Green Infrastructure Report: Baltimore City

Technology Resources for Enhancing the Network of Protected Lands in the Greater Baltimore Region

September 2015

The Chesapeake Conservancy's mission is to achieve a healthier Chesapeake Bay watershed by connecting people with its wildlife and history, conserving landscapes and rivers, and restoring its natural resources.

We serve as a catalyst for change, advancing strong public and private partnerships, developing and using new technology, and driving innovation throughout our work.

From our founding, we have embraced the National Park Service's Captain John Smith Chesapeake National Historic Trail as an inspiration and framework for our work in the region.

Cover photo by Flickr user Rupa Panda.

Contents

Launch of the Baltimore Wilderness Coalition. (From left) U.S. Congressman Dutch Ruppersberger; U.S. Congressman John Sarbanes; Baltimore City Mayor Stephanie Rawlings-Blake; Nick DiPasquale, Director of the Chesapeake Bay Program; and Ben Grumbles, Maryland Secretary of the Environment (Photo by Chesapeake Conservancy).

Executive Summary

With the generous support of the France-Merrick Foundation, the Chesapeake Conservancy presents this *Green Infrastructure Report*. This report describes three new resources to advance goals to **conserve** existing green spaces, **restore** degraded lands, and **connect** citizens to the City's natural resources.

The tools presented in this report are designed to support the Greater Baltimore Wilderness Coalition (GBWC), in its mission to protect and enhance the region's green infrastructure, and Baltimore City managers, in their work to track and achieve goals outlined in the *Baltimore Sustainability Plan*.

Conserve

At the onset of the GBWC initiative, the steering committee agreed that a critical first step to creating a connected network of greenspaces is to identify those areas that have the potential to be conserved and restored for public access and/or wildlife habitat. To address this need, the Conservancy has produced the *Baltimore City Land Cover Classification* using advanced software and analytical techniques. The classification effectively distinguishes greenspaces, such as grass and forest, from other surfaces, such as asphalt, bare earth, and water.

Results of this analysis estimate that 28% of Baltimore City's land area has tree canopy cover. This may be used as an interim assessment of the City's effort to achieve 40% tree canopy cover by 2037.

The *Baltimore City Land Cover Classification* can be viewed using a simple online map viewer (http://arcg.is/1FdbibW) and will be made available for download (Figures 2 and 3).

This land cover data can be combined with other local and regional datasets to better prioritize areas for conservation. For example, the Conservancy has created a map that highlights tree canopy within protected and unprotected areas and their relation to the *Green Infrastructure Assessment*, a dataset of critical hubs and corridors produced by the Maryland Department of Natural Resources, a member of the GBWC steering committee (Figure 4). These areas of unprotected tree canopy represent opportunities for conservation that would strengthen the existing green infrastructure network and enhance habitat connectivity throughout the City—goals that are central to the mission of the GBWC.

Restore

The restoration of Masonville Cove from a dumping site to the nation's first Urban Wildlife Refuge Partnership united the efforts of a diversity of partners and led to the creation of the GBWC. Following this example, restoring some of the City's approximately 17,000 vacant lots provides GBWC partners with the opportunity to maintain this momentum and enhance Baltimore's network of green infrastructure.

Building on the efforts of the Baltimore City-led *Growing Green Initiative*, and working with the Baltimore Office of Sustainability, the Conservancy has developed the ***Vacant Lot Opportunities Analyst*** to guide potential green infrastructure projects on vacant lots (Figure 5). This simple geographic information system (GIS) tool assesses the City's vacant lots using site selection criteria presented in the Office of Sustainability's *Green Pattern Book*, a resource that outlines eight different redevelopment options, including urban farms, neighborhood parks, green parking, and more.

This tool makes assessing a particular lot, or finding lots that meet specific criteria, quick and easy. For example, planners interested in siting a neighborhood park with athletic fields can search for lots that are at least an acre in size, have minimal tree coverage, and have a low slope—all selection criteria provided by the *Green Pattern Book*. Advancing vacant lot redevelopment projects speaks directly to GBWC goals of increasing greenspace, making greenspaces accessible to all residents, and engaging communities in the natural world.

Links to the resources in the *Green Infrastructure Report*

Baltimore City Land Cover Classification

Web map viewer: http://arcg.is/1FdbibW

For original data: please email info@chesapeakeconservancy.org

Vacant Lot Opportunities Analyst

Tool and data: please email info@chesapeakeconservancy.org

Park Finder: Baltimore

Web application: http://chesapeakeconservancy.org/apps/ParkFinderBaltimore

Connect

GBWC members believe access to nature is a basic human need and an American right. With *Equity* as a core pillar of the initiative, partners are keenly interested in ensuring that underserved neighborhoods and communities have renewed connections to their local environment. Therefore, the Conservancy has created a series of maps to gauge accessibility to public open spaces in Baltimore, displaying areas that are within either a quarter, half, or three quarters of a mile walk to a public open space (Figure 6).

In order to determine which communities are most in need of new public open space, the Conservancy conducted an additional analysis based on a modified version of a methodology pioneered by the Trust for Public Land. Areas more than a quarter mile from a public open space were categorized into levels of need based on population density, median household income, and median age of residents (Figure 7). Areas categorized as "very high" need were those census blocks with high population density, low median household income,

and low median age. Creating and enhancing public access in these communities would improve the equity of access to nature and its benefits.

To encourage residents to be aware of and make use of their public open spaces, the Conservancy has developed an accompanying web application, *Park Finder: Baltimore* (Figure 8). Users can enter an address in a desktop web-browser or mobile device and the application will display public open spaces within a five-, 10-, or 15-minute walk (equivalent to a quarter, half, and three quarters of a mile walk) from that location. Each entry includes a direct link to Google Maps, pre-configured with walking directions from the provided location.

City residents and visitors may use this application to discover the public open spaces most accessible to them or to petition for additional greenspaces in their communities. *Park Finder: Baltimore* encourages the exploration of the region's rich natural and cultural resources, reinforcing the GBWC's pillar of *Discovery* and promoting stewardship of these resources.

Report Organization

This report begins with an introduction to the GBWC and a description of how the *Green Infrastructure Report* fits in with its ongoing activities. The next three sections discuss in greater detail the new resources developed for this project by the Chesapeake Conservancy: the ***Baltimore City Land Cover Classification***, the ***Vacant Lot Opportunities Analyst***, and ***Park Finder: Baltimore***. Each of these sections outlines how

critical datasets were collected and/or created, what insights were gained from the process, how the results will be delivered to the wider conservation community, and recommendations for future action. The last section concludes with an example of how these tools can be used in tandem to support science-driven and equitable conservation decisions-making.

Introduction

Greater Baltimore Wilderness Coalition

The Greater Baltimore Wilderness Coalition (GBWC) is a voluntary alliance of local, state, and federal agencies and independent organizations that support the vision of expanding a connected and protected green infrastructure network in populous central Maryland (Figure 1). The GBWC operates under the framework of four core pillars: *Resilience, Equity, Biodiversity,* and *Discovery* (outlined in Table 1).

This collaborative effort formally launched on June 1, 2015. At that time, Baltimore City's Mayor Stephanie Rawlings-Blake, U.S. Congressman John Sarbanes, and U.S. Congressman Dutch Ruppersberger endorsed the initiative. Together, partners will work to improve the integrity and accessibility of the region's greenspaces for all citizens. To learn more about this project visit: http://www.chesapeakeconservancy.org/baltimore-wilderness.

Table 1. In the pursuit of its vision, the GBWC works under the framework of four core pillars described below.

Resilience	The Coalition seeks to improve regional capacity to respond successfully to the impacts of climate change through green infrastructure investments.
Biodiversity	The Coalition supports new partnerships and initiatives to reconnect, restore, and protect habitat by enhancing the network of protected land and water resources.
Equity	The Coalition believes access to nature is a basic human need and strives to expand opportunities for an increasingly urbanized population to connect with nature.
Discovery	The Coalition believes a protected green infrastructure network provides the best classroom for a life of learning about and becoming stewards of our natural world.

Masonville Cove

The GBWC was catalyzed by the effort to designate Masonville Cove Environmental Education Center as the nation's first Urban Wildlife Refuge Partnership. Masonville Cove sits on the southern side of the Baltimore Harbor, on the Middle Branch of the Patapsco River. The adjacent communities are geographically isolated and challenged by income inequality, concentrated poverty, limited public transportation, high crime, and low high school graduation rates.

Today, Masonville Cove, which once was a dumping site for dredge material, boasts 70 acres of water and 54 acres of restored wetlands, nature trails, and a protected bird sanctuary. In 2013, Masonville Cove was officially designated as the U.S. Fish and Wildlife Service's first Urban Wildlife Refuge Partnership, an initiative striving to make the outdoors more meaningful and accessible to urban audiences. Masonville Cove continues to serve as a cornerstone of the GBWC initiative and an enduring case study for restoration and environmental education. To learn more about this project and the center's environmental programs, visit: http://www.masonvillecove.org.

Following the success of the Masonville Cove project and the official launch of the GBWC, the initiative embarked on a major project related to coastal resiliency. The *Coastal Resilience Project's* primary objective is to improve regional capacity to respond to the impacts of climate change by developing a vision for resiliency. Currently, the team is mapping existing green infrastructure that contributes to coastal storm resilience, prioritizing opportunities for enhancement, and evaluating governance mechanisms for managing and protecting a green infrastructure network. The project is ongoing and represents a major source of activity by the GBWC. To learn more about this project visit: http://www.conservationfund.org/projects/gbwc-coastal-resilience-project.

Figure 1. Greater Baltimore Wilderness boundary.

Green Infrastructure Report

The Chesapeake Conservancy has developed this *Green Infrastructure Report* to describe and promote three new resources available to the City of Baltimore and other GBWC partners that may be used to guide efforts to conserve existing greenspace, restore degraded lands, and connect citizens to the region's natural resources.

The first is the ***Baltimore City Land Cover Classification***, a high-resolution dataset that categorizes Baltimore's landscape into seven land cover types, including both vegetated spaces and impervious surfaces. The second is the ***Vacant Lot Opportunities Analyst***, a simple geographic information system (GIS) tool that allows users to search for and identify vacant lots that are suitable for certain green infrastructure projects. The third is ***Park Finder: Baltimore***, a web application for finding public open spaces within walking distance to a particular location within the City.

In addition to supporting the work of the GBWC, these resources can also assist City planners who are interested in tracking and achieving green infrastructure goals set out by the *Baltimore Sustainability Plan*. In particular, the City seeks to double Baltimore's tree canopy by 2037 to approximately 40% of the total land area and to
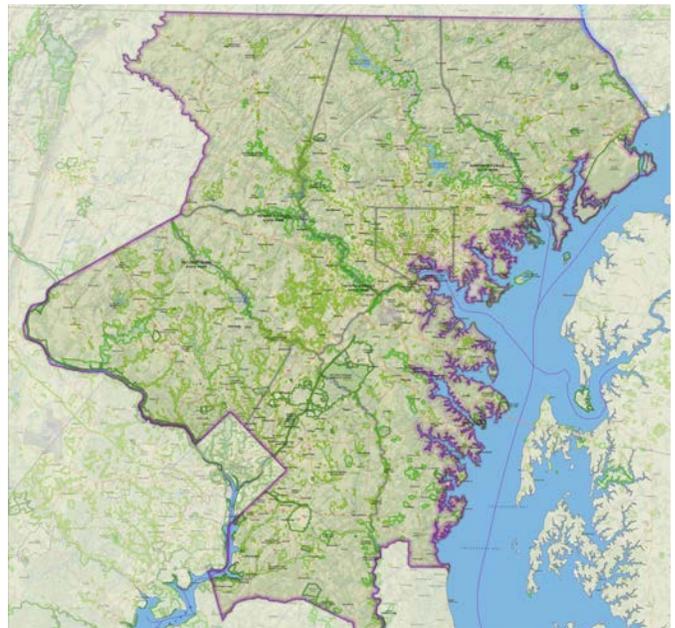
provide safe, well-maintained public recreational space within a quarter mile (five-minute walk) of every citizen. The ***Baltimore City Land Cover Classification*** estimates existing urban tree canopy cover to be approximately 28% of the total land area (excluding the Inner Harbor water area), while ***Park Finder: Baltimore*** identifies several areas lacking access to public open spaces within a quarter mile walking distance. This information is critical to understanding where efforts to enhance greenspace have been successful and which areas still require attention.

The following sections will describe these three resources in greater detail, explaining how critical datasets were collected and/or created, what insights were gained from the process, how the results will be delivered to the wider conservation community, and recommendations for future actions.

What is green infrastructure?

Green infrastructure refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water.

(As defined by the U.S. EPA)

Conserve

In order to understand the Baltimore landscape and identify opportunities to protect ecologically valuable lands, the Chesapeake Conservancy has created the ***Baltimore City Land Cover Classification*** (Figure 2). This is a high-resolution dataset that categorizes Baltimore's landscape into seven land cover types, such as forest and impervious surface. Both the GBWC and the City seek to conserve and restore green infrastructure, and this dataset may be used to set goals and track progress in this effort.
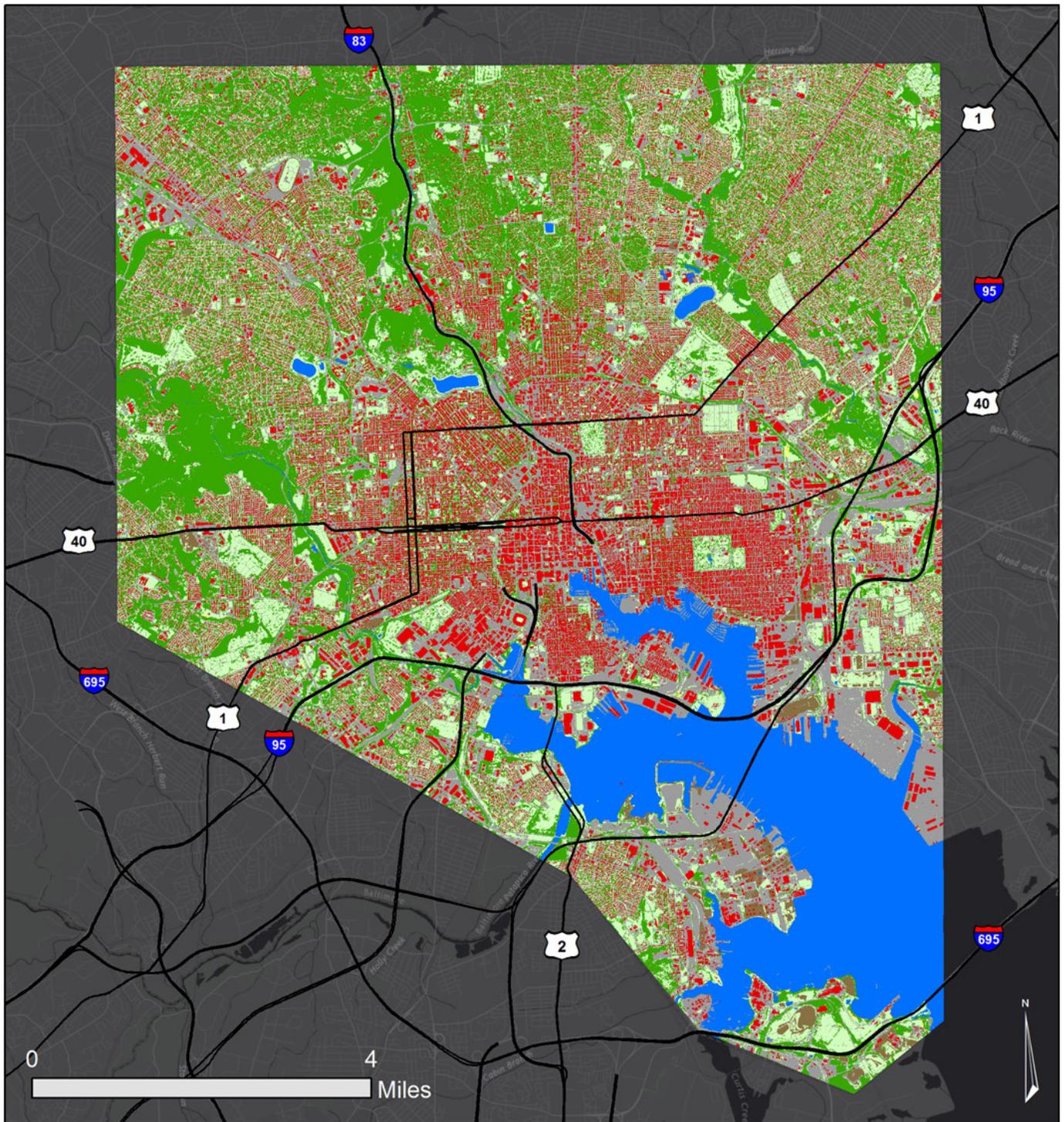
The ***Baltimore City Land Cover Classification*** dataset is particularly pertinent to the execution of the *Baltimore Sustainability Plan*, which outlines 29 goals, organized into seven themes, for creating a more resilient Baltimore that is responsive to both economic and natural risks. One of these themes, "Greening," is focused on preserving natural spaces and promoting community well-being through urban agriculture and increased access to outdoor recreation areas. This is also consistent with the GBWC's framework for achieving their vision.

One of the *Plan*'s goals is to double the City's tree canopy by 2037 to approximately 40% of total land area. In order to track the success of this objective, the City publishes annual estimates of net gains and losses of the number of trees in Baltimore. These numbers are based on tree counts from several different agencies and non-governmental organizations, including some GBWC members. However, tree counts can be costly, time consuming, and site-specific.

A more efficient and accurate method for estimating tree canopy cover is to use computer-based remote sensing techniques that analyze aerial imagery of the City landscape. The last comprehensive remote sensing estimate of tree canopy cover in Baltimore was based on aerial imagery from 2007 and published by the Maryland Department of Natural Resources (MD DNR). That study estimated that approximately 27% of Baltimore City's land area was covered by tree canopy.

The new ***Baltimore City Land Cover Classification*** allows for an updated estimate of urban tree canopy cover. The classification is based on aerial imagery from 2013 and effectively distinguishes seven different land cover types (Table 2) at a one-meter pixel resolution, providing a highly accurate snapshot of the City's tree canopy cover.

The ***Baltimore City Land Cover Classification*** also provides a core dataset for many types of advanced analysis, including habitat connectivity assessments and stormwater models. This is a significant upgrade from other freely available datasets, such as the conventionally used 30-meter National Land Cover Dataset (NLCD). The ***Baltimore City Land Cover Classification*** is part of a larger effort by the Conservancy to generate high-resolution land cover data throughout the Chesapeake Bay watershed. This new data will replace the NLCD in the Chesapeake Bay Program's upcoming "Phase 6" suite of water quality models.

Figure 2. *Baltimore City Land Cover Classification*. This map displays the land cover classification for the City of Baltimore using seven classes. Both land and water areas are considered, including the Inner Harbor region. The classification was produced using 2013 aerial imagery and 2008 LiDAR-derived elevation data.

Land Cover Type	Acres (58,813)	% of Total		Land Cover Type	Acres (58,813)	% of Total
Forest	14,692	25%	Structures	8,860	15%
Shrub/Scrub	35	<1%	Impervious	16,052	27%
Low Vegetation	11,545	20%	Water	6,902	12%
Barren	727	1%	Major Roads		

Data and Methods

The **Baltimore City Land Cover Classification** was completed using two primary datasets: (1) aerial imagery obtained from the National Agriculture Imagery Program (NAIP) in 2013; and (2) laser-derived elevation data (LiDAR), produced in 2008. NAIP imagery is obtained for the entire United States every two to three years during the agricultural growing season. These images, which are taken from low-flying airplanes, have a one-meter pixel resolution and are composed of four wavelengths of light (green, blue, red, and near-infrared). LiDAR data is also collected via aircraft, using a quick series of laser bursts to accurately determine elevation information, such as ground level, tree canopy area, and building heights. Such information is useful in differentiating landscape features, such as roads from buildings, and forests from fields.

The analysis used a "rule-based" classification technique and was completed using a combination of Exelis ENVI and ESRI ArcMap software packages. For each land cover class, a series of user-defined rules were created to determine whether an area qualified as a particular type of land cover. For example, a forest class rule might include qualities such as a height of at least three meters and a higher than average near infrared light reflectance. After processing, Conservancy staff completed a manual quality control process, correcting the vast majority of misclassified areas.

Land Cover Type

■ Forest	■ Structures		
■ Scrub/Shrub	■ Impervious		
■ Low Vegetation	■ Water		
■ Barren			

Figure 3c/3d. 1:15,000   Figure 3a/3b. 1:7,500
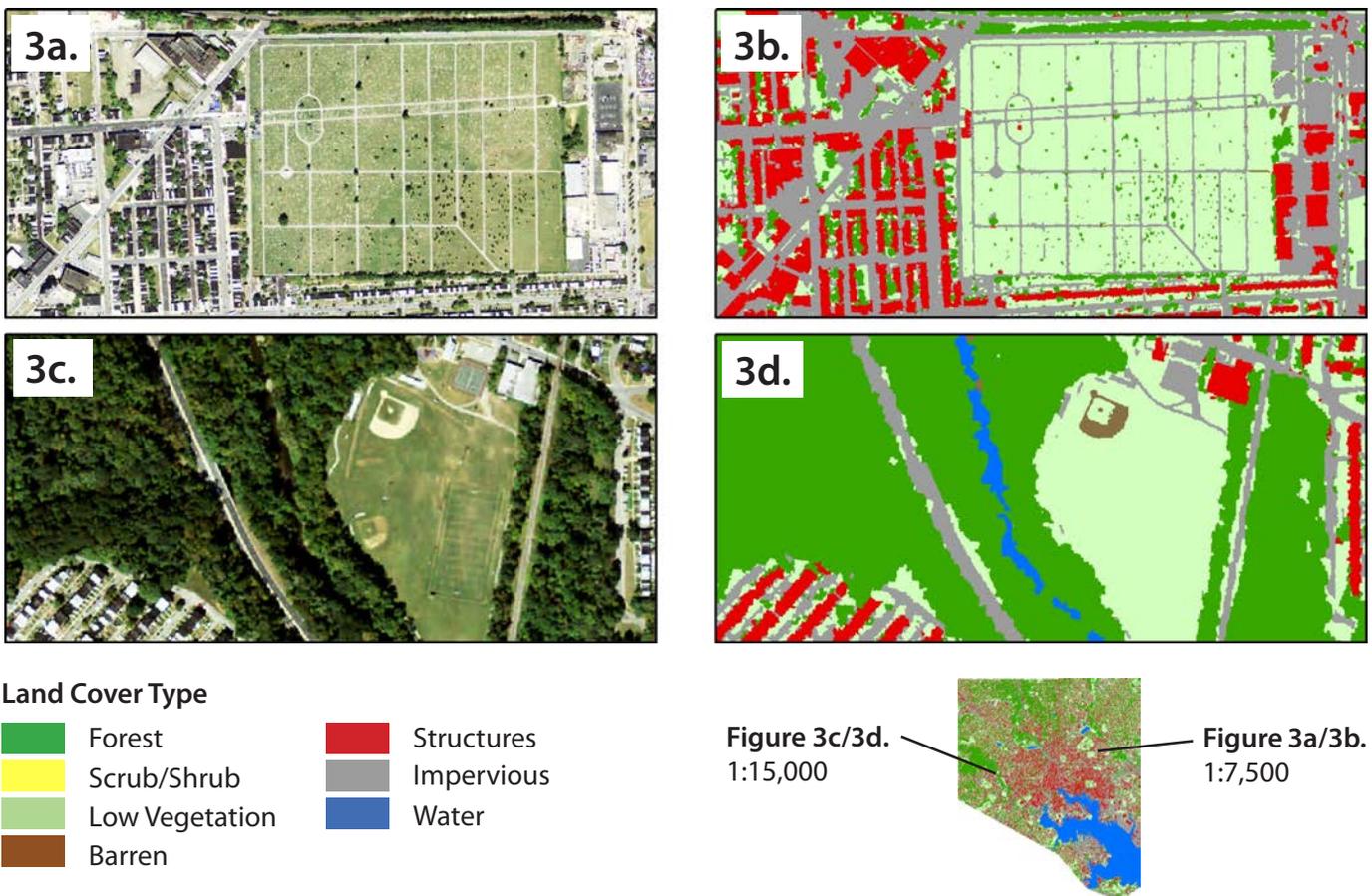
Figure 3. Comparison of aerial imagery and land cover classification at various scales. Figures 3a and 3c display aerial imagery from two different locations in the City of Baltimore. By comparison, figures 3b and 3d display the derived land cover classification of the same areas. Figure 3b highlights the ability of the analysis to distinguish single trees in a dense urban environment. However, shadow coverage created some difficulty distinguishing the underlying land cover type in some areas, as shown by the fragmented stream in figure 3d.

Results

The ***Baltimore City Land Cover Classification*** estimates that just under half of Baltimore's landscape is covered by some type of green space: 25% forest; 20% low vegetation; and <1% shrub/scrub (Figure 2). In contrast, 42% of the landscape is covered by some type of developed space: 27% impervious surface; and 15% structures. Water covers most of the remaining area, at 12%. Approximately 1% of the City landscape is covered by bare ground. A comparison of the land cover map and the aerial imagery used to derive the classes highlights the level of precision associated with using one-meter imagery (Figure 3).

When estimating urban tree canopy cover, it is useful to consider only the land area that could possibly be forested. In Baltimore, this means excluding the Inner Harbor water region. After this major water body has been eliminated from the analysis, the Conservancy's classification estimates the City's tree canopy cover to be 28.3%. This estimate is slightly higher than the figure published by a collaboration of partners under the Baltimore Ecosystem Study (based on imagery from 2007), which estimated the City's tree canopy to be 27.4% of total land area.

This does not necessarily mean that the amount of tree canopy has increased by 0.9%. Inconsistencies in the aerial imagery, including shadow cove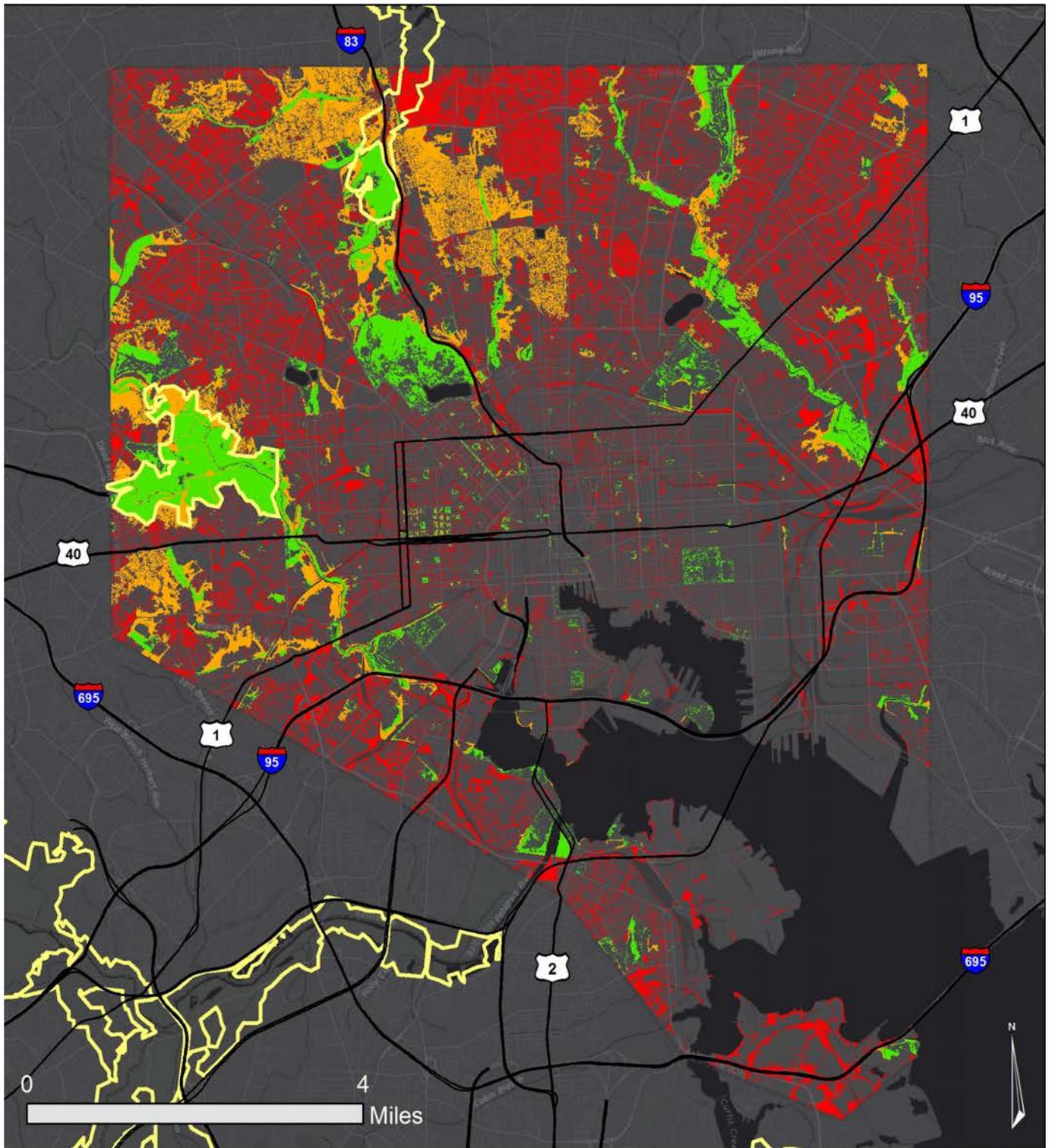rage, contribute to some margin of error. However, this analysis does provide a useful estimation of tree canopy coverage across the City and an indication of which areas have gained or lost tree canopy when compared with classifications from years past.

The classification also serves as a basis for secondary analysis. For example, areas of tree canopy cover can be extracted from the larger classification and separated into three categories: (1) within an existing protected area (e.g. a park); (2) adjacent to tree canopy within an existing protected areas (within five meters); and (3) not adjacent to tree canopy within an existing protected area (Figure 4). Overlaid with ecologically significant hubs and corridors identified by the Maryland *Green Infrastructure Assessment*, tree canopy that is adjacent to forested areas within existing protected areas can be prioritized for conservation based on how well they fill gaps and enhance ecological connectivity.

Such information could be useful to GBWC partners who are interested in opportunities for infiltration of stormwater runoff, the presence of forested corridors for wildlife habitat, or a network of connected walking or biking trails. This is merely one example of how this new land cover dataset may be combined with other regional and local datasets to prioritize and inform action.

Table 2. Description of land cover classes used in the ***Baltimore City Land Cover Classification***.

Land Cover Class	Examples	Acres (58,813)	% of Total
Water	Streams, bays, ponds	6,902	12%
Forest	Tree canopy, single trees	14,692	25%
Shrub/Scrub	Tall grass, large bushes	35	< 1%
Low Vegetation	Short grass, small bushes	11,545	20%
Barren	Soil, dirt, sand	727	1%
Structures	Buildings, cell towers, transmission lines	8,860	15%
Impervious	Roads, sidewalks, parking lots, asphalt, concrete	16,052	27%

Figure 4. Protected and unprotected tree canopy cover. This map displays both protected and unprotected tree canopy cover in the City of Baltimore. Protected tree canopy cover is displayed in green. Unprotected tree canopy cover is separated into two categories: (1) contiguous forest patches that are adjacent to existing protected tree canopy (within 5 meters) in orange; and (2) forest patches not adjacent to protected tree canopy (red). Hubs and corridors defined by the Maryland *Green Infrastructure Assessment* are shown in pink.

Legend:
- Tree canopy within existing protected area (e.g. park)
- Unprotected tree canopy: adjacent to existing protected tree canopy
- Unprotected tree canopy: not adjacent to existing protected tree canopy
- Hubs and corridors (MD *Green Infrastructure Assessment*)
- Major roads

Delivery

Individuals interested in viewing the ***Baltimore City Land Cover Classification*** can access this information using a simple online map viewer (http://arcg.is/1FdbibW). In addition to being able to review the overall classification map, users can toggle through other layers that highlight subsets of the data, such as tree canopy cover.

Ultimately, the web application will be upgraded to include download features so that users can select a subset of data for use in their own analysis and custom applications. An example of an existing web page which accomplishes a similar goal is the USGS National Map Viewer, which allows site visitors to download datasets from a designated area of interest (http://viewer.nationalmap.gov).

Recommendations and Next Steps

The ***Baltimore City Land Cover Classification*** should be used to inform GBWC activities, including the ongoing *Coastal Resiliency Project* that is cataloging green infrastructure. In addition, it can serve as an interim assessment for the City's goal of doubling the urban tree canopy cover by 2037. The efficient and cost-effective technique developed by the Conservancy to create this new dataset can also be replicated in the future as new aerial imagery of the greater Baltimore area is produced, allowing the City to track progress on a regular basis.

In addition, a more comprehensive prioritization analysis could be completed with the help of GBWC members and other partners, such as identifying areas of tree canopy cover that are critical to supporting wildlife habitat. For instance, these datasets could be combined with existing data on biodiversity, such as the i-Tree tools produced by the U.S. Forest Service, extensive ecological datasets and models created as part of the long-term *Baltimore Ecosystem Study*, and citizen science collected at Masonville Cove's *BioBlitz*, to help identify areas of high biodiversity that are in need of further study and protection. The time and data requirements for this type of analysis are beyond the scope of this project. However, this type of analysis could be a first task for the GBWC *Biodiversity* working group to help establish a baseline and set priorities.

Ridgely's Cove, former industrial location currently under consideration for restoration (Photo by Chesapeake Conservancy).

Restore

In 2014, Baltimore City Mayor Stephanie Rawlings-Blake launched the *Growing Green Initiative*, an effort to encourage redevelopment of vacant lots into an integrated network of greenspaces. As a part of this initiative, the City produced the *Green Pattern Book*, a resource that helps individuals and organizations understand how they might transform these vacant lots into community assets. The guidebook presents eight different "green patterns" for communities to consider, including urban farms, neighborhood parks, green parking, and more (Table 4). For all eight patterns, the *Green Pattern Book* provides site selection criteria to guide restoration efforts.

Working with the Baltimore Office of Sustainability, the Chesapeake Conservancy has developed the *Vacant Lot Opportunities Analyst* to support this initiative. This simple GIS tool allows users to search for and identify vacant lots that are appropriate for a particular redevelopment type (Figure 5). The tool is driven by the site selection criteria provided by the *Green Pattern Book*, which have been translated from narrative descriptions into quantifiable and "mappable" terms.

Using the *Vacant Lot Opportunities Analyst*, users can quickly sort through approximately 17,000 vacant lots located within the City and understand which lots are best suited for which projects. For example, planners interested in siting a neighborhood park with athletic fields can search for lots that are at least an acre in size, have minimal tree coverage, and have a low slope—all selection criteria originally provided by the *Green Pattern Book*.

Redevelopment of vacant lots into useable greenspace is also directly in line with the goals of the GBWC, which seeks to provide underserved communities with a more equitable share of the City's natural resources. Depending on the location and pattern of a vacant lot, a redevelopment project may also provide urban wildlife habitat and increased resiliency to flooding.
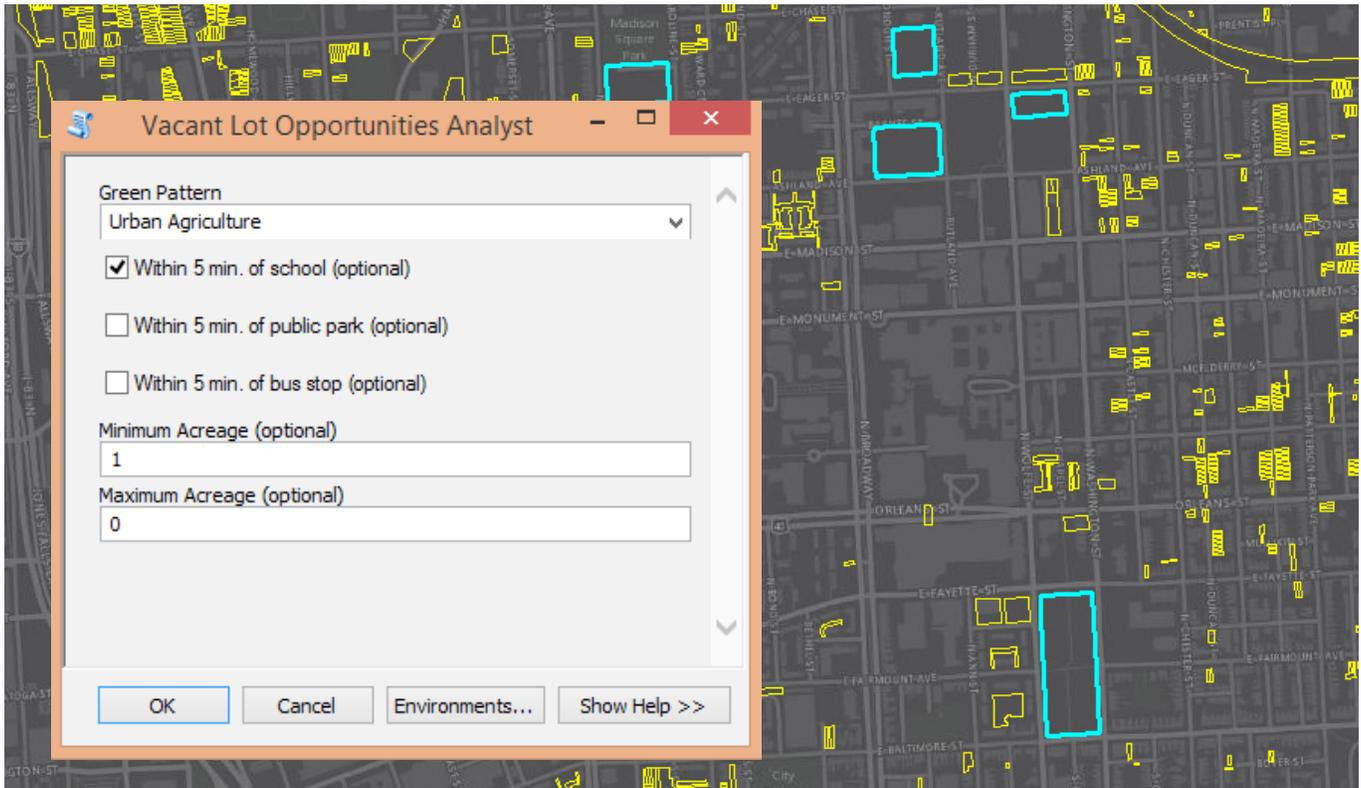
Figure 5. Screenshot of *Vacant Lot Opportunities Analyst*. This is a simple GIS tool developed to help prioritize vacant lots for redevelopment into eight different green infrastructure projects. The project types and suitability criteria were based on the City's *Green Pattern Book*, a resource that provides information and inspiration for individuals and groups looking to redevelop vacant lots in their community.

Data and Methods

The first step to developing the query tool was interpreting and translating the site selection criteria provided by the *Green Pattern Book*. Some criteria were explicit: "Sites for urban agriculture should be a minimum ½ acre lot." Other criteria were less clear: "Minimal slope of existing tree cover." In the latter case, reasonable values were assigned based on literature review, data availability, and team discussion.

To create one searchable layer of vacant lots, the original vacant lot layer (last updated in March 2014) was overlaid with several other datasets in ESRI ArcMap to extract their values (Table 3). Accessibility to schools, parks, and bus stops was determined using a network analysis that defined areas within a five-minute (quarter of a mile) walk to these places. The details of this methodology are described in the *Connect* section of this report. Proximity to roads, streams, and particular land

cover types was determined using a 20-meter buffer. See Table 4 for the criteria used in the final analysis.

In the *Vacant Lot Opportunities Analyst*, users are asked to select the following criteria for their search: a redevelopment type ("green pattern"); whether or not they would like the lot to be within a five-minute walk of a school, park, or bus stop; and a minimum and maximum acreage for the lot. For example, in Figure 5, the user is searching for vacant lots that are suitable for urban agriculture, are near schools, and are at least one acre in size. After clicking the "OK" button, the *Vacant Lot Opportunities Analyst* highlights those parcels that match the user's specified criteria. Given no minimum or maximum acreage, a standard query of each project type will return the most suitable vacant lots from all 17,000 in the City.

Results

Based on the results of the *Vacant Lot Opportunities Analyst*, the managers can gain insight into redevelopment potential across the City. According to this analysis, of over 17,000 vacant lots, 13,137 and 6,859 are suitable for the "Clean and Green" and "Community Managed Open Space" project types, respectively (Table 4). Project types with more stringent requirements, such as "Urban Agriculture" and "Green Parking," returned far fewer opportunities. It is also important to note that some lots are suitable for several redevelopment types.

The results of the *Vacant Lot Opportunities Analyst* should not be interpreted as meaning that the highlighted parcels are the *only* vacant lots suitable for a particular project type. Instead, the highlighted parcels are simply the *most* suitable vacant lots according to criteria described in the *Green Pattern Book*.

After a query is run, the user can use additional ArcGIS tools and datasets to learn more about a project opportunity. For example, zoning for a particular vacant lot could be explored through tax parcel layers. Or, tree canopy layer described previously may be used to determine if planting trees in a vacant lot would add to a nearby forested corridor. Exploring additional datasets will help the user assess the feasibility of a project and plan the next steps in the redevelopment process, such as applying for permits, conducting soil surveys, and determining water availability.

Of course, geospatial analysis is not a replacement for on-the-ground information. Therefore, once lots are identified through this tool, those interested in redeveloping the lot should complete a site visit to assess final feasibility.

Table 3. Data sources for vacant lot query tool (hyperlinks included where available).

Source	Datasets Obtained
Open Baltimore	Parcels, vacant lots, roads
Baltimore City View	Schools, bus stops
Maryland iMAP	Slope
Baltimore City Department of Planning	Parks
U.S. Geologic Survey	Streams
Chesapeake Conservancy	Land cover

Table 4. Vacant lot analysis based on Baltimore City's *Green Pattern Book*. This table displays the number of Baltimore's vacant lots determined to be suitable for various redevelopment projects according to the ***Vacant Lot Opportunities Analyst*** tool developed by the Chesapeake Conservancy. The tool uses criteria translated from Baltimore City's *Green Pattern Book*, a resource that provides information and inspiration for individuals and groups looking to redevelop vacant lots in their community. For more information about the book, visit www.baltimoresustainability.org/growinggreen.

Green Pattern *Criteria*	Number of suitable lots (17,085 total)	Near Schools (Within 5-min. walk)	Near Parks (Within 5-min. walk)	Near Bus Stops (Within 5-min. walk)
Clean and Green *Visible from non-alley road* *Near community ammenity (within 5-min. walk of school, park, or bus stop)*	13,137	7,352	9,978	9,147
Community Managed Open Space *Less than 5% slope*	6,859	3,339	4,362	4,196
Urban Agriculture *Greater than 0.5 acres* *Less than 7.5% slope* *Less than 25% tree cover*	229	71	115	96
Stormwater Management *Greater than 0.125 acres* *Greater than 25% impervious surface surrounding the lot*	1,497	539	842	847
Green Parking *Less than 5% slope* *Less than 25% tree cover* *Greater than 25% impervious surface*	99	58	58	63
Urban Forests and Buffers *Greater than 5% slope* *Greater than 0.25 acres* *Greater than 25% forest cover surrounding the lot* *Within 20 meters of a stream*	266	72	202	79
Neighborhood Parks (with athletic field) *Less than 5% slope* *Less than 50% tree cover* *Greater than 0.125 acres*	921	311	431	460

Mix of occupied and abandoned rowhouses in Baltimore's Oliver Neighborhood (Photo by L.F. Chambers).

Delivery

The *Vacant Lot Opportunities Analyst* is for internal use by the City of Baltimore's Office of Sustainability. At this time, neither the vacant lot data layer nor the query tool is publically available.

Recommendations and Next Steps

This *Vacant Lot Opportunities Analyst* will be used as a prototype that the City can use to develop into a more comprehensive tool. A team of stakeholders should be assembled to finalize and formalize site suitability criteria (which were interpreted internally at the Chesapeake Conservancy for this iteration of the tool) to ensure that the intents of the *Green Pattern Book* are accurately reflected. In particular, definitions for a "reasonable distance" from any given community amenity should be discussed and agreed upon. Alternatively, the *Vacant Lot Opportunities Analyst* could allow users to enter a distance they think is appropriate.

Additionally, the *Vacant Lot Opportunities Analyst* should be upgraded to analyze groups of connected vacant lots, which maybe be redeveloped together. A group of vacant lots could be suitable for certain redevelopment options that each lot would not be suitable for individually. This is relevant for green infrastructure projects with minimum acreage recommendations such as an urban agriculture site.

This analysis of the City's vacant lots provides insight into quality of life and quality of habitat throughout the many communities of Baltimore and can help inform decision making as the GBWC moves forward. These vacant lots present unique opportunities to revitalize community spaces in line with the four pillars of the GBWC: *Resilience, Biodiversity, Equity,* and *Discovery*. In the future, the *Vacant Lot Opportunities Analyst* may be made publically accessible so that local partners, schools, and communities may take on redevelopment projects for their own vacant lots.

In moving forward with redevelopment projects, it will be essential for partners to engage community members in the discussion to ensure that the implementation of these green patterns is supported and in line with the community's desires. The City is beginning to do this as part of a new project to study vacant lots in some of the City's most underserved communities. Earlier this year, the Baltimore Office of Sustainability was granted $200,000 from the U.S. Environmental Protection Agency to hold community meetings to select seven sites and to carry-out soil testing to identify the safest and most suitable reclamation use of vacant lots. There is a tremendous opportunity to incorporate the data created in this *Green Infrastructure Report* to provide evidence-based support for vacant lot analysis and site selection. This may also serve as a pilot for how vacant lot redevelopment projects may be carried out in the future.

Dr. Mamie Parker gives a presentation about careers in conservation to students at Ben Franklin High School at Masonville Cove, Baltimore (Photo by Devin Ray, USFWS).

Connect

The *Baltimore Sustainability Plan's* collection of "Greening" objectives, introduced in the *Conserve* section of this report, includes the explicit goal of providing safe and well-maintained public recreational space within a quarter mile (five-minutes walking distance) of all Baltimore residents. GBWC members, City managers, and community organizations are actively contributing to this goal by supporting the construction and maintenance of recreational spaces, as well as by raising awareness about the benefits of time spent outdoors. In particular, GBWC partners seek to ensure that traditionally underserved neighborhoods have equitable access to these resources.

Despite these efforts, there are still many communities in Baltimore that lack satisfactory access to greenspace. Five years after the initial release of the City's *Sustainability Plan*, a comprehensive inventory of existing and potential outdoor recreational spaces is only in the very early stages, according to the Office of Sustainability's 2014 *Annual Report*.

However, in the meantime, other tools can be used to assess how well Baltimore is meeting its need for public open spaces. The Trust for Public Land gave Baltimore a 50/100 using its ParkScore analysis (http://parkscore.tpl.org/city.php?city=Baltimore), reporting that 92,096 city residents do not have access to a public open space within a half mile. Meanwhile, studies demonstrate that access to nature benefits health, reduces crime, spurs investment, and improves local economies.

In an effort to expand this assessment to match the City's accessibility goal, the Chesapeake Conservancy has emulated a portion of The Trust for Public Land's ParkScore methodology to determine which areas of the City have access to a public open space within a quarter mile walking distance.

The Conservancy has also developed ***Park Finder: Baltimore***, an accompanying web application that educates and engages the public by enabling them to search for public open spaces that are within walking distance from a given location. Ideally, this application will be used by city residents and visitors to either access the public open spaces closest to them or to petition for more greenspace in their communities.
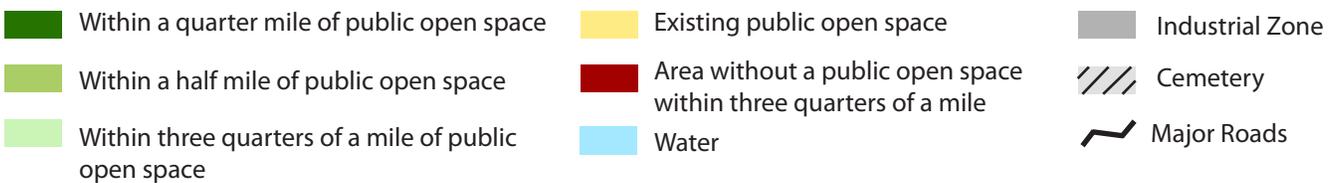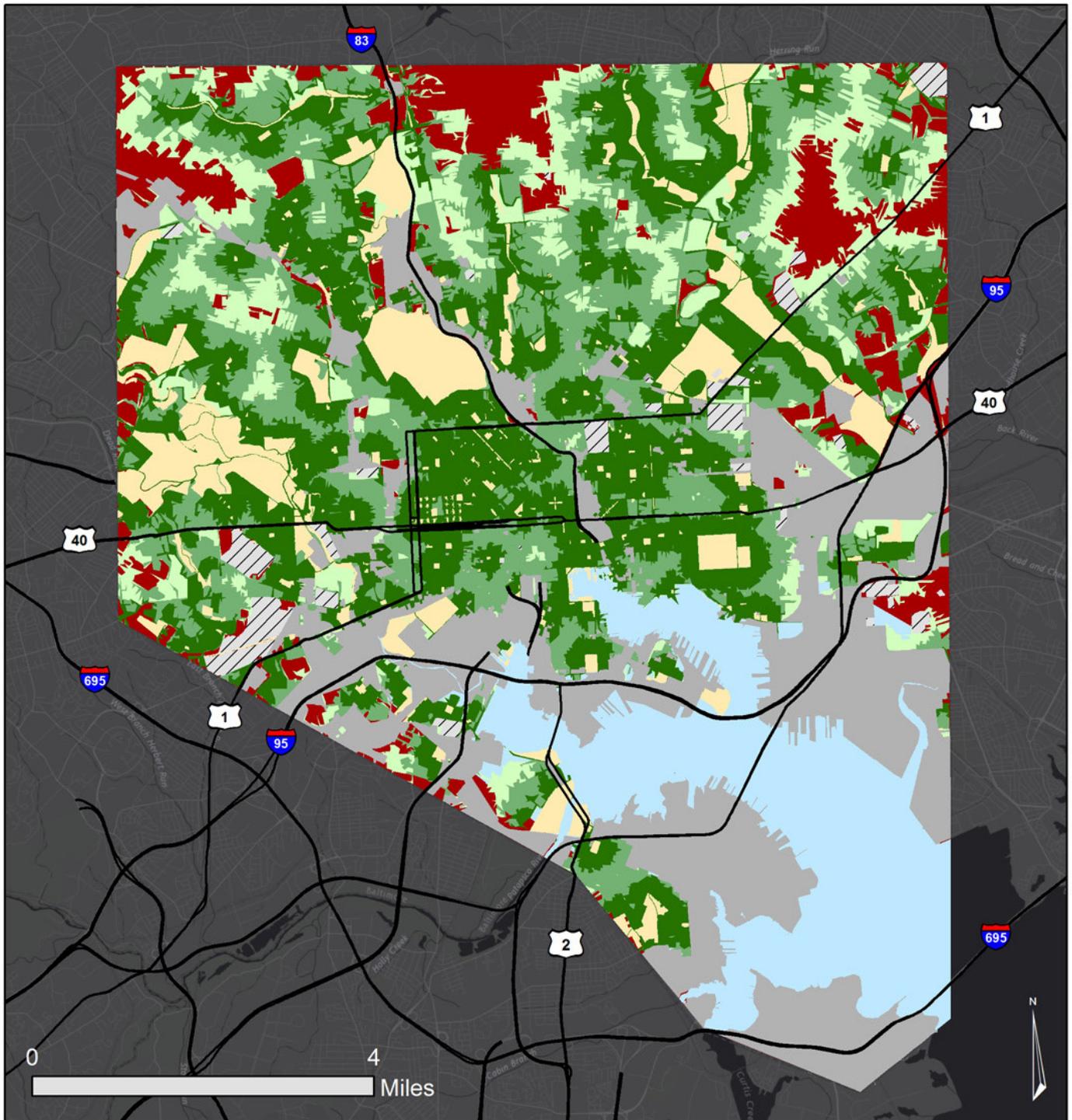
Figure 6. Walkability analysis of public open spaces in the City of Baltimore. This map displays areas in Baltimore City that are within a quarter, half, and three quarters of a mile walking distance (shades of green) to an existing public open space. It also displays those areas that do not have access to a public open space within three quarters mile (dark red). Access to public open spaces was determined using a network analysis in ESRI ArcGIS. Highways and limited access roads were excluded, assuming these areas to be inaccessible to pedestrians.

Data and Methods

Determining true walkable access to public open spaces requires a complex analysis that considers the common barriers that pedestrians face, such as highways and restricted access industrial zones. To accomplish this, Conservancy staff edited the Baltimore City street network dataset to remove roads that are inaccessible to common foot traffic, such as highways, on-ramps, tunnels, and restricted-access roads. In some cases, Google Maps Street View was used to determine the walkability of streets in areas where it was unclear if walking was possible.

Next, ArcGIS Desktop's "Network Analyst," an advanced modeling tool, was run for each public open space within the city limits. This tool takes a point, or a set of points, and calculates how far an individual could travel in any direction from that point using the network of roads. The result appears on the map as a starburst shape spreading away from the point of origin, and is called a service area. Three service areas were calculated for each public open space, representing either a quarter, half, or three quarters of a mile. The Conservancy used evenly spaced points around the park boundaries to represent park entrances because more accurate GPS point locations of park entrances were unavailable.

Although the Conservancy explored accessibility to public open spaces within a quarter, half, and three quarters of a mile, the City is particularly interested in prioritizing gaps in access within a quarter mile. Therefore, the Conservancy used parts of the Trust for Public Land's ParkScore methodology (which considers half mile service areas) to conduct a gap analysis of locations outside of the quarter mile service areas. Neighborhoods outside of quarter mile service areas were separated into census blocks and categorized as having one of three levels of need for public open spaces: "moderate," "high," and "very high." Areas categorized as "very high" need were those census blocks with high population density, low median household income, and low median age (Figure 7).

In order to turn this analysis into a tool for the public, the walkability map (Figure 6) was used as the basis for *Park Finder: Baltimore*. To make the distance-based service areas more meaningful to the average user, the application refers to the equivalent walking times: five, 10, and 15 minutes. The application was constructed with a combination of HTML/CSS and several Javascript libraries, including the ArcGIS API.

Results

In total, approximately 35,840 acres of Baltimore City's land area (excluding the Inner Harbor water area) lie outside a quarter mile walk of a park, approximately 22,400 acres lie outside a half mile walk, and approximately 14,720 acres lie outside a three quarters of a mile walk (Figure 6). However, citizens in these areas may still have access to privately-held open space made available to community members by schools or religious organizations, for example.

Mapping public open space within a quarter mile of each citizen provides insight into the City's goal of improving access outside of that area (Figure 7). This analysis revealed that most gaps in access occur outside of the city center. However, in terms of need, most of the access-deprived communities are located within, or closely surrounding, the city center in areas often characterized by higher population density, lower median income, and lower average age.
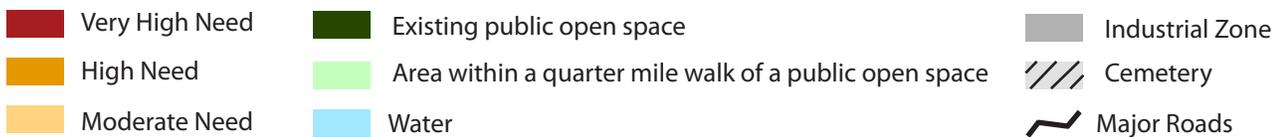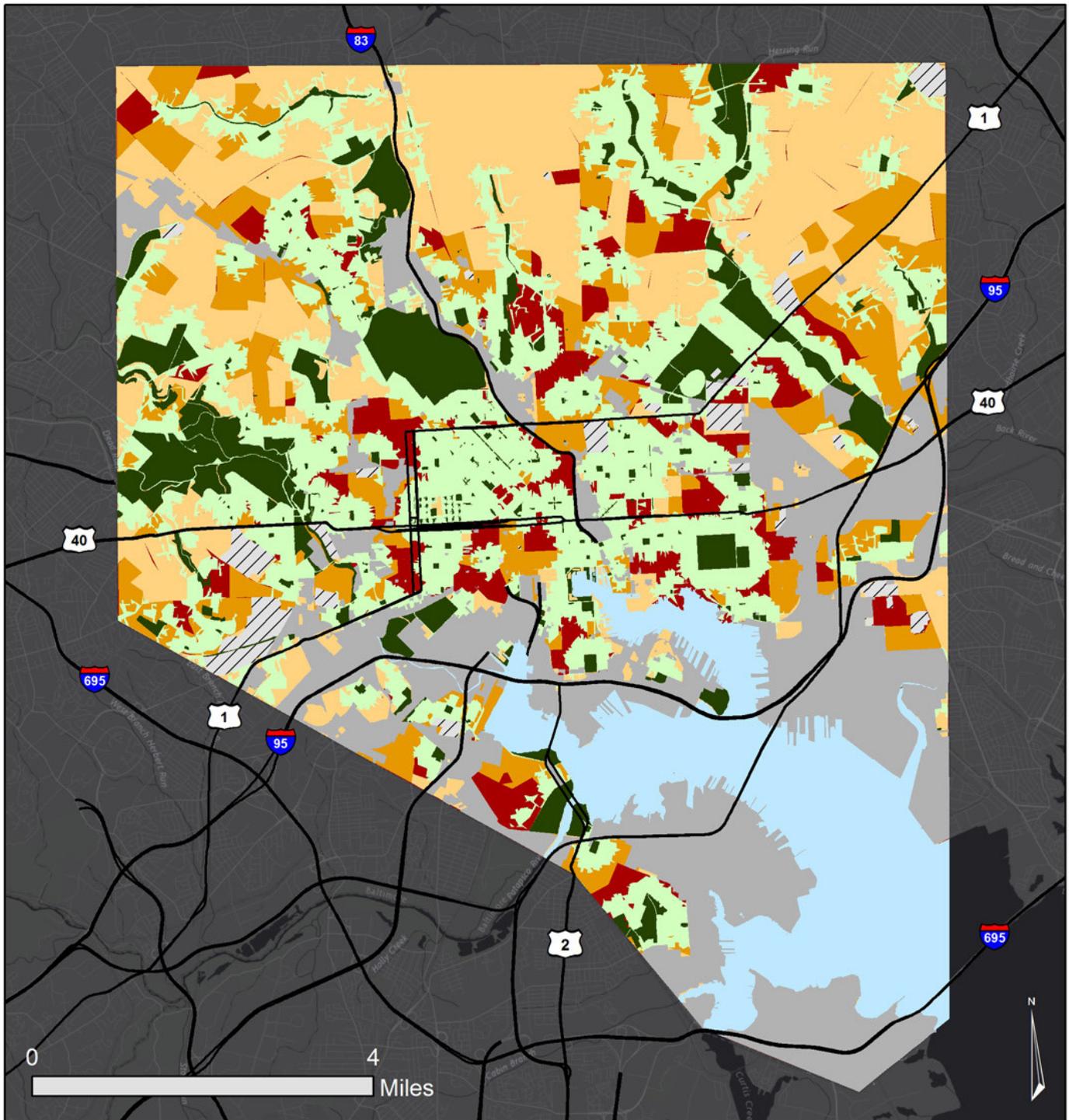
Figure 7. Prioritization of areas without a public open space within a quarter mile. This map displays areas in Baltimore City that lack access to a public open space within a quarter mile walk. The level of need is separated into three categories: 'moderate need' (light orange); 'high need' (dark orange); 'very high' (red). These categories are based on an index calculated using population density, median household income, and median age. Both the analysis and index are based on a modified version of a methodology pioneered by The Trust for Public Land called ParkScore, developed to measure how well U.S. cities are meeting the need for parks (parkscore.tpl.org).

Figure 8. *Park Finder: Baltimore* web application. This free application allows users to discover public open spaces that are within a five-, 10-, and 15-minute walk. These times are based on a walkability analysis completed using ArcGIS Network Analyst and are equivalent to a quarter, half, and three quarters of a mile walking distance.

Delivery

The Conservancy has made this information available to the public through the free *Park Finder: Baltimore* web application (http://chesapeakeconservancy.org/apps/ParkFinderBaltimore/). Users can enter an address in a desktop web-browser or their mobile device to display which public open spaces are within a five-, 10-, and 15-minute walk (Figure 8). These times are based on average walking speed and are equivalent to a quarter, half, and three quarters of a mile, respectively. Each park entry includes a direct link to Google Maps, pre-configured with walking directions to the public open space from the provided location.

On both desktop and mobile devices, the application can be accessed using a simple web browser and requires no extra plugins or extensions. This is in contrast to some existing park finder applications that force users to download and install a self-contained "app." In the mobile version of *Park Finder: Baltimore*, users are able to enter their current location as the starting point, making it highly functional on the go.

Druid Hill Park, Baltimore (Photo by Andrew Hazlett).

Recommendations and Next Steps

The walkability maps presented here provide information about which communities lack sufficient access to public open spaces in the City of Baltimore. They should be used to establish immediate and long-term goals based on which communities are most in need of access to greenspaces, as well as inform actions by GBWC partners. Additional analyses should be conducted to determine which locations provide the most optimal increase in accessibility.

Park Finder: Baltimore should be promoted as part of the GBWC initiative to City residents as a way to educate and engage them about public open spaces within their communities. The website will be improved based on user feedback and updated as new recreational areas are established. If available,

information about facilities and amenities should be incorporated for every park entry so that users may filter results to show only public open spaces that provide activities in which they are interested. To further engage the public, 'park reviews' could be added to the app, allowing users to comment on the accessibility, safety, and amenities of each open space.

Finally, as suggested by the *Baltimore Sustainability Plan*, a more rigorous inventory of existing outdoor spaces should be conducted; one that includes school grounds and accessible streams and wooded areas that may not be represented in the City's park dataset. Perhaps this could be an opportunity to work with GBWC partners and local schools.

Integrating the Tools

The integration of these three resources provides powerful information that can be used to focus limited resources to accomplish projects that are in line with the GBWC's four pillars (*Resilience, Biodiversity, Equity* and *Discovery*) and the City's *Sustainability Plan* goals. The following example highlights how the Conservancy's innovative new datasets and tools can be used to support and enhance collective work.

Ultimately, the opportunities identified through these datasets and analyses will be available to strengthen on-the-ground efforts across the region. In moving forward with projects, members of the communities should be engaged in the development and redevelopment of greenspaces. Local expertise should also be sought to help determine the feasibility of various redevelopment options in particular locations.

Figure 9. Belair-Edison neighborhood.

CASE EXAMPLE: THE BELAIR-EDISON NEIGHBORHOOD

The Belair-Edison neighborhood is located in northeast Baltimore (Figure 9). Through the Conservancy's walkability assessment, this neighborhood was identified as a community with areas that are in very high need of public open space within a quarter mile (Figure 10). While some residents are located close to Clifton Park or Herring Run Park, the southern and central parts of Belair-Edison have fewer public open spaces in which to recreate. In addition, the ***Baltimore City Land Cover Classification*** indicates that this neighborhood has only 35% green cover (forest, shrub/scrub, and low vegetation), well below the City neighborhood average of approximately 47% green land cover (Table 5).

Based on results from the ***Vacant Lot Opportunities Analyst***, there are 80 vacant lots in this community that may provide opportunities to address the need for public open space (Table 6). For example,
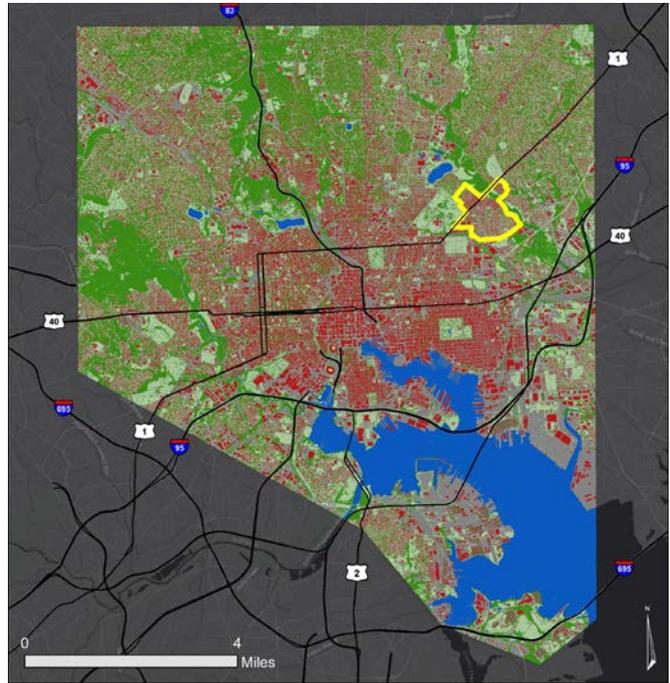
two vacant lots within this neighborhood meet the initial criteria for redevelopment into urban agriculture (less than 7.5% average slope and less than 25% tree cover) and one vacant lot meets the initial criteria for redevelopment into a neighborhood park with an athletic field (less than 5% slope, less than 50% tree cover, and greater than 0.125 acres). An urban farm or neighborhood park could potentially provide the community with a healthy greenspace that fosters a greater connection to nature among its residents.

One can imagine the wealth of possibilities in a place like Belair-Edison to create new greenspaces and engage community members in realizing their vision for their neighborhood. The Conservancy's tools can enhance existing neighborhood greening efforts being pursued by the City and community organizations.
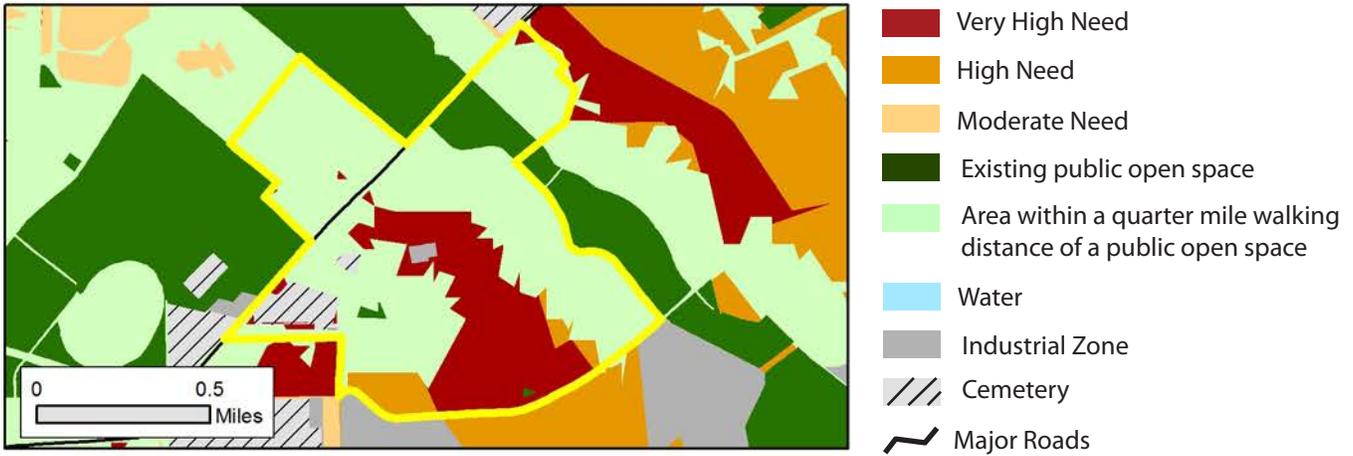
Figure 10. Walkability gap analysis of Belair-Edison neighborhood. Using a methodology described in the *Connect* section of this report, this map displays which areas are in most need of a public open space.
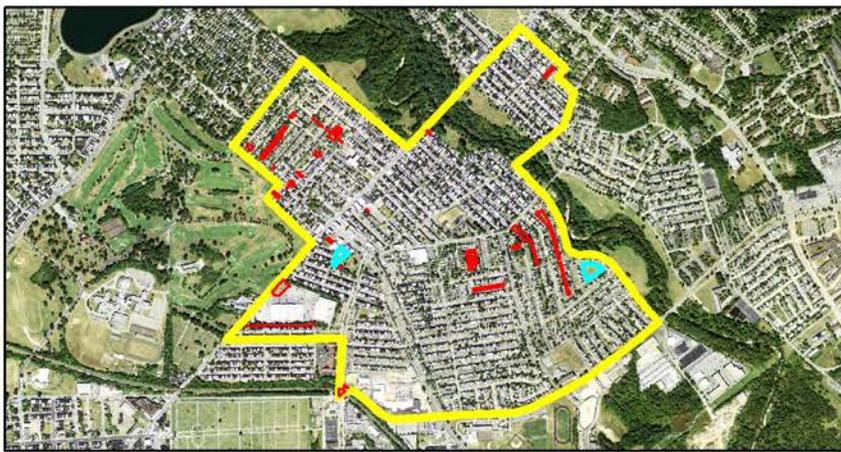

Figure 11. Land cover composition of Belair-Edison neighborhood.

Table 5. Land cover proportions of Belair-Edison neighborhood.

Land Cover Type		Belair-Edison	Avg. for all city neigh.*
	Forest	12%	26%
	Shrub/Scrub	0%	<1%
	Low Veg.	23%	21%
	Barren	<1%	<1%
	Structures	26%	21%
	Impervious	38%	31%
	Water	<1%	<1%

Not including Inner Harbor water area

Neighborhood boundary

Vacant lot

Vacant lot suitable for redevelopment into urban agriculture or neighborhood park with athletic field

Figure 12. Urban agriculture and neighborhood park opportunities on vacant lots in Belair-Edison neighborhood.

Table 6. Vacant lot analysis of Belair-Edison neighborhood based on Baltimore City's Green Pattern Book.

Green Pattern	Number of suitable lots (80 total)
Clean and Green	6
Community Managed Open Space	12
Urban Agriculture	2
Stormwater Management	10
Green Parking	0
Urban Forests and Buffers	0
Neighborhood Parks (with athletic field)	1

Inner Harbor, Baltimore (Photo by Flickr user m01229).

Conclusion

Each of the three resources described in this report is designed to aid the City of Baltimore and other GBWC partners in identifying and prioritizing conservation and restoration opportunities within the City. They can be used together or separately to better understand specific issues related to conservation, restoration, and connecting the public with their natural surroundings. The ***Baltimore City Land Cover Classification*** provides an updated snapshot of urban tree cover canopy and an indication of where gaps exist within the City's network of green infrastructure. The ***Vacant Lot Opportunities Analyst*** helps City managers determine which vacant lots are most suitable for the green infrastructure projects outlined by the *Green Pattern Book*. Finally, ***Park Finder: Baltimore*** provides citizens with the knowledge and opportunities to discover Baltimore's rich natural resources.

The Conservancy's innovative new tools will support the efforts of the GBWC as it works in Baltimore under the guidance of its four core pillars: *Resilience, Equity, Biodiversity*, and *Discovery*. Using the Conservancy's new tools in tandem illuminates potential communities to engage and projects to support. These tools should be used as a guide, from which partners follow-up with additional analyses, site visits, and community meetings before moving forward with a particular project. Together, the City, other GBWC partners, and City residents have the opportunity to create a greener Baltimore, benefiting communities, visitors, wildlife, and ecosystem services.

The Chesapeake Conservancy remains committed to incorporating innovative strategies into the conservation movement and ensuring access to resources that support collaborative and scientifically-driven decisions. The maps and tools presented here represent another step in that direction, encouraging effective and equitable conservation that contributes to healthier people and places within the Chesapeake Bay watershed.

Chesapeake Conservancy

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