

The Hudson to Housatonic Regional Conservation Partnership

Urban Conservation Mapping Project: A Case Study in Norwalk, Connecticut



Organizations that Made this Project Possible:



H2H is an interstate Regional Conservation Partnership (RCP), comprised of 50+ partners including land trusts, conservation commissions, municipal and state governments, nature centers, regional businesses, and a variety of conservation non-profits. Partners work together to advance the pace of regional land protection and stewardship across the H2H landscape, by collaborating across geographic and political boundaries to enhance connections between people and nature. Stretching from the Hudson River in New York State to the Housatonic in Connecticut, the H2H region contains a spectrum of landscape features: from forests and farmlands, to suburban and urban communities. To learn more about H2H, visit our [story map](#) and [website](#).



The Norwalk Land Trust works to promote an understanding of the benefits of protected land by providing educational opportunities for community members, and advising landowners regarding the techniques and benefits of land preservation. The Norwalk Land Trust is currently a steward of 28 parcels of land—about 100 acres—in Norwalk, CT. Since 1973 they have sought to balance nature and development by acquiring land and preserving it in its natural state for the benefit of Norwalk residents and future generations. To learn more about the Norwalk Land Trust, visit their [website](#).



Highstead

Highstead is a regional conservation non-profit based in Redding, Connecticut. It is dedicated to increasing the pace of land protection in New England and beyond through science, sound stewardship and collaboration with diverse partners. Highstead envisions a healthier, more livable world for all by working with partners to responsibly conserve the land that sustains us and to steward our natural spaces, resources, and communities thoughtfully and inclusively. Highstead embraces the [Wildlands & Woodlands Farmlands & Communities vision](#), a bold vision to ensure a thriving New England landscape and to support the communities that depend on it. Highstead is the host (home) partner for H2H and coordinates partnership activities. Read more about Highstead's work on their [website](#).

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Guide draft March, 2021. For more information about this guide, please contact H2H Coordinator Katie Blake at kblake@highstead.net

Introduction to Urban Conservation Mapping

Cities are complex human and natural ecosystems. Heavily developed and densely populated, American cities are home to a growing majority of the US population, with 82% of American residents living in urban areas as of 2018, and a projected 89% by 2050¹. With these impending demographic changes in mind, it is no surprise that many conservation organizations have recently begun to announce new urban-specific conservation efforts.² The Nature Conservancy, for example, remarks in their 2017 urban conservation guide that their work in cities is “at once similar to and divergent from The Conservancy’s more traditional conservation practices.”³ With this they are getting at one of the greatest challenges of urban conservation. Although many of the goals of urban conservation are shared with its exurban and rural counterparts—sustainable land usage, community access to natural space, health of human and non-human organisms—reaching these goals requires an in-depth analysis of how urban ecosystems work, one that considers social factors and histories unique to cities, such as histories of redlining⁴ which today lead to unequal exposure to environmental hazards and lack of access to natural spaces. To properly conserve a city, we must consider these social forces alongside ecological ones.

The goal of urban conservation mapping is to broaden the definition of conservation from a strict focus on land and natural resource protection to include additional forms of environmental health, such as urban greenspace restoration, backyard habitats, and environmental justice issues like equal access to open space. The values of protecting land and maintaining ecological function through proper stewardship remain present in urban conservation mapping, but we prioritize the values and needs relevant to urban residents, or stakeholders. Urban conservation mapping allows us to produce a model of a city that combines resident stakeholder values, ecological stewardship goals, and the physical characteristics of the city to map out where strategic conservation activities are most needed.

¹ The United States defines “urban” as a densely settled territory that meets UN minimum population density requirements for a city, and with 2,500 inhabitants or more. United Nations, Department of Economic and Social Affairs, Population Division (2019). World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420). New York: United Nations. [URL](#).

² See [Appendix C](#) for a full list of urban conservation projects that influenced the development of this GIS project

³ The Nature Conservancy (2017). Field Guide to Conservation in Cities in North America: Version 1.0. *The Nature Conservancy and Center for Whole Communities*. [URL](#).

⁴ Redlining is defined as the “illegal discriminatory practice in which a mortgage lender denies loans or an insurance provider restricts services to certain areas of a community, often because of the racial characteristics of the applicant’s neighbourhood [sic].” Britannica, T. Editors of Encyclopedia (2014, September 11). *Redlining*. *Encyclopedia Britannica*. <https://www.britannica.com/topic/redlining>.

The following document presents a case study outlining the process and technical methods involved in the development of an urban strategic conservation mapping model for the City of Norwalk, Connecticut. Carried out by the Hudson to Housatonic (H2H) Regional Conservation Partnership (RCP) in partnership with the Norwalk Land Trust, the Norwalk Urban Conservation Mapping Project produced an interactive conservation [web map](#), as well as this document. The [web map](#) is a publicly available tool that can help guide the conservation decision-making process and aid conservation organizations and city governments in understanding, for example, which neighborhoods would most benefit from access to limited resources such as funding for green infrastructure or street trees. While the methods used in the Norwalk Urban Mapping Project were specific to the priorities set forth by Norwalk partners, we created this document to share with partners in the H2H region (and beyond). Though the following text is not a definitive guide to urban mapping, we hope that sharing our process will shed light on the utility of urban mapping as a conservation tool and can be referenced by cities embarking on their own urban mapping projects.

Background of the Norwalk Urban Mapping Project

The Norwalk Urban Conservation Mapping Pilot Project (the project's official name) was born out of a need identified by the H2H partnership to develop a conservation mapping model that considers the value and ranks the priority of conservation activities in human-dominated landscapes. In 2018, the H2H partnership first undertook a similar strategic conservation mapping project focused on identifying the areas of highest conservation value across the entire partnership region—from rural areas to cities—as a way to prioritize land conservation activities and limited resources. The 2018 H2H Strategic Conservation Mapping Project, as it was called, was guided by H2H partner input and the development of a model, termed the *Areas of Highest Conservation Value*, for the region considered a variety of environmental attributes in its analysis such as distance to protected open space, critical wildlife habitat, and watershed resources. Developed with primarily rural landscapes and biodiversity valuations in mind, it was unable to account for the unique developed characteristic and health and social issues of cities. Using the original framework, the true conservation value of cities when compared with their rural neighbors couldn't be realized. Thus, partners decided to exclude urban areas from the 2018 model and instead pursue a separate conservation model specifically for the region's urban areas at a later date.

In the spring of 2019, H2H endeavored to create this new urban model. First, extensive research on urban mapping models was conducted by Highstead Conservationist Tara Whalen. H2H was not the first to create such a tool, and we wanted to learn from methods and practices already successfully employed. Whalen completed a review of relevant literature and held interviews with conservation professionals who had experience in some form of urban strategic conservation planning or mapping.⁵

⁵ See [Appendix C](#) or a full list of sources and organizations cited in Whalen's interview.

Through her research, Whalen found there were seven common “drivers,” an environmental or social value, important to urban conservation projects:⁶ Human Connectivity, Ecology, Public Health, Equity and Social Factors, Recreation, Flood Risk, and Urban Heat Island. Each driver is described by a list of data or “criteria” that is relevant to the driver and predicts it in some way. For example, the Human Connectivity driver includes criteria such as “public transportation stops” while the Ecology driver includes criteria such as “critical habitat areas.” Whalen’s research also revealed to H2H that it would be wise to focus on developing an urban mapping model for a single city in the H2H region, as opposed to a general model that could be applied to any city. This was because the specific drivers and criteria in a mapping tool would likely be heavily based on the unique geographic, infrastructural, and social characteristics of a city, and the goals of the mapping tool would be informed by the specific priorities of the city stakeholders and residents, as well as data availability. Focusing on a single city was also a way to test model viability before trying to create a more general mapping tool. The City of Norwalk, CT was chosen as the urban conservation project pilot city because of the Norwalk Land Trust’s membership and activity in H2H and their interest in and ability to take on a project like this together with Highstead (H2H’s host organization and project lead).

Before You Begin

The remainder of this document attempts to describe the complete process used by H2H to create the Norwalk Urban Conservation Mapping Tool, from the project team’s first engagement with stakeholders, to presenting the finished mapping tool and planning next steps. To streamline the reading process, the body of the document was written to be succinct and non-technical, providing a description of the roles and responsibilities of the members of the project team, and an overview of the “phases” or types of work done to produce the mapping tool. [Appendices A – C](#) at the end of the document provide exhaustive descriptions of data sources, GIS mapping methods, model results, and a full list of the stakeholders involved in the development of the mapping tool.

Overview of the Project Process

Project Roles and Responsibilities

It takes a village to map a village. Many people came together to make the Norwalk Urban Mapping Project happen. Our team had a general idea of roles and expectations, and we communicated regularly to maintain understanding and transparency. Below we summarize the different roles and responsibilities that surfaced through this project and specify who filled each role on our team. With these descriptions we hope to give an example of where to start when it comes to assigning roles

⁶ For a full list of the drivers and criteria used in our final analysis visit [Appendix B, Table 2](#).

and delegating tasks, but you may end up with different team roles based on the structure of your organization, the resources you have access to, or simply what works best for you.

Project Team

Project Leader and Manager:

The Project Leader and Manager is responsible for keeping the ball rolling. They bear the responsibility of seeing the project through to completion, organizing and coordinating project team and stakeholder meetings, setting deadlines, delegating responsibilities, communicating with stakeholder partners, and making the big decisions about the project's direction. The Project Leader and Manager for the Norwalk mapping project was Katie Blake, Conservationist at Highstead and H2H coordinator. Blake met regularly with the Norwalk Land Trust to discuss the project and keep things moving. Blake facilitated communications about the project with H2H partners; met with Norwalk stakeholders; helped collect data; delegated responsibilities; led presentations, meetings, and outreach; and more.

Local Community Champion and Convener

Conservation mapping is an inherently collaborative process, so the role of Local Community Champion and Convener (Community Champion for short) is extremely important in connecting the project team with community stakeholders in order to maximize collaboration and communication. Lisa Shanahan, a board member of the Norwalk Land Trust, City Council Board Member, and H2H partner, assumed the role of Community Champion, using her many "hats" and existing ties to the Norwalk community to bring stakeholders to the table. She introduced the project team to Norwalk city employees, such as members of the city's Public Works and Planning and Zoning departments, who would have been difficult to contact without having a prior connection and ended up providing valuable data for the mapping process. She also arranged meetings at which city stakeholders could learn about the project and provide feedback from the perspective of those living and working in the city.

During our Norwalk urban mapping process, having Shanahan as our Community Champion was especially important because Blake, our Project Leader and Manager, was not from Norwalk and did not know the city well or have personal connections with Norwalk stakeholders. However, if the Project Leader and Manager were leading a mapping project in a city that they knew well and had connections in, that role and the Community Champion could easily be one in the same.

Lead GIS-person:

Having a dedicated GIS-person to handle the collection, organization, and GIS analysis of data is essential. Casey Hamilton, Conservation Associate of Highstead, assumed the role of Lead GIS-person for the Norwalk mapping project. Hamilton's central duties included

collecting data from online sources, compiling that data in layers with data received from stakeholders, and making sure these data layers were formatted properly and stored in appropriate locations. Hamilton performed all of the GIS analysis, assembled the final Action Maps,⁷ and drafted this guide. Finally, Hamilton assisted Blake, the Project Leader, in presentations and outreach.

Our project team consulted with Brian Hall, a GIS expert at Harvard Forest, Harvard University, throughout the mapping process to reinforce the validity of the GIS analyses performed by Hamilton. Hall checked and approved the various GIS analyses performed on data layers and provided guidance during the project's beginning to both Hamilton and Blake on questions such as the types of analyses that should be performed and how the data layers should be presented. Hall was also instrumental in creating the [web map](#) for this project.

Norwalk Community Partners

The development of the Norwalk Urban Conservation Mapping Project was completed only through the combined input and efforts of many stakeholders, including landowners, city managers, government employees, nonprofits, and many others. Stakeholders contributed to the mapping project by participating in meetings, suggesting relevant data to be included or removed, reviewing draft maps, and providing overall feedback and direction. The role of stakeholders in each stage of the mapping process will be explained further in the [Project Phases](#) section.

Crucial in a mapping project's success, stakeholders should come from a variety of organizations and communities across the city. Failing to connect with a wide range of stakeholders will likely lead to a more biased final mapping model.⁸ The stakeholders involved in our mapping project included: H2H partners, members of the Norwalk Land Trust, City government employees from the Public Health, Public Works, Planning and Zoning, and Recreation and parks Departments, the Tree Advisory Council, the Water Quality Commission, the Conservation Commission, other NGOs like the Trust for Public Land, the Norwalk Preservation Trust, the Norwalk Tree Alliance and community organizations like the Norwalk Historical Society and the Maritime Aquarium—and many more. See [Appendix A](#) for a complete list of stakeholders.

⁷ “Action Maps” are one of the deliverables of the urban mapping process. They will be explained further in [Phase III](#) of the Project Process section.

⁸ For more information about and strategies for identifying, involving stakeholders in environmental projects, visit the following paper: Luyet, V., Schlaepfer, R., Parlange, M. B., & Buttler, A. (2012). A framework to implement stakeholder participation in environmental projects. *Journal of environmental management*, 111, 213-219. [URL](#).

Project Phases

The following section outlines a narrative five distinct “phases” that we use to describe the types of work conducted throughout the life of the Norwalk Urban Conservation Mapping Project. It should be noted that not all aspects of the process were linear as we often had to revisit earlier steps in an iterative fashion.

Phase I: Planning and Stakeholder Engagement

Over the course of 6 months, our Project Leader and Community Champion pulled together a series of meetings with community stakeholders in order to inform the construction of this mapping model. The goal of these meetings was to understand local priorities and values as a foundation for building the model, and to provide opportunities for feedback and input in the modeling process as it progressed. Different phases of the model were presented to stakeholders during these meetings and from here the model was further refined. It was also during these meetings that we learned of additional data the model should consider, described below in Phase II. Our Community Champion was the lead in pulling these stakeholder meetings together and key in outlining an engagement strategy for this project to optimize support and utilization of this tool.

Phase II: Data Collection and Research

Here, the Project Leader and Lead GIS-person took time to learn about the priorities and values of stakeholders as a way to inform what data should be considered in the Norwalk urban mapping model. Their goal was to revise the initial data criteria list developed by Whalen through her research⁹ and create a new criteria list specific to Norwalk. Many of the [stakeholders](#) they reached out to were associated with the City of Norwalk, though some were members of organizations whose scope is broader than a single town but include Norwalk (such as the Western Connecticut Council of Governments (WestCOG)). Altogether, these stakeholders were crucial for suggesting Norwalk-specific spatial data to be included. The criteria list was continually revised as the team received feedback from the Norwalk Land Trust and Norwalk stakeholders.¹⁰ Without their input, the final map would have been more generic, low resolution, and would not have spoken to the interests of Stakeholders.

Data accessibility and compatibility with GIS software limited what data the Project Team could use when creating the Norwalk urban mapping model. Some data were not available for private use, some were incompatible with the necessary GIS format for the spatial

⁹ See [Appendix B, Table 1](#) for an outline of the seven urban conservation drivers and their corresponding criteria found during Whalen’s literature review.

¹⁰ See [Appendix B, Table 2](#) for the finalized list of drivers and criteria used to make the Norwalk Urban Conservation Mapping Model.

analysis being pursued, and some data types that Whalen found in her research simply did not exist or could not be found for the City of Norwalk.

Phase III: GIS Analysis

Once the list of data was compiled, the team began GIS analysis lead by the Lead GIS-Person. The majority of GIS analysis was conducted via a process called co-occurrence modeling. Co-occurrence modeling operates by overlaying data layers on one another to highlight areas of overlap, or “co-occurrence” of high-value features. Co-occurrence modeling is appropriate for a project such as conservation mapping because it provides a way to combine multiple criteria together and show where on the map the criteria overlap. Map readers can then interpret these areas of overlap as most important, or “priority areas,” because they contain a high number of the agreed-upon values of significance that were put into the model.

In general, the Norwalk Urban Conservation Mapping Project used the same co-occurrence modeling structure as the 2018 H2H Strategic Conservation Map, but the team had to make some alterations for the urban-centric context of this project. A significant change for the urban-centric model was made in the final outputs of the GIS analysis. Instead of a singular final co-occurrence layer (for the 2018 map that was the *Areas of Highest Conservation Value* layer), which would be produced by inputting *all* of the drivers and criteria into the same model, the team made three models or “Action Maps,” each with a different combination of the data. This change was made for two reasons:

1. The team realized that since the criteria they were mapping in the urban model were all so different from one another, one final centralized co-occurrence layer composed of these disparate data layers would be nonsensical or impossible to interpret. For example, natural areas shown in the Ecology driver would likely score low in the Urban Heat Island driver, which generally highlight areas dominated by blacktop. Combining these two drivers, along with the other five, would produce a final co-occurrence layer with little purpose or meaning.
2. Through the overall mapping process, particularly in the research, outreach, meetings, and presentation phases, the team began to see how “urban conservation” as a concept was becoming more expansive in scope compared to the conventional “conservation” activities in the exurban and rural portions of a region, in which the primary conservation activity is often land protection. This shift in emphasis from a single type/goal of conservation to multiple types/goals of conservation is shown in the creation of the seven drivers of urban conservation which use vastly different criteria and datasets than the exurban/rural mapping project. Still, it took going through the urban mapping

process for the project team to fully appreciate that urban conservation can mean many different things besides land protection, like increasing tree planting in a neighborhood, identifying where access to green space is limited, or understanding which communities are most at risk of climate change impacts. Because of this, the team recognized a need, not for one ambiguous final layer but rather several layers—Action Maps—each with a distinct purpose and call to action that is easy to interpret and fits into this expanded view of urban conservation.

For a more detailed look at the GIS modeling process, including step-by-step instructions on data manipulation within the GIS program, consult [Appendix B: GIS Methods and Data: Detailed Step-By-Step](#).

Phase IV: GIS Products and Documentation

Once final data outputs were produced, it was time to organize the data in [web map](#) format and record the technical process.

Lead GIS-Person Hamilton compiled the data and final action map outputs from the GIS analysis into a final [web map](#). The [web map](#) includes *Final Driver Maps* which contain the specific co-occurrence output layer for each of the seven drivers considered by this model. The *Details on Drivers* section includes each data layer considered in the analysis. Each of these individual data layers can be turned on or off, allowing users to view an individual criterion, or all of the criteria together via the final co-occurrence. The [web map](#) also includes the three *Final Action Maps* as final co-occurrence output layers and includes a section called *Details on Final Action Maps* that outlines the layers that went into the analysis. Finally, the [web map](#) includes some data layers not included in the model, such as roads and highways, water features, protected land, and other features that provide spatial context and allow readers to orient themselves when viewing the analysis results.

Detailed note-taking of our mapping methodology took place throughout the project process, but transforming these notes into a readable document format occurred mostly after the GIS analysis and mapping were complete. This documentation became the GIS Methods Detailed Step-By-Step section of this guide ([Appendix B](#)) which serves as a step-by-step look into the GIS analyses that went into every criterion from all seven drivers, detailing GIS tools used, model structure, and the rationale behind each analysis. It also includes a full list of data sources, an inventory of relevant files, and a brief narrative on the process.

Phase V: Presentations and Outreach

The final step was to compile this information in a format appropriate for sharing with stakeholders, H2H partners, and others interested in urban conservation mapping. The project team has created several variants of PowerPoint presentations for the purpose of sharing, and has presented at meetings with the H2H Land Protection Working Group, stakeholders in Norwalk, the Norwalk City Common Council, and the entire H2H partnership at an all-partner meeting.

Moving forward, the project team will be giving more presentations to interested parties, communicating with H2H partners about the project, and getting materials to those partners who request them. We also hope to assist in getting other urban areas started on similar projects by providing documents like this one that outline an example urban conservation framework.

Conclusion:

The intent behind this project was twofold. First, to produce the [web map](#) and documents themselves which are intended to be used by members of H2H, the Norwalk Land Trust, and other stakeholders in the City of Norwalk for conservation activities and city planning. The Norwalk Urban Conservation Mapping Model has already been used in aiding grant applications and identifying areas in need of restoration. The [web map](#) can also be used as a tool to use in strategic conservation planning or in planning/zoning. Some examples include identifying:

- Areas important open space to protect/conserve
- Strategic wildlife habitat corridors
- Areas most vulnerable to the impacts of climate change
- Areas suitable for green infrastructure projects
- Areas of high conservation priority to avoid in siting development
- Neighborhoods most in need of public services to mitigate the effects of climate impacts

The [web map](#) can also be a useful tool to:

- Aid in prioritizing projects and directing use of limited resources
- Increase fundraising potential and bring support to grant applications
- Aid in the identification of new partnerships and project allies
- Enhance and increase community outreach and education potential
- Facilitate transparency and connections across sectors- environmental, public health, planning, etc.

The second intent of this project is accomplished through this document, which presents a detailed account of the process Norwalk undertook that other interested parties can follow to guide their urban conservation mapping projects.

Although there is no one-size-fits-all guide to urban conservation mapping, we hope sharing the process and lessons learned in Norwalk will aid you in the mapping efforts of your cities. This guide was made with H2H partners in mind. We are interested in hearing about your conservation mapping processes and any best practices you learn or challenges you face. Please feel free to reach out to H2H Coordinator [Katie Blake](#) with any questions or to receive more information on this project.

Appendix A: Full List of Norwalk Stakeholders

1. Bike/Walk Commission
2. City of Norwalk Department Heads and Staff:
 - a. Conservation Commission
 - b. Economy and Community Development
 - c. Engineering
 - d. Operations and Public Works
 - e. Planning and Zoning
 - f. Recreation and Parks
 - g. Transportation and Nobility
3. Connecticut Conservation League
4. Connecticut Land Trust Conservation Council
5. Former Darien Land Trust Director
6. Harbor Management Commission
7. Harbor Watch
8. Historic Commission
9. Keep Norwalk Beautiful
10. Maritime Aquarium
11. Mayor's Water Quality Commission
12. Norwalk Historical Society
13. Norwalk Land Trust
14. Norwalk Pollinator Pathway
15. Norwalk Preservation Trust
16. Norwalk River Valley Trail
17. Norwalk River Watershed Association
18. Norwalk Tree Alliance
19. Redevelopment Agency
20. Rowayton Historical Society
21. Tree Advisory Commission
22. Shellfish Commission
23. Skip the Straw/Plastics

Appendix B: GIS Methods and Data Sources

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Model Overview

This section outlines the technical process behind the Norwalk Urban Conservation Mapping Project. The model outlined in this document has been tailored specifically to the City of Norwalk and thus includes data and analyses that may prove less relevant to other cities. However, the overall model flow and data categorizations can be used in any urban conservation mapping project.

The Norwalk Urban Conservation Mapping Project is composed of data categorized as seven ‘drivers’ of urban conservation: Human Connectivity, Ecology, Urban Heat Island, Equity and Social Factors, Flood Risk, Recreation, and Public Health. We associated each of these drivers with spatial data layers consistent with the value of the driver and which represented features found within the city’s boundaries. These data were scored and then overlaid on one another, in a process called “co-occurrence modeling,” to identify areas with a higher degree of overlap across layers. These areas of overlap, or co-occurrence, are suggested to be areas of priority for city projects and investments and are intended to provide planning and management assistance to the city, and the Norwalk Land Trust and its many partners

The final output included three final “action” maps. The purpose of these maps is to provide more targeted and actionable objectives for the audience reading the map. The focus of each of the “action” maps were based off of the interests and priorities of Norwalk Stakeholders, as well as what

criteria and drivers naturally made sense together. The three “action” maps are 1) Preservation/Conservation, 2) Equitable Access to Nature, and 3) Climate Change Risk Areas. Each was created using a recombination of the 37 data layers used to populate the seven drivers in such a way as to highlight areas throughout the city for specific land protection, stewardship, and restoration projects. These maps were created in part in response to feedback from a suite of stakeholders and other partners which reflected a need for maps with a heightened sense of purpose in comparison to the seven drivers, and which could answer specific social and environmental questions facing the city.

Data were selected to be included in this GIS model based on research conducted by Highstead Conservationist Tara Whalen in the spring of 2019. From this research, Tara developed a list of common drivers of urban conservation values from other urban conservation projects and from the point of view of people living and working in urban communities. Her research led to the seven categorical urban drivers listed below, and also a preliminary list of potential “criteria” that could be included within each driver (Table 1).

From stakeholder input the Project Leader and Lead GIS-Person refined the original list of criteria to better reflect the needs and priorities of Norwalk. We also considered data accessibility and compatibility when developing this list. (Table 2).

Table 1: Initial proposed urban conservation criteria

Driver	Potential Criterion
Human Connectivity	Access to Public Transit
Human Connectivity	Connections to parks and green space
Human Connectivity	Routes to Schools
Human Connectivity	Routes to job-rich districts
Human Connectivity	Bike paths
Human Connectivity	Trails
Human Connectivity	Walkability to Grocery Stores
Human Connectivity	Critical Infrastructure
Urban Heat Island	Impervious surface
Urban Heat Island	Urban Heat Islands - Day
Urban Heat Island	Urban Heat Islands – Night
Urban Heat Island	Tree Canopy
Urban Heat Island	High Albedo Roofs & Surfaces
Urban Heat Island	Tree Gaps in Parks, Open Space, and Trails
Urban Heat Island	Street Tree Gap
Urban Heat Island	Land Surface Temperature
Urban Heat Island	Plant Trees in Vegetated Medians
Flood Risk	Current Flood Zones

Flood Risk	Projected Flood Zones
Flood Risk	Wetlands, Water Bodies, Streams, and Buffers
Flood Risk	Combined Sewer Overflows
Flood Risk	Impervious Surface
Flood Risk	Stormwater Runoff
Flood Risk	Escarpment Areas
Flood Risk	Water Quality
Flood Risk	Roadside Green Stormwater Infrastructure
Flood Risk	Coastline
Recreation	Publicly-owned Local, State, and National Parks, Trails, and Open Space
Recreation	School Parks with a Joint-Use Agreement with the Local Government.
Recreation	Privately-owned Parks Managed for Full Public Use
Recreation	10-Minute Walkable Service Areas (ESRI)
Equity and Social Factors	Low-Income Households
Equity and Social Factors	Single Parent Households Percent/Area
Equity and Social Factors	Seniors Over 64
Equity and Social Factors	Children Under 5
Equity and Social Factors	Population with Less than a High School Education
Equity and Social Factors	Linguistic Isolation
Equity and Social Factors	Minority Population
Equity and Social Factors	Access to a Vehicle
Equity and Social Factors	Persons with Disabilities
Equity and Social Factors	Population Density
Equity and Social Factors	Park Gap
Public Health	Percent of Population with Respiratory Disease
Public Health	Percent of Population with Pediatric Asthma
Public Health	Percent of Population with COPD
Public Health	Percent of Population with Diabetes
Public Health	Percent of Population with Cardiovascular Disease
Public Health	Percent of Population with Heart Disease
Public Health	Percent of Population at High Risk for Stroke

Public Health	Percent of Population with Obesity
Public Health	Percent of Population with Depression/Anxiety
Public Health	Tree Canopy Near Medical Facilities
Ecology	Distance to the Coast
Ecology	Distance to Major Rivers
Ecology	Index of Ecological Integrity
Ecology	Percent Tree Canopy
Ecology	Rare species
Ecology	Resilient Areas
Ecology	Important Habitat
Ecology	Regional Conservation Priorities
Ecology	Land cover

Table 2: Final modeled urban conservation criteria (list developed for Norwalk based on stakeholder input).

Driver	Final Modeled Criterion	Data Source
Human Connectivity	Norwalk Walking Routes	Norwalk Open Data
Human Connectivity	Public transportation stops	MetroCOG ¹ + WestCOG ²
Human Connectivity	Parkserve ³ 10-minute walk to park zones	The Trust for Public Land - ParkServe
Human Connectivity	Norwalk Bike Paths	Norwalk Open Data
Human Connectivity	Norwalk Roads	Norwalk Open Data
Urban Heat Island	Impervious Surface Cover	UCONN - CT ECO ⁴
Urban Heat Island	Tree Canopy Cover	WestCOG
Flood Risk	Riparian Buffers	CT DEEP ⁵
Flood Risk	Flood Zones	CT DEEP - FEMA
Flood Risk	Water Quality - Surface	CT DEEP
Flood Risk	Water Quality - Ground	CT DEEP
Flood Risk	Coastal Boundary	CT DEEP
Flood Risk	Inundation Frequency	CT DEEP
Recreation	Parks and Recreation	Norwalk Open Data + Norwalk P&R Department
Recreation	Norwalk River Valley Trail System	Highstead
Recreation	Norwalk Historic Points	Steven Birney - Norwalk GIS Analyst
Recreation	Norwalk Historic Buildings	Steven Birney - Norwalk GIS Analyst
Recreation	National Historic Registry	Steven Birney - Norwalk GIS Analyst
Equity and Social Factors	% minority	EJScreen ⁶
Equity and Social Factors	% low-income	EJScreen
Equity and Social Factors	% less than high-school	EJScreen

	education	
Equity and Social Factors	% under age five	EJScreen
Equity and Social Factors	% under age 64	EJScreen
Equity and Social Factors	Population density	Census Data - WestCOG
Public Health	Asthma rate	Centers for Disease Control and Prevention
Public Health	Diabetes rate	Centers for Disease Control and Prevention
Public Health	Stroke rate	Centers for Disease Control and Prevention
Public Health	Coronary Heart Disease rate	Centers for Disease Control and Prevention
Public Health	Obesity rate	Centers for Disease Control and Prevention
Public Health	Mental Health Not Good Days rate	Centers for Disease Control and Prevention
Public Health	Particulate Matter Concentration	EJScreen
Public Health	NATA Respiratory Hazard Index	EJScreen
Ecology	Index of Ecological Integrity	North Atlantic Landscape Conservation Collective
Ecology	CT Natural Diversity Database Areas	CT DEEP
Ecology	CT Critical Habitat Areas	CT DEEP
Ecology	High-quality Shellfish Habitat	CT DEEP
Ecology	CT Natural Land Cover	UConn CLEAR ⁷

1. Connecticut Metropolitan Council of Governments; 2. Western Connecticut Council of Governments; 3. ParkServe is an initiative of the Trust for Public Land (TPL) which uses ESRI's Network Analysis dataset to calculate 10-minute walkable service areas surrounding public parks in cities across the US; 4. University of Connecticut – Connecticut Environmental Conditions Online; 5. Connecticut Department of Energy and Environmental Protection; 6. Environmental Justice Screening and Mapping Tool – EPA; 7. University of Connecticut Center for Land Use Education and Research

GIS Methods Step-By-Step

The following sections describe the data layers and specific settings used within the GIS for our particular project. We present the details on methods in section 1 through 1C for GIS users only because they may not be of interest to the majority of readers.

1: ArcGIS Settings:

All of the following analyses were performed in ArcMap GIS software version 10.7 (ESRI 2019).

Before we performed any analysis, we set ArcMap environments to standard settings at the .mxd level to remain consistent throughout the modeling process. We used a projected coordinate system, NAD_1983_2011_StatePlane_Connecticut_FIPS_0600 (Meters) for every analysis. For raster analysis, we set the raster cell size to 30x30 as this was the finest collective resolution across our raster data inputs. We used a region-wide raster layer (Index of Ecological Integrity - see [Table 2: Data Layers](#)) as a snap raster, and a 1km buffer of the Norwalk Boundary layer as a set processing extent to ensure we capture the entirety of the city, even when features of interest do not extend to the city bounds.

The necessary mask to use varied between analyses - and thus, between ModelBuilder models - so these were set at the model environment level or, if specific to one tool, at the tool environment level within each model.

Nearly all of the following analyses were performed in ModelBuilder, a reoriducible automationThe co-occurrence method was used to identify priority areas based on the presence of multiple overlapping criteria. Criteria data layers were rasterized and scored according to the presence or absence of the criterion in space--in most cases, cells with the criterion present were scored 1, while absence was scored 0.

1A. Geoprocessing Tools

Several tools and settings are used throughout all analyses in this project to ensure consistency across the outputs. Data are almost always re-scaled to quantities using the **Slice** tool, set with 99 Equal Area bins for raw data, five for driver indices, and ten for final layer outputs. This is done because quantiles are usually more informative than raw data, in that scores are relative to the values of the rest of the cells in the dataset; for example, a score of 3 in the raw Preservation/Conservation Action Layer could seem somewhat low, but that score must be assessed relative to the highest score in the region. In reality, those cells might be re-scored into a 7 following Slicing, meaning that those cells score higher than 70% of all other data in the layer--suggesting that these might be priority areas for conservation.

The **ArcGIS tools “Is Null”** and **“Con”** are used frequently throughout the analysis. **Is Null** turns all cells scored with NoData as 1, and all other cells 0. **Con** is a Reclassify tool that assigns cells values based on a SQL statement or an input raster. These tools are most often used following a transformation from vector to raster data, such as **Polygon to Raster**, to fill up the cells in the extent with numerical values, rather than NoData. Then, **Con** is used on this output to re-classify cells to their proper scores, following the purpose of the driver in which the analysis is taking place. Note that this is the most common method using these tools, but it is not the only one.

1B. Weighting

In the current version of the model, every layer is weighted equally with a value of 1. Weighting parameters are included in the model for easy accessibility and potential for changing based on the desires of stakeholders or other players. But, the stakeholders in this project did not provide any preference in weighting some layers more than others, nor have we determined this to be necessary in our judgment. As it stands currently, each layer is multiplied by a weighting factor (currently **1** for all layers) using the **Times** tool before being summed with other layers in the same driver to produce a **Driver Index**.

1C. Driver Indices

Each layer in each of the seven drivers is summed via **Cell Statistics** to produce individual **Driver Indices**. These layers can be used for projects targeting one of the seven drivers. Each **Driver Index** is **Sliced** into five equal-area bins creating a quintile score for the driver.

The following section is organized by driver. It outlines the purpose of each driver, the data that occupies each driver, and the analyses performed on those data within ModelBuilder.

2: Drivers

2A. Public Health

The purpose of this driver is to identify areas of highest concentrations of public health issues. Thus, the model scored those areas with the highest rates of public health issues, vs. giving a low score to areas with low rates of public health problems.

The public health driver includes eight layers:

- National Air Transportation Association Respiratory Hazard Index (NATA RHI)
- Particulate Matter Concentration (PMC),
- Asthma Rate,
- Diabetes Rate,
- Stroke Rate,
- Coronary Heart Disease,
- Obesity Rate,
- Mental Health Not Good for ≥ 14 days Rate.

NATA RHI and PMC are sourced from EJScreen, while other layers are rates derived using small area estimation (SAE) from CDC “500 cities” self-reported survey of adults aged 18 years and older. All of these data were collected at the census tract level.

The GIS analysis for the Public Health driver proceeded in the following manner:

- Started with raw 500 cities dataset from CDC and EJScreen data and extracted tracts within Norwalk
- Built ModelBuilder pre-models:

- Public Health Iterative Sub-model
- Public Health Index Sub-model
 - These models are nested inside the main model
- ModelBuilder main model:
 - Six **Polygon to Raster** operations using CDC “500 cities” dataset. Each Polygon to Raster used a different field to create the raster, with each field corresponding to a criterion.
 - Two **Polygon to Raster** operations using the EJScreen dataset. Each used a different field to create a raster, with each corresponding to the two remaining criteria from this dataset (NATA RHI & PMC).
 - These outputs were then placed into an intermediate file geodatabase, and each was set as a **Precondition** to running the nested model, PublicHealth_ItSub.
- Public Health Iterative Sub-model instructions:
 - Start with the geodatabase in which the above rasters were placed.
 - Use **Iterate Rasters** to iterate through this folder.
 - Perform **Slice** operation (99 equal-area) on rasters
 - Perform **Con** operation on rasters with parameters:
 - True = 1
 - False = 0
 - SQL statement: Value >=50
 - This process selects cells within tracts listed as having the highest 50% rate of each public health driver and assigning those cells a value of 1.
- The result of these processes is eight raster layers containing cells scoring 0 or 1. 1-scored cells are the 50% of cells with the highest rates of the Public Health criterion of that layer. 0-scored cells are the 50% of the cells with the lowest rates.
- Next, we overlay these layers on top of one another in the Public Health Index Sub-model to produce the **Public Health Index**.
 - This model begins with the **Precondition** via a Boolean variable that the Public Health Iterative Sub-model has already been run.
 - I.e., this forbids the Public Health Index Sub-model from running before the Public Health Iterative Sub-model
 - Use **Times** tool to multiply each criterion raster layer with its associated Weighting Factor (which was set at 1 for all raster layers).
 - Then, use **Cell Statistics** with the eight criteria layers as inputs. Set statistic to **Sum**.
 - **Slice** into five Equal Area quintiles.
 - The result is the **Public Health Index**, the final layer of the Public Health Driver, depicting the co-occurrence of the above eight Public Health layers.

2B. Ecology

The overall purpose of the Ecology Driver is to identify areas in the urban landscape exhibiting the highest degree of ecological importance.

The Ecology driver consists of five data layers: Index of Ecological Integrity (IEI), Natural Diversity Database Areas, Critical Habitat Areas, Shellfish Classification Areas, and CT Land cover.

Descriptions of these criteria are as follows:

- **IEI** is a layer that reflects the ability of areas to support biodiversity over sustained periods by combining metrics of intactness and resilience.
- **Natural Diversity Database Areas** show approximate locations of rare/endangered species and communities.
- **Critical Habitat Areas** is a layer created by the CT DEEP that depicts areas of critical habitat important for rare and endangered species in the state of CT. It is an amalgamation of numerous studies by state agencies, NGO's, universities, etc.
- **Shellfish Classification Areas** depict the classification of currently existing shellfish beds based on safety for consumption.
- **CT Natural Land Cover** depicts 15 different land cover classes across CT, with high scores assigned to natural land cover classes.

The GIS analysis for the Ecology driver proceeds in the following manner:

- Start with two pre-models to format data
 - **Ecological_clip:**
 - Starts with Ecological_raw.gdb - the file geodatabase housing the raw ecological data layers.
 - Use **Iterate Feature Classes** to cycle through vector data layers in Ecological_raw.gdb.
 - **Clip** via NorwalkTractsBoundsForClipping and place in geodatabase Ecological_inputs.gdb
 - **Ecological_mask:**
 - Starts with Ecological_raw.gdb - the file geodatabase housing the raw ecological data layers.
 - Use **Iterate Rasters** to cycle through rasters in Ecological_raw.gdb.
 - **Extract by Mask** via NorwalkTractsBoundsForClipping and place in geodatabase Ecological_inputs.gdb
 - Note: These pre-models are optional because the main model Mask will be set to NorwalkTractsBoundsForClipping, which will force only the cells overlapping the Norwalk Tracts layer to be output at the end of the model. We used pre-models here to cut down on processing time in the main model.
- Main model:
 - **Critical Habitat**
 - Start with clipped Critical Habitat layer

- Converted to raster using **Polygon to Raster** via arbitrary field
 - **Is Null** assigns null cells with a value of 1 and non-null cells with a value of 0
 - **Con** operation with parameters
 - Value = 0
 - True = 1
 - False = 0
- The end result is a raster layer in which cells within critical habitat areas (regardless of type) are valued at 1 while all other cells in the extent have a value of 0.
- **Natural Diversity Database**
 - Identical procedure to **Critical Habitat**; see above.
- **Land Cover**
 - Start with a clipped Land Cover layer
 - **Reclassify** based on ecological importance as determined by stakeholders and the GIS team.
 - Water, grassland, & wetlands - 1, Forests - 0.5, & Barren/Developed/Turf - 0
 - Reclassify only supports integer values; thus, water/grasslands/wetlands scored 1, barren/developed/turf/right-of-ways 0, and forests scored **2** (as placeholder)
 - **Con** operation with parameters
 - Value = 2
 - True = 0.5
 - False = Input Raster
 - This operation turns the 2's placeholders into desired 0.5 value while maintaining 1's and 0's for other classes
 - The end result is a raster layer which classifies highly ecologically important land cover classes (grasslands, water, wetlands) with value 1, moderately ecologically important land cover classes (forests) with value 0.5, and all other classes with value 0.
- **Index of Ecological Integrity**
 - IEI is mostly NoData for urban areas like Norwalk; thus, we can consider areas with any data at all as especially important ecologically in the context of an urban landscape, even if these areas have low scores compared to the rest of the dataset at a regional scale.
 - There is, nonetheless, variation in the data, with some cells peaking around 0.7-0.8 (IEI is scaled 0-1).
 - It is appropriate then, in our judgment, to consider the top 50% of scored data as extremely important for ecological resilience in the urban landscape (Value - 1), with other cells, though scored low, still considered relatively important for ecological integrity in the landscape context of an urban

environment (Value - 0.5). This is the rationale we used to score this layer using the following procedure.

- Begin with masked IEI layer
 - **Slice** (99 equal area)
 - **Con** operation with parameters
 - Value \geq 50
 - True = 1
 - False = 0.5
 - This gives cells with high integrity value 1 and low integrity value 0.5. Cells with no data are classified as NoData.
 - **IsNull**
 - Gives NoData cells value 1 and all other cells value 0
 - **Con** operation with parameters
 - Value = 1
 - True = 0
 - False = IEI_con (output of the first Con operation in this process)
 - This turns cells identified as NoData in the previous step to 0, and cells with data returned to the values given in the original Con.
- The end result is a layer with cells in the top 50% of IEI scores with values of 1, representing extreme importance in terms of ecological integrity, cells in the bottom 50% of IEI scores with values of 0.5 representing moderate importance in terms of ecological integrity, and areas without any IEI data as 0 for no ecological integrity.
- **Shellfish classification areas**
 - Start with clipped Shellfish layer
 - **Polygon to Raster** via Class field
 - Creates raster with cells given value according to class (whether the area is safe for shellfishing)
 - **Reclassify** based on Class
 - Conditionally Approved & Approved classes assigned value 1
 - All other classes & NoData assigned value 0
 - The end result is a raster layer with 'safe' shellfishing areas with a value of 1, 'unsafe' areas with a Value 0.
- Next, we overlay these criteria on top of one another to produce the **Ecology Index**
 - Use **Times** tool to multiply each criterion raster layer with its associated Weighting Factor of 1 in this case.
 - Use **Cell Statistics** with the five Times created in the previous step as inputs. Set statistic to **Sum**.
 - **Slice** into five Equal Area quintiles.

- The end result is the **Ecology Index**, the final layer of the Ecology Driver, depicting co-occurrence of the above five Ecology criteria.

2C. Equity and Social Factors (ESF)

The purpose of the Equity and Social Factors driver is to identify areas that contain the highest rates of the above listed demographic factors - these are essential areas to prioritize for environmental projects because there exists a long history of environmental injustice surrounding underserved communities in this country. Thus, these areas represent potentially important zones to consider for future city management projects.

The ESF driver contains six layers, all related to demographic information. These are: % minority, % low-income, % less than high-school education, % under age five, % over age 64, and population density. Data for the first five criteria are sourced from EJScreen, and are collected at the census block group resolution. Population density comes directly from census data and is collected at the tract level.

The GIS analysis for the Equity and Social Factors driver proceeded in the following manner:

- Start with main model:
 - Bring in raw EJScreen & Census pop. density data layers
 - **Clip** these to Norwalk Municipal Bounds layer
 - Five **Polygon to Rasters** on EJScreen layer with each of the criteria as rasterization fields
 - One **Polygon to Raster** on Census tract layer with population density as rasterization field
 - Place these in intermediate folder - Equity_SocialFactors_inputs.gdb - and make **Preconditions** to the sub-model nested within this main model
- Sub-model:
 - Start with Equity_SocialFactors_inputs.gdb
 - Use **Iterate Raster** on this folder
 - Perform **Slice** operation (99 equal area) on rasters
 - Perform **Con** operation on rasters with parameters:
 - True = 1
 - False = 0
 - SQL statement: Value >=50
 - This selects cells within tracts listed as having the highest 50% rate of each ESV driver, and assigning those cells a value of 1
- The result of these processes is six raster layers containing cells scoring 0 or 1. 1-scored cells are the 50% of cells with the highest rates of the Equity and Social Factors criterion of that layer. 0-scored cells are the 50% of cells with the lowest rates.

- Next, we overlay these criteria on top of one another to produce the **Equity and Social Factors Index**
 - Occurs in sub-model 2 with **Precondition** via Boolean variable that sub-model 1 has already been run
 - Use **Times** tool to multiply each criterion raster layer with its associated Weighting Factor
 - Use **Cell Statistics** with the six criteria layers as inputs. Set statistic to **Sum**.
 - **Slice** into five Equal Area quantiles.
 - The end result is the **Equity and Social Factors Index**, the final layer of the Equity and Social Factors Driver, depicting co-occurrence of the above six Equity and Social Factors criteria.

2D. Flood Risk

The purpose of the Flood Risk driver is to combine data associated with flood risk, like flooding likelihood analyses and proximity to coastal areas, to help identify overall areas in which one could expect the worst effects of flooding to occur.

The Flood Risk driver is composed of four layers. These are: Riparian Buffers, Flood Zones, Coastal Boundary, & Inundation Frequency. Descriptions of these criteria are as follows:

- **Riparian Buffers:** This layer depicts a 50m buffer from hydrographic features throughout the state of CT, including ponds, rivers, streams, lakes, and the ocean. It is buffered by 50m to account for the important anti-flooding/erosion function that riparian buffers offer, and the buffer itself is the feature that is scored in our analysis.
- **Flood Zones:** This layer, produced by the Federal Emergency Management Agency (FEMA), ranks areas in terms of flood risk. Flood risk is defined by the probability of a given area experiencing a severe flood; either 1% chance (a once-every-100-years flood), 0.2% chance (a once-every-500-years flood), or low flood risk (everywhere else that is less than 0.2%). This layer will be rasterized based on flood risk.
- **Coastal Boundary:** Shows boundaries of land and water considered “coastal areas” by the state.
- **Inundation Frequency:** Layer shows frequency of inundation based on the “Sea Levels Affecting Marshes Model” (SLAMM). Layer provides higher temporal resolution to supplement FEMA flood zones.

The GIS analysis for the Flood Risk driver proceeded as follows:

- Start with ModelBuilder pre-model to format raw data layers:
 - **Clip** on the five raw vector layers, clipping to NorwalkTractsBoundsForClipping
 - **Extract by Mask** on raw Inundation raster layer, extracting by NorwalkTractsBoundsForClipping
 - Note: This pre-model is optional, because the main model Mask will be set to NorwalkTractsBoundsForClipping, which will force only the cells overlapping the

Norwalk Tracts layer to be output at the end of the model. We used this pre-model here in order to cut down on processing time in the main model.

- Main model:
 - Set mask to NHydroBuffFin_3
 - This mask is necessary to use for the Flood Risk driver specifically because it excludes hydrographic features from analysis. This driver is intended to show flood risk for terrestrial areas, not hydrographic features themselves.
 - For details on how we constructed this mask, please go to section **6Bv** of the Appendix.
 - **Riparian Buffers layer:**
 - Start with clipped hydrography layer
 - **Dissolve** hydrography polygons
 - **Buffer** 50m (~165ft)
 - **Erase**
 - Set buffered layer from the previous step as input
 - Recycle original raw Hydrology layer as erase layer
 - **Polygon to Raster** via arbitrary field
 - **Is Null**
 - This step cleans up cell values from the previous step which could be wide-ranging based on the selected field for conversion
 - Assigns NoData pixels 1 - i.e. areas not included in the hydro buffer, and all other areas 0 - i.e. the hydro buffers
 - **Con** with parameters:
 - Value = 1
 - True = 0
 - False = 1
 - This swaps the scores from the previous step to correctly score riparian buffer areas with 1, all other areas 0
 - Note: The following step is one applied to all layers in this driver, in order to re-score water features themselves as 0. We use the mask mentioned at the start of this section to first exclude water features from the analysis (NoData), then do the following to rescore as 0 to maintain consistency and functionality throughout the map. To do this we:
 - Set in-tool environment settings to Mask: NorwalkMunicipalBoundaries for the remaining analyses for this layer.
 - This is done to override the model-level Mask excluding water features set at the beginning of this section.
 - **Is Null**

- This step assigns cells scored as NoData to 1 (those being water features based on the model-level mask described above) and all other cells to 0.
 - **Con** with parameters:
 - Value = 0
 - True = Original Input
 - False = 0
 - This step changes the water features scored to 1 in the previous step to 0 as they should be. It also reassigns all other cells back to their original scores developed through the above analysis.
 - The end result is a layer with riparian buffers only scored 1, and all other areas (including the hydrographic features from which the buffer emanates) scored 0.
- **Coastal Boundary:**
 - Start with clipped coastal boundary layer
 - Converted to raster using **Polygon to Raster** via arbitrary field
 - **IsNull** to turn null cells value 1, and all other cells value 0
 - **Con** with parameters:
 - Value = 0
 - True = 1
 - False = 0
 - This switches values to get cells within coastal boundary features scored 1, all other cells score 0.
 - Note: The following step is one applied to all layers in this driver, in order to re-score water features themselves as 0. We use the mask mentioned at the start of this section to first exclude water features from the analysis (NoData), then do the following to rescore as 0 to maintain consistency and functionality throughout the map. To do this we:
 - Set in-tool environment settings to Mask: NorwalkMunicipalBoundaries for the remaining analyses for this layer.
 - This is done to override the model-level Mask excluding water features set at the beginning of this section.
 - **Is Null**
 - This step assigns cells scored as NoData to 1 (those being water features based on the model-level mask described above) and all other cells 0.
 - **Con** with parameters:
 - Value = 0
 - True = Original Input

- False = 0
 - This step changes the water features scored to 1 in the previous step to 0 as they should be. It also reassigns all other cells back to their original scores developed through the above analysis.
- The end result is a layer with cells within “coastal area” boundary scored 1, all others scored 0.
- **Flood Zones**
 - Start with clipped FEMA layer
 - **Polygon to Raster** using FLD_ZONE field
 - **Reclassify** based on flood classification - A, AE, V, VE = 1; 0.2 pct annual flood = 2; all else = 0
 - The score of 2 for 0.2 pct annual flood class is a placeholder for an eventual 0.5 score because the Reclassify tool only accepts integer values, and these cells need to be scored slightly lower to indicate a lower flood risk.
 - **Con** with parameters:
 - Value = 2
 - True = 0.5
 - False = FEMA input
 - This swaps the aforementioned 2-score placeholder with desired 0.5 score
 - Note: The following step is one applied to all layers in this driver, in order to re-score water features themselves as 0. We use the mask mentioned at the start of this section to first exclude water features from the analysis (NoData), then do the following to rescore as 0 to maintain consistency and functionality throughout the map. To do this we:
 - Set in-tool environment settings to Mask: NorwalkMunicipalBoundaries for the remaining analyses for this layer.
 - This is done to override the model-level Mask excluding water features set at the beginning of this section.
 - **Is Null**
 - This step assigns cells scored as NoData to 1 (those being water features based on the model-level mask described above) and all other cells as 0.
 - **Con** with parameters:
 - Value = 0
 - True = Original Input
 - False = 0

- This step changes the water features scored to 1 in the previous step to 0 as they should be. It also reassigns all other cells back to their original scores developed through the above analysis.
 - The end result is a Flood Zone raster layer with high-risk areas for flooding scored as 1 (100-year flood zones), less severely risky areas (500-year flood zones) = 0.5, least risky areas = 0.
- **Inundation Frequency**
 - Start with masked SLAMM layer
 - **Reclassify** based on Inundation Frequency: 30-day, 60-day, 90-day inundation = 1, 10-year inundation = **2**, all else = 0
 - 2 -score is a placeholder for an eventual 0.5 score since **Reclassify** does not accept non-integer values
 - **Con** with parameters
 - Value = 2
 - True = 0.5
 - False = Input Raster
 - This swaps the aforementioned 2-score placeholder with desired 0.5 score
 - Note: The following step is one applied to all layers in this driver, in order to re-score water features themselves as 0. We use the mask mentioned at the start of this section to first exclude water features from the analysis (NoData), then do the following to rescore as 0 to maintain consistency and functionality throughout the map. To do this we:
 - Set in-tool environment settings to Mask: NorwalkMunicipalBoundaries for the remaining analyses for this layer.
 - This is done to override the model-level Mask excluding water features set at the beginning of this section.
 - **Is Null**
 - This step assigns cells scored as NoData to 1 (those being water features based on the model-level mask described above) and all other cells 0.
 - **Con** with parameters:
 - Value = 0
 - True = Original Input
 - False = 0
 - This step changes the water features scored to 1 in the previous step to 0 as they should be. It also reassigns all other cells back to their original scores developed through the above analysis.

- The end result is a raster layer that scores cells based on inundation frequency with highest-frequency areas scored 1, less-frequent scored 0.5, and very infrequently inundated scored 0.
 - Note: The data in this layer are very similar (spatially and informationally) to the FEMA layer; however, SLAMM operates at a higher temporal resolution (10-day to 90-day inundation frequency) so both layers have merit. In the end, by using both of these layers, the model will highlight areas at-risk for flooding, but will emphasize even more those areas that are being frequently inundated as well.
- Next, we overlay these layers on top of one another to produce the **Flood Risk Index**
 - Use **Times** tool to multiply each criterion raster layer with its associated Weighting Factor
 - Use **Cell Statistics** with the six criteria layers, as inputs. Set statistic to **Sum**.
 - **Slice** into five Equal Area quantiles.
 - The end result is the **Flood Risk Index**, the final layer of the Flood Risk Driver, depicting co-occurrence of the above six Flood Risk criteria.

2E. Urban Heat Island

The purpose of the Urban Heat Island driver is to identify areas that are at the highest risk for experiencing urban heat island effects.

It contains two layers:

- **Impervious Surface Cover:** This layer is drawn from the CT ECO data repository of the University of Connecticut. It was created based on color infrared aerial imagery from 2012 and updated using 2012 planimetric data.
- **Urban Tree Canopy Cover:** This layer is drawn from a Western Connecticut Council of Governments (WestCOG) analysis which utilized 2016 NAIP and 2016 LiDAR SEM and DEM layers to map tree canopy cover across the region

The GIS analysis for the Urban Heat Island driver proceeded as follows:

- Main model:
 - Start with raw data layers
 - **Clip** to Norwalk Municipal Bounds
 - **Urban Tree Canopy Cover:**
 - **Polygon to Raster** via arbitrary field
 - **Is Null**, turning NoData cells into 1-value, all others 0.
 - The end result is a raster layer with areas without tree canopy scored 1 and areas with tree canopy scored 0.
 - **Impervious Surface Cover:**
 - **Polygon to Raster** via arbitrary field

- **Is Null**, turning NoData cells into 1-value, all others 0.
- **Con** with parameters:
 - Value = 0
 - True = 1
 - False = 0
 - This switches the 1-scores from the previous step (no impervious cover) to 0, and the 0-scores (impervious surface) to 1.
- The end result is a layer in which areas covered by impervious surface are scored 1, while areas not covered by impervious surface are 0.
- Next, we overlay these criteria on top of one another to produce the **Urban Heat Island Index**
 - Use **Times** tool to multiply each criterion raster layer with its associated Weighting Factor.
 - Use **Cell Statistics** with the two criteria layers as inputs. Set statistic to **Sum**.
 - **Slice** into five Equal Area quantiles.
 - The end result is the **Urban Heat Island Index**, the final layer of the Urban Heat Island Driver, depicting co-occurrence of the above two Urban Heat Island criteria.
 - Altogether, this layer can help to identify areas at-risk of experiencing the worst urban heat island impacts -- i.e. those areas lacking tree canopy cover and high in impervious surface cover.

2F. Human Connectivity

The purpose of this theme is to identify areas with the highest levels of human connectivity. Human Connectivity here, in the urban context, is being defined as ways for human beings to move around.

The Connectivity driver consists of five criteria: Norwalk Walking Routes, Public Transportation Stops, Parkserve 10-minute Walk Service Areas, Norwalk Bike Paths, and Norwalk Roads.

Descriptions of these criteria are as follows:

- **Norwalk Walking Routes:** Norwalk Health Department mapped dozens of walking routes throughout the city to encourage people to get outside and explore the city.
- **Public Transportation Stops:** WestCOG public transportation stops.
- **ParkServe 10-minute Service Areas:** ParkServe calculated 10-minute walkable service areas from parks throughout the US.
- **Norwalk Bike Paths:** This layer contains both currently existing and proposed bike routes throughout the city, but we focus on currently existing paths for the sake of analysis.
- **Norwalk Road Density:** Density analysis performed on layer of roads running through Norwalk.

GIS analysis for these layers proceeded as follows:

- Start with **pre-model** to format raw data layers:

- **Clip** on the five raw vector layers, clipping to NorwalkTractsBoundsForClipping
- Note: This pre-model is optional, because the main model Mask will be set to NorwalkTractsBoundsForClipping, which will force only the cells overlapping the Norwalk Tracts layer to be output at the end of the model. We used this pre-model here in order to cut down on processing time in the main model.
- **Main model:**
 - **Public Transportation Stops:**
 - **Euclidean distance**
 - **Slice**
 - Equal Area 99 zones
 - **Con**
 - Value ≥ 50
 - True = 0
 - False = 1
 - The end result is a layer with the 50% of cells closest to stops are assigned valued 1 and all others are valued 0.
 - **Norwalk Road Density:**
 - **Line Density**
 - Map units, search radius default
 - **Slice** 99 equal area
 - **Con**
 - Value ≥ 50
 - True = 1
 - False = 0
 - The end result is a layer where the 50% of cells with highest road density are assigned value of 1, while the other 50% of cells are valued 0.
 - **ParkServe 10-minute walk:**
 - **Polygon to raster** via arbitrary field
 - **Is Null**
 - **Reclassify**
 - 1 = 0
 - 0 = 1
 - The end result is a raster layer in which cells inside of service areas are assigned value 1, and cells outside service areas are assigned value 0.
 - **Norwalk Walking Routes**
 - **Buffer**
 - 0.5 miles (represents standard 10-minute walk distance), dissolve all
 - **Polygon to Raster** via arbitrary field
 - **IsNull**
 - **Reclassify**
 - 1 = 0

- 0 = 1
 - The end result is a layer with cells within 0.5 miles of walking paths are scored 1, and other cells are scored 0.
- **Norwalk Bike Routes**
 - **Buffer**
 - 0.5 miles (represents standard 10-minute walk distance)
 - **Polygon to Raster** via arbitrary field
 - **Is Null**
 - **Con** with parameters
 - Value = 0
 - True = 1
 - False = 0
 - The end result is a layer in which cells within bike route buffer are scored 1, and cells outside bike route buffer are scored 0.
- Next, we overlay these criteria on top of one another to produce the **Connectivity Index**
 - Use **Times** tool to multiply each criterion raster layer with its associated Weighting Factor
 - Use **Cell Statistics** with the five criteria layers as inputs. Set statistic to **Sum**.
 - **Slice** into five Equal Area quantiles.
 - The end result is the **Connectivity Index**, the final layer of the Connectivity Driver, depicting co-occurrence of the above five Connectivity criteria.

2G. Recreation

The purpose of the Recreation driver is to highlight areas of recreational importance throughout the city, suggesting that these areas are important to conserve for the recreational opportunities they offer city dwellers.

The Recreation driver consists of five different layers: Parks and Recreation Facilities, Norwalk River Valley Trail System, Norwalk Historic Buildings, Norwalk Historic Points, & National Historic Registry. Descriptions of these layers are as follows:

- **Parks and Recreation:** Polygons of parks and other recreational facilities maintained by Norwalk P&R department. Addresses obtained from P&R were cross-checked with Norwalk Open Space layer and extracted to obtain a layer with open spaces only directly related to/used for recreational opportunities.
- **Norwalk River Valley Trail System:** Line layer showing the NRVT trail system along the Norwalk river through the city.
- **Norwalk Historic Buildings:** Line shapefile outlining historic buildings in Norwalk
- **Norwalk Historic Points:** Historic points of interest in Norwalk
- **National Historic Registry:** Parcels in Norwalk that are classified as historic features of interest by the National Historic Registry

The GIS analysis for the Recreation driver proceeded as follows:

- Start with **pre-model** to format raw data layers:
 - **Clip** on the five raw vector layers, clipping to NorwalkTractsBoundsForClipping
 - Note: This pre-model is optional, because the main model Mask will be set to NorwalkTractsBoundsForClipping, which will force only the cells overlapping the Norwalk Tracts layer to be output at the end of the model. We used this pre-model here in order to cut down on processing time in the main model.
- **Main model:**
 - **Parks and Recreation**
 - Start with the clipped parks layer
 - **Polygon to Raster** via arbitrary field
 - **Is Null**
 - **Con** with parameters:
 - Value = 1
 - True = 0
 - False = 1
 - This swaps the values from Is Null in the previous step
 - The end result is a raster layer valuing cells within areas of P&R facilities 1, and all other cells at 0.
 - **Norwalk River Valley Trail System**
 - Start with clipped NRVT layer
 - **Buffer**
 - 100m
 - **Is Null**
 - **Con** with parameters
 - Value = 1
 - True = 0
 - False = 1
 - The end result is a raster layer valuing cells within 100m of the trail system at 1, and all others at 0.
 - **Norwalk Historic Points**
 - **Pre-model formatting:**
 - Merge 2 Historic Points data layers together
 - **Buffer**
 - 50m
 - Dissolve all
 - **Polygon to Raster** via arbitrary field
 - **Is Null**
 - **Con** with parameters:
 - Value = 1

- True = 0
 - False = 1
 - This swaps the values from Is Null in the previous step
- The end result is a raster layer valuing cells within 50m of historic points at 1, and all other cells at 0. The intent of this scoring being that areas within 50m of historic points likely include the properties they are on, areas of access, etc., and these things should be prioritized for the protection of historic features.
- **National Historic Registry**
 - Identical methods to **Public Open Space**; see above
 - Note: These methods were followed because the Registry data is at the parcel level already; it is understood that it is the features within these parcels that are of importance, and thus the parcels in which they are located should be prioritized for protection/conservation.
- **Norwalk Historic Buildings**
 - **Pre-model formatting:**
 - Layer received in line format - perform **Feature to Polygon** in order to turn line data (which delineated historic buildings by their outline) into polygon data
 - **Buffer**
 - 30m
 - Dissolve All
 - **Polygon to Raster** via arbitrary field
 - **Is Null**
 - **Con** with parameters:
 - Value = 1
 - True = 0
 - False = 1
 - This swaps the values from Is Null in the previous step
 - The end result is a raster layer valuing cells within historic buildings plus cells within 30m of historic buildings at 1, and all other cells at 0. 30m buffer was chosen (in contrast with 50m buffer of historic points layer) based on the data type -- these are polygons and thus the buffer layer includes the area of the polygons themselves in addition to the buffer, so we reduced the buffer distance compared to the point layer in order to best remain consistent.
- Next, we overlay these criteria on top of one another to produce the **Recreation Index**
 - Use **Times** tool to multiply each criterion raster layer with its associated Weighting Factor
 - Use **Cell Statistics** with the five criteria layers as inputs. Set statistic to **Sum**.
 - **Slice** into five Equal Area quantiles.

- The end result is the **Recreation Index**, the final layer of the Recreation Driver, depicting co-occurrence of the above five Recreation criteria.

3: Final Co-Occurrence Action Maps

Through multiple meetings with stakeholders, GIS professionals, and others, we recognized a need for final co-occurrence layers that feature some sort of recombination of our data that would produce more meaningful, actionable outputs. We decided to start with the end goal in mind, thinking of what potential actions our map audience might want to take, and how we could combine our data in ways to serve those purposes. In this way, we created three categories, each with a unique, actionable purpose utilizing different combinations of the data already within the model. We did not incorporate any new data for these layers, as we wanted them to be re-combinations of our existing data, but combined in ways that confer different stories and have elevated use beyond the raw theme indices. Though we did not include new data, in some cases we performed minor new analyses to achieve the goal of the category. The following section details the three categories, their purposes, the data and analyses that went into their creation, and how this concept may be transferred to the generalized model.

We developed three different maps for this final analysis: the *Priority Land for Conservation Action Map* which highlights areas of high conservation value, the *Ensuring Equitable Access to Nature Action Map* which identifies areas in need of public green space, and the *Climate Risk Mitigation Action Map* which shows areas at high risk for climate-related hazards. Each of these maps was built using co-occurrence modeling, but also involved other unique data manipulations.

3A. Climate Risk Mitigation Action Map

The first final action layer is centered on Climate Risk Mitigation. It is intended to highlight areas at greatest risk of experiencing negative climate-related hazards - namely increased flooding/storm damage and elevated temperatures.

With this goal in mind, we used a combination of the **Flood Risk (FR)** driver, **Urban Heat Island (UHI)** driver, and **Equity and Social Factors (ESF)** driver. Flood Risk and UHI were selected because of our data, these reflect the physical, on-the-ground conditions that exacerbate climate risk. ESF was included to bring in the element of environmental justice, recognizing that underserved communities are often those hit hardest by environmental pollution, degradation, and, increasingly, climate-related hazards.

- The GIS analysis for creating this layer proceeded as follows:
 - Take FR, UHI, and SF sliced indices and combine using **Cell Statistics**.
 - Set statistic to **Sum**.
 - **Slice** into ten equal-area deciles.

- Three **Extract by Attributes** - Each with a SQL expression variable titled “Priority Selection Threshold,” with expressions Value >= 7, Value >= 8, and Value >=9.
- **Con** with parameter:
 - True = 1
 - This Con simply reassigns the value of the pixels selected in each threshold as 1 for ease of use.
 - These extractions create three new layers for visual clarity: one which selects pixels in the top 70th percentile, one which selects pixels in the top 80th percentile, and one which selects pixels in the top 90th percentile. These layers are useful to use alone to visualize top-scoring areas without having to look at all of the data within this final Action Layer.
- The result of this model is a raw-score layer, which is a product of the combination of all of the inputs without further manipulation, a sliced version of this raw-score layer showing scores in deciles for easy interpretation, and three threshold layers showing top-scoring cells within three different percentile thresholds. For example, these are co-occurrence layers showing highest-scoring areas as those with the greatest level of climate-related risk based on propensity for flooding, degree of impervious surface/lack of tree canopy cover, and social factors like income level, minority population, and others.

3B. Priority Land for Preservation/Conservation Action Map

The purpose of this final action layer is to identify areas in the city of Norwalk that could be considered priorities for conservation/preservation based on environmental quality and recreational potential.

Thus, this layer is composed primarily of the **Ecology** and **Recreation** drivers. This selection of data is similar to how traditional strategic conservation mapping is performed, and the H2H exurban model functioned: basing priority land for conservation principally on ecological and recreational factors. We also added layers from other themes that fit into the ecologically and recreationally valuable framework that embodies this layer. These were:

- **Riparian Buffer** is an important layer for highlighting areas adjacent to water features, which are highly important for protecting against erosion and mitigating storm surge - thus being valuable areas to conserve. In the main analysis, this layer is housed in the **Flood Risk** theme.
- **Bike Paths** from **Connectivity**. We included this layer because it has strong recreational implications, one of the main things we wanted to cover in this category. The other layers in the **Connectivity** theme do not fit into this category in the same way, so we decided to add Bike Paths in separately.
- **Distance to Protected Land**. This is often included in conventional strategic conservation maps since it is usually best to protect land that is near other protected lands. This is

especially important in rural maps for the sake of connecting protected spaces, which is very important to creating wildlife corridors, bolster landscape resilience, and increase the overall area of intact permanently protected habitat, all of which have significant, positive ecological implications. These same benefits may be transferable to the urban landscape, albeit on a smaller scale, which is why we include this new analysis here.

- The procedure for creating this layer proceeded as follows:
 - Model Environment:
 - **Output Coordinates** set to
NAD_1983_2011_StatePlane_Connecticut_FIPS_0600
 - **Processing Extent Snap Raster** set to IEI (index of ecological integrity layer used throughout analysis for snapping)
 - **Raster Analysis Mask** set to NorwalkTractsBoundsForClipping
 - Adding Distance to Protected Land Analysis
 - Start with the Protected Land layer (in our case, this is protected_lands_merge_complete. This layer is a compilation of protected land data collected throughout the H2H region).
 - Perform **Euclidean Distance**, specifying 30m cell size.
 - **Slice** into 99 equal-area centiles.
 - **Con** with parameters:
 - Value \geq 50
 - True = 0
 - False = 1
 - This scores the 50% of cells closest to protected land as 1, all other cells 0.
 - Since we are adding additional data layers into analysis for this action layer, we decided to sum all of these layers together individually, rather than adding the total Ecology index and Recreation index layers with the new data layers - this method allots equal weight for all data to be included in the final layer.
 - For every data layer, including Bike Paths (final version drawn from Connectivity Index), Riparian Buffer, and Distance to Protected Land, we add a variable of type **Double**, naming each “%Name% Weighting Factor” where %Name% is an in-line substitution for the name of the data layer. We set these variables equal to 1, then use **Times** to multiply each variable with its associated data layer.
 - We use this step essentially to create placeholder weighting factors for anyone who wants to weight these data when using the tool. This procedure is identical to the creation of our driver indices.
 - Next, we use **Cell Statistics** set to the **Sum** statistic to add all of the data layers together.
 - Perform two **Extract by Masks** - first a Hydrography mask which highlights all areas not classified as hydrographic features, then a Protected Land mask, which highlights all areas not classified as already protected lands.

- We include this step to reinforce the focus of this Action Layer being to identify priority *lands* within the bounds of the city for conservation. Thus, according to this goal, we should not be including water or already protected land in this analysis.
 - These masks were prepared in a separate model we use throughout this mapping project. See Appendix **6Bv** for details on this model.
 - **Slice** into ten equal-area deciles.
 - Three **Extract by Attributes** - Each with a SQL expression variable titled “Priority Selection Threshold,” with expressions Value >= 7, Value >= 8, and Value >=9.
 - **Con** with parameter:
 - True = 1
 - This Con simply reassigns the value of the pixels selected in each threshold as 1 for ease of use.
 - These extractions create three new layers for visual clarity: one which selects pixels in the top 70th percentile, one which selects pixels in the top 80th percentile, and one which selects pixels in the top 90th percentile. These layers are useful to use alone to visualize top-scoring areas without having to look at all of the data within this final Action Layer.
 - The result of this model is a raw-score layer, which is a product of the combination of all of the inputs without further manipulation, a sliced version of this raw-score layer showing scores in deciles for straightforward interpretation, and three threshold layers showing top-scoring cells within three different percentile thresholds.

3C. Ensuring Equitable Access to Nature Action Map

The third and final action layer is Equitable Access to Nature. Our intent behind this layer is to highlight areas where people are perhaps in greatest need of access to nature. We define “access to nature” as being within a 10-minute walk of a park - thus, for this layer, we rely heavily on the Trust for Public Land’s (TPL) ParkServe analysis, which calculates the percentage of residents within a 10-minute walk to green space in cities across the country. This analysis is performed using ESRI’s network analyst, which draws “service areas” - the 10-minute walkable areas surrounding public green space, accounting for walking paths, roads, and barriers. We use these service areas borrowed from TPL’s analysis for Norwalk’s parks as the basis for our Equitable Access to Nature layer. We also factor in **Public Health** and **Equity and Social Factors** in recognition that access to green space has been shown to improve public health outcomes, and often these spaces are increasingly inaccessible to underserved communities. The layer scores areas outside of ParkServe’s service areas as priority areas for park placement based on granting access to green space to underserved communities with the highest rates of public health issues.

- The procedure for creating this layer proceeded as follows:
 - Creation of **Non-Service-Area Mask**

help identify areas with potential high-risk for experiencing the Urban Heat Island effect, due to the co-occurrence of impervious surface and lack of tree canopy cover; this purpose is noted in the UHI-dedicated section of this document. The UHI Index is not, in contrast, a predictive model for future UHI effects, or empirical evidence for increased temperatures at high-scoring locations within the layer. It serves only to highlight where the co-occurrence of UHI-associated criteria takes place.

Another limitation has to do with the tool’s spatial accuracy. The resolution of our tool is 30x30 meters (~1/4 acre), which is relatively coarse for an area the size of Norwalk. We were forced to use this raster cell size because it is the finest collective resolution of all of our data. Thus, we do not recommend using this model to pinpoint precise locations for potential projects; rather, we suggest it to be most useful early on in the planning process as a broad, guiding tool to select more general locations where projects should or should not take place.

Finally, as noted elsewhere in this documentation, this pilot project is specific to the City of Norwalk. Though we intend to adapt it to a broader framework that could be applied to other urban areas throughout the H2H region, this model includes data and processes specific to the needs of the City of Norwalk. It should not be used in its current state to draw any conclusions about other urban areas.

Table 3: Data Sources for Norwalk Urban Map

Criterion/Data Type	Name of Datasets Used	Data Sources	Link (if open source)
Norwalk Walking Routes	“Walk Routes”	Norwalk Open Data	https://gis-norwalk.opendata.arcgis.com/datasets/walk-routes
Public transportation stops	“GBT Stops” + “Transit”	MetroCOG + WestCOG	http://gis-ctmetro.opendata.arcgis.com/datasets/gbt-stops?geometry=-73.810%2C41.089%2C-72.936%2C41.179 ; https://westcog.org/analytics/data/
Park Service Areas	“ParkServe_Service_Areas”	The Trust for Public Land - ParkServe	https://www.tpl.org/parkserve/downloads
Norwalk Existing Bike Paths	“NorwalkBikeRoutesOpenData”	Norwalk Open Data	http://gis-norwalk.opendata.arcgis.com/datasets/norwalkbikeroutesopendata/

			data
Norwalk Roads	“Area Roads Major”	Norwalk Open Data	http://gis-norwalk.opendata.arcgis.com/datasets/area-roads-major?geometry=-73.474%2C41.074%2C-73.327%2C41.119
Impervious Surface Cover	“2012 Impervious Cover”	UCONN - CT ECO	https://cteco.uconn.edu/ctmaps/rest/services/Impervious/Impervious_2012_StatePlane/MapServer
Tree Canopy Cover	“Canopy”	WestCOG	https://westcog.org/analytics/data
Riparian Buffer	“Connecticut Hydrography Polygon”	CT DEEP	https://ct-deep-gis-open-data-website-ctdeep.hub.arcgis.com/datasets/connecticut-hydrography-set
Flood Zones		CT DEEP - FEMA	https://ct-deep-gis-open-data-website-ctdeep.hub.arcgis.com/
Water Quality - Surface	“Ground Water Quality Classifications Polygon”	CT DEEP	https://ct-deep-gis-open-data-website-ctdeep.hub.arcgis.com/datasets/ground-water-classifications-polygon
Water Quality - Ground	“Surface Water Quality Classifications Polygon”	CT DEEP	https://ct-deep-gis-open-data-website-ctdeep.hub.arcgis.com/datasets/surface-water-quality-classifications-set
Coastal Boundary	“Coastal Boundary”	CT DEEP	https://ct-deep-gis-open-data-website-ctdeep.hub.arcgis.com/datasets/coastal-

			boundary
Inundation Frequency	“Inundation Frequency Initial Results (2010) SLAMM”	CT DEEP	https://ct-deep-gis-open-data-website-ctdeep.hub.arcgis.com/
Parks and Recreation	“Open Space” + Norwalk Parks & Recreation Facility Addresses	Norwalk Open Data + Norwalk P&R Department	https://gis-norwalk.opendata.arcgis.com/datasets/open-space
Norwalk River Valley Trail System	“NRVT”	Highstead	NA
Norwalk Historic Points	“HistoricPoints”	Steven Birney - Norwalk GIS Analyst	NA
Norwalk Historic Buildings	“HistoricBuildingsPoly”	Steven Birney - Norwalk GIS Analyst	NA
National Historic Registry	“National_Historic_Registry_1”	Steven Birney - Norwalk GIS Analyst	NA
% minority	“EJSCREEN_StatePct”	EJScreen	ftp://newftp.epa.gov/EJSCREEN/2019/
% low-income	“EJSCREEN_StatePct”	EJScreen	ftp://newftp.epa.gov/EJSCREEN/2019/
% less than high-school education	“EJSCREEN_StatePct”	EJScreen	ftp://newftp.epa.gov/EJSCREEN/2019/
% under age five	“EJSCREEN_StatePct”	EJScreen	ftp://newftp.epa.gov/EJSCREEN/2019/
% under age 64	“EJSCREEN_StatePct”	EJScreen	ftp://newftp.epa.gov/EJSCREEN/2019/
Population density	“CensusBlock”	Census Data - WestCOG	https://westcog.org/analytics/data
COPD rate	“500 Cities: Census Tract-level Data”	Centers for Disease Control and Prevention	

Diabetes rate	“500 Cities: Census Tract-level Data”	Centers for Disease Control and Prevention	https://chronicdata.cdc.gov/500-Cities-Places/500-Cities-Census-Tract-level-Data-GIS-Friendly-Fo/k86t-wghb
Stroke rate	“500 Cities: Census Tract-level Data”	Centers for Disease Control and Prevention	
Coronary Heart Disease rate	“500 Cities: Census Tract-level Data”	Centers for Disease Control and Prevention	
Obesity rate	“500 Cities: Census Tract-level Data”	Centers for Disease Control and Prevention	
Mental Health Not Good Days rate	“500 Cities: Census Tract-level Data”	Centers for Disease Control and Prevention	
Particulate Matter Concentration	“EJSCREEN_StatePct”	EJScreen	ftp://newftp.epa.gov/EJSCREEN/2019/
NATA Respiratory Hazard Index	“EJSCREEN_StatePct”	EJScreen	ftp://newftp.epa.gov/EJSCREEN/2019/
Index of Ecological Integrity	“iei-r_2010_v3.1”	North Atlantic LCC	https://www.sciencebase.gov/catalog/item/58b5a7ffe4b01ccd54fde201
CT Natural Diversity Database Areas	“NATURAL_DIVERSITY_DATABASE”	CT DEEP	https://ct-deep-gis-open-data-website-ctdeep.hub.arcgis.com/datasets/natural-diversity-database
CT Critical Habitat Areas	“CRITICAL_HABITAT_POLY”	CT DEEP	https://ct-deep-gis-open-data-website-ctdeep.hub.arcgis.com/datasets/critical-habitats
Shellfish Classification Areas	“SHELLFISH_AREA_CLASS_POLY”	CT DEEP	https://ct-deep-gis-open-data-website-ctdeep.hub.arcgis.com/datasets/shellfish-area-class-poly

CT Land Cover	“2015lc_v2-03_ctstp83”	UConn CLEAR	http://clear.uconn.edu/projects/landscape/download.htm#top https://www.mrlc.gov/data
Protected Open Space	“protected_lands_merge_complete”	Highstead/Harvard Protected Open Space layer	NA
Norwalk Neighborhoods	“Neighborhoods”	Norwalk Open Data	https://gis-norwalk.opendata.arcgis.com/datasets/neighborhoods
Norwalk Municipal Boundaries	“CONNECTICUT_TO_WN_BOUNDARY”	CT DEEP	https://ct-deep-gis-open-data-website-ctdeep.hub.arcgis.com/datasets/connecticut-and-vicinity-town-boundary-set
Norwalk Parcels	“Parcels 2018”	Norwalk Open Data	https://gis-norwalk.opendata.arcgis.com/datasets/parcels-2018

Appendix C: Literature Review and Existing Models

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