)
      - Total Mean difference: \(\frac{\text{Average white population near Permits} - \text{Average white population near mitigation sites}}{\text{total population within block group}}\)
      - % Mean difference: \(\frac{\% \text{ of white population near Permits} - \% \text{ of white population near mitigation sites}}{\text{total population within block group}}\)
Non-White Population:
- Used average of non-white population that have permits sites by block group
  - Percent: \( \frac{\text{total nonwhite population surrounding permit sites}}{\text{total population within permit block group}} \times 100 \)
- Used total number of nonwhite populations that have mitigation sites by block group
  - Percent: \( \frac{\text{total nonwhite population surrounding mitigation sites}}{\text{total population within mitigation block group}} \times 100 \)
- Total Mean difference: (Average nonwhite population of Permits - Average total population of mitigation sites)
- % Mean difference: (Average total nonwhite population of Permits - Average total population of mitigation sites)

Repeated above steps for each racial demographic being analyzed (includes Black, American Indian, Asian, Native Hawaiian, and some other race alone)

Education
- Associates degree and below:
  - Used average number of people who have an associate degree or below within block groups that have impact and mitigation sites located within them
  - Total Mean difference: (Average total population with associate degree or below around Permits - Average total population with associate degree or below of mitigation sites)
- Bachelor’s degree and above:
  - Took the average number of people who have a bachelor’s degree or above within block groups that have permit and mitigation sites located within them
  - Total Mean difference: (Average total population with bachelor’s degree and above around Permits - Average total population with bachelor’s degree and above of mitigation sites)

Household Income
- Median Household Income
  - Found the median household income for block groups that have permits sites located within them
  - Found the median household income for block groups that have mitigation sites located within them
  - Total Mean difference: (Median income near Permits - median income near mitigation sites)
- % of Total Site Type
  - Used the number of block groups, where a permit site is located, whose median household income fall below 200% of the poverty level ($51,500) and compared it with the total number of permit sites
    - \( \frac{\text{# of block groups below } 51,500}{\text{total # of permit sites}} \)
- Used the number of block groups, where a mitigation site is located, whose median household income fall below 200% of the poverty level ($51,500) and compared it with the total number of mitigation sites
  - (# of block groups below $51,500/total # of mitigation sites)

Explanation of ILF Service Area 5 (Merrimack) and Service Area 8 (Middle Connecticut)
Table Data (Table 3.6 and Table 3.11):

ILF Service Area 5 and 8:

I organized the data into 3 categories: population, household income and education. All information in this table reflects Populations in Service Area 5.

- Population
  - Total population:
    - Permit sites: Added up the total population in Service Area 5 or 8 that have permits sites by block group
    - Mitigation sites: Added up the total population in Service Area 5 or 8 that have mitigation sites by block group
      - Percent: (total population surrounding permit or mitigation site/total population of state) x 100
      - This percentage says how many people are living near permit sites or mitigation sites in Service Area 5 or 8, compared to the entire state
    - Total Mean difference: (total population of Permits - total population of mitigation sites)
    - % Mean difference: (% total population of Permits - % total population of mitigation sites)
  - Population density:
    - Data was only given by census tract*
    - Used pop density formula (convert area of land and water by sqmi, into sqkm)
      - Used the average population density of census tracts (where permits are located)
      - Used the average population density of census tracts (where mitigation sites are located)
  - Separated the populations by racial demographics, and added up took average
    - White Population:
      - Used total number of white populations that have permits sites by block group
        - Percent: (total white population surrounding permit sites/total population within block group) x 100
- Used average of white population that have mitigation sites by block group
  - Percent: (total white population surrounding mitigation sites/total population within block group) \times 100
- Total Mean difference: (Average white population near Permits - Average white population near mitigation sites)
- % Mean difference: (% of white population near Permits - % of white population near mitigation sites)
  - Non-White Population:
    - Used total number of non-white populations that have permits sites by block group
      - Percent: (total nonwhite population surrounding permit sites/total population within block group) \times 100
    - Used average of nonwhite population that have mitigation sites by block group
      - Percent: (total nonwhite population surrounding mitigation sites/total population within block group) \times 100
    - Total Mean difference: (Average nonwhite population of Permits - Average total population of mitigation sites)
    - % Mean difference: (Average total nonwhite population of Permits - Average total population of mitigation sites)
  - Repeated above steps for each racial demographic being analyzed (includes Black, American Indian, Asian, Native Hawaiian, and some other race alone)

- Education
  - Associates degree and below:
    - Used average number of people who have an associate degree or below within block groups that have impact and mitigation sites located within them
    - Total Mean difference: (Average total population with associate degree or below around Permits - Average total population with associate degree or below of mitigation sites)
  - Bachelor’s degree and above:
    - Took the average number of people who have a bachelor’s degree or above within block groups that have permit and mitigation sites located within them
    - Total Mean difference: (Average total population with bachelor’s degree and above around Permits - Average total population with bachelor’s degree and above of mitigation sites)

- Household Income
  - Median Household Income
    - Found the median household income for block groups that have permits sites located within them
- Found the median household income for block groups that have mitigation sites located within them
- Total Mean difference: (Median income near Permits - median income near mitigation sites)
  - % of Total Site Type
    - Used the number of block groups, where a permit site is located, whose median household income fall below 200% of the poverty level ($51,500) and compared it with the total number of permit sites in Service Area 5
      - (# of block groups below $51,500/total # of permit sites)
    - Used the number of block groups, where a mitigation site is located, whose median household income fall below 200% of the poverty level ($51,500) and compared it with the total number of mitigation sites in Service Area 5
      - (# of block groups below $51,500/total # of mitigation sites)
Appendix G: What Do We Know About What to Do with Dams?: How Knowledge Shapes Public Opinion About Their Removal in New Hampshire

I led an assessment of public knowledge and preferences about dams in New Hampshire, which was based on data from questions submitted to a 2018 Granite State Poll (GSP) survey. The GSP is a regular survey of a representative sample of New Hampshire adults conducted by the Survey Center at the University of New Hampshire. This research resulted in a June 2020 UNH Carsey Brief, included below and available at: https://scholars.unh.edu/carsey/407/. With two of my co-authors, Drs. Ashcraft and Hamilton, I also led a webinar on this research, which is available at: https://www.youtube.com/watch?v=_MRIv0r3UJc.
What Do We Know About What to Do With Dams?

How Knowledge Shapes Public Opinion About Their Removal in New Hampshire

Simone Chapman, Catherine M. Ashcraft, Lawrence C. Hamilton, and Kevin Gardner

On March 13, 1996, the failure of the Meadow Pond Dam in Alton, NH unleashed 92 million gallons of water downstream, causing one death, two injuries, more than $5 million in damage to homes, damage to about a quarter mile of road, and power outages. More recent dam failures across the country, such as in Oroville, CA and Midland, MI, highlight the continuing challenges dam owners face in maintaining aging dams and upgrading them to meet current safety requirements. New building in floodplains and more intense rainfall in coming decades will likely make today’s safety challenges more acute. New England, with over 14,000 dams, has a dense cluster of older ones and, for many, failure would likely cause loss of life and significant economic damage.

As a result, dam owners across New England are engaged in contentious policy discussions about what to do with dams that are aging, require costly upgrades, and no longer provide their intended benefits. In many cases the long-term environmental and safety benefits of removing these dams outweigh the short-term costs of removal. For example, Exeter, NH decided to remove its historic downtown Great Dam in 2016 in order to restore the Exeter River. In other cases, owners of specific dams may decide to repair and maintain a dam for other benefits, such as recreational opportunities, drinking water supply, and community identity. For example, in 2019 voters in Newmarket, NH decided to repair and keep the Macallen Dam on the Lamprey River.

Publicly owned dams are the most obvious challenge, but the public also has significant influence over the roughly 75 percent of dams in the state that are privately owned. Private as well as municipal dams are eligible to use public funds, such as loans from the state-legislated Dam Maintenance Revolving Loan Fund, for maintenance, repair, improvement, and removal, and grants from the Aquatic Resources Mitigation Fund for preservation, restoration, and enhancement of wetlands and streams. Publicly funded state dam inspectors regulate the repair, reconstruction, maintenance, and operation of dams. And decisions about dams affect the state’s stewardship of natural resources, including water, fish, and wildlife, held in trust for public benefit.

Surveys of Public Opinion

An earlier series of statewide surveys in 2018 provided the first representative data at the state level about how New Hampshire residents weigh different tradeoffs regarding dam removal and how demographic factors influence their preferences. Faced with tradeoff questions about whether to remove dams or keep them to
preserve New Hampshire's industrial history, recreational opportunities, or waterfront property values, a majority of respondents favored dam removal. Only when the tradeoff involved dams that supply electricity did a majority prefer keeping them instead. In general, younger adults, women, and Democrats more often preferred dam removal.

To effectively steward New Hampshire's financial, human, and natural resources, it is important to know more about residents' preferences for keeping or removing dams in general. It is also important to know how salient this issue is for New Hampshire residents and how well informed they feel they are. While to some, dams may seem ubiquitous in New England, do most New Hampshire residents feel they hear and read much about dams? And does what they hear or read make any difference in their preference for keeping or removing dams? To investigate these questions, the October 2018 Granite State Poll asked 607 New Hampshire residents the following questions:

There are thousands of dams in rivers all around New Hampshire. Many of these dams no longer serve their intended purpose. For environmental or safety reasons, some people think these dams should be removed. Other people prefer to leave the dams in place. Have you heard or read about the issue of dam removal?

- I have heard or read a lot about dam removal.
- I have heard or read a moderate amount about dam removal.
- I have heard or read a little about dam removal.
- No, I have not heard or read about dam removal.

With regard to keeping or removing dams in New Hampshire, which of the following comes closest to your own opinion?

- I think dams should be removed in most cases.
- Removal may be a good idea in some cases.
- I do not think any dams should be removed.

Effects of Knowledge

How does knowledge about dam removal affect people's opinions? Figures 2 and 3 put the knowledge and opinion questions together. In Figure 2 we see that large majorities (78 to 85 percent) of those who say they have heard a lot, a moderate amount, or a little about this issue favor removing dams in at least some cases. The largest group of respondents, however, is those who say they have heard or read nothing about this issue (see Figure 1). Figure 2 shows that the no-knowledge group is least likely (58 percent) to support dam removal.

Figure 3 focuses on the strongest opinion, that old dams should be removed in most instances. Here the information gradient is steep, ranging from 18 percent support for removing most old dams among those best informed on this topic, to just 3 percent among the least. Taken together, Figures 2 and 3 suggest

Source: NH Granite State Poll, October 2018 (n = 607).

FIGURE 1: RESPONSES TO QUESTIONS ABOUT (A) DAM-REMOVAL INFORMATION AND (B) DAM-REMOVAL OPINIONS

(a) How much have you heard or read about issue of dam removal?

<table>
<thead>
<tr>
<th></th>
<th>A lot</th>
<th>Moderate</th>
<th>Little</th>
<th>Nothing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>5</td>
<td>10</td>
<td>22</td>
<td>63</td>
</tr>
</tbody>
</table>

(b) Which comes closest to your own opinion about dam removal?

<table>
<thead>
<tr>
<th></th>
<th>Most cases</th>
<th>Some cases</th>
<th>Not remove</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td>6</td>
<td>61</td>
<td>18</td>
<td>16</td>
</tr>
</tbody>
</table>
that a better-informed general public would be more supportive of dam removal for environmental or safety reasons.

**Policy Implications for New Hampshire**

Given the significance of dam decisions for state resources, public safety, community identity, and ecosystems, there is a need for information about public preferences to guide stewardship decisions. Our survey results indicate a majority of New Hampshire residents favor removing at least some dams, and support for dam removal rises with level of knowledge: people with at least some knowledge of this topic are more likely to favor removal of some or most dams. Yet a high fraction of New Hampshire residents say they have heard nothing about dam removal issues, and the greatest opposition to dam removal comes from this no-information group.

There is a clear need for enhanced public information about different dam management options—doing nothing, repairing and maintaining them, or removing them—and the associated short-term and long-term costs and benefits. Our findings highlight the importance of communication efforts and the need to better inform New Hampshire residents about dam issues, for example through news stories.
Endnotes


9. This Granite State Poll survey involved cell and landline telephone interviews of randomly selected adults, carried out by the Survey Center at the University of New Hampshire. In addition to these dam surveys, the Granite State Poll has been widely used both for political polling and scientific research. On environment- and science-related questions, its results often closely resemble those of nationwide surveys. See, for example, L.C. Hamilton, E. Bell, J. Hartter, and J.D. Salerno, “A Change in the Wind? U.S. Public Views on Renewable Energy and Climate Compared,” Energy, Sustainability and Society 8 (2018), https://doi.org/10.1186/s13705-018-0152-5. Sampling weights, which mathematically adjust survey results to represent the state’s population, are used in Figure 1 and other analyses in this brief.

10. Statistical significance results shown in Figures 2 and 3 (p < 0.001 in both cases) reflect t tests from probability-weighted logit regressions of dam opinions on self-assessed knowledge.

11. Ibid.

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What to Do With Dams: An Assessment of Public Opinion to Inform the Debate in New Hampshire (July 2019)
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