Restoration: Bridging the Gaps A Graphic Translation of Ecological Restoration

RESTORATION: BRIDGING THE GAPS

A GRAPHIC TRANSLATION OF ECOLOGICAL RESTORATION

A Thesis Presented

by

ALYSSANDRA BLACK

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Approved as to style and content by:

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Robert L. Ryan, Committee Chair

____

Patricia McGirr, Committee Member

____

Timothy D. Zimmerman, Committee Member

____

Elisabeth Hamin, Department Chair

Landscape Architecture and Regional Planning

ABSTRACT

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MAY 2016

ALYSSANDRA BLACK, B.S.L.A UNIVERSITY OF CALIFORNIA, DAVIS

M.L.A., UNIVERSITY OF MASSACHUSETTS, AMHERST

Directed by: Professor Robert L. Ryan

The terms restoration ecology and *ecological restoration* are used interchangeably confusing the definition and work of ecological restoration and its many components. Restoration ecology is a type of scientific practice whose work will be a component of a restoration project while ecological restoration is the sum of practices, social, historical and ecological that constitute the field of restoration (Higgs, 2005). Within our rapidly urbanizing society the role of ecological restoration and restoring ecosystem services is increasingly important, especially within our coastal cities. The goals of restoration differ when the classification of restoration techniques is by ecosystem service, not ecological function, framing restoration around people's use of the ecosystem, not the ecosystems needs. The problems faced in restoration work affect social, historical and ecological aspects that reach beyond the physical and political boundaries of the restoration site. Ecological restorationists need to understand the differences in framing that a non-universal definition for *ecological restoration* creates, while also understanding how to bridge these differences. One solution is graphic communication and representation of the different components that scientists and non-scientists alike can understand. This study uses restoration project plans to illustrate the goals within projects, and shows where the goals of scientists and designers conflict and harmonize. Shown through map overlays and graphics, this comparison provides professionals within the field, with resources and illustrations to better communicate. In addition, graphics and matrices will illustrate key terms, concepts and the intersection of restoration types with habitat types, ecosystem services and social components. In conclusion, this study addresses differences in ways of learning, and kinds of knowledge other than science needed in ecological restoration projects, and uses graphics to bridge these gaps.

KEYWORDS: Ecological Restoration, infographics, landscape architecture, data visualization, human ecology

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CHAPTER 1

INTRODUCTION

Restoration Ecology versus Ecological Restoration

The rise in ecological restoration necessitates discussion about the role of ecological restoration and how to measure its success. This discussion begins with the difference between restoration ecology and ecological restoration, and the different definitions of ecological restoration. Restoration ecologists define ecological restoration as "the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed" (Clewell et al., 2004, p. 3) while Eric Higgs defines ecological restoration as "the ensemble of practices that constitute the entire field of restoration, including restoration ecology as well as the participating human and natural sciences, politics, technologies, economic factors, and cultural dimensions" (Higgs, 2005, p. 159). Professions doing restoration work use the terms restoration ecology and ecological restoration synonymously. Understanding the differences between the definitions and roles provides an opportunity to bridge the gap between the varying professionals of ecological restoration. 'Ecological restoration' encompasses all professionals working on restoration projects. 'Restoration ecology' pertains only to ecologists working on restoration. In this thesis I will distinguish between restoration ecology and ecological restoration by highlighting and illustrating different approaches to ecological restoration projects. Though both terms focus on restoring natural systems, I will discuss restoration ecology as framed solely around the ecological systems, while ecological restoration incorporates social, historical, cultural and recreational components as well as ecological components. This latter, holistic approach incorporates current human needs rather than return to one historic ecological ecosystem. Within this definition of ecological restoration, restoration ecologists would be a member of the restoration team. For design professionals this approach and distinction is important to understand because it frames the integration of ecological restoration and design projects allowing us to balance people and nature. Following this chapter, ecological restoration will be defined as a holistic approach incorporating social, cultural, historical and ecological practices while allowing the ecosystem to function harmoniously with nature and people.

Within our rapidly urbanizing society the role of ecological restoration and restoring ecosystem services is increasingly important. As our populations increase we are moving towards urban cities, specifically along the coasts with 43 % of the entire U.S. population living around estuaries and with the area around estuaries only accounting for 13% of the total contiguous land in the United States (EPA, 2007) (Figure 1). An estuary is a semi-enclosed body of water where the river meets the sea. The limit of the estuary is from the sea, up the river as far as there is a salt intrusion or a tidal limit. This limit is not always year round and can include features such as sand bars which change the amount of salt and fresh water mixing (Wolanski, 2007). This has and will continue to negatively impact our ecosystems. Due to the amount of population within estuarine ecosystems and the projections of urbanization, this thesis will focus on estuarine ecosystems specifically, looking at estuaries and their restoration as a complex or whole, identifying ways to integrate restoration along the complex. To slow down and attempt to mitigate these degradations, design professionals need to understand which ‘ecosystem services’, the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life (Daily, 1997), are important within these coastal ecosystems and how to successfully restore them. The classification of ecological restoration by ecosystem service frames restoration anthropogenically not ecologically. To utilize the knowledge and expertise of restoration ecologists, design professionals need to be aware of this difference in framing.

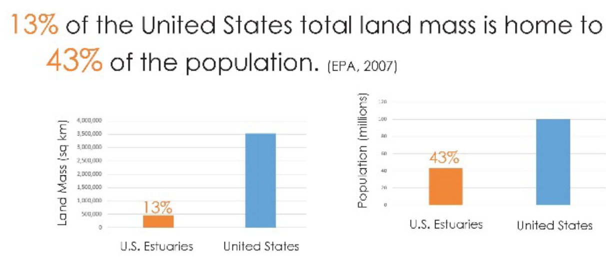


Figure 1: U.S. Population and Land Mass Statistic

The Significance of Social Components in Ecological Restoration Projects

Restoration ecologists frame restoration projects around ecologic needs and processes within a site while ignoring the social, cultural or historic. Design professionals frame projects by social, historical, cultural and ecological needs, with some having an emphasis on ecological restoration. Although each component is important, their emphasis within the project is site specific, providing an opportunity to illustrate the opportunities and constraints in projects. This illustration can provide a means of communication for the design professional and the scientist. The interaction between the ecological and social is usually at odds because most restored ecosystems do not incorporate people, many sites specifically prevent people from interacting with the site because of potential anthropogenic degradation. This thesis will focus on this interaction by translating and teaching design professionals' basic ecological knowledge of restoration within estuarine ecosystems and providing ways to integrate the human dimension into restoration sites while limiting the anthropogenic effects.

Access to large natural areas is necessary for human health and instilling in humans the importance of preservation, conservation and restoration. Without access to nature future generations will not understand the necessity of nature to their health and well-being, which is why it is key to include the human dimension in ecological restoration projects.

The Role of Infographics for Ecological Restoration

Design professionals are taught in school using graphics, maps and diagrams. To successfully translate the science and restoration techniques of estuarine ecosystems, an understanding of how non-scientists learn science is needed. Efforts of landscape ecologists such as Richard Forman, James Olson and Richard T.T. Dramstad (1996) in their book *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning* and landscape architects such as Ian McHarg (1992) give us examples of successful ways to graphically represent science and ecology pictorially.

Forman, Olson and Dramstad (1996) illustrate the basic principles of landscape ecology pictorially, one of the only books graphically representing ecological principles. Using their graphics in the context of small scale to the broader landscape allows for design professionals to see graphically how their design decisions affect the ecology at the larger scale. McHarg (1992) illustrates a method of how to overlay the different aspects of a site and show where there are patterns, opportunities and constraints through a series of map overlays.

Due to design professionals' direct involvement with ecological restoration projects, research on graphic translation of data and graphic representation of science will focus specifically on them. The material produced will apply to scientists and design professionals with prior knowledge in ecological restoration.

Thesis Goals

Professionals within the restoration field use different definitions in relation to ecological restoration, as defined in the introduction. Landscape architects and design professionals have an opportunity to be involved and to utilize ecological restoration in their designs, but unfortunately only a handful of design professionals are working on ecological restoration projects specifically with restoration ecologists and scientists. Many attempt to incorporate ecological restoration techniques but lack the proper background. This thesis aims to understand the role of design professionals in ecological restoration projects and the key components in effectively learning restoration techniques. The goals are: 1) to provide design professionals with key information needed to understand ecological restoration within estuarine ecosystems, while identifying and translating terms used by both professions; 2) to create matrices which illustrate the connection of restoration techniques to habitat types, ecosystem services and social components; and 3) to analyze case reviews to show the goals of restoration ecologists and design professionals and illustrate graphically the opportunities and constraints between these goals.

Thesis Organization

The organization of this thesis follows; Chapter I Introduction, Chapter II Methodology, Chapter III Literature Review, Chapter IV Case Reviews, Chapter V Research and Data Visualization through Infographics, and Chapter VI Conclusion. The Methodology chapter outlines the three different methods used, literature review, case reviews, and data visualization through infographics. The Literature Review explores the different natural and social components within restoration projects, how they are translated to inform restoration projects and the different ways social and natural scientists frame ecological restoration. The Case Reviews chapter utilize a categorization of restoration components to evaluate its success holistically. Data visualization through infographics chapter illustrates the 3 component iterative method of; literature review, case reviews and infographics. Finally, the Conclusion offers recommendations for the future of ecological restoration projects in integrating social and natural components and build upon this for further research.

Research Purpose

My research purpose is to connect estuarine ecosystems functions with ecological restoration techniques and translate them into graphics for design professionals. Due to the integration of restoration techniques and how they are monitored, the graphics will be tailored to design professionals rather than the public. Through my research of estuarine ecosystems and restoration projects, I hope to determine best practices of integrating recreation into ecological restoration techniques.

Research Questions

Estuarine Ecology and Restoration:
What are the main processes, species and interactions needed to understand estuarine ecosystems?
What successful restoration and monitoring techniques of estuarine ecosystems?

Ecological Restoration and Recreation:
How can recreation be integrated into ecological restoration techniques within estuarine ecosystems?

Graphic Communication:
What are the most effective ways to graphically translate the science of estuarine ecosystems, restoration and monitoring techniques to design professionals?

Hypothesis

Design professionals understand quantitative and scientific information better when it is translated into graphics rather than text and charts. Clearly defining restoration ecology and ecological restoration will help to show design professionals ways to holistically design restoration projects with the help of restoration ecology.

Process

Although the thesis is outlined in a linear fashion the research conducted is a 3 component iterative process, each component informing the others simultaneously (Figure 2). The literature review, case reviews and data visualization through infographics were all conducted simultaneously informing the other in different stages of the process. The use of mind maps and spatial organization (Figure 3) allowed for the purpose and research questions to quickly shift after the proposal was completed. A mind map allows for connections and to identify relationships while providing a visual of the whole. (Brown, 2009). The research purpose designated the audience as design professionals and the research information being in one direction. Through initial research it became apparent the need for the audience to be broader than just design professionals and to include the whole field of ecological restoration practitioners. This shift allowed for the research information to flow between the ecological restoration practitioners, from natural scientists to social scientists and to design professionals, who cross disciplines.

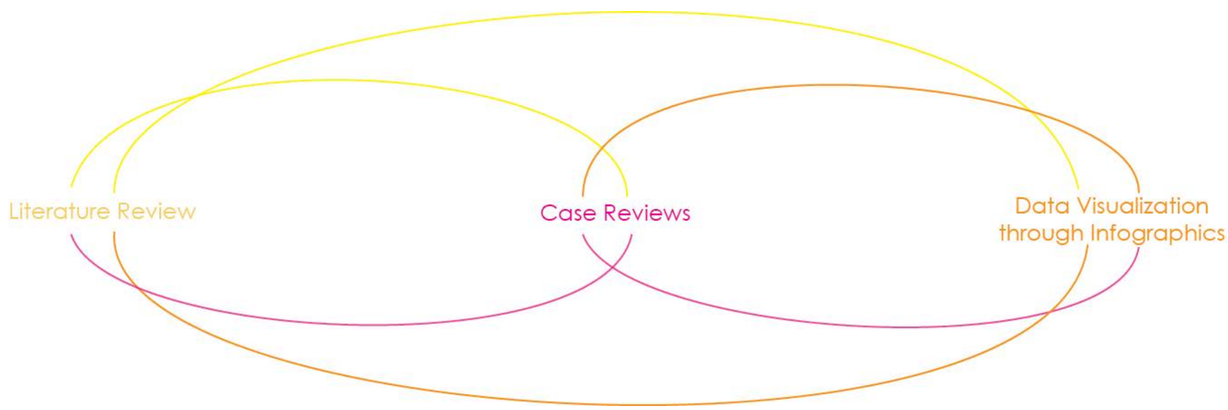


Figure 2: 3 Component Iterative Process

Figure 3: Mind Map

The specificity of recreation among social components was too limited in translating aspects of social science information to natural scientists. In integrating the two to create holistic ecological restoration projects there needed to be all social components represented. With this adaptation the research question, “How can recreation be integrated into ecological restoration techniques within estuarine ecosystems?”, would read, “How can social components, such as history, culture, recreation, public access, and aesthetics be integrated into ecological restoration techniques within estuarine ecosystems?”

CHAPTER II

METHODOLOGY

Determining the success or failure of ecological restoration projects is effected by the definitions, criteria, goals, metrics and monitoring techniques of the restoration project, which differ between design professionals and scientists. To determine the criteria, metrics, and monitoring, the difference between ecosystem service and ecological function needs to be established. Ecosystem services are based anthropogenically while ecological functions are based ecologically. According to Gretchen Daily (1997), ecosystem services are processes through which natural ecosystems, and the species that make them up, sustain human life. Ecological function is ecologic health–that is, biogeochemical processes, which are normally invisible to people because the anthropogenic effects on these processes are not primarily visual (Beardsley, 2013). The aspect of ecological function we do perceive is the change in the vegetation and species, or biodiversity. Prior to the 1990s, ecological function was considered to include strictly the biogeochemical processes of an ecosystem and not the species within the ecosystem. During the early 1990s, however, ecological function expanded to include biodiversity in addition to biogeochemical processes. Measuring biodiversity with the number of species as the only metric is really just measuring the taxonomic diversity within the landscape, which gives an inaccurate measure of other recognized factors of biodiversity, such as genetic, spatial, or temporal variation within the same species. An expanded definition of **biodiversity** defined as; all dimensions of diversity of life, including genetic, ecological, taxonomic, spatial and temporal variation (Shahid Naeem, Beardsley, 2013). This shift in measuring biodiversity is important for managing biodiversity in the context of ecological function because it allows for a common interest and understanding between natural and social scientists. Biodiversity is an aspect of ecological function that social scientists can understand and relate to because it is incorporated in ecosystem services, aesthetics and habitat.

The difference in framing – centering a project on ecosystem service or ecological function – illustrates the difference in evaluating ecological restoration projects. If natural scientists are evaluating ecological restoration projects by ecological function (which does not incorporate any social components) they will deem projects as a success or failure differently than social scientists. Within *ecological restoration* Higgs (2005) proposes historical, social, cultural, political, aesthetic and moral factors which are not outlined in any of the evaluations of ecological restoration projects. A key aspect not emphasized by Higgs is outreach and public participation. Cairns Jr (1995) speaks to the idea in eco-societal restoration where restoration ecology requires the input of society to be successful.

Evaluating based off of ecosystem services illustrates the benefits of the environment at no cost to us, i.e. services that would need to be provided if the environment were to no longer exist (Costanza et. al 1997; Daily, 1997). Within social science there is no singular method of evaluation, which creates problems when expressing the importance of the social components of restoration to others working on a given project. Through my research I found that the current methods of evaluation are based on statistical data about the reduction of anthropogenic degradation (illustrated through quantitative data); the amount of public support; and awards granted.

Case studies are a widely used method of evaluating projects and many professions utilize this method, but reviewing case studies is not a widely used method in the design profession. Within landscape architecture there is not a clear understanding of the difference between case study and case review. Mark Francis (1999) establishes a methodology for case studies in landscape architecture and references similar programs from other design professions. Francis defines a case study as a "well-documented and systematic examination of the process, decision-making and outcomes of a project that is undertaken for the purpose of informing future practice, policy, theory and/or education" (Francis, 1999, p. 9). Within the design profession specifically, a clear distinction between a case study and a case review is lacking. A case review is less vigorous in its evaluation methodology, and design professionals typically use case studies as data for their case review. The Landscape Architecture Foundation has developed, using Francis' methodology, the Case Study Investigation (CSI) program. Each case study has a team composed of a faculty member and a student evaluating a landscape for its environmental, economic, and social benefits. The product is a Case Study Brief which is available for practitioners and researchers to utilize (Landscape Architecture Foundation, 2016).

Evaluation of ecological restoration projects based on ecological function is determined by the data gathered through monitoring techniques, such as photopoint, expert observation, field testing and transects. Pre and post-monitoring data is used to determine if a project was successful in meeting the goals of the restoration. Monitoring techniques are specific to the ecosystem being restored – terrestrial or aquatic – but there are overarching steps necessary to the monitoring program: "reference systems, temporal and spatial scale, action thresholds, sample distribution and desirable characteristics of monitoring parameters" (Holl and Cairns, 2002, p. 411). According to Holl and Cairns Jr. (2002) chapter in *Handbook of ecological restoration*, monitoring is often used to describe three different activities: sampling/surveying, surveillance, and monitoring. Their definition of monitoring is *surveillance which ensures that predetermined quality control conditions are being met, rather than the gathering of data at specific points in time or surveillance over a period of time* (Holl and Cairns, 2002). This clarification seeks to avoid the collection of endless data that is never used to evaluate the project's success but rather to promote necessary planning and implementation of a successful monitoring program (Holl and Cairns, 2002). For the purpose of this thesis these monitoring techniques will be graphically represented: expert observation, field testing, transects, and photo-point (Figure 4-6). These monitoring techniques allow for long term analysis of data and are successful techniques for measuring the restoration of estuarine ecosystems. Although, these monitoring techniques are a component within an ecological restoration project and are a way to help determine the success or failure of an ecological restoration project they are not part of the methods used to evaluate ecological restoration projects for this thesis.

Figure 4: Monitoring Techniques: Expert Observation

Figure 5: Monitoring Techniques: Field Testing

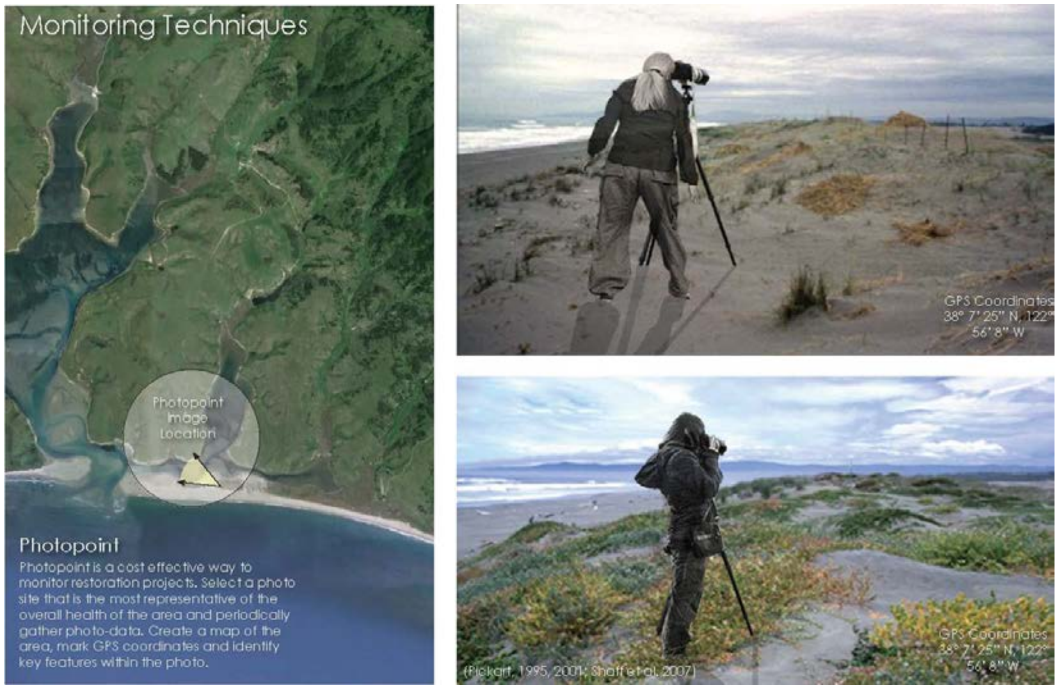


Figure 6: Monitoring Techniques: Photopoint

The process of evaluating ecological restoration projects and selecting two exemplary case review projects is as follows: a review of ecological restoration projects; defining criteria for ecosystem, scale and placement along the development gradient (Figure 7); and recurrent themes in the literature review. The Society of Ecological Restoration provides a database of projects and supplementary literature that utilizes case studies and the Landscape Architecture Foundation provides a database of case study briefs which provide literature on the projects. Since there are only 100 case study briefs, another database of projects needed to be identified. The other database utilized are the ASLA Awards, which have juries of experts in the field to evaluate Landscape Architecture projects in a variety of categories. These awards are considered a benchmark for successful design which makes them a good comparison.

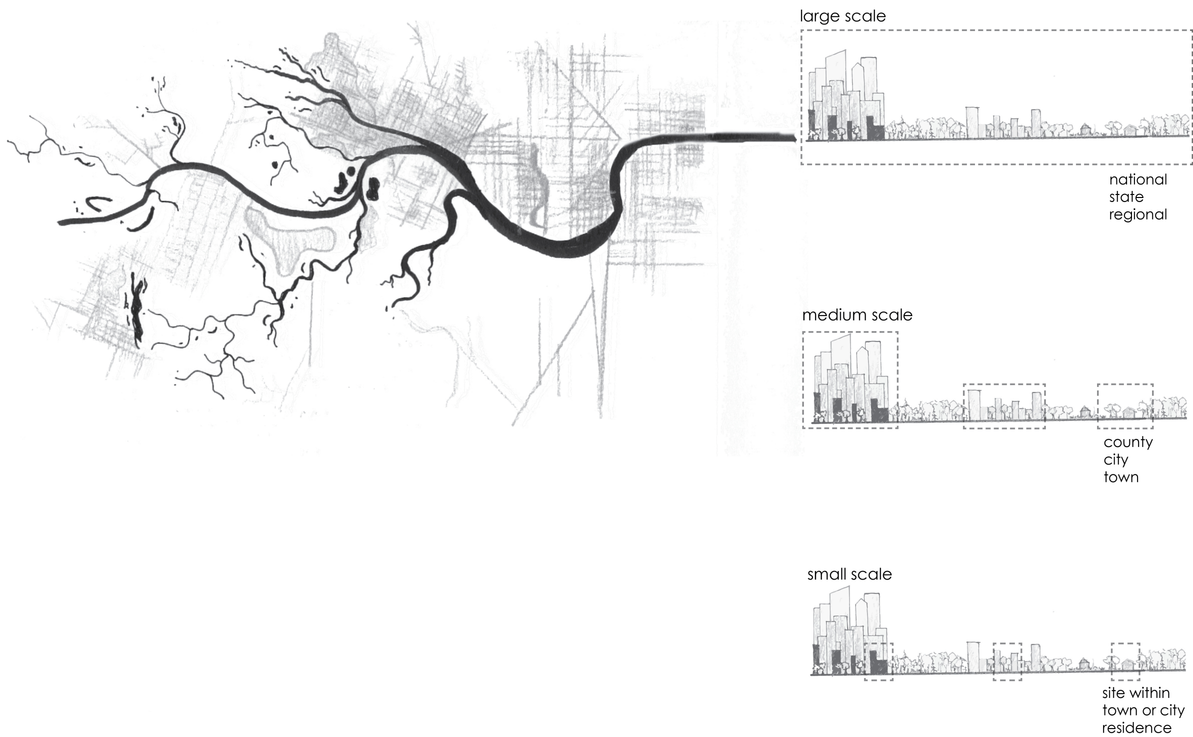


Figure 7: Restoration Scale and Density

To properly evaluate an ecological restoration project, the evaluation must establish that ecological restoration is on a spectrum that runs between wild, rural, suburban, and urban. Natural and social components are important throughout the spectrum but the importance of social factors increases proportionally with *increases* in the amount of development and human density (Weinstein, 2007). In contrast, the importance of natural components increases proportionally with *decreases* in the amount of development and human density (Weinstein, 2007). Due to the level of population, 43% in 13% of land mass, and degradation, outlined by the EPA's National Estuaries Program, Estuarine Ecosystems were chosen as the ecosystem of focus (Figure 8 and 9). Preliminary research indicated the need for a large scale comparison of projects. A key component typically lost in ecological restoration documentation is the understanding of the impacts at the larger watershed scale and an approach to restoration at this watershed scale. The case reviews chapter outlines two case reviews: Orongo Station

Master Plan and Restoration and Jamaica Bay Restoration Plan, and then an analysis of ecological restoration design competitions. The criteria (Figure 10) for evaluating the case reviews includes: scale, project type, categories, placement along the development gradient, and how it is measured afterwards. This criteria was created after: a review of the projects within the project databases, and a review of the literature for projects with publications.

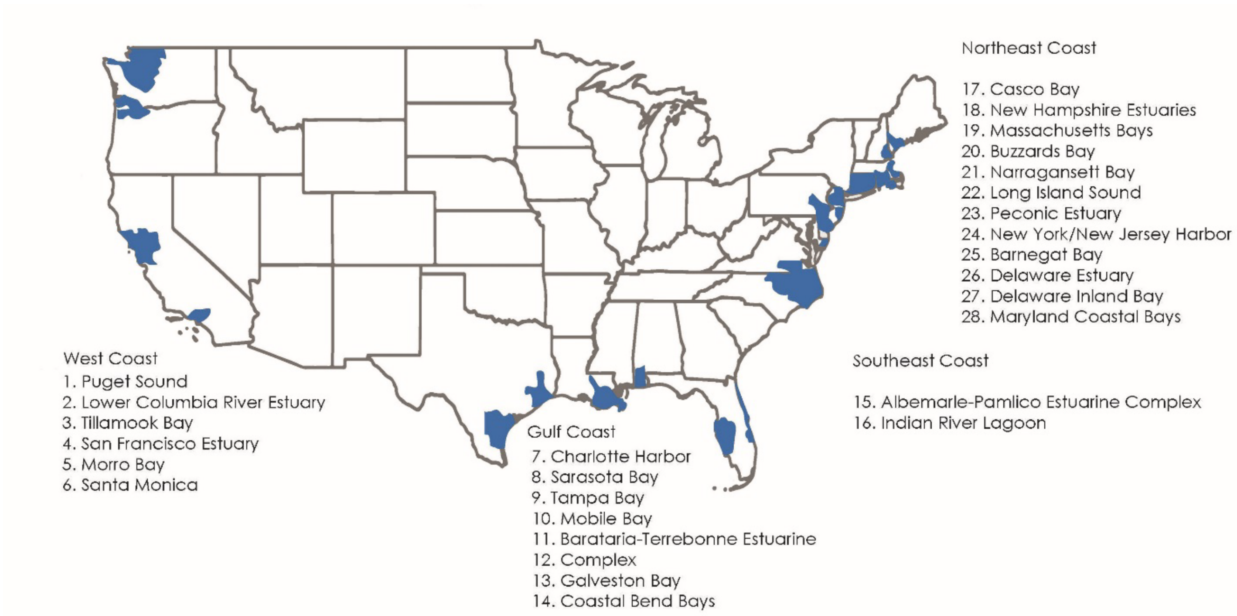


Figure 8: EPA National Estuaries Program Map

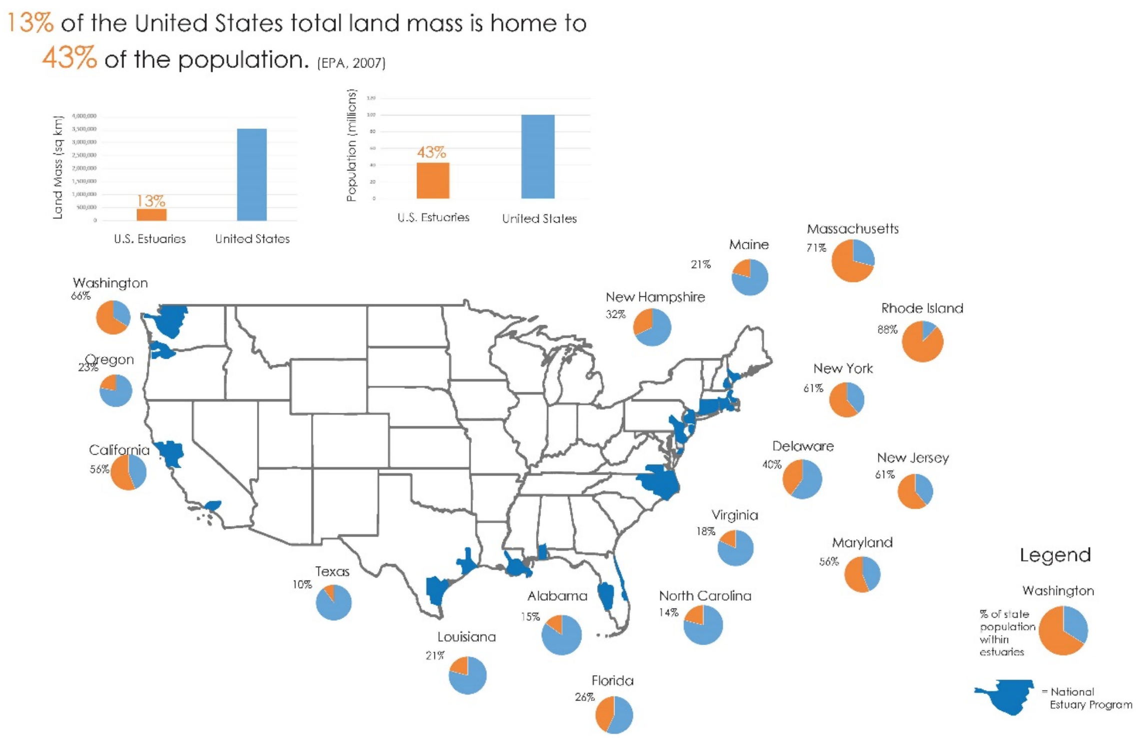


Figure 9: State Population within each National Estuary of Concern

Criteria for Case Review Selection

Scale

Project Type

Categories:

- Social
- Ecology
- Management and Planning
- Outreach

Placement along Development Gradient

Metric

Figure 10: Criteria for Case Review Selection

The complexity of these projects and the differing components within the projects led to a newer classification of components that illustrate the overlap in the ecological and human needs. Based on the different framing between natural and social scientists on the evaluation criteria for ecological restoration projects this thesis uses new evaluation criteria which integrate the two approaches (Figure 11). Framed within the 'spectrum of development' there are four categories: 1) social, 2) ecological, 3) planning and management, and 4) outreach which are used to evaluate success or failure in ecological restoration projects. *Social* includes history, culture, recreation, public access, and aesthetics. *Ecology* includes water quality, erosion control, flood control, health benefits, biodiversity, ecological function and history. *Planning and management* includes multi-disciplinary, watershed restoration planning, pre-post monitoring, regulation/permitting, and long-term management. *Outreach* includes environmental education, community based design, and stewardship. These will be outlined further in the evaluation of the case reviews.

Figure 11: Criteria for Evaluating Ecological Restoration Projects

The literature review and case reviews led to a third method which I termed, data visualization through infographics. The literature review identifies a gap in the application of the term *ecological restoration* in practice and frames the need for a graphic translation of scientific information and restoration techniques to promote ecological restoration in practice. The case review evaluation outlines the divide between natural and social components within completed restoration projects and the integration of both components within two projects. Finally, the data visualization through infographics uses the research conducted in the two previous steps to create infographics to better communicate scientific information and restoration techniques. These graphics work to illustrate key ecological processes within estuarine ecosystems and necessary components of restoration techniques, and then place them spatially to better understand their interactions. (Due to the scope of this thesis, there will not be a graphic representation of each restoration technique, how it restores the ecological functioning, or the complexity of its interaction in estuarine ecosystems.) The data visualization through infographics section illustrates the necessary information for clearer communication between natural and social scientists, who can utilize each other's expertise for the betterment of the restoration project. Providing a framework for professional integration by defining terms, concepts and placement of restoration techniques allows for better integration of the two disciplines.

CHAPTER III

LITERATURE REVIEW

The literature within this thesis is a mixture of peer-reviewed literature and gray literature. Gray literature includes governmental documents, documentation from nonprofits or research groups, literature for science teachers and science literature for children. The literature review covers: estuarine ecology; graphic representation and data visualization; ecosystem services and ecological function; restoration ecology versus ecological restoration; and monitoring techniques. The material from the literature review and the case reviews led to a graphic translation of ecological restoration. A pairing of two graphics; one analytical and one spatial.

Estuarine Ecology

Due to the influx of freshwater runoff from rivers and saltwater from the sea, estuaries are one of the most complex ecosystems. An estuary is where the land meets the sea, a mixing of salt and fresh water through tidal change and geomorphology. They create salinity zones through an ecologically diverse continuum. The volume of freshwater influence the circulation and distribution of nutrients throughout the ecosystem (Kemp et al., 2005; Malone et al., 1999). Although salinity is an important factor in the zonation of estuaries, defining estuaries based only on salinity reduces the valuation of other environmental and biological variables. Scientists like Day (2012), Kaiser (2011), Williams (2011), Wolanski (2007) and Bertness (2006) classify estuaries in different ways, for the purpose of this proposal estuaries will be classified by four different processes: geologic formation, tidal regime, sediment composition, and salinity levels.

Geomorphologically, estuaries can be formed in three ways, coastal plain formation, bar-built formation and tectonic formation. Coastal plain formation is the most common formation where a glacier or fjord creates a river valley, melts and creates a eustatic sea level rise. A eustatic sea level rise is the uniform change in sea level by the change in the volume of water in the ocean. Because of the glacial action and sill deposition, these estuaries tend to be anoxic, lack or absence of oxygen, where few organisms live. Bar-built formation happens when sediment deposits form a bar over time. This limits the amount of mixing of saltwater with the river. Further deposits can lead to the flow being completely cut off in the dry season, called a blind estuary. Tectonic formation is when tectonic plates move and lower the land to allow the seawater to mix with a bay or delta. The San Francisco Bay is an example of tectonic estuarine formation. The San Andreas Fault depressed the land which allowed the bay to fill with seawater and form the estuary (Kaiser et al., 2011; Day et al., 2012).

Another way to identify estuaries is by tidal range. There are four categories of tidal range: microtidal (<2m range), mesotidal (2-4m), mactotidal (4-6m) and hypertidal (>6m) (Kaiser et al., 2005, 155). These tidal ranges can be manipulated by anthropogenic degradation and urbanization. Due to this high level of variability manipulation can affect organisms' habitats, function, survival and reproduction. The complexity of estuaries and the wide variance in ecological and biological composition leads to the term estuarine ecosystems. Estuarine ecosystems encompass both intertidal and subtidal systems. Intertidal systems include salt marshes, tide pools, algal flats, mud flats, oyster reefs and mussel beds. Subtidal systems include seagrass beds, sandy shoals, soft muddy bottoms and mollusk beds.

The U.S. Department of Interior Fish and Wildlife Service has a classification system that defines estuarine as the systems, intertidal and subtidal as the subsystem and then the classes. The classes for intertidal are aquatic bed, reef, streambed, rocky shore, unconsolidated shore, emergent wetland, scrub-shrub wetland and forested wetland. The classes for subtidal are rock bottom, unconsolidated bottom, aquatic bed and reef (Figure 12). Through further research an understanding of the composition of each will allow for identification of the systems that are the same with different names or which are different and why

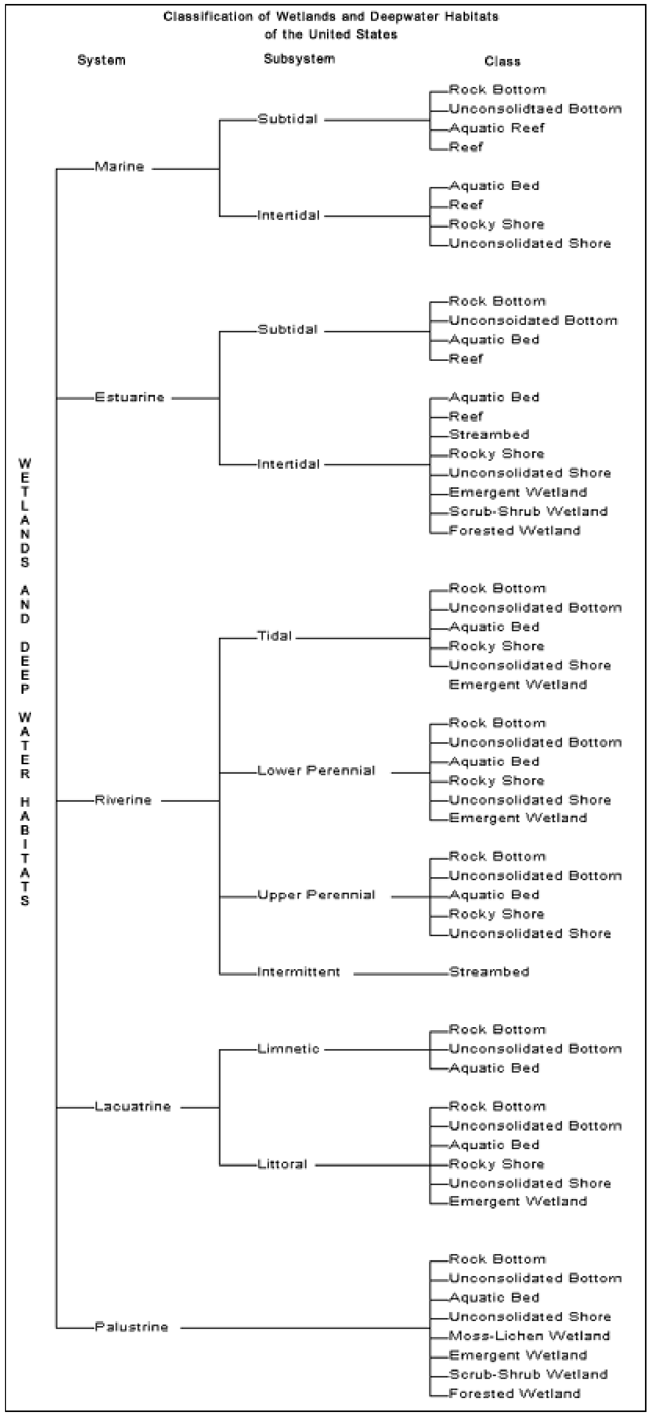


Figure 12: U.S. Fish and Wildlife Classification Hierarchy (Source: Cowardin et al., 1979)

The degradation to estuarine ecosystems is a visual indicator of anthropogenic damage upstream. Many of the effects of development are not visible to people until they are combined over an entire watershed. Estuarine ecosystems tend to be some of the most complex and delicate ecosystems, slight alterations can have drastic effects to their ecological balance. The areas around estuaries tend to be the most populated areas in the United States with over 43% of the entire U.S. population. Yet, the area around estuaries only account for 13% of the total contiguous land in the United States (EPA, 2007). Estuarine ecosystems offer a suite of ecosystem services that we benefit from. Food production being one of the most widely used to help restore or protect estuaries because over 75% of U.S. commercial fish catch and 80-90% of recreation fish catch are done within estuaries (NOAA, 1990; NRC, 2000). Understanding the needs, ecologically and anthropogenically, of these estuarine areas is important to learn how best to restore them and gain back the ecosystem services and ecological function we have lost. The restoration of these estuarine ecosystems requires projects to be interdisciplinary and allow for changes within the system over time.

Graphic Representation of Science and Data

Graphic representation of ecological systems, within landscape architecture, began with the drawings and overlays by Ian McHarg. His work with maps and overlaying different components to create a comprehensive plan led to the work of GIS. This concept and analysis is one of the founding principles in how landscape architects think about graphic representation of ecological systems. His book *Design with Nature* is unprecedented in its graphic simplicity of complex ecological systems. Coupled with the book *Landscape Ecology Principles in Landscape Architecture and Land-Use Planning* by Dramstad, Olson and Forman (1996), they provide landscape architects with basic landscape ecology principles in graphic form. The initial interest in how landscape architects learn ecological systems through ecology stemmed from these two books.

Literature on science education lends itself to gray literature rather than purely peer-reviewed because it utilizes documents oriented towards school teachers. Three important components researched, related to science education: literature on estuarine ecology, the way people learn, and how to design infographics to be understood by a broad audience. Nonprofits, literature for school teachers and existing graphics of estuarine ecosystems compose the information used within the graphics created for this thesis. To identify the key components within ecosystems several current conservation and restoration projects' documentation are used. San Francisco Bay Subtidal Habitat Goals Project illustrates the scientific classification of sediments with images. The document has chapters on the different habitat types and maps of the location and extent of the habitat zones. This projects document facilitated in the habitat type and restoration technique graphic.

Visual learners make up 65% percent of all people (Gangwer, 2009; Kranzler, 1999). Visual learners understand information most effectively pictorially with diagrams and pictures (Kranzler, 1999). Science education material currently does not reflect the amount of visual learners, graphics of ecology and science are most commonly found in elementary school material and shift to text and complex graphs of scientific processes in middle school. The lack of graphic representation stems from the split between 'hard' science and 'soft' science (Roth & Bowen, 2007). Ecology falls within the 'soft' science because it is field based where 'hard' science applies to sciences that are laboratory based (Roth & Bowen, 2007). In identifying this split Roth (2007) and Bowen (2007) make a case for the integration of non-traditional forms of education to engage all types of learners.. There are several non-traditional forms of education, the one used in this thesis is a form of graphic representation, infographics. The creation of infographics depends on their use either: in field research projects; restoration projects design; or use in museums, national parks or online. The pioneer in translating scientific information into graphic representation, infographics, is Edward Tufte. His research differs from current infographic research because it provides knowledge on what information to show in the graphic and the components needed within the graphics. Current infographic research is about showcasing successful infographics and how they are being circulated to the public, less on the process of turning data into graphics. Edward Tuftes research is still used today as a guide on how to translate data into graphics.

According to Tufte the visual techniques for depicting quantities include direct labels (dimensions in architectural drawings); encodings (color scales and shadows); and self- representing scales (including objects of known scale, ie a pencil or car) (Tufte, 1990). To demonstrate these visual techniques Tufte uses Josef Koudelka's photograph, 'The Urge to See Prague, August 22, 1968' (Figure 13). The photograph uses a watch in the foreground (direct labels), shadows and gray light (encoding) and soviet tanks in the distance (self-representing scales) to illustrate the emptiness of the streets during the 1968 soviet invasion of Czechoslovakia (Tufte, 1990).

Figure 13: Joseph Koudelka 'Urge to see Prague, August 22, 1968' (Source: Tufte, 1990)

Ecosystem Services and Ecological Function

Ecosystem services are based anthropogenically while ecological function is based ecologically. Ecosystem services are the processes or services from natural ecosystems which sustain human life (Daily, 1997). Ecological function is ecologic health–that is, biogeochemical processes, which are normally invisible to people because we do not visually see our effect on them (Shahid Naeem, Beardsley, 2013). Through the literature on restoration efforts by social scientists the understanding of the difference became apparent. Documents such as *Ecosystem and Human Well-Being* by the (Millennium Ecosystem Assessment), *A Typology for the Classification*, *Description and Valuation of Ecosystem Functions (*de Groot et al., 2002), *Goods and Services and Estimates of Ecosystem Service Values from Ecological Restoration Projects in Massachusetts* (Mass Department of Fish and Game Division of Ecological Restoration, 2014) illustrated the complexity of using ecosystem services and ecological function in the same evaluation. Having projects use both metrics is one problem, while only using one metric is another problem when trying to compare and evaluate projects. Comparing documents from all levels of government gave a broader picture of the problem that arises when using one or both metric.

The literature from the natural scientists used ecological function as the measure of success or failure which is not directly comparable to the evaluation of ecosystem services. The clarification and framing for this thesis led to a more extensive review of governmental documents and then further onto a review of academic documentation. Further research led to the discussion between the governmental agencies and academics on the valuation process to better successfully restore and quantify the restoration. *The Value of the World's Ecosystem Services and Natural Capital*, *Ecosystem Services: A Fragmentary History* by Costanza et al. connects ecosystem service, ecosystem function and natural capital in one article which best synthesizes the complexity involved. This problem between the metrics needs to be resolved so we can better evaluate the projects and garner support for more ecological restoration projects.

Restoration Ecology and Ecological Restoration

What is restoration? If we are restoring an ecosystem what does that entail? What historical time are we using as our control to restore to? Restoration in itself losses the quality of naturalness we are striving to restore. Once biodiversity is lost an ecosystem is changed forever. We can work to restore certain aspects of the ecosystem but it can never be restored to its original state, because of this restoration is design. We are choosing what aspect we want to restore and how we need the ecosystem to function for the biodiversity as well as the human dimension. This way of thinking allows for a new way of looking at restoration to incorporate the new ecosystems we have created through urbanization. To incorporate this approach into restoration techniques there needs to be a clear understanding of the difference between restoration ecology and ecological restoration. Restoration ecology and ecological restoration tend to be used interchangeably when they refer to two separate components, "while sometimes including elements of restoration ecology, ecological restoration may be thought of as the entire sum of practices that address the goals of restoration, including those that encompass the human dimensions: social, political, technological, economic, cultural, and religious" (Weinstein, 2007, p.365; Higgs, 2005). This distinction is key to creating more holistic restoration designs that address multiple aspects of the ecosystem.

Understanding how to successfully include all of these goals is not usually accomplished in restoration projects. Cairns, Weinstein and Higgs elaborate on the role of restoration ecology within ecological restoration and eco-societal restoration, "the process of reexamining human society's relationship with natural systems so that the repair and destruction can be balanced and perhaps, restoration practices ultimately exceed destructive practices" (Weinstein, 2007, p. 366; Cairns, 1995, p.

9). This approach may answer this question, can we integrate restoration ecology and social components to restore the damage of the past and prevent further anthropogenic damage?

When starting an ecological restoration project it is important to identify what kind of estuarine ecosystem and scale the project will be at. For example take two separate urban estuarine ecosystems, one has poor water quality, the other has flooding issues. These different ecosystems will cause planners to use two different approaches to the restoration but they will utilize the same holistic ecosystem wide restoration framework to restore. The framework needs to allow each project to have a focus while keeping in mind the larger ecosystem. Within the field this is not usually emphasized because of several barriers, city or state boundaries, funding or political approaches as well as incorporation of projects from multiple disciplines. These approaches to restoration and barriers are addressed in the book series by the Society of Ecological Restoration as well as the *Handbook of Ecological Restoration Volume 2 Restoration in Practice*.

Monitoring Techniques

Despite the variety in restoration techniques there are overarching steps necessary to monitoring; “reference systems, temporal and spatial scale, action thresholds, sample distribution and desirable characteristics of monitoring parameters” (Holl and Cairns, 2002, p. 411). The literature used to supplement these parameters is from ecotoxicology and restoration ecology based on their long history of rigorous monitoring techniques. According to Holl and Cairns Jr. (2002) monitoring is often used to describe three different activities: “sampling/surveying, surveillance, and monitoring” (Perrow and Davy, 2002). Their definition of monitoring is the *surveillance which ensures predetermined quality control conditions are being met, not the gathering of data at specific points in time or surveillance over a period of time* (Holl and Cairns, 2002). Pre-monitoring and post-monitoring data is used to determine if a project was successful in meeting the goals of the restoration.

The monitoring techniques used in this thesis are expert observation, field testing, transects, and photo-point (Aronson and Clewell, 2013; Block et al., 2001; Holl and Cairns, 2002). There is one predominant monitoring technique, transects, to measure species diversity. This can be used to identify the success of native species restoration, invasive species restoration, seagrass restoration and kelp bed restoration. Utilizing the definition of surveillance by Holl and Cairns Jr. (2002) will avoid the collection of endless data that is never used to evaluate the project's success, first measure the species diversity, predetermined, before restoration and then measure the species diversity over the following years. These measurements can allow us to enhance our restoration of native species to allow for designed plantings versus the introduction naturally of species. This process of predetermined quality control conditions hope to promote the necessary planning and implementation for a successful monitoring program (Holl and Cairns, 2002).

Monitoring techniques allow for a long term analysis of data which can be compared across varying restoration sites. The need for a long-term dataset is especially important to reduce the rate of biodiversity loss. Magurran et al. (2010) outline the biggest challenge in distinguishing the change is the identification of loss attributed to anthropogenic activities versus natural change. False alerts and modifications are integral in their discussion of methodological issues.

In determining the most effective monitoring techniques the difference in framing between ecosystem services and ecological function create a challenge in determining the metrics involved. Within the discussion of ecosystem services this is a problem, data is collected in various ways and scattered throughout peer-reviewed literature and gray literature. In order to make a comparison among ecosystem services there needs to be a “standardized framework for the comprehensive assessment of ecosystem functions, goods and services” (de Groot et al., 2002, p. 393). In de Groot, Wilson and Boumans (2002) classification they outlined 23 ecosystem functions which provide the largest number of goods and services. Beginning with a standardized framework to create a comprehensive assessment of ecosystem functions, goods, and services, they used this to outline the ecosystem functions and create a matrix which link the functions to the main ecological socio-cultural and economic valuation methods (de Groot et al., 2002). This article is a start to answering the question of how to monitor these restoration efforts but Gretchen Daily poses an interesting idea which needs to be considered. Valuation of ecosystem services, “resolving fundamental philosophical issues (such as the underlying bases for value), the establishment of context, and the defining of objectives and preferences, all of which are inherently subjective” need to be considered (Daily, 1997, 7). Although de Groot (2002), Wilson (2002) and Boumans (2002) have created a framework for the evaluation this subjectivity poses a problem in the acceptance in the public realm to the valuation.

Despite the complexity of ecological restoration there is a need for a graphic translation of the literature, projects and data involved in ecological restoration. This thesis hopes to begin the translation of information through infographics to further the incorporation of the restoration professionals.

CHAPTER IV

CASE REVIEWS: JAMAICA BAY, ORONGO STATION AND DESIGN COMPETITIONS

Ecological restoration occurs on a spectrum of development (Figure 14). There is a need for differing levels of intervention based on the amount of development in the site. This is not to say that ecosystem health is sacrificed in this evaluation but rather that the importance of social factors increases proportionally with *increases* in the amount of development and human density. There are two problems in evaluating ecological restoration projects: the framing between ecological health and ecosystem services, and the lack of unified classification of ecological restoration components. With varying metrics of evaluation it is difficult to determine ecological restoration projects success comparatively.

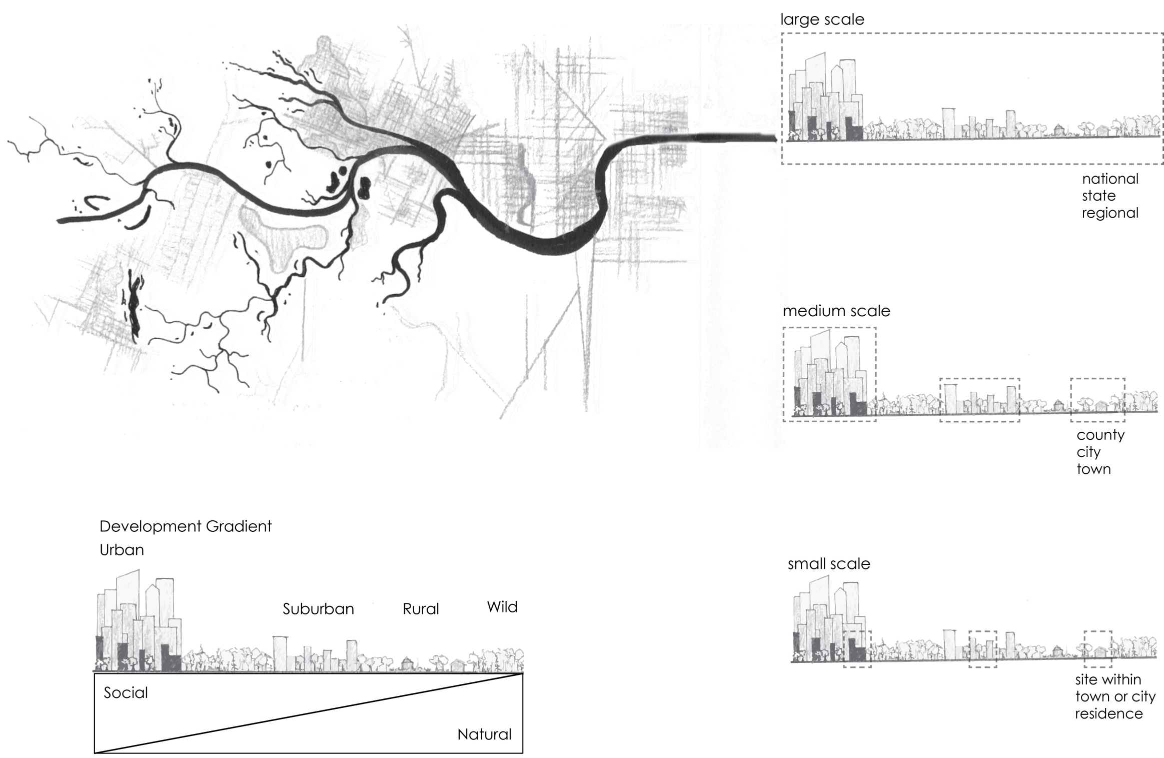
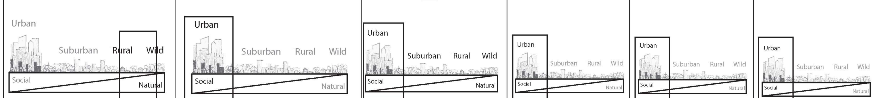


Figure 14: Development Gradient

To compare restoration projects across the disciplines this thesis will use classifications; social, ecological, planning and management, and outreach. Social includes history, culture, recreation, public access, and aesthetics. Ecology includes water quality, erosion control, flood control, health benefits, biodiversity, ecological function and history. Planning and management includes multi-disciplinary, watershed restoration planning, pre-post monitoring, regulation/permitting, and long-term management. Outreach includes environmental education, participatory/community based and stewardship (Figure 15).

Criteria for Case Reviews and Project Evaluation

Criteria for Case Review Selection	Case Review 1 Orongo Station: Master Plan	Case Review 2 Jamaica Bay Restoration Plan	Rebuild by Design	Design Competitions Rising Tides	Rising Currents	Sea Change Boston
Scale	30,000	27,025 acres HRE Watershed Restoration Area: 25 miles	27,025 acres	27,025 acres	27,025 acres	27,025 acres
Project Type	Built	Built	Theoretical	Theoretical	Theoretical	Theoretical
Categories:						
Social	☑	☑	☑	☐*	☑	☐*
Ecology	☐*	☑	☑	☐*	☑	☑
Management and Planning	☐*	☑	☑	☐*	☐*	☐*
Outreach	☑	☑	☑	☐*	☐*	☐*
Placement along Development Gradient						
Metric	Ecological Function Ecosystem Service	Ecological Function Ecosystem Service	n/a	n/a	n/a	n/a



* Fulfills one or more of the sub-categories but not all.

Figure 15: Criteria for Case Reviews and Project Evaluation

Analysis of built ecological restoration projects demonstrates the disconnect between different land scales as well as between different subject areas. Degradation occurs across the watershed, while restoration projects typically do not occur at the landscape or watershed scale, but specifically addressing one aspect of the problem. A watershed approach allows for the integration of restoration techniques that restore the entire ecosystem. To work at this scale natural scientists need to collaborate with governmental agencies, policy makers, and designers. Two case studies, Jamaica Bay, NY and Orongo Station, NZ, were selected because they include the larger watershed scale and integrate social and ecological components. They incorporate all the aforementioned categories but vary in their incorporation of the sub-categories ie watershed restoration, community-based design, ecological function and recreation, demonstrating the diversity among ecological restoration projects (Figures 16).

	Case Review 1	Case Review 2	Design Competitions			
	Orongo Station: Master Plan	Jamaica Bay Restoration Plan	Rebuild by Design	Rising Tides	Rising Currents	Sea Change Boston
Social	☑	☑	☑	☐	☑	☐
History	☑	☑	☑	☑	☑	☑
Culture	☑	☑	☑	☑	☑	☑
Recreation	☑*	☑	☑	☐	☑	☐
Aesthetics	☑	☑	☑	☐	☑	☐
Ecology	☐	☑	☑	☐	☑	☑
Ecosystem Services	☐	☑	☑	☑	☑	☑
Ecological Function	☑	☑	☑	☐	☑	☑
History	☑	☑	☑	☑	☑	☑
Management and Planning	☐	☑	☑	☐	☐	☐
Watershed Restoration	☑	☑	☑	☑	☑	☑
Multi-Disciplinary	☑	☑	☑	☑	☑	☑
Long-Term Management	☑	☑	☑	☑	☑	☑
Pre-Post Monitoring	☐**	☑	☑	☐	☐	☐
Outreach	☑	☑	☑	☐	☐	☐
Community-Based Design	☑	☑	☑	☐	☑	☐
Public Participation	☑	☑	☑	☐	☐	☑
Environmental Education	☑	☑	☑	☑*	☑*	☑

*Recreation only includes pedestrian access for walking/hiking.

** Pre-Post Monitoring was completed but they did not publish or provide access to it by the public.

*Environmental Education includes community outreach and public participation post design proposals.

Figure 16: Evaluation of Case Reviews

Gateway National Recreation Area: Jamaica Bay Restoration Plan

The Jamaica Bay case review is the only project that fulfills all 4 categories and sub categories. Jamaica Bay is the Gateway National Recreation Area and it is part of the Hudson-Raritan Estuary. There is a restoration plan for Jamaica Bay and an overall comprehensive restoration plan for the estuary. In addition to crossing political and governmental boundaries to look at the restoration from a watershed approach this project combines: ecological restoration of the marshlands with environmental education opportunities, access to these restored areas through passive and active recreation opportunities which allow people from a highly urban area to recreate in a large natural area. This projects unique approach to its political and governmental cooperation makes it an exemplary ecological restoration project.

Gateway National Recreation Area, NYC is the first urban national recreation area, with the first urban park unit of the National Park Service, Jamaica Bay (Black and United States, 1981). (Figure 17) Gateway was established in 1972 with the goal of bringing the national park service experience to a metropolitan area (NPS, 2014). This experience is important in all metropolitan areas but the needs and challenges in accomplishing this goal have drastically changed in the 21st century. The Gateway National Recreation Area legislative boundary is 27,025 acres which extends into adjacent waters. The park manages 21,680 acres of land and water. The remaining 5,345 acres are managed by other federal, state or private agencies (Black and United States, 1981). Jamaica Bay is the largest of the three units that make up the Gateway with 19,000 acres of land, bay and ocean waters. The unit includes: Plumb Beach, Floyd Bennett Field, Bergen Beach, Canarsie Pier, Pennsylvania Avenue and Fountain Avenue Parks, Frank Charles Memorial Park, Hamilton Beach, Spring Creek, Jacob Riis Park, Fort Tilden, Breezy Point Tip and the Jamaica Bay Wildlife Refuge in the center of the bay (Black and United States, 1981).

Figure 17: Gateway National Recreation Area Map (Source: Gateway NRA GIS Division of Natural Resources, 2003)

The Gateway National Recreation Area is located within the Hudson-Raritan Estuary (HRE) which is one of the most urbanized estuaries in the nation. Historically the estuary was used for commercial and industrial purposes which led to overall degradation, habitat loss, poor water quality, sediment contamination and loss of access for the public. The impact by urbanization, runoff and shoreline modification, and the freshwater inflow from wastewater treatment plants and combined sewer systems have led to a rapid increase in the degradation of the gateway; specifically in Jamaica Bay. Due to the degradations the overall health of the ecosystem has impacted the ecosystem services utilized by the urban population. The severity of the impacts on the New York-New Jersey Harbor, part of the Hudson-Raritan Estuary, led to recognition by Congress in 1988 as an estuary of national importance and acceptance into the National Estuary Program (USACE et al., 2009). In 1996 the Comprehensive Conservation and Management Plan developed by the Harbor Estuary Program included a comprehensive strategy for habitat protection and restoration. This program led several agencies to develop HRE Ecosystem Restoration Feasibility Study in 1999. The recognition by Congress not only led to documentation and plans to restore the estuary but also initiated a partnership between federal, state, non-profit, university and community groups which is changing the way watershed restoration is being organized. The idea of restoring for ecological and social components is a newer approach to restoration and is included in the documentation of the estuary.

The Hudson-Raritan Estuary Comprehensive Restoration Plan draft, created in 2009, by the US Army Corp of Engineers, outlines a comprehensive strategy for restoration and coordinates specific restoration projects. The CRP is a two volume document: Volume 1 provides as outline and framework for estuary restoration, development of Target Ecosystem Characteristics (TECs), and short and long term objectives while Volume 2 provides targets for restoration, and technical guidance for planning and conducting individual restoration goals to meet TECs (USACE et al., 2009). The policy issues addressed in Volume 1 regarding resource conservation are: habitat exchange issues, placement of fill in water, beneficial use of dredged material for habitat restoration, attractive nuisance issues and issues affecting management of contaminated sediments (USACE et al., 2009) The scope of this paper is focusing on the restoration goals and targets outlined in the CRP (1.2) and specific restoration projects within Jamaica Bay, which is an HRE study area. Although the case review boundary is Jamaica Bay within the Gateway National Recreation Area, only a portion of the Jamaica Bay HRE study area, this document provides targets and guidance on how to implement 'watershed restoration' within the entire HRE. Making the connection between the restoration of the bay versus restoration of the watershed.

Although this plan is one of the more in-depth and collaborative restoration plan is does not include a comprehensive restoration design for a system wide restoration, the success is measured on a project-by-project basis without consideration of its success in the health of the entire estuary. In the CRP they even state that there isn't a permanent staff member identified for harbor-wide restoration within any of the Program Management teams. They provide strategies to solve this but to date this vital position does not exist. One strategy provided is that the CRP be a living document where agencies can update and learn from restoration successes and failures within the estuary.

HRE has a long history of degradation from commercial and industrial development, which has altered the ecosystem's community structure, habitat types and species populations (USACE et al., 2009). To develop a plan the USACE team established an understanding of the systems approach for ecological restoration. Utilizing throughout the document *ecological restoration*, as defined by the Society of Ecological Restoration: the process of assisting with the recovery of an ecosystem that has been degraded, damaged or destroyed. Through a series of workshops and meetings the team acknowledged that the estuary will remain populated, reshaped by humans, and that they would utilize a "renaturing" approach to habitat restoration (USACE et al., 2009). This approach "entails designing an ecosystem where nature and people co-exist, a system wherein environmental and societal needs are equivalent ecosystem elements" (USACE et al., 2009; Bain et al., 2007). A key element from a holistic approach to ecological restoration is the scientists agreeing that the restoration program should include restoring a variety of habitats that are intertwined with human dominated areas to allow public access to the estuary. Within the restoration plan, access and environmental education have a significant role. Providing access to the water, kayaking, bird watching, bicycle paths (Figure 18-21), and walking trails, show the public that their health and access to nature matter, which often is over looked in highly urban areas. In addition the NPS offer programs and internships for young adults and students to learn and participate in the restoration. The acknowledgment of a restoration method which includes social values, specifically access, to these restored areas makes this plan important to promote.

Figure 18: Kayaking in Jamaica Bay (Source: nycgo.com staff, 2015)

Figure 19: Bird watching in Jamaica Bay (Source: Andrew Baksh, 2014)

Figure 20: Access to Jamaica Bay and Community Workshops (Source: New York City DOT, 2014)

Figure 21: Environmental Education (National Park Service, 2014)

The CRP Program Goal is to develop a mosaic of habitats that provides society with renewed and increased benefits from the estuary environment. The team identified 11 Target Ecosystem Characteristics (TEC) (Figure 22) based on estuarine-dependent habitat types, habitat complexes, contamination issues, and societal values. The 11 TEC's are coastal wetlands; islands for waterbirds; coastal and maritime forests; oyster reefs; eelgrass beds; shorelines and shallows; habitats for fish, crabs and lobsters; tributary connections; enclosed and confined waters; sediment contamination; and public access. Within these 11 TEC's the scientists established both short term and long term objectives. These objectives will be crucial in the measurability and assessment of the projects (USACE et al., 2009).

Table 3-1. Short-Term and Long-Term Objectives for Target Ecosystem Characteristics (TECs) in the Hudson-Raritan Estuary (HRE) study area, including a list of ecosytem services offered by each TEC.

TEC	2015	2050	Ecosystem Services
Coastal Wetlands	One new wetland that provides at least five primary functions in each HRE region (1,200 total acres)	Continue restoration at a rate of 400 acres per year for a total system gain of 15,200 acres	Climate regulation, Disturbance regulation, Water supply, Erosion control and sediment retention, Nutrient cycling, Waste treatment, Refugia, Food Production, Recreation
Habitat for Waterbirds	Enhance at least one island in each of the four main island groups within the HRE study area	All islands in the four main island groups provide roosting and nesting sites	Biological control, Recreation, Cultural
Coastal and Maritime Communities	Establish one new forest of at least 50 acres and rehabilitate at least 200 additional acres of existing forest.	Establish 500 acres of new forest among three sites, and rehabilitate another 500 acres of existing forest.	Gas regulation, Climate regulation, Disturbance regulation, Erosion control and sediment retention, Refugia, Cultural
Oyster Reefs	500 acres of reef habitat across 10-20 sites	5,000 acres of established oyster reef habitat	Refugia, Cultural
Eelgrass Beds	Create one test bed in each HRE region	Three established beds in each HRE region capable of supporting eelgrass	Nutrient cycling, Refugia, Cultural
Shorelines and Shallows	Establish new shorelines and shallows sites in three HRE regions	Restore all available shorelines and shallows sites in three HRE regions, and two sites in other planning regions	Disturbance regulation, Water supply, Erosion control and sediment retention, Nutrient cycling, Waste treatment
Fish, Crab, and Lobster Habitat	Complete a set of two functionally related habitats in each HRE region	Complete four sets of at least two functionally related habitats in each HRE region	Biological control, Refugia, Food Production, Recreation, Cultural
Tributary Connections	One less barrier per year to passage between at least three different inland habitats	Continue reconnecting habitats at a rate of one project per year until all barriers within the HRE study area are removed or made passable	Gas regulation, Climate regulation, Disturbance regulation, Erosion control and sediment retention, Biological control, Refugia, Recreation, Cultural
Enclosed and Confined Waters	Improve the water quality or environmental conditions of eight confined water bodies to meet their current designated use classification	Improve the water quality or environmental conditions of eight confined water bodies to meet the criteria of their receiving waters	Water regulation, erosion control & sediment retention, nutrient cycling, waste treatment, food production, recreation, refugia.
Sediment Quality	Isolate or remove at least 25 acres of contaminated sediment	Isolate or remove at least 25 acres every 2 years	Nutrient cycling, Refugia, Cultural
Public Access	Create one access point and upgrade one access point in each of the HRE regions per year	All waters of the HRE are accessible within a short walk or public transit trip	Recreation, Cultural

Figure 22: Target Ecosystem Characteristics (USACE, 2009)

Within the HRE, Jamaica Bay (Figure 23) is made up of a mosaic of tidal wetlands, beaches, islands, marshes, upland forests and open ocean with more than 325 species of birds, 35 species of butterflies, and 338 fish species recorded by Briggs and Waldman (2002) for New York's marine waters as well as many threatened or endangered plants (Castro and Myers, 1993). More than 70 birds utilize the bay for their breeding populations, among them herons, long-legged waders, nesting grassland birds and beach-nesting birds (Castro and Myers, 1993).

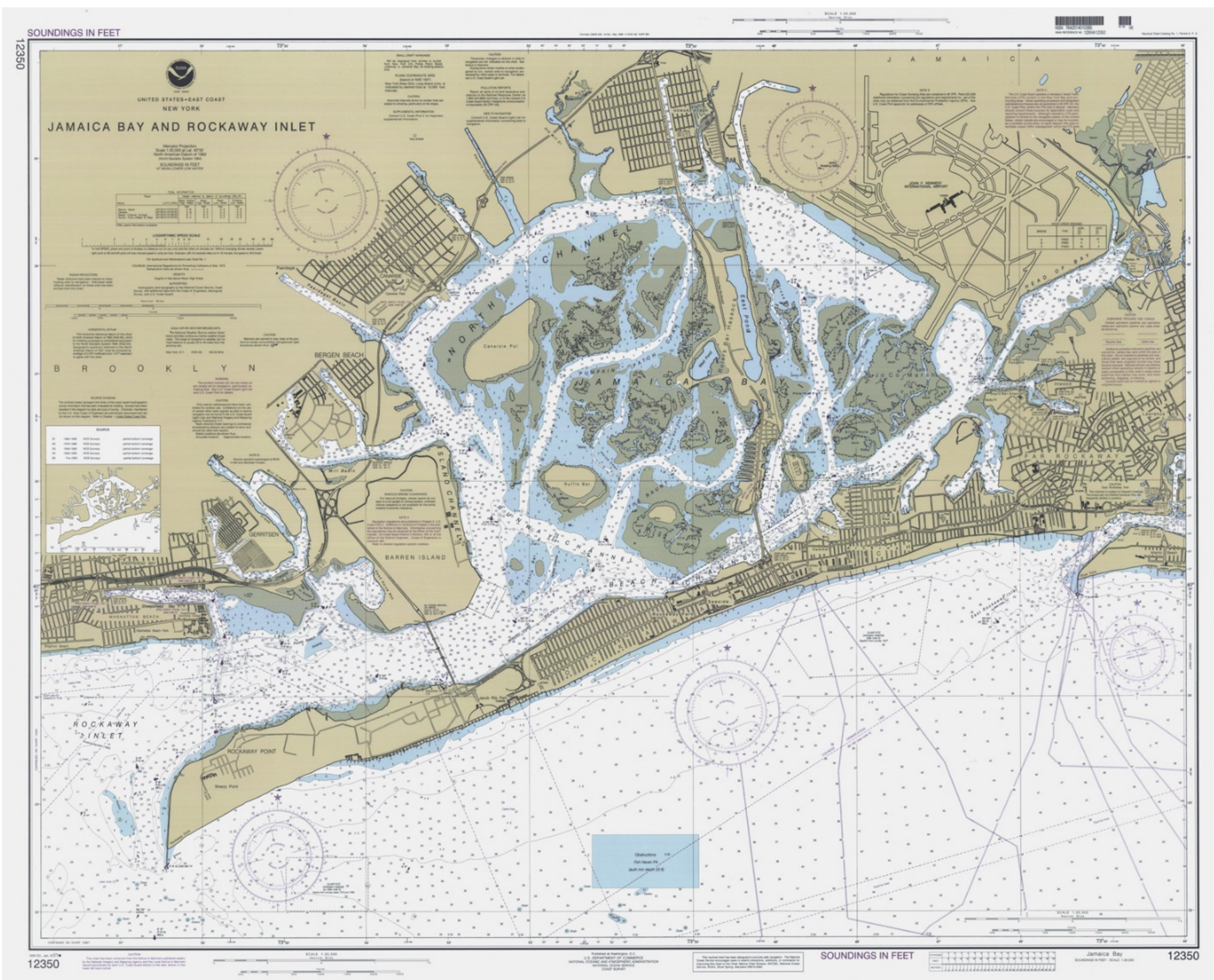


Figure 23: Map illustrating the different zones that make up Jamaica Bay (Source: NOAA, 2001)

Responding to climate change and sea-level rise Hartig (2002), Gornitz (2002), Kolker (2002), Mushacke (2002), Fallon (2002) conducted research on the effects of human activity and sea-level rise on salt marshes. Analysis of historic maps of the marsh islands shows a diminished size of about 12% since 1951 (Hartig et al., 2002). (Figure 24) This means that since 1974 the amount of low marsh vegetation has decreased by 38% with the smaller islands losing about 78% of their vegetation cover. With these projections the marsh lands of Jamaica Bay will not withstand the degradation and sea level rise.

Figure 24: Marsh loss from 1951-2003 (Source: National Park Service, 2007)

Swanson (2008) and Wilson's (2008) research shows that there may not be just one connection to the loss of marsh islands but rather that the processes of recontouring and dredging the bay may have also contributed to the problem. The loss of the islands themselves is one problem but the loss of vegetation affects a majority of the species on the islands. The dominant vegetation in this area is *Spartina alterniflora*. Although the area of the marsh is predominantly one species, *Spartina* has different subspecies that are adapted to specific elevations, increasing the overall species diversity. Within marsh restoration it is important to propagate plugs of *Spartina alterniflora* from wild seed and not just from clippings to maximize genetic diversity (Novy et al, 2010).

Within the HRE there are a variety of restoration projects. In Jamaica Bay specifically restoration work is on the disappearing marsh land. The HRE has experienced a more than 60% conversion of vegetated salt-marsh islands to intertidal and subtidal mudflats, decreasing the amount of land for nesting and habitat for species like the horseshoe crab (Rafferty et al., 2010). Between 1951 and 2008, 647.5 hectares (1,600 ac) of salt marsh were lost; the current rate of loss is 7.7 hectares (19 ac) per year. (Rafferty et al., 2010). The current rate of loss for Jamaica Bay specifically is about 44 acres per year. (Castagna, 2011) This loss of marsh islands is currently being researched, with hypothesis of its contributions, shoreline development, sediment degradation, manipulation of the geomorphology, and water quality issues. The contribution of loss of marsh land due to sea level rise is under comparison with the effects of *bathymetry*, the measurement of water depth at various places in a body of water (Merriam Webster), modification from dredging (Hartig et al., 2002). Swanson (2008) and Wilson (2008) studied different sites along the estuary, measuring the sea level and the tidal records, analyzing historic aerials of the bay with current aerials and the study sites in Jamaica Bay showed more loss than other sites along the estuary. Historical increases in tidal range have resulted in high-tide water levels today that are 56–78% greater than increases due to sea level rise (Swanson & Wilson, 2008). The recontouring and deepening of the bay in the 20th century led to a modification of the tidal characteristics. With this modification the changes to the bay by sea level rise, combined with a lack of input of sedimentation from shoreline erosion has led to a loss of marsh islands and increased the tidal wetlands. This change has affected many of the shore nesting birds, the horseshoe crabs and other migratory birds.

Species restoration within urban estuaries is under debate because the factors affecting habitats, which limit species population, are unknown. Recently a study of the horseshoe crab in an urban estuary, Jamaica Bay, and its potential for ecological restoration presents a few ideas for the restoration as well as reasons why there is a declining population (Botton et al., 2006). The hypothesis is that the decline is based on a lack of suitable sand for the spawning of the crabs. Due to pollution, eroded beaches and shorelines, and an increase in intertidal wetlands the horseshoe crabs are not producing a large number of eggs and the eggs they do lay have a high mortality rate. Within Jamaica Bay the only inflow of "freshwater" is through the wastewater treatment plants and runoff from development. This has led to pollution from wastewater and boats from the harbor (Cochran et al., 2009). This pollution has not only affected the horseshoe crab but has limited the growth and increased the mortality of the eastern oyster (Levinton et al., 2013). Restoration for the oyster is being considered in the bay but the debate of which oyster, due to a pathogen on the eastern oyster, to grow and harvest has not been decided.

The two locations of marsh restorations in Jamaica Bay are the Big Egg Marsh Restoration and the Elders Point East and West Restorations. The Elders Point East Restoration (Figure 25) was completed in 2006. The island complex was historically 132-acres but over time degraded into two separate islands, east is 49 acres and west is 40 acres (Castagna, 2011 Rafferty et al., 2010). For this restoration the United States Army Corps of Engineers New York District partnered with the U.S. Department of the Interior National Park Service, U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS), New York City Department of Environmental Protection, Port Authority of New York and New Jersey, and New York State Department of Environmental Conservation. The restoration began with the pumping of 250,000 cubic yards of dredged sand and placing it in specific elevations around the island. (Figure 26) Then native plant species were hand-planted around the marsh, spike grass was grown from seeds collected around Jamaica Bay (Rafferty et al., 2010). The dredged sand was recycled from other parts of the harbor and used to rebuild the island, saving the city money and helping save the environment. The unique part about this restoration is that the USACE (2009) and NPS waited to complete the west part of the island complex until they had monitored the east restoration to determine what failed or succeeded. A mark of success for the east restoration was the return of dozens of horseshoe crabs to the island and their successful breeding. The west restoration started in 2009 with 240,000 cubic yards of dredged sand. This time they took into consideration how the sand settles on site while working on grading the elevations. Seedlings became the primary form of native species replanting because the hand-plantings were labor- and cost- intensive and did not take to the site as well.

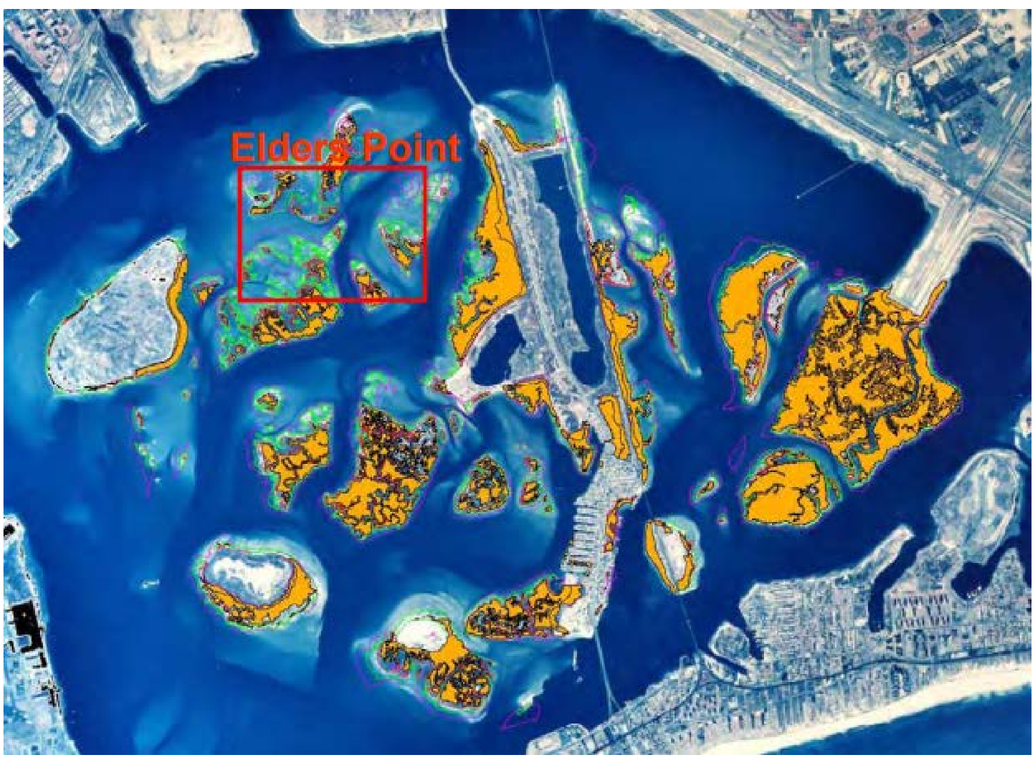


Figure 25: Elders Point Restoration Location Map (Source: National Park Service, 2012)

Figure 26: Elders Point Restoration Aerial Photo (Source: US Coast Guard, 2010)

Working on east restoration plan first allowed the team to monitor and assess the restoration, make modifications and then scale up the restoration for the west restoration. The hope is that the scale up will lead to the restoration being applicable to other marsh island restoration sites at a commercial level. This restoration project works to advance the goals of the HRECRP in developing a mosaic of habitats that provide maximum ecological and societal benefits to the region (Castagna, 2011).

The restoration at a comprehensive, watershed scale poses many challenges in understanding the ecological functions and degradations while designing a way to restore in a highly urbanized and culturally significant area. The attempt to have a consistent assessment of the restoration success or failure across the estuary and amend the documents accordingly is a noble effort to restore an urban estuary holistically. The collaboration between the various agencies, across political boundaries, has led to the beginning of a new political approach to comprehensive restoration planning. Through reviewing the literature the team has identified the loss of marsh islands as a key problem, some of the causes of their degradation, and species that are key to this ecosystem and are directly affected by the loss of this habitat. Overall the work being done on Jamaica Bay and the Hudson Raritan Estuary is an example for all comprehensive restoration plans of an entire estuary.

Jamaica Bay offers a diverse amount of information allowing all restoration professionals the opportunity to learn from this case review. The only component not included in this exemplary project is a concise document providing advice/how to for other projects. To find all of the information on this case review a person has to spend time looking through a very comprehensive plan, and many websites with supplemental documentation. Because the project uses a holistic approach to ecological restoration it should be easily accessible to other restoration professionals.

Orongo Station Master Plan

Orongo Station Master Plan fulfills almost all of the categories (Figure 27), only missing in ecosystem service approach and pre-post monitoring. The incorporation of these two sub categories could have occurred but they were not included with the publications of the case review. Differing from the Jamaica Bay case review Orongo Station has a different set of political and cultural constraints that lead to a restoration with a working agricultural component while maintaining the cultural history and restoring the ecological history.

	Case Review 1 Orongo Station: Master Plan
Social	☑
History	☑
Culture	☑
Recreation	☑*
Aesthetics	☑
Ecology	☐
Ecosystem Services	☐
Ecological Function	☑
History	☑
Management and Planning	☐
Watershed Restoration	☑
Multi-Disciplinary	☑
Long-Term Management	☑
Pre-Post Monitoring	☐**
Outreach	☑
Community-Based Design	☑
Public Participation	☑
Environmental Education	☑

*Recreation only includes pedestrian access for walking/hiking.

** Pre-Post Monitoring was completed but they did not publish or provide access to it by the public.

Figure 27: Case Review Evaluation: Orongo Station Master Plan

Orongo Station Master Plan (2002-2012) is unprecedented in its integration of designers, public officials, private stakeholders, natural scientists, local experts, and the indigenous Maori people to create a harmonious ecological restoration project in New Zealand. Due to the importance historically and culturally the ownership of this site prompted a sale where the land would be permanently protected. In 2002 the Ngai Tamanuhiri, a mauri trust, attempted to purchase the property but didn't have the funds. A foreigner, John Griffin, initiated a purchase shortly after. The New Zealand government was able to impose conditions upon the sale to help the preservation of the land. The land is divided into two trusts, the Queen Elizabeth II Trust and a trust with Ngai Tamanuhiri to protect the property from further commercial development. In addition to the trusts Mr. Griffin hired a restoration team to restore the property (New Zealand Government, 2002). The master plan (Figure 28) was designed by a diverse team with Nelson Byrd Woltz Landscape Architects as the lead. The Orongo Station Master Plan's site is a three-thousand-acre sheep farm in New Zealand. The site is composed of Orongo Station, Mapere Station, Te Kuri a Paoa, and the Tuatara Preserve. Te Kuri a Paoa, Young Nick's

Head, is the station’s primary notoriety. This promontory is important to New Zealand's history as the landing site of the Horouta Canoe, which carried the first of the Maori settlers, as well as the vessel carrying the first English settlers. (Beardsley, 2013) The site is diverse in its ecology and ecosystem types but has been altered drastically by human use, much like the rest of New Zealand. First the Maori settlers cut down the forests for fire, shelter, and agriculture, then the English settlers brought in invasive mammals–mice, cats, and rabbits–which have decimated the native and endemic species of birds, amphibians, and insects. Having been converted into sheep farms with heavy agricultural use and cattle grazing, the natural ecology of the temperate rainforest, cliffs, and estuary were lost. With this site being a working agricultural fram, it presents a unprecedented challenge to the process of ecological restoration.

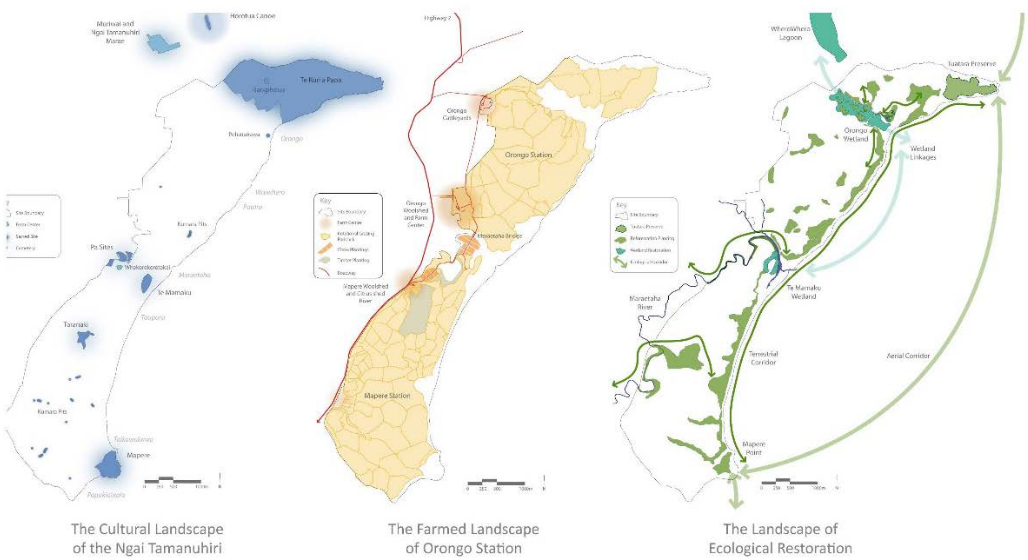


Figure 28: Orongo Station Master Plan (Source: Nelson Byrd Woltz Landscape Architects, ASLA 2010)

The promontory, Tuatara Preserve, is an important location for nesting migratory birds and the tuatara, an endangered reptile. Sheep grazing has limited the amount of native vegetation and the introduction of pests and rodents have decimated the nesting populations. The restoration of this portion of the site includes an installation of a predator-proof fence, the eradication of pests and rodents, a dense planting of coastal woodland trees, and methods to attract bird species to the peninsula. The coastal woodland tree planting is the first step in reestablishing the temperate rainforest, the historic ecology of the peninsula. With this reestablishment the goal is to bring back the tuatara. The tuatara's habitat included the exposed cliffs of the north island. The predator-proof fence is a newer attempt at stopping a continued invasion of pests into an eradicated site. The fence is a 1,640 foot long excluder with below grade flange repels and a flange at the top to prevent climbing rodents (Beardsley 2013, 160). Coupled with an extensive rodent and pest eradication program at the site, this technique has been effective in eliminating the pests and protecting the nesting bird populations. (Figure 29)

Figure 29: Invasive Species Removal, Native Species Restoration (Source: Nelson Byrd Woltz Landscape Architects, ASLA 2010)

Designing at the master plan scale allowed the design team to think about the site not as separate interconnected systems but rather as one unified ecosystem (Figure 30), an approach which is not normally available within many site scale ecological restoration projects because the project sites are not owned or managed by the same person. Historically surrounding the cliffs on the northern side of the property were tidal wetlands. The master plan involved restoring a tidal wetland (Figure 31) which was previously drained for expanded grazing paddocks and constructing a freshwater wetland to provide a diversity of habitats (Beardsley, 2013). The design of the two wetland systems is separated by an earthen dam which directs rainwater to the freshwater wetland and allows walking access to the area (Figure 32). The freshwater wetland area is designed to handle seasonal flooding. To provide specific habitat types for birds and amphibians, the wetland design incorporated a careful arrangement and sizing of islands, with steep banks to protect against predators during nesting season (Beardsley, 2013) (Figure 33).

Figure 30: Restoration Plan (Source: Nelson Byrd Woltz Landscape Architects, ASLA 2010)

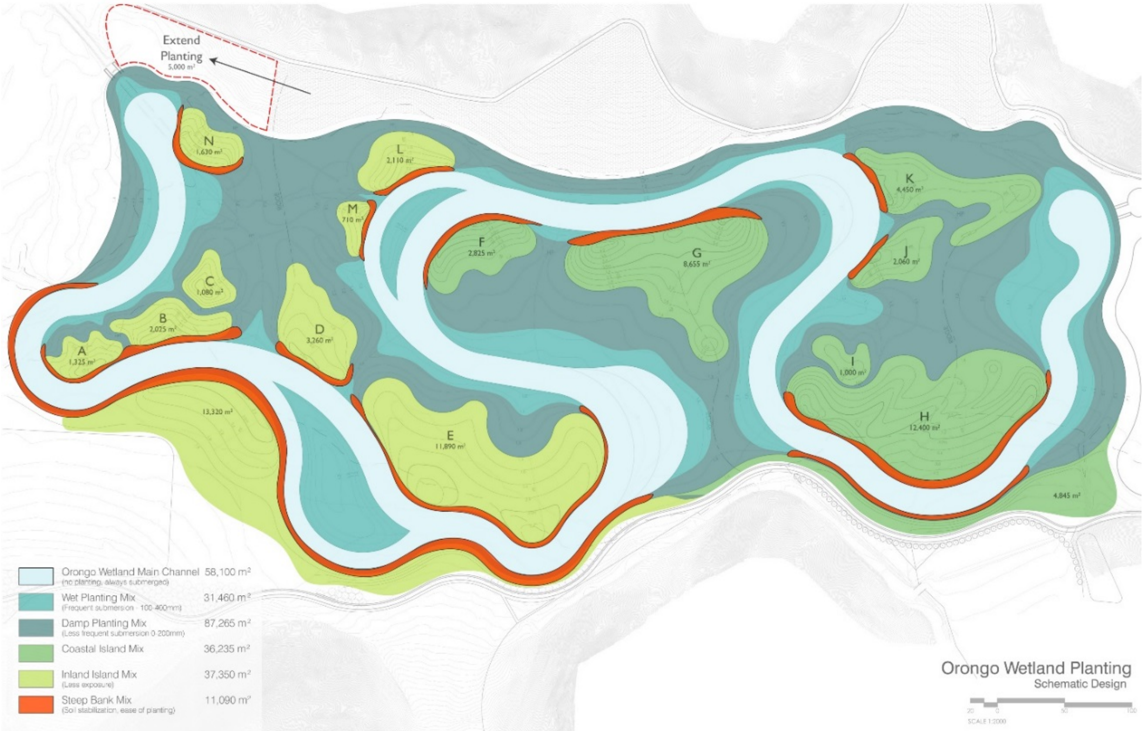


Figure 31: Wetland Restoration and Planting Design (Source: Nelson Byrd Woltz Landscape Architects, ASLA 2010)

Figure 32: Earthen Dam (Source: Nelson Byrd Woltz Landscape Architects, ASLA 2010)

Figure 33: Post Wetland Restoration (Source: Nelson Byrd Woltz Landscape Architects, ASLA 2010)

Demonstrated in the master plan and diagrams is a two-part phasing of reforestation to the uplands and other portions of the site, a process necessitated by grazing degradation. The reforestation both facilitates the wetland restoration bank stabilization and stabilizes the cliff sides from erosion related to high wind and sea spray. The reforestation along the wetlands provides habitat and a necessary corridor for species around the wetlands. Connecting this reforestation along the wetlands to the 5.5 miles of uplands abutting the preserve creates a large diverse habitat corridor. Five hundred thousand trees have been planted at Orongo Station to date, which is important to restoring the eroding coastline (Beardsley, 2013). Integrated with the restoration of the cultural landscape this becomes a bold statement of the importance of conservation. The cultural landscape restoration includes: the restoration of a cemetery; restoration and preservation of the earthen defensive structures, fishing encampments, and pits where the Maori stored staple food crops; the design of the farm operations; the homestead and preservation of the historic house; and creating important sight and pedestrian access to cultural and historical sites.

The land around the Orongo Station is significant to the local Maori tribe, the Ngai Tamanuhiri (Beardsley, 2013). The site is home to remnants of earthen defensive structures, fishing encampments, and pits where they stored their staple food crop. In the master plan design process the team engaged the local Maori tribe to restore a cemetery to which the tribe previously had limited access. Designing alongside the local farmers and the local tribe is important in restoring the cultural and ecological landscape while integrating agricultural practices. In this collaboration between the design team and the local tribe, integrating agricultural practices with the restoration of Maori cultural landscapes became a regional model. Most Maori tribes historically worked the land. Providing the opportunity to continue this tradition, allows them to pass on traditions while providing jobs for tribe members. Jobs tend to be scarce where tribes are typically reside.

The majority of New Zealand is dealing with a problem of working agricultural land not having functioning ecological benefits. This has led to a significant decline in the endemic and native biodiversity throughout the country. In search of a balance the design team looked for ways of integrating restoration and farming operations while redesigning the main functions of the farming operation. The surrounding area of the farming operations is the Maraetaha River, the Te Mamaku wetland, and the Ngai Tamanuhiri site of sacred significance on the peak of the prominent hill of Taranaki (Beardsley, 2013). The design of the farming operation took into considerations the architecture of the farm and the culturally significant sites. With the farm operations designed to have a multi-functional courtyard , a bridge and road over the Maraetaha River was designed to provide connection to the farm and to frame the floodplain in a way that celebrates the physical and cultural landscape (Figure 34). The design includes a rotating grazing paddock, citrus blocks, the cemetery, a homestead with gardens, and a work yard. The road and bridge align on a straight axis across the floodplain to the peak of prominent hill of Taranaki (Beardsley, 2013) (Figure 35). In the search for a more balanced farming practice the designers worked with the farmers to design citrus plantings in the

Maraetaha portion of the site. Allowing access to the farm operations provided jobs for the local people in the tribe. In the layout of the fields the perimeter has native reforestation plantings to help with biodiversity, filtration of sediment from the site, and erosion control along the riverbank (Beardsley, 2013). The arc of the perimeter tree plantings mimics the curvature of the river on the adjacent edge of the citrus fields. Careful consideration of the experience through the Maraetaha site celebrates and reveals significant sites and views out to the Pacific Ocean.

Figure 34: Bridge across the Maraetaha River (Source: Nelson Byrd Woltz Landscape Architects, ASLA 2010)

Figure 35: Layout of the agricultural fields, river and bridge to foster a relationship to the broader landscape. (Source: Nelson Byrd Woltz Landscape Architects, ASLA 2010)

The last component of the design is the homestead which uses native plants and earthworks to illustrate the story of New Zealand's ecology and culture through a series of gardens around the building. The homestead uses the historic house and is surrounded by formal and informal spaces for entertaining, play, and discovery (Beardsley, 2013) which create a lens for visitors to understand the national importance of conservation efforts in the landscape (Beardsley, 2013).

Despite all the restoration efforts and the collaboration between the design team and the local Maori tribe there is little talk or research that shows how the team worked and how the research was produced. This project is unprecedented in its level of ecological restoration, with its tribe outreach and interdisciplinary collaboration between natural and social scientists, but it fails at producing documentation in a form to further restoration research. After an extensive search there is only scientist mentioned on the project. He hasn't provided any publications, aside from a basic website and could not be contacted for further conversation. The only documentation outside of magazine articles is in the book *Designing Wildlife Habitats*.

Orongo Station is an exemplary project but not in its outreach in furthering the stewardship outside the site or for other natural and social scientists wanting to replicate the success. For this project to be applicable to other places the documentation needs more accessibility to natural and social scientists and more comprehensive. It is unknown if there were pre-monitoring data or if the client has been monitoring the site since its restoration. The reason for a lack of data could be either that the design is too recent or that the site simply is not being monitored. It is important to have a system in place for social and natural scientists to use for comparability among projects, and this project did not contribute to such a system.

The success of this project can be evaluated by the number of awards it has received from design and social science organizations. It has received multiple awards from the New Zealand Institute of Landscape Architects (NZILA): Award of Excellence in Rural, Farm and Park Category, Georage Malcolm Supreme Award, and the Sustainability Award of Excellence. In addition to the awards from NZILA the project received an Honor Award for Analysis and Planning from the American Society of Landscape Architects. (ASLA, 2010) Despite the amount of awards, the only publication on the project, aside from the award write-ups, is in the book *Designing Wildlife Habitats* for the Dumbarton Oaks Symposium in 2010. Dumbarton Oaks was historically observed as a research institution for the humanities focusing on garden and landscape studies. In recent years the program's foci have shifted to be more diversified, with such topics for the symposia as: "vernacular and regional landscapes, theme parks, nature and ideology, places of commemoration and sacred and profane rituals in the gardens and landscapes" (Beardsley, 2013, p. 1). Yet only once has the symposium addressed the intersection of landscape design and environmental management, with the topic of "environmentalism in landscape architecture" (Beardsley, 2013, p. 1) and only once has it looked specifically at the intersection of science and design, in 2004. The symposium documented in *Designing Wildlife Habitats,* chapters by different contributors in an edited book, builds on the two topics to look at the "role of design in the protection, management, restoration, and even wholesale re-creation of habitat for wildlife" (Beardsley, 2013, p. 1). The Jamaica Bay case review worked to produce documentation on the individual restoration techniques, the collaboration, how the work is integrated, and produced documents for the public so they could better understand the efforts. This is key in creating stewardship around the project and engaging the public so they understand their role in the restoration.

As society faces the challenges to ecology from anthropogenic degradation design professionals are faced with a new challenge of how to solve climate change, a problem which is bound to cause as much ecological disturbance as social disturbance. Design has not only the ability to be the change in how we think about infrastructure–*gray* and *green*–but it also has the ability to be the catalyst for change in the research being conducted. The designs need to be thought of as a form of research, a way of raising questions, testing hypotheses, and documenting successes and, maybe more importantly, failures (Beardsley, 2013). In this exploration of data visualization through infographics a new category of case reviews becomes important: design competitions.

Design Competitions

Jamaica Bay and Orongo Station demonstrate two different approaches to ecological restoration, with important intersections of social and natural components. They include all components of social and natural within this classification but they also exhibit the diversity in the sub categories. (Figure 36) This case review analysis only accounted for built projects, with the criterion for *built* being *restored several years ago to allow time for monitoring of the restoration.* A different approach to evaluating ecological restoration projects is to look at: design research and design competitions. Design research is used to describe the research completed by design professionals who have received research grants or are working with professors. The level at which natural scientists cannot restore to the historic ecosystem due to development and human needs is an opportunity to explore new methods of intervention. These methods of intervention are an opportunity to collaborate and design new ways to restore. This is shown through design competitions. Traditionally design competitions are limited to design professionals–architects, landscape architects, and urban planners. The new trend within design competitions is to incorporate natural scientists, policy makers, the community, and stakeholders. The important component of the design competition is that the winning design is implemented or the project is published. Publication is important in demonstrating the work to the public and for setting precedent for further use of the presented ideas. The design competitions chosen show the evolution of design competitions; their use of graphics, incorporation of allied professions, and ecological restoration. Working from basic to complex this grouping of design competitions illustrate the potential to tackle the complexity of ecological restoration projects and produce graphics and material understandable to the public.

	Case Review 1	Case Review 2	Design Competitions			
	Orongo Station: Master Plan	Jamaica Bay Restoration Plan	Rebuild by Design	Rising Tides	Rising Currents	Sea Change Boston
Social	☑	☑	☑	☐	☑	☐
History	☑	☑	☑	☑	☑	☑
Culture	☑	☑	☑	☑	☑	☑
Recreation	☑*	☑	☑	☐	☑	☐
Aesthetics	☑	☑	☑	☐	☑	☐
Ecology	☐	☑	☑	☐	☑	☑
Ecosystem Services	☐	☑	☑	☑	☑	☑
Ecological Function	☑	☑	☑	☐	☑	☑
History	☑	☑	☑	☑	☑	☑
Management and Planning	☐	☑	☑	☐	☐	☐
Watershed Restoration	☑	☑	☑	☑	☑	☑
Multi-Disciplinary	☑	☑	☑	☑	☑	☑
Long-Term Management	☑	☑	☑	☑	☑	☑
Pre-Post Monitoring	☐**	☑	☑	☐	☐	☐
Outreach	☑	☑	☑	☐	☐	☐
Community-Based Design	☑	☑	☑	☐	☑	☐
Public Participation	☑	☑	☑	☐	☐	☑
Environmental Education	☑	☑	☑	☑*	☑*	☑

*Recreation only includes pedestrian access for walking/hiking.

** Pre-Post Monitoring was completed but they did not publish or provide access to it by the public.

*Environmental Education includes community outreach and public participation post design proposals.

Figure 36: Case Reviews Evaluation

Three design competitions and one research initiative were reviewed: Rising Currents, Re-build by Design, Rising Tides, and Sea Change: Boston. Rising Tides is a traditional design competition, in which a design team submits a proposal, the committee selects a winner and several runners up, and the designs are posted on the website. Re-build by Design and Rising Currents are competitions in which the teams are selected to work on the projects for an extended period of time, set up more like a research project than a traditional design competition. Sea Change: Boston is different in that a design firm designed an exhibit to present innovative ways to approach sea level rise in Boston and started the conversation among the different interest groups.

Rising Tides

Rising Tides (Figure 37-39) was a design competition for the San Francisco Bay. The competition was open to everyone from designers to artists to the general public. The sponsors of the competition included the San Francisco Bay Conservation and Development Commission (BCDC), National Oceanic and Atmospheric Administration (NOAA), American Institute of Architects San Francisco (AIASF), BPS Reprographics, Ferry Building Marketplace (Equity Office) and the Port of San Francisco (Meckel, 2009). Rising Tides sought responses to the questions: How do we build in an area that is dry, now, but that may be wet in the future? How do we retrofit existing shoreline infrastructure such as shipping ports, highways, airports, power plants, and wastewater treatment plants? Can we imagine a different shoreline configuration or settlement pattern that allows temporary inundation from extreme storm events? And how do we provide flood protection inland of marshes without drowning the wetland when the water rises? After all the entries were submitted, there was an exhibition in San Francisco for the public to view the design ideas. This process is an example of the emerging efforts of design competitions to think about anthropogenic ways to mimic nature and start to restore within estuarine ecosystems. It predates the other competitions discussed in this chapter and set precedents followed by these other competitions. This competition shows the importance of opening a dialog on the West Coast about sea level rise and the innovative ways to approach this problem by utilizing designers and graphic representation (Figure 39). In having an exhibition for the public to participate in it became a conversation outside of the design team, creating an opportunity for next steps.

Figure 37: Rising Tides Exhibit (Source: Meckel et al., 2009)

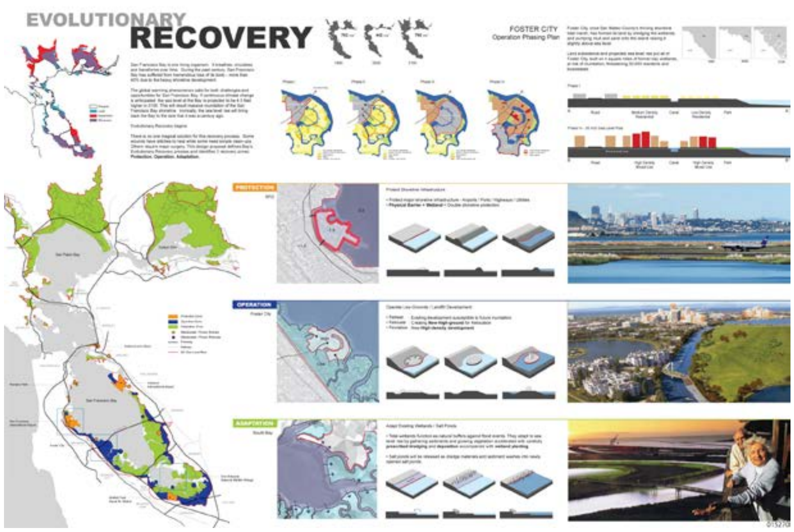


Figure 38: Rising Tides Competition Entry (Source: Meckel et al., 2009)

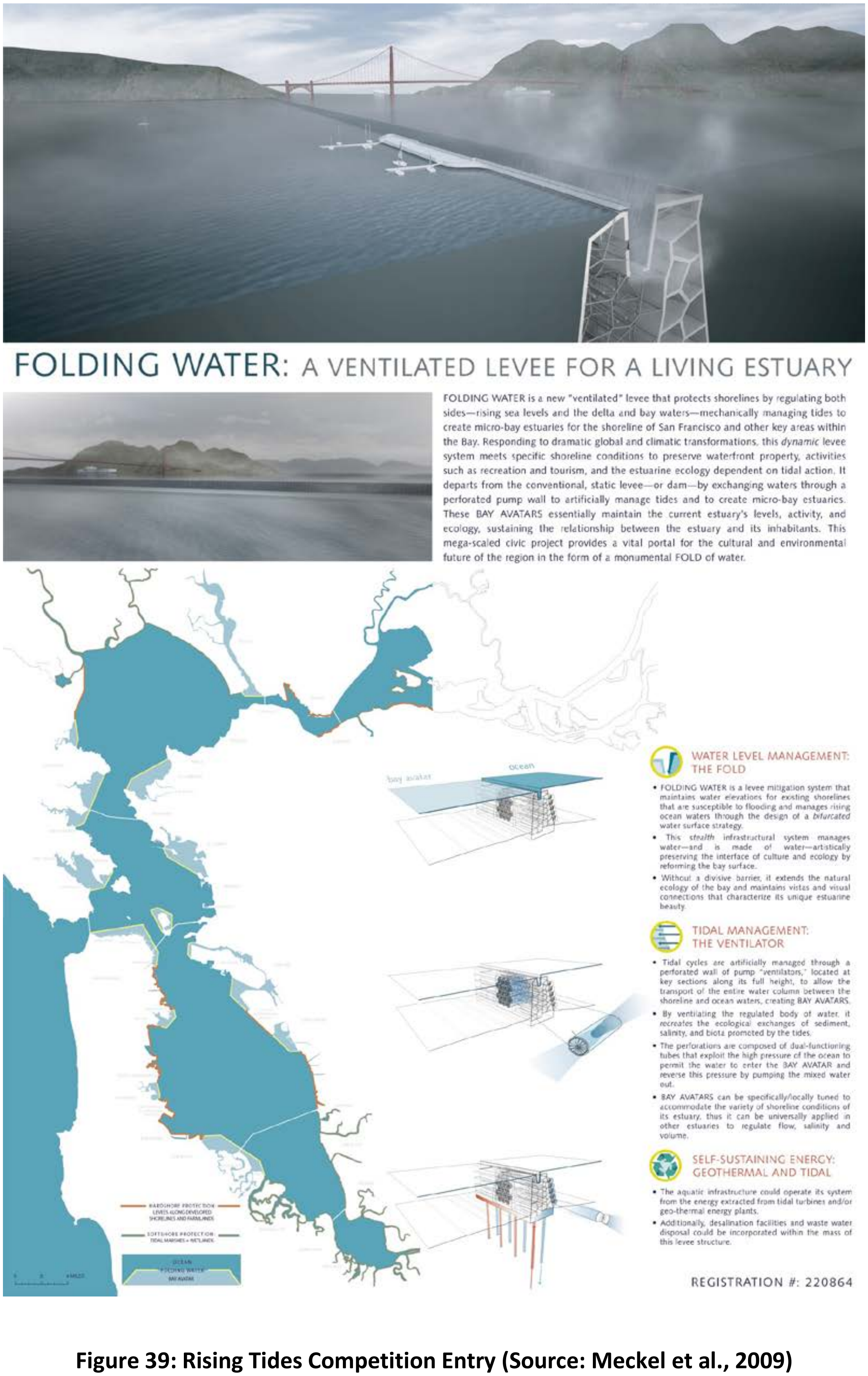


Figure 39: Rising Tides Competition Entry (Source: Meckel et al., 2009)

Design Competitions

	Rebuild by Design	Rising Tides	Rising Currents	Sea Change Boston
Social	☑	☐	☑	☐
History	☑	☑	☑	☑
Culture	☑	☑	☑	☑
Recreation	☑	☐	☑	☐
Aesthetics	☑	☐	☑	☐
Ecology	☑	☐	☑	☑
Ecosystem Services	☑	☑	☑	☑
Ecological Function	☑	☐	☑	☑
History	☑	☑	☑	☑
Management and Planning	☑	☐	☐	☐
Watershed Restoration	☑	☑	☑	☑
Multi-Disciplinary	☑	☑	☑	☑
Long-Term Management	☑	☑	☑	☑
Pre-Post Monitoring	☑	☐	☐	☐
Outreach	☑	☐	☐	☐
Community-Based Design	☑	☐	☑	☐
Public Participation	☑	☐	☐	☑
Environmental Education	☑	☑*	☑*	☑

*Environmental Education includes community outreach and public participation post design proposals.

Figure 40: Evaluation of Design Competition

Rising Currents: Projects for New York Waterfront

Rising Currents (Figure 41 and 42) is a joint project from MoMA, New York and P.S.1 Contemporary Art Center, sponsored by The Rockefeller Foundation. It is unique in its conception because it is organized by an art museum and art center rather than the more traditional non-profit or government agency. This approach from an art perspective brings a different level of graphic representation of the data than other competitions. P.S. 1 Contemporary Art Center has an architects-in-residence program which brought together four interdisciplinary teams to re-envision the coastline of New York and New Jersey and design new forms of "soft" infrastructure within the New York Harbor. Soft infrastructure refers to approaching infrastructure in an ecological fashion. It is broader than just green infrastructure, which is typically referring to stormwater management in urban or suburban areas. Coupled with the 3 month program was an installation of the proposals which included a wide array of models, drawings, and analytical materials (Museum of Modern Art, 2009). The teams were assigned five different zones (Figure 43) of the New York Harbor to tackle the problem of sea level rise. The teams looked at predictions of up to 30 feet of sea level rise with storm flooding. Although this prediction is daunting it is also an opportunity to generate new ideas on how it could be tackled.

Figure 41: Rising Currents Exhibit (Source: Museum of Modern Art New York, 2011)

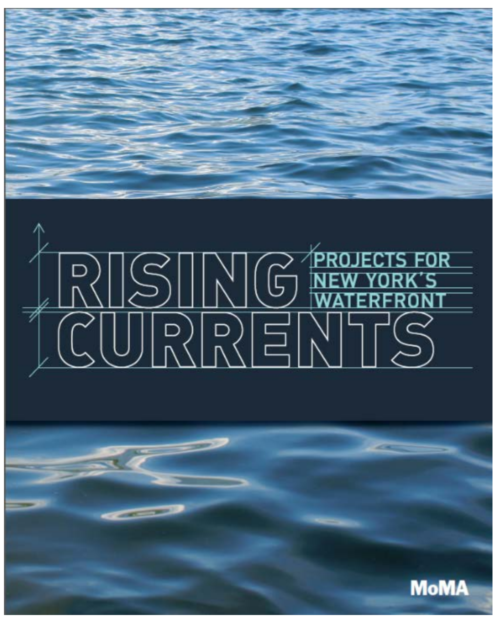


Figure 42: Rising Currents Publication (Source: Museum of Modern Art New York, 2011)

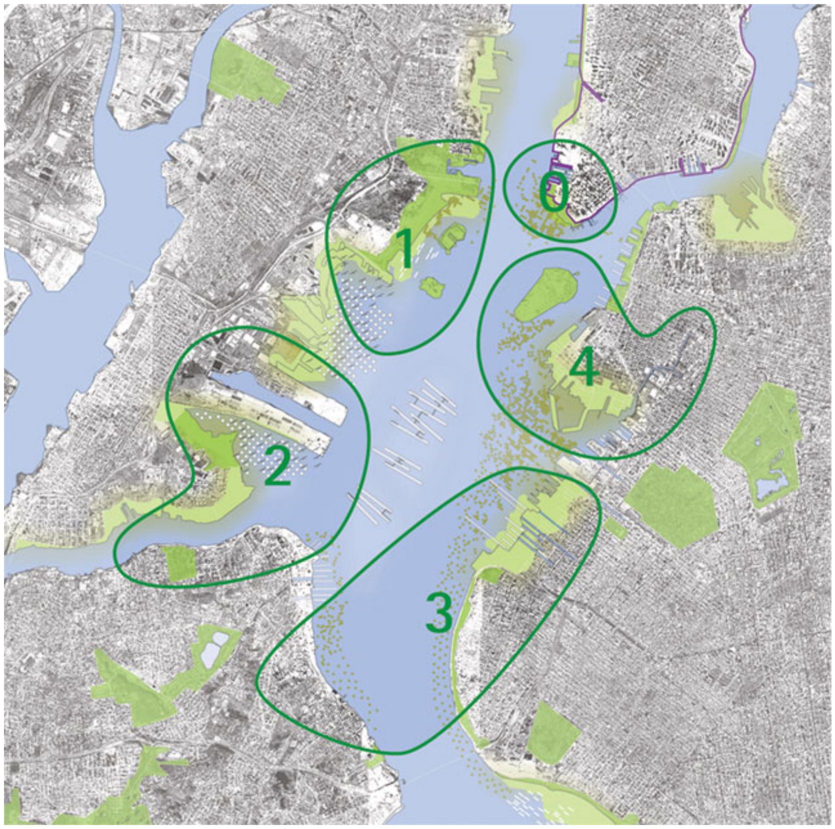


Figure 43: Rising Currents 5 Zones (Source: Museum of Modern Art New York, 2011)

The Zones and Teams for the project are (Figure 44):

<u>Zone 0</u>: Lower Manhattan and the northern edge of the Upper Bay,

Team: ARO and dlandstudio

<u>Zone 1</u>: Northwest Palisades Bay/ Hudson River area in the NJ area including: Liberty Park/Ellis Island and Statue of Liberty and waters

Team: LTL Architects

<u>Zone 2</u>: Southwest Palisade Bay/Kill van Kull area including Bayonne NJ, Bayonne Piers and northern Staten Island and waters

Team: Matthew Baird Architects

<u>Zone 3</u>: South Palisade Bay/Verrazano Narrows area including eastern Staten Island and Bay Ridge and Sunset Park and waters

Team: nARCHITECTS

<u>Zone 4</u>: Northeast Palisade Bay/ Buttermilk Channel and Gowanus Canal area including Governors Island, Red Hook and waters

Team: SCAPE

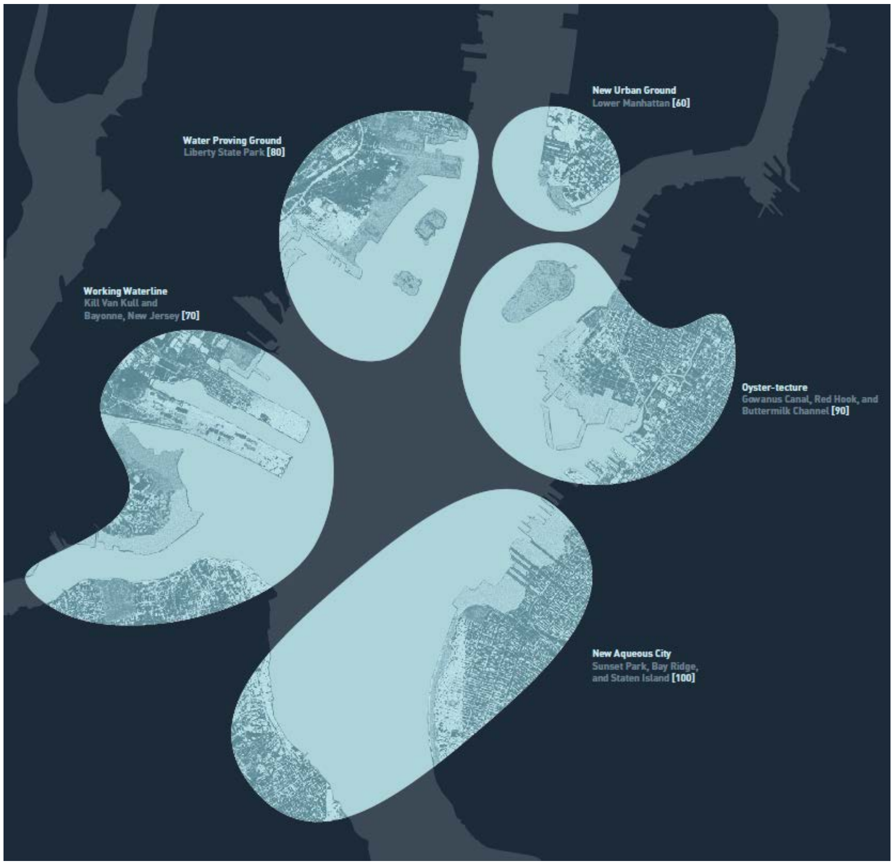


Figure 44: Zones and Teams for Rising Currents Design Competition (Source: Museum of Modern Art New York, 2011)

The success of the project is not necessarily the designs or ideas, but their production and documentation. In an exhibition setting, opening dialog among expert advisors about the general project and a publication this furthers the research and brings a database of innovative ideas for others to use. This process allowed for a publication of both the designs and the comments and critiques by the design teams, the public, and the expert advisors (Bergdoll, 2011). This type of project is a creative way to approach the problem of sea level rise, but the main critique (which is said about most design competitions) is that it is not “shovel ready”. “Shovel ready”, designs ready to be built after the presentation and without additions drawings. Although the ideas are innovative they could not be applied to a site tomorrow as they lack the necessary components to move into an immediate construction phase. Pairing these competitions with plans to build the experimental designs would make these proposals stronger and help move design competitions and research away from the strictly theoretical into the realm of *data visualization through infographics*. The main difference with this design competition is that the design teams utilized scientists and mimicked ecological processes within their designs as well as an exhibit and publication of the competition. The traction from this competition and the effects of hurricane sandy led to the next design competition, Rebuild by Design.

Rebuild by Design

The newest design competition on coastal restoration, Rebuild by Design, is based around the region affected by Hurricane Sandy. Sponsored by Rockefeller Foundation, Institute for Public Knowledge New York University, Van Alen Institute, The Municipal Art Society of New York, and Regional Plan Association (Figure 45). It was named one of CNN's 10 Best Ideas of 2013 (Griggs, 2013).The competition was over a one year period. After the winning proposals were announced, the group formed local coalitions to develop fundable, implementable solutions that inform new policies (Rockefeller Foundation et al., 2013). Working at a regional scale, the collaborative design teams were able to create more resilient standards of development and design in response to the communities' needs. It is exemplary in its integration of social and natural components through the design and the team collaboration. Moving in this direction in the future on built projects will engage all of the necessary professionals in the projects and promote this holistic watershed approach to ecological restoration.

Figure 45: Rebuild by Design (Source: Rockefeller Foundation et al., 2013)

Launched by U.S. HUD Secretary Donovan, the competition guidelines explicitly outlined the goal of developing innovative, implementable proposals. The phases of the project included: community-based design-driven research (Figure 46), analysis and outreach; meetings with experts from the region, elected officials, and local groups; and the development of more than 40 design opportunities Rockefeller Foundation et al., 2013) (Figure 47-50). These phases led to developing and refining of concepts (Figure 51-56).

Figure 46: Community-based design-driven research (Source: Rockefeller Foundation et al., 2013)

Figure 47: Collaborative Research (Source: Rockefeller Foundation et al., 2013)

Figure 48: Rebuild by Design Presentations (Source: Rockefeller Foundation et al., 2013)

Figure 49: Rebuild by Design Community Workshops (Source: Rockefeller Foundation et al., 2013)

Figure 50: Rebuild by Design: Community Engagement (Source: Rockefeller Foundation et al., 2013)

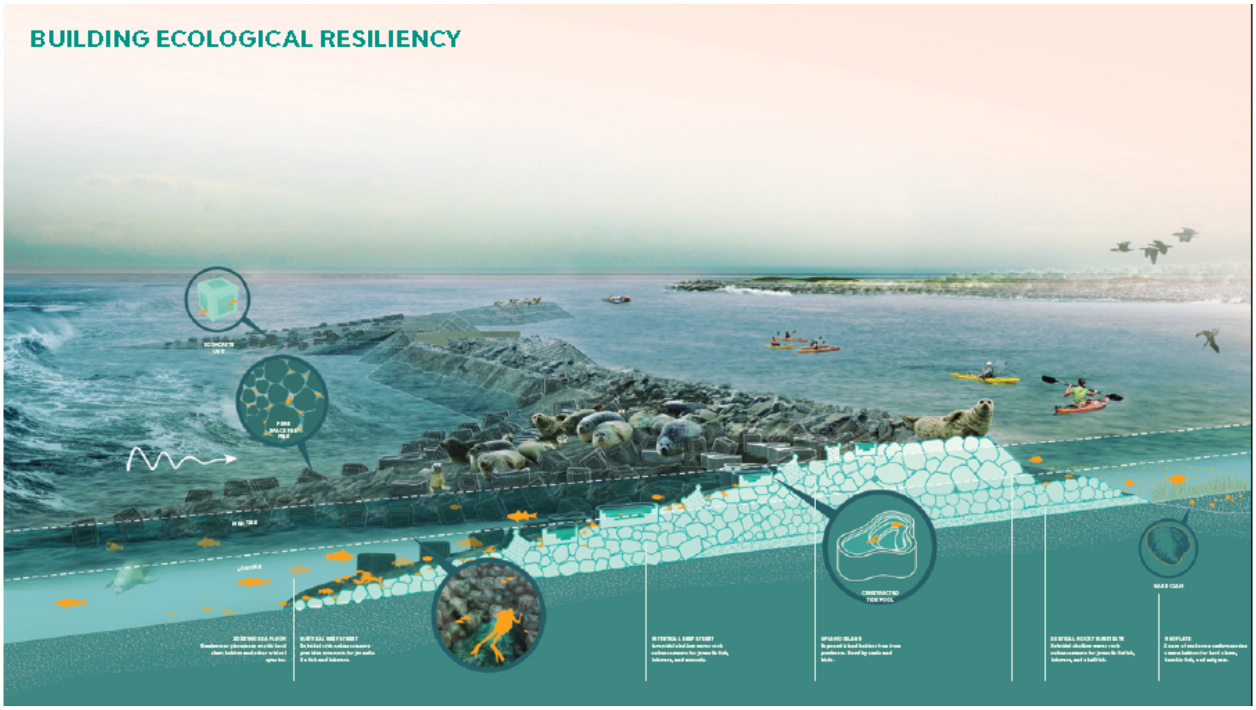


Figure 51: Sample of SCAPE Entry (Source: Rockefeller Foundation et al., 2013)

Figure 52: Sample of SCAPE Entry (Source: Rockefeller Foundation et al., 2013)

Figure 53: Sample of WEST 8 Entry (Source: Rockefeller Foundation et al., 2013)

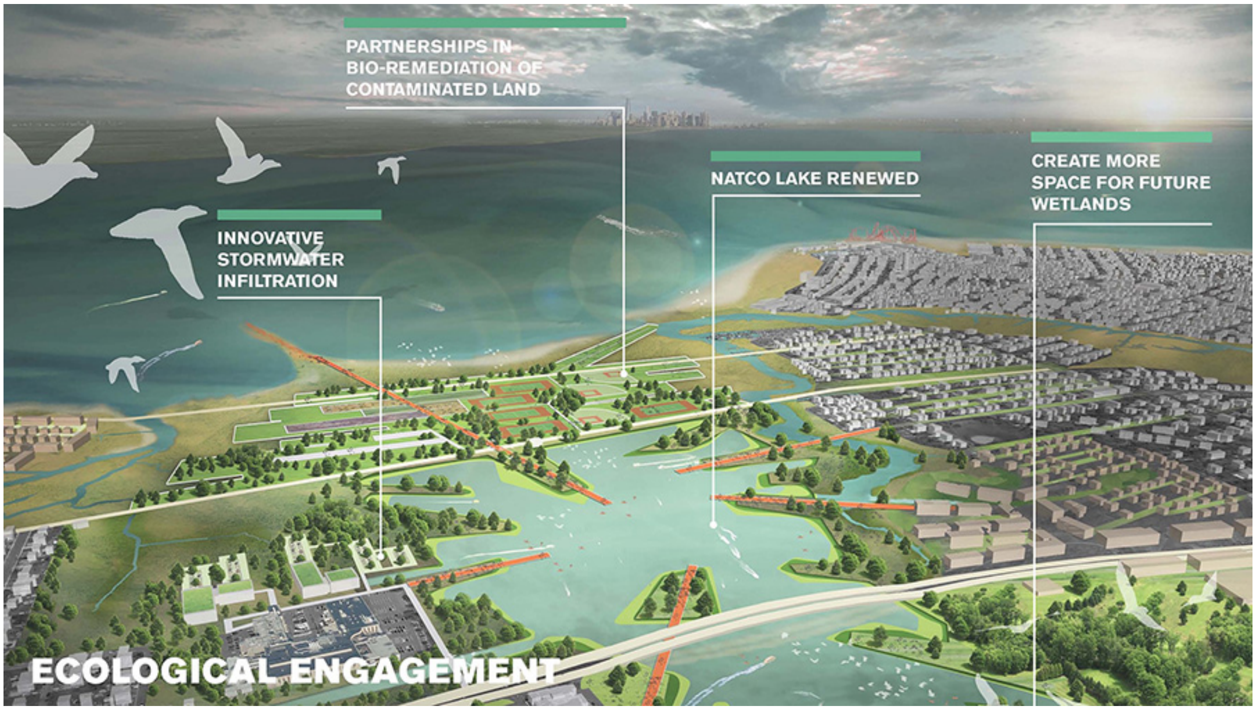


Figure 54: Sample of Sasaki Entry (Source: Rockefeller Foundation et al., 2013)

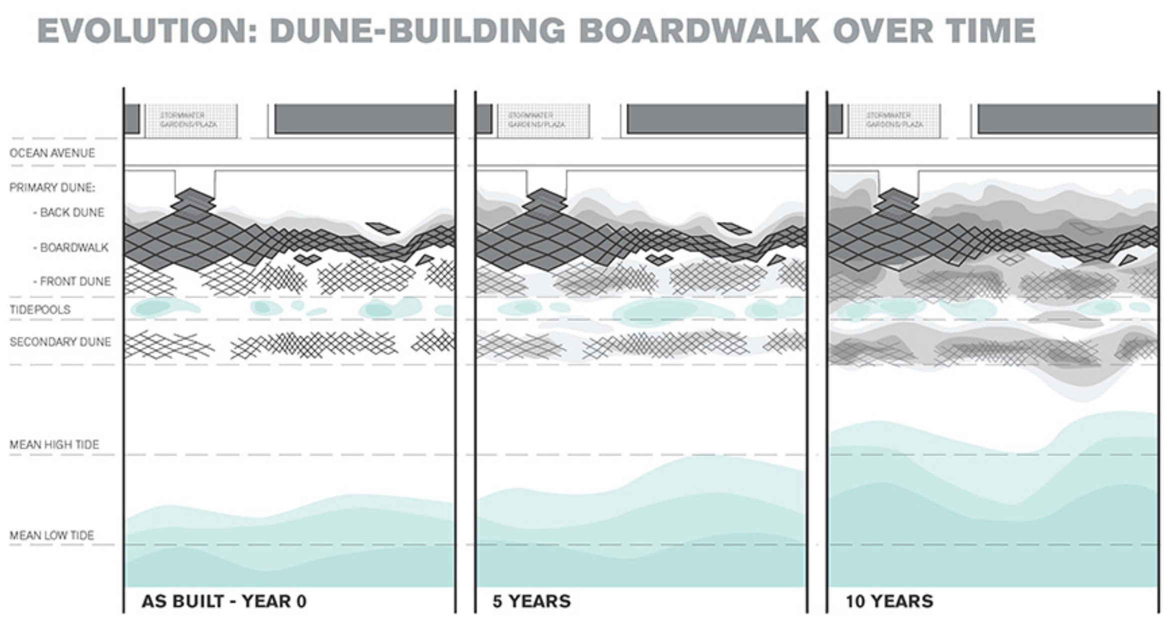


Figure 55: Sample of Sasaki Entry (Source: Rockefeller Foundation et al., 2013)

The first phase of regional research connected the needs of the region with infrastructure, ecology and waters while addressing funding and social issues. This research was then presented to experts of the region, through workshops, forums and tours. The next phase stemmed from data visualization through infographics, using the iterative process to develop 40 design opportunities. The 40 opportunities were then presented to the public, the research advisory group, and local and federal governmental agencies. The jury represented all interest groups of the projects. From the 40 opportunities, 10 were chosen to be developed further. The importance of this project is that in every phase community approval and outreach was required, which is not a typical requirement of a design competition. The last phase required a level of detail and feasibility so teams sought out local stakeholders. The distribution of stakeholders varied between sites but generally included residents, non-profit organizations, business owners, government and elected officials and others (Rockefeller Foundation et al., 2013). From fall 2013 to spring of 2014, teams "convened over 300 small group meetings and more than 50 community workshops and outreach events throughout New York and New Jersey", to work with the communities and share their designs with the general public (Rockefeller Foundation et al., 2013).

Many criticisms of design competitions involve a lack of readability in the graphics, being that they are "too artistic" and do not accurately translate the message. In the proposals the quality of graphic communication had to be understandable at over 50 community workshops with the public, ages ranging from children to elderly. Implementing the critiques by the public and representing them in a graphic form puts these graphics at an unprecedented level. The next steps of this project are very important for this project to be a case study for other projects. As the agencies move forward in the designs there needs to be proper pre-post monitoring. This design competition currently is going on and will be interesting to see how the proposals will be implemented.

Sea Change: Boston

One team from the Rebuild by Design challenge, Sasaki Associates, curated an exhibition (Figure 56-66) of research on Boston's vulnerability to sea level rise. Using their firm's interdisciplinary practice, Sasaki engaged engineers, academia, and advocacy to plan at the building, city, and regional scale for Sea Change (Sasaki Associates, 2014). The exhibition showcased the research to the broader community in an interactive fashion using graphics and interactive multimedia. The exhibition was a call to action to develop a regional plan for the greater Boston area.

Figure 56: Sea Change Boston Exhibit (Sasaki, 2014)

Figure 57: Sea Change Boston Exhibit (Sasaki, 2014)

Figure 58: Sea Change Boston Exhibit (Sasaki, 2014)

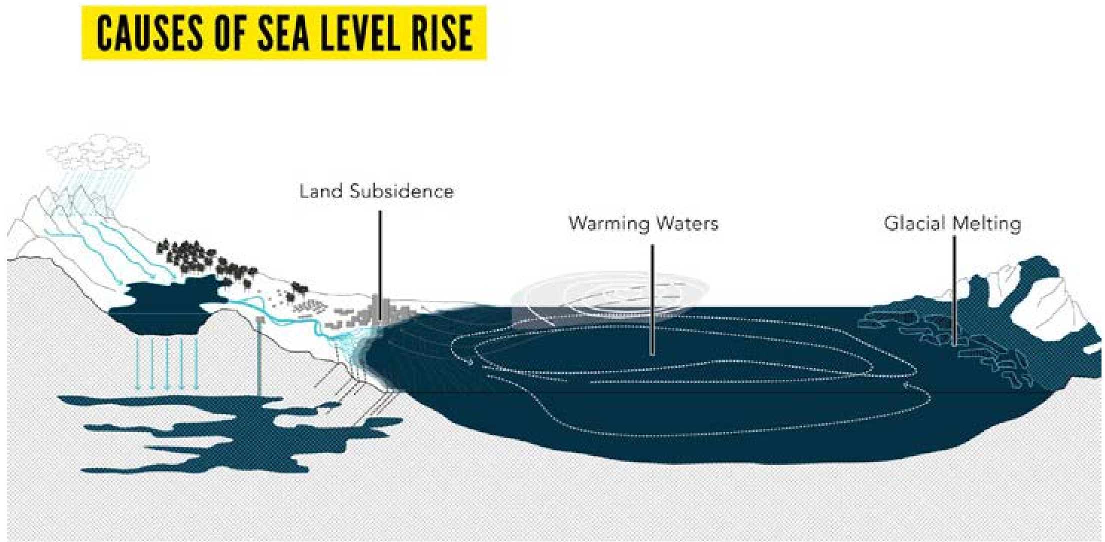


Figure 59: Sea Change Boston Exhibit (Sasaki, 2014)

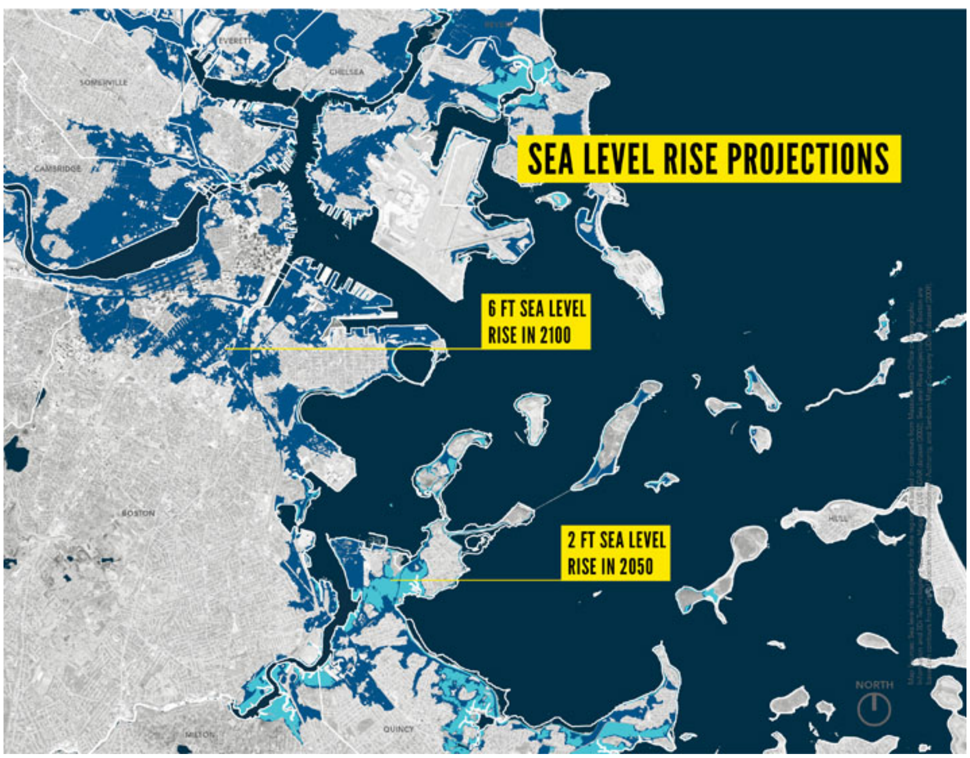


Figure 60: Sea Change Boston Exhibit (Sasaki, 2014)

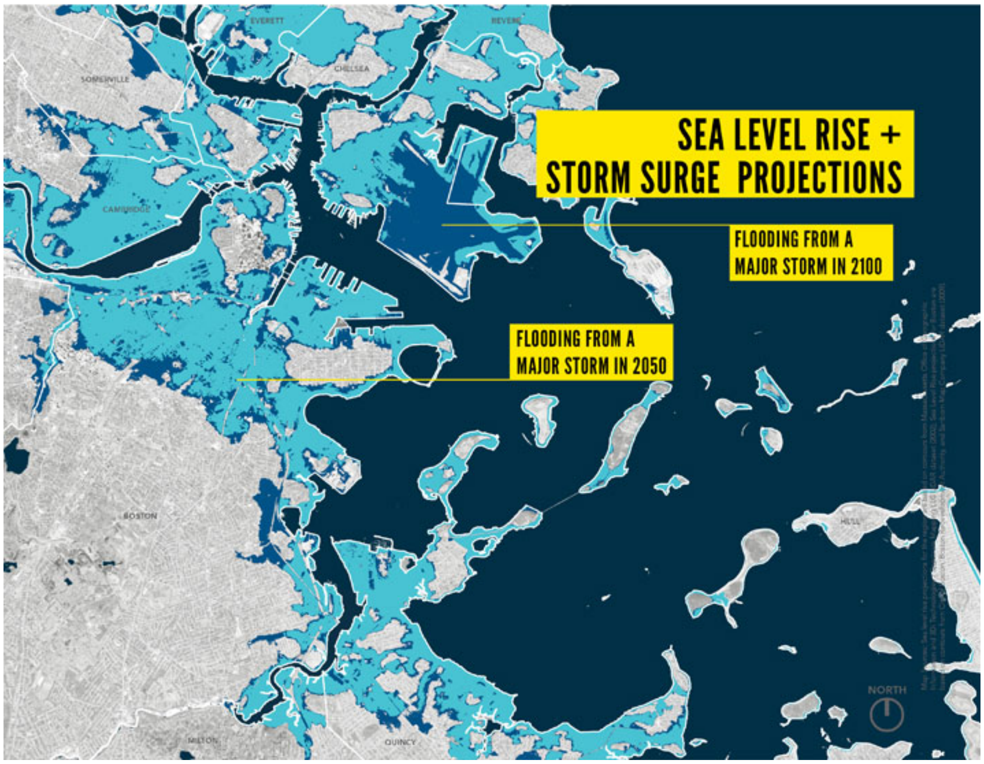


Figure 61: Sea Change Boston Exhibit (Sasaki, 2014)

Figure 62: Sea Change Boston Exhibit (Sasaki, 2014)

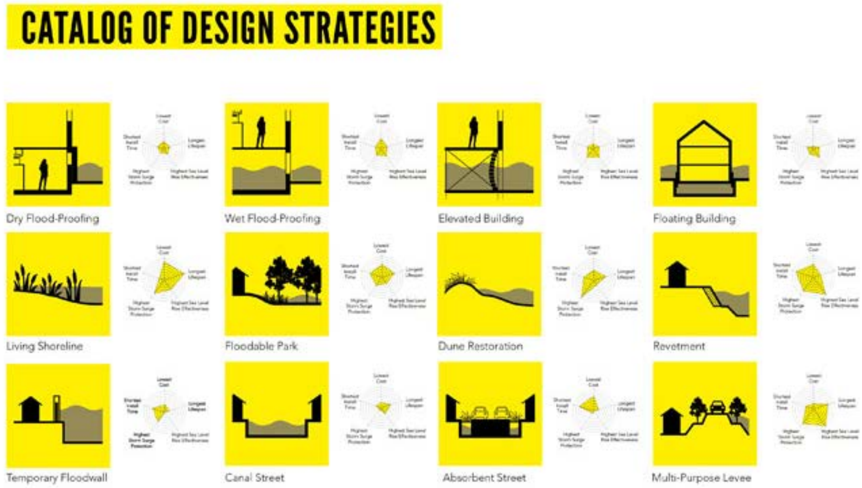


Figure 63: Sea Change Boston Exhibit (Sasaki, 2014)

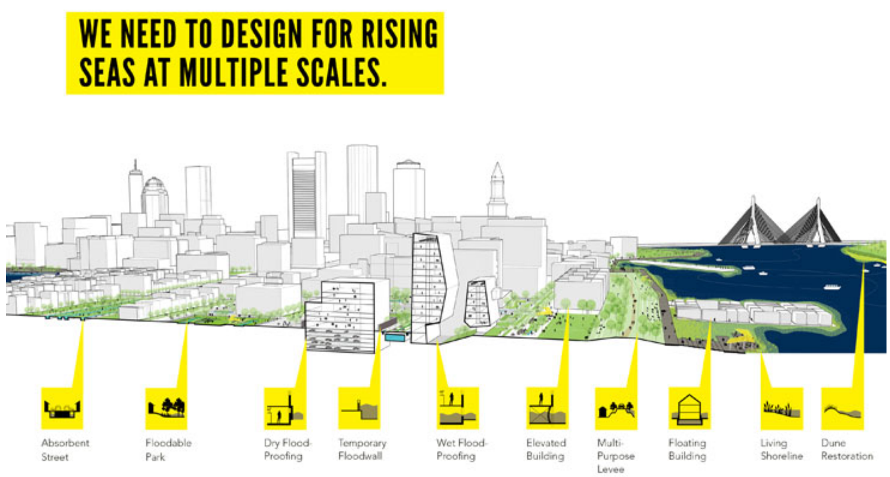


Figure 64: Sea Change Boston Exhibit (Sasaki, 2014)

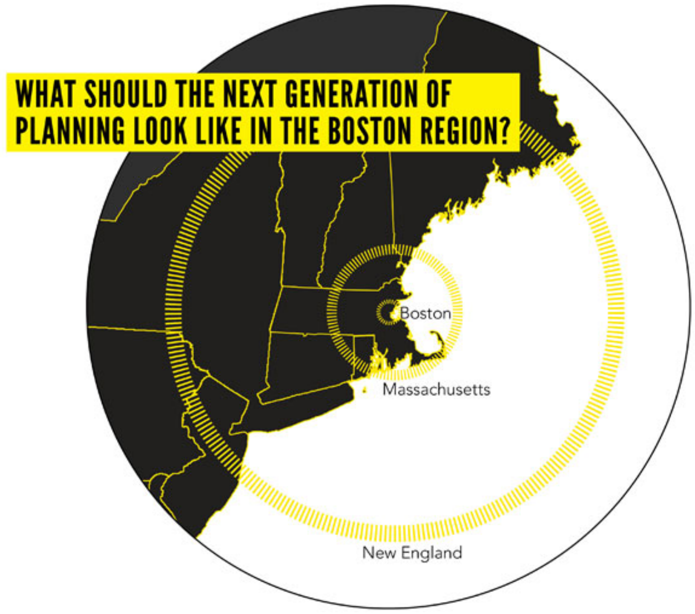


Figure 65: Sea Change Boston Exhibit (Sasaki, 2014)

Following the exhibition, a symposium was held to foster discussion about the challenges Boston faces and how to prepare for sea level rise. The symposium brought together designers, engineers, city leaders, academics, and community members for a day-long conversation. This type of initiative is important in the wake of natural disasters and large storm events because the urgency for this type of planning is apparent to officials and the public. The inclusion of all types of interest groups is important but the team is lacking in its inclusion of natural scientists. This is not to say they were not included in the process but they are an integral component which needs to be stated.

Sea Change: Boston is a wonderful example of an initiative, of ecological restoration, to help solve sea level rise in new and innovative ways. It not only integrates all of the social components, but it also integrates ecological components with new ways to restore ecologically in a highly urbanized area. Despite this involvement of natural scientists is not apparent when looking at the project and needs to be stated more clearly. The balance of social and ecological components and the contribution of both would be a recommendation for future initiatives like this.

The work and publication of these design competitions and research initiatives is furthering the collaboration of natural and social scientists to imagine new ways to solve the problem of sea level rise and anthropogenic degradation. These collaborations and publications are the beginning of a change in the approach of ecological restoration. The products allow for the public and other collaborators to understand the varying levels of the restorations. As the design competitions have evolved the level of graphics allow for a better understanding of the complexity of the projects and the varying professions involved. The level of graphic products need to be translated into all of the projects to better understand the complexity of the projects. A successful component of these design competitions are the extensive exhibition/ gallery presentations which allow the public to engage in the project but also provide a space for dialog.

The case studies outlined in this chapter offer different approaches to the complexities within ecological restoration. Jamaica Bay emphasizes environmental education, research publication, recreation and access. Orongo Station emphasizes an integration within the cultural landscape and with the historic ecological landscape. Both projects have differing levels of outreach, a local audience in NZ, local and international audience through on the ground efforts and website access of publications. Integrating these projects with the approach of the design competitions connection to art, for exhibitions and more legible graphics, and publications on the projects to further the dialog and the research. As the problems which ecological restoration solves become more severe the transfer of information across disciplines, knowledge bases, and ages will become more important. For the understanding of our impacts on the environment, younger generations, who are growing more visually oriented, need to be exposed to the system dynamics and their impacts as an individual and collectively.

CHAPTER V

RESEARCH AND DATA VISUALIZATION THROUGH INFOGRAPHICS

Estuarine ecosystems are complex due to several factors: varying levels of salinity, tidal regime, sediment composition, geologic formation, and interaction between aquatic and terrestrial ecosystems. The interaction and intersection of these factors creates some of the most complex ecosystems. The diverse continuum of theses ecological factors can be compared to the diverse continuum of development. Trying to understand the interaction between ecological factors and social factors without a common language has created a disconnect within ecological restoration projects. Terms, definitions, techniques and spatial zones differ between the sciences despite the geographic areas being the same. Integration within the profession, on these projects, starts with an understanding of all components involved in an ecological restoration project and having a baseline understanding of the ecosystem, development size, and scale of the project (Figure 66).

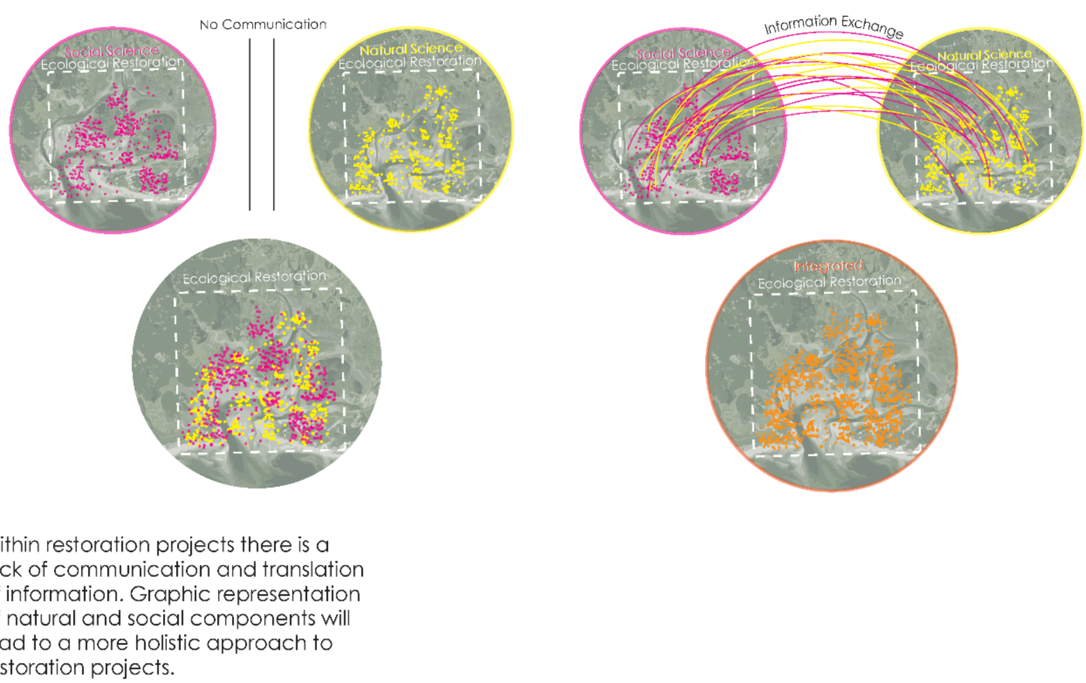


Figure 66: Integration of Ecological Restoration

Despite the considerable amount of research on estuarine ecosystems there is a lack of knowledge on the mechanisms regulation and structuring aquatic plant populations; how vegetation affects ecosystems; the interaction of phytoplankton and zooplankton populations; and how the soil composition needs to be reconstructed for successful restoration (Perrow and Davy, 2002). Due to the current state of research on these processes and the associated restoration efforts it became apparent that the goals of creating a typology of restoration techniques within estuarine ecosystems was not possible. The challenge led to a shift in literature reviewed to more grey literature to understand the key zones, species, and process to better communicate with natural scientists. Peer-reviewed literature is based in science writing and less in graphic representation of the research. Gray literature from governmental agencies, non-profits, science education and children literature books is geared more toward the public's understanding of the research. This became important in the process of breaking down complex estuarine ecology into information representable in a graphic. The Handbook of Ecological Restoration outlined the different restoration techniques that are currently being used within estuarine ecosystems; seagrass restoration, prescribed burns, dam removal, sediment recovery, native species re-planting, invasive species removal, dune restoration, beach nourishment, and kelp bed restoration, which led to a more specific review of the systems within the restorations. These techniques should not happen singularly and many of them occur within each other.

Conducting research in a spatial fashion by organizing the research visually and by using the 3 component iterative process allowed for the research to evolve into a different set of answers than originally expected. The thesis proposal identified one main problem, the lack of graphic representation of natural and social components of restorations. Visual learners make up 65% of all people (Ganger, 2009; Kranszler, 1999) so why are we not representing these processes and connections graphically? The initial goal was to produce the graphics for design professionals, i.e. graphically represent the restoration techniques and how they would restore the ecosystem degradation. But based on the complexity and neoteric natural science research, the unknown long term effects of the restoration techniques and the long term effects of climate change shifted the graphics created to illustrate zones, terms, classifications, techniques and uses from an analytical view and a spatial view. This allows the graphics to be two directional and reach more ecological restoration professionals. The pairing of the graphics allows for further research to expand on the items chosen for this thesis and provides an opportunity to document the various designs of restoration projects which can inform further projects.

In designing these infographics, processes within estuaries that became important to lay out are ones that have different terminology among the sciences. The zones within estuarine ecosystems, naming classifications, and pictorial examples create a baseline of information for conversing across the sciences. The literature review and the number of projects utilizing each restoration technique were the criteria for creating the list of restoration techniques in estuarine ecosystems. These techniques should not happen singularly and many of them occur within each other. The literature of the restoration efforts by natural scientists expose the singularity, either because they were looking for specific data about a species or species interaction, or because the research published was on only one portion of the restoration. Using the US Fish and Wildlife cross section (Figure 67) of an estuary as the base for comparison, three sections were created. This section provided the base which then incorporated, non-science names (Figure 68), restoration techniques (Figure 69), and social uses (Figure 70). Each restoration professional can gain information from the layers to better communicate with other restoration professionals. Whether it be the names of zones, locations of restoration techniques, social uses within the zones or a mixture of these.

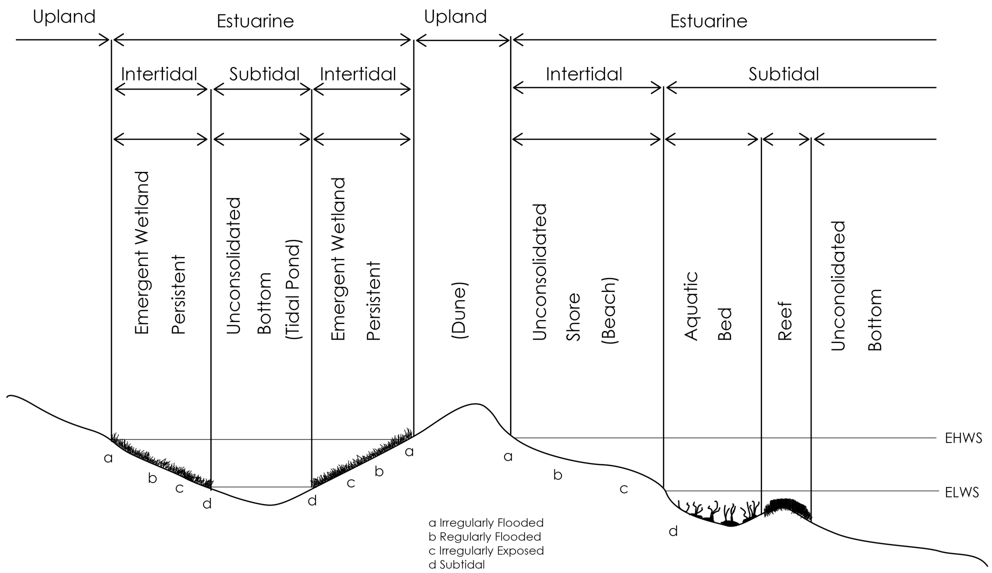


Figure 67: U.S. Fish and Wildlife Estuarine Cross Section (Source: Cowardin et al., 1979)

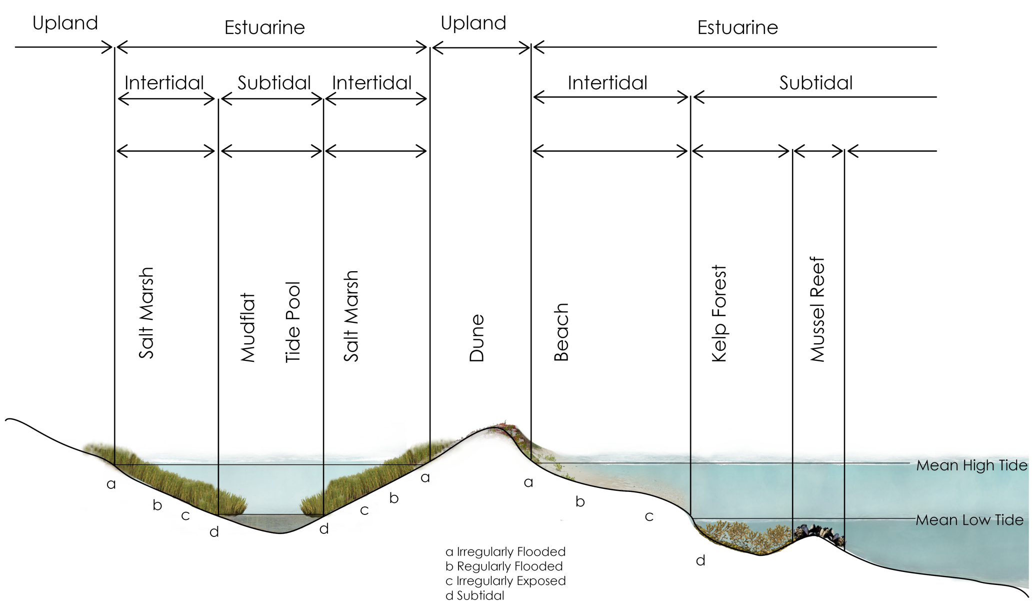


Figure 68: U.S. Fish and Wildlife Estuarine Cross Section with Non-Science Classification

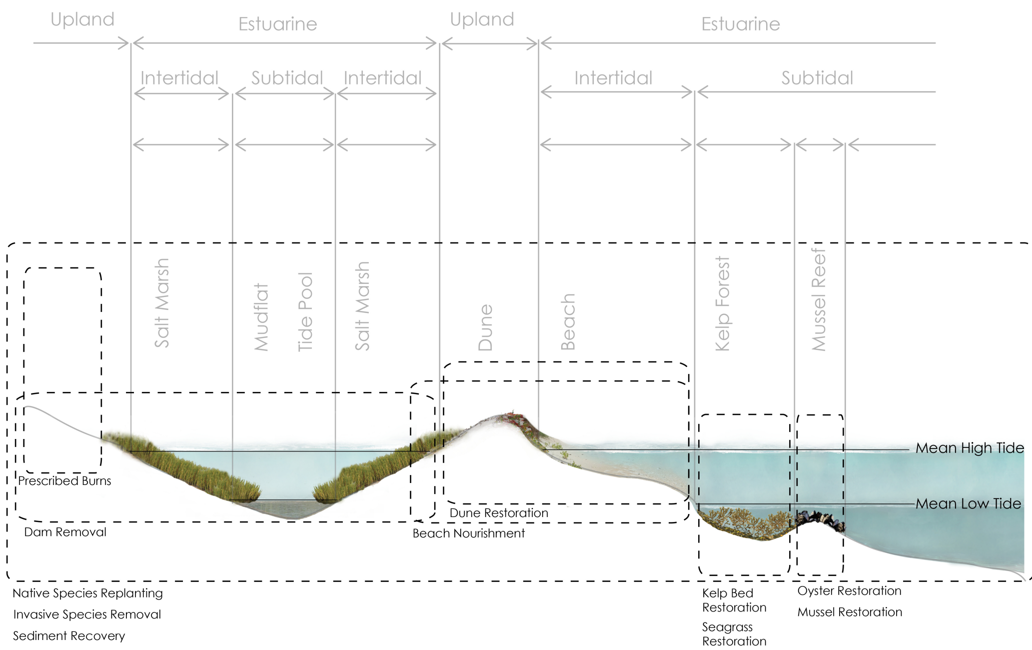


Figure 69: U.S. Fish and Wildlife Estuarine Cross Section with Restoration Techniques

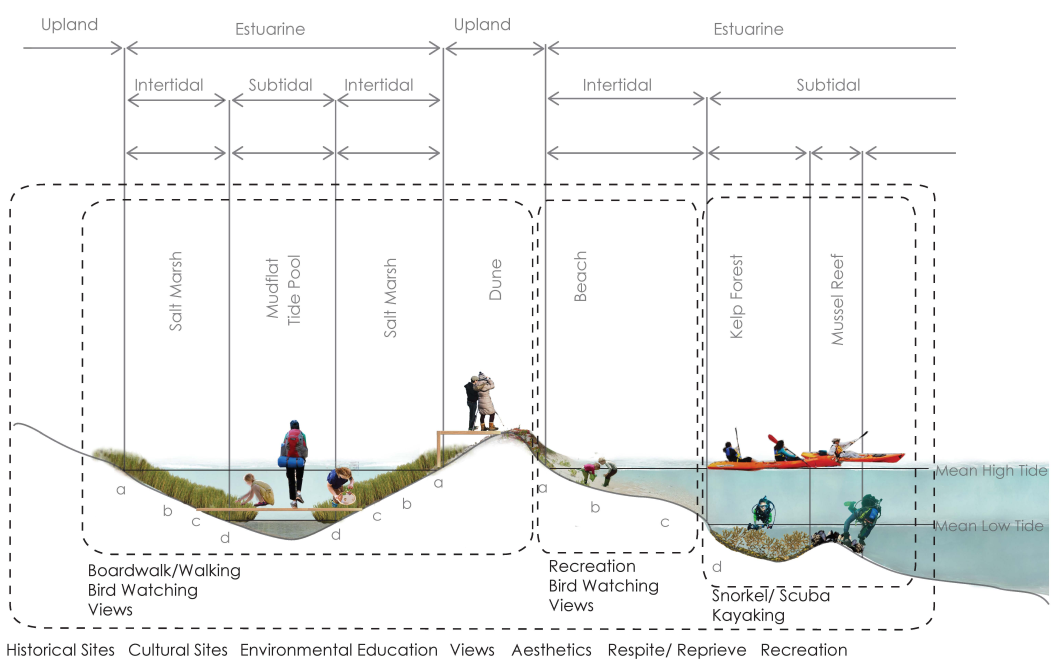


Figure 70: U.S. Fish and Wildlife Estuarine Cross Section with Restoration Techniques and Social Uses

Ecosystem service and ecosystem degradation are two different ways of classifying the process of alteration to an ecosystem. Ecosystem degradation is classifying based on the degradation to the system i.e. loss of species diversity, sedimentation, whereas ecosystem services is classifying based on the service that is lost due to degradation. The use of ecosystem service classification for this graphic allows for the analysis between the restoration techniques and the ecosystem services they restore (Figure 71 and 72), rather than restoration techniques and the ecological function they restore. That analysis would be good to add to this graphic in the future, to help facilitate in the use of both on ecological restoration projects. Since design professionals use ecosystem services as their metric it allowed for the comparison analytically and illustratively. The EPA National Estuary Program provided a classification for ecosystem degradation through their list of National Estuary Program Environmental Concerns which helped in matching the degradations with the restoration techniques (Figure 73). The graph compares the degradations to the 28 estuaries in the program and depicts the most pressing degradations across the nation which led to specific restoration problems to further research.

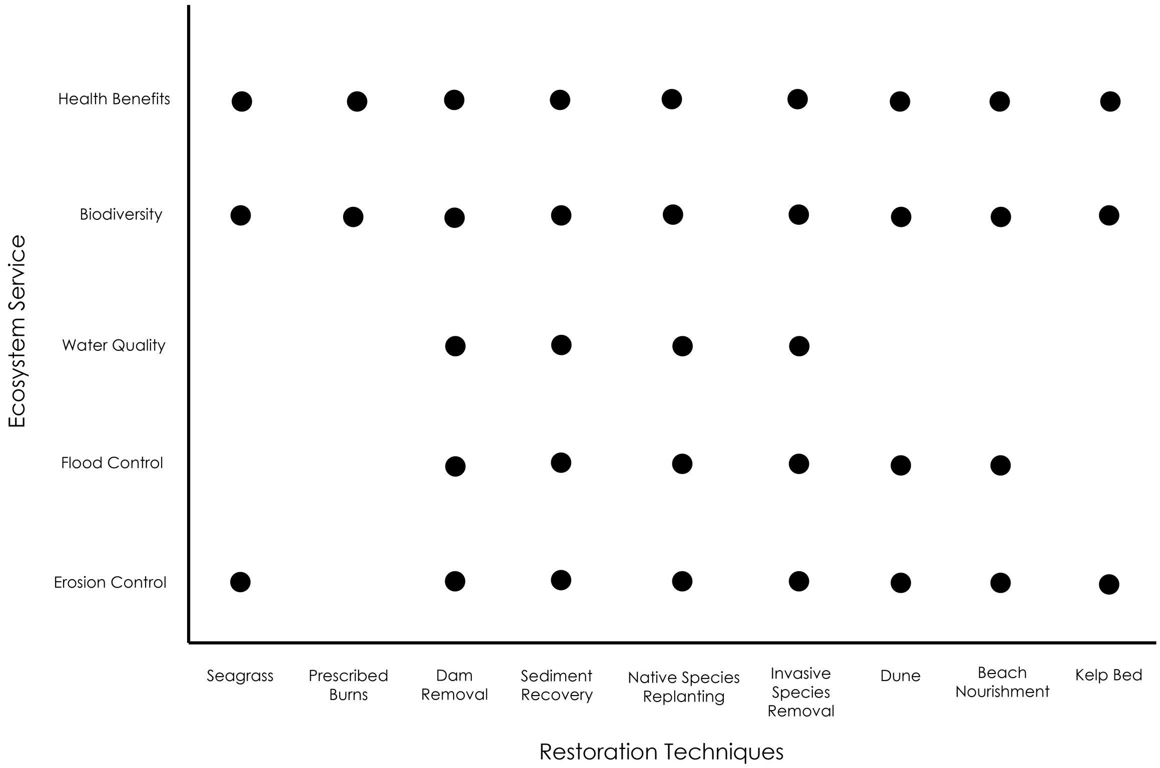


Figure 71: Relationship between restoration techniques and ecosystem services, analytical

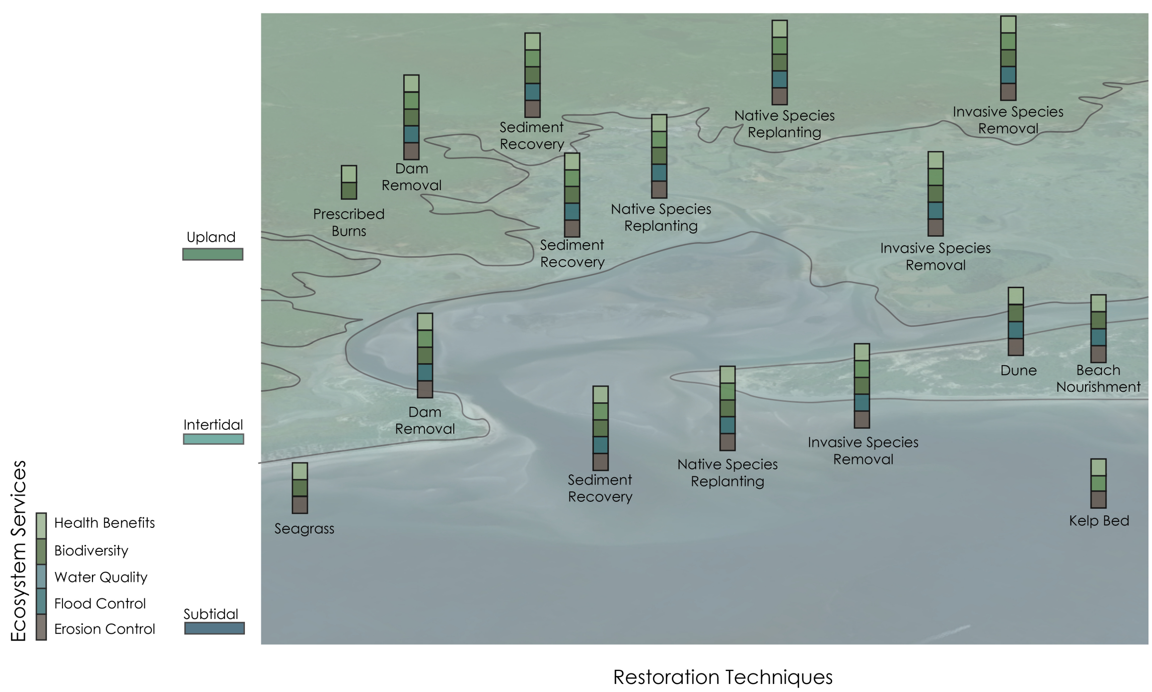


Figure 72: Relationship between restoration techniques and ecosystem services, analytical

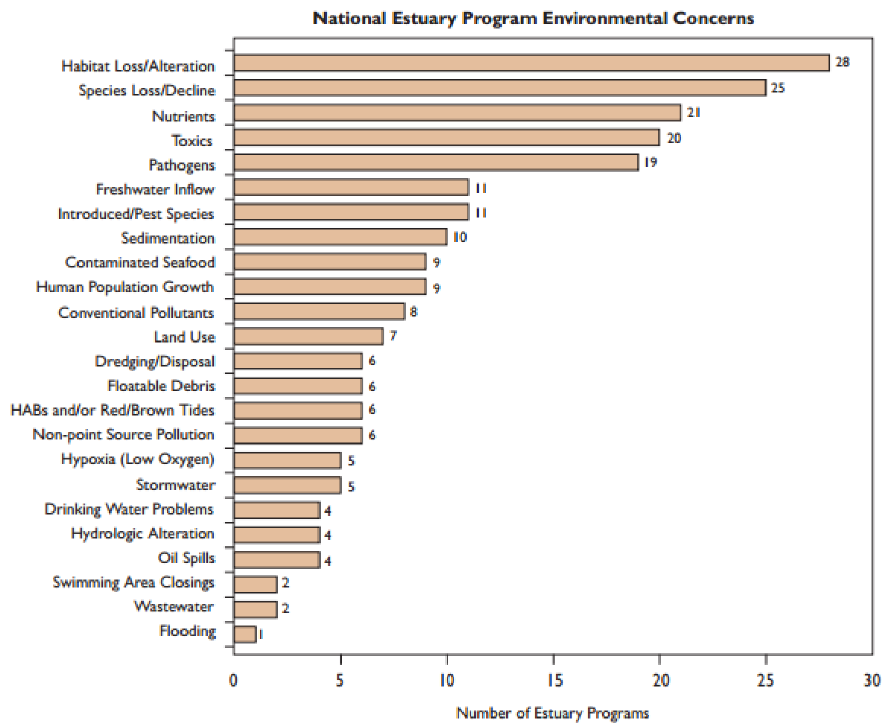


Figure 73: National Estuary Program Environmental Concerns (Source: EPA, 2007)

Coupled with these, habitat types and ecosystem services, are two graphics that show the relationship between habitat types and restoration techniques (Figure 74 and 75). These graphs demonstrate the relationship of habitat types and restoration techniques spatially. With these together restoration professionals can visually compare what everyone is saying and what it means in their profession. A third type of graphic clarifies the different zones and names within estuarine ecosystems utilizing the tree structure by the US Fish and Wildlife Classification (Figure 76), which breaks down the intertidal and subtidal classes into subclasses. The tree structure only includes the names of the classes which is difficult to link to actual estuarine systems. Images of classes (Figure 77) allows for social scientists to connect the area usually with the natural scientist classification despite them using a different name.

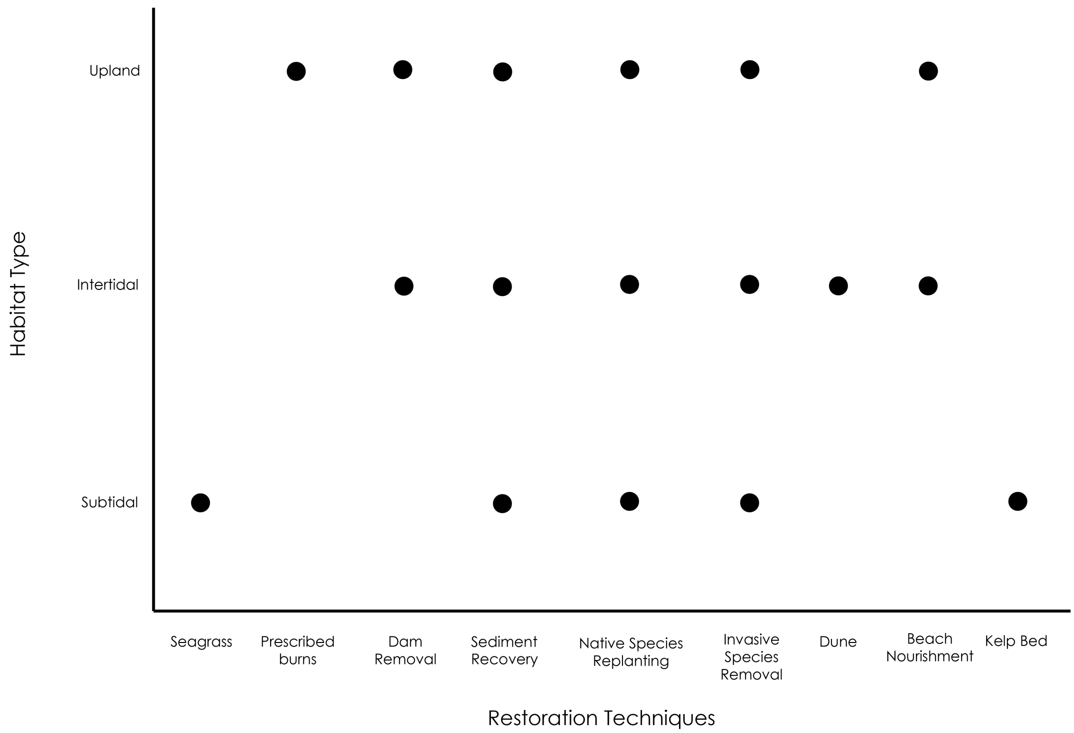


Figure 74: Relationship between habitat type and restoration techniques, analytical

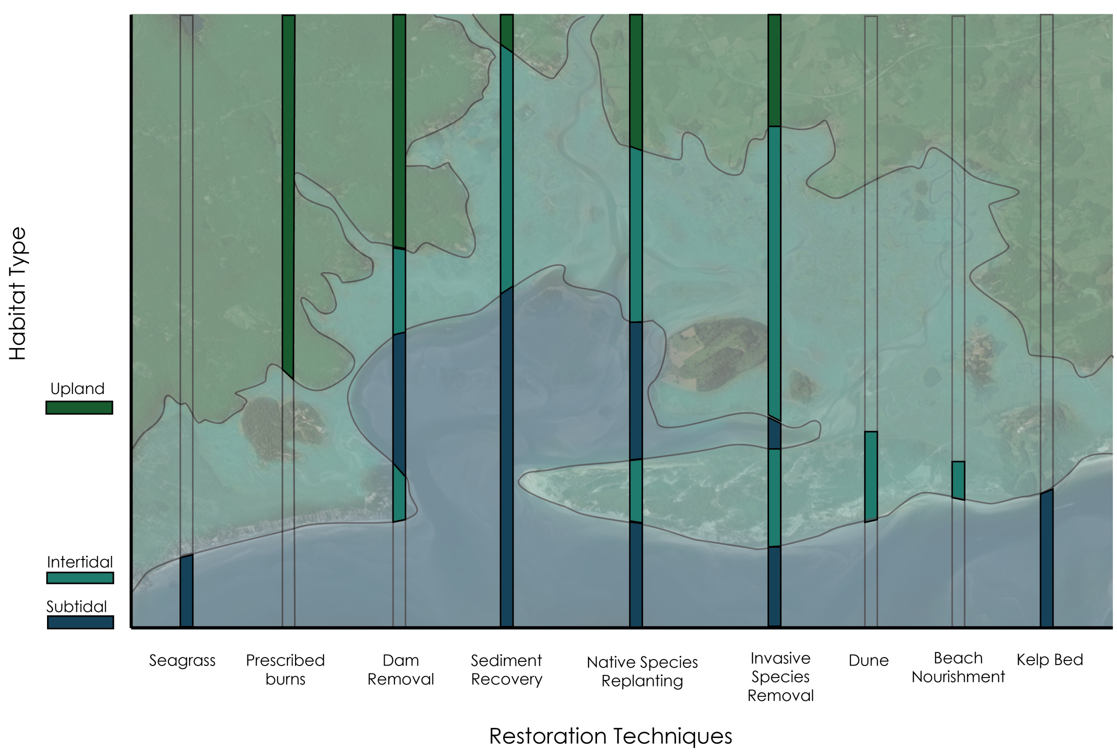


Figure 75: Relationship between habitat type and restoration techniques, spatial

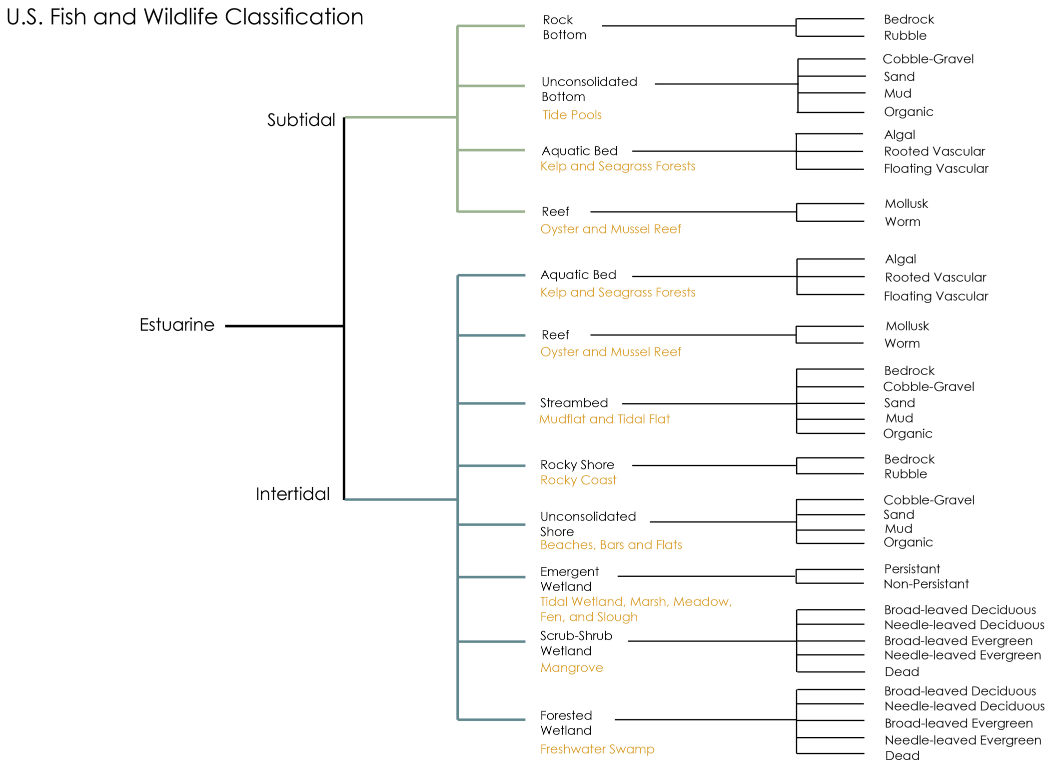


Figure 76: Comparison of U.S. Fish and Wildlife classes and non-science classes of estuarine ecosystem (Source: Cowardin et al., 1979; Black, 2016)

Figure 77: Images of the U.S. Fish and Wildlife classes within an estuarine ecosystem

Through this process of data visualization through infographics and shifting to look at more gray literature two main problems became evident: the lack of graphic literature on ecological systems for non-scientists, and the lack of documentation about the ecological results of socially successful ecological restoration projects. There are more successful ecological restoration projects than originally thought but the reason it was not immediately evident due to the lack of publication of those projects. Orongo Station is a perfect example of this; unless the project is well known or the person is looking at cultural or historic restoration they wouldn't know of the success as a holistic ecological restoration project. This is one of the problems that ecological restorationists need to be aware of to have more successful projects. Documentation and representation of all the people involved in the project is an extremely important aspect which can dictate the success or failure of an ecological restoration project. Within the field of ecological restoration there is a desire for landscape architects to publish their projects that include ecological restoration. This is needed to further the development of metrics to evaluate the projects and to allow design projects to be cited in further research. The effort from natural scientists to engage and collaborate with social scientists is an important opportunity that should be utilized.

CHAPTER IV

CONCLUSIONS

The Future of Ecological Restoration and Recommendations

Restoration ecology is a relatively new profession. As such, the field of ecological restoration has not clearly defined its role among restoration projects or the role of natural and social scientists. In defining ecological restoration the profession needs to find the balance between social and ecological needs and identify the definition. The next step is in promoting that definition to a broader audience than just natural scientists.

As the climate changes and we continue to grow our population, the ecosystems will be altered in new ways. This means new ways that we will need to approach development and new adaptations in the ways that we restore. Design is moving to utilizing multi-disciplinary teams, composed of more than just design professionals. With this move it will be important to understand the difference in framing and how to best communicate with each other.

An important aspect is understanding how the modifications to the ecosystems will be communicated. In highly urban areas the ecology doesn't resemble any of the historic ecology. Many are calling this a novel urban ecosystem because it is highly manicured and greatly transformed from the historic ecology. Along with this shift is the need to create new ecosystems in places they were not historically. The design of these new ecosystems must illustrate the experimental or safe-to-fail idea to allow for us to learn.

The future of ecological restoration has the opportunity to make a substantial difference on ecosystems and humans. This includes creating places of refuge and reprieve from urbanity or bringing habitat into the urban fabric to allow the city to breathe. With this opportunity comes a responsibility to do it in a way that others can learn from through documentation and publication and move the research forward to better the lives of all species.

Further Research

Due to the complexity of ecological restoration among the varying professions and the specific ecosystems there are opportunities for further research. The success and failures of restoration techniques within estuarine ecosystems is important for the improvement of restoration projects. Research on estuarine ecology specifically presents opportunities in translating estuarine science into graphics for visual learners. The information gained from these can help people better understand how the restoration technique works ecologically. This research can be applied to all ecosystems, not just estuarine ecosystems. It also can allow for an understanding of why a restoration technique was or wasn't successful. With ecological information in graphic form it will be easier to understand how to integrate experimental restorations.

In an effort to understand the current state of ecological restoration techniques it would be an interesting challenge to translate past projects graphically. Creating not only a database of restoration projects but also having the research accessible to non-natural scientists. This avenue of research would allow for the profession of ecological restoration to have a base knowledge to supplement further research of new restoration techniques.

Majority of the research and graphic creation for this thesis were geared towards social scientists in order to understand natural science, while facilitating translation between the terminology of natural and social scientists. Due to the timeframe of the project graphics were not created in how to translate the design process for natural scientists. The research on design competitions and the process of the Rebuild by Design competition lays the groundwork for the creation of graphics to translate this process. The understanding of community based design, including local and federal governmental agencies, elected officials, non-profits, local business owners, residents and the public, the varying levels of community based design and how natural scientists fit into the process is a step needed in this translation to be fully considered in both directions.

These opportunities for further research are based on the ecological aspects for social scientists to utilize. The opportunities for further research to better translate the social aspects to natural scientists would be more documentation of restoration projects conducted by design professionals. This documentation would be best developed though after a clearly defined set of categories, for social and natural, which define the methodology and one clear set of metrics for evaluation. This needs to be created in collaboration with social and natural science to be balancing the two. In creating this set of metrics there needs to be a clear understanding and rationale to ecological function and ecosystem services.

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