City of Bowie
Memorandum

Thursday, February 29, 2024
Alfred D. Lott, ICMA-CM, CPM,
City Manager

STATUS REPORT

1. Sustainability Grants for Businesses

POM Studio Architects, located on Mitchellville Road, is the latest recipient of a Sustainability Grant for Businesses, as well as the newest member of the MD Green Registry and the Green Bowie Business Program. POM, under the leadership of Ms. Portia Strahan, took dedicated steps to enhance the insulation for the attic space, installed a fresh air ventilator, and sealed duct work as needed to obtain reimbursement. As part of the grant program, the City requires each business to be in good standing and to join the free MD Green Registry program. Once joining the registry, they are also a Green Bowie Business and are listed on our webpages and promoted on social media. POM's MD Green Registry profile is attached. The Sustainability Grants for Businesses will end at the end of FY24.

2. Partnering with Local Universities

In light of recent discussions brought forth by Councilmember Ndebumadu at the 2/20 Council meeting regarding partnering with local universities to obtain some degree of consulting services when applicable and to provide the students with experiential opportunities for learning, the Department of Planning and Sustainability wanted to share a recent project that addressed this objective.

In fall of 2023, a senior cohort of University of Maryland Environmental Science & Policy students partnered with the Sustainability Manager for their capstone research project. The project was a cost-benefit analysis and a draft policy for prioritizing ecological landscaping, namely through the use of native species, in our City landscape practices. This objective was given in the Council-approved Climate Action Plan Implementation Plan, City Government sector, Action 4 (Carbon Sequestration), Objective 5- Develop a Native Species Promotion Policy for Internal Use. The students completed their study, which is attached here, and presented it to members of Planning & Sustainability and Community Services. At the time, they were not able to present at a Council meeting.

If desired, the Sustainability Manager can further brief the Council on this project at a future meeting.

Maryland Green Registry MEMBER

The Maryland Green Registry promotes and recognizes sustainable practices at organizations of all types and sizes. Members agree to share at least five environmental practices and one measurable result while striving to continually improve their environmental performance.

POM Studio Architects

2905 Mitchellville,Rd Ste 205
Bowie MD 20716
202-297-7891
pomstudio.com
Architecture
Member since February 2024

Management and Leadership

☑ **Environmental Restoration and Community Environmental Projects**

POM Studio Architects participate in at least one community environmental project a year.

Waste

☑ **Solid Waste Reduction and Reuse**

During our office renovation, 600-700 pounds of material was reused including metal studs. We also repurposed used doors from other construction sites and a community reuse warehouse.

☑ **Recycling**

We recycle approximately 600 gallons of recyclable office and architectural material a year. We recycle paper, plastic, and aluminum from our office and take usable metal studs and other materials to a scrap metal recycle yard.

Energy

☑ **Energy Efficiency**

We have LED light fixtures throughout our space. Size of windows and placement *of doors allow natural daylight to penetrate deeper into the space to eliminate use of interior lights. Tankless instahot water heaters are underneath sinks and are super efficient.*

Transportation

☑ **Employee Commute/Customer Travel**

Our office is close enough to home to walk.

☑ **Efficient Fleet Vehicles**

Our office has one electric vehicle.

Carbon Crusaders

Ecological Landscaping for the City of Bowie

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ENSP 400: Capstone in Environmental Science and Policy
University of Maryland, College Park
Fall 2023

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Executive Summary

In alignment with its Climate Action Implementation Plan (CAP), the City of Bowie has undertaken an initiative to reach carbon sequestration goals through the increased usage of ecological landscaping. An expressed goal of the city is to reduce turfgrass usage in locations where the functional and recreational benefits of turfgrass are not required. To facilitate the attainment of this goal, this report provides policy recommendations to the City of Bowie that promote the use of sustainable landscaping practices and makes specific recommendations for converting public space turf areas to more sustainable landscapes. The report also contains a cost-benefit analysis for the proposed landscape conversions and provides an overview of a StoryMap that was created to summarize, in an easy-to-understand manner, the primary factors that influenced the recommended landscape conversions and how these sites should be managed.

Drawing inspiration from Portland's Climate Action Plan, it is recommended that the city emphasizes going beyond increasing tree canopy cover as a primary method for increasing carbon sequestration. Recommended policies for the city to implement are to amend the Bowie CAP to include robust green infrastructure targets, as well as draft a supporting document or manual that guides and incentivizes ecological landscaping initiatives throughout the city. The city should also consider the development of a Watershed Management Plan that would support ecological landscaping initiatives through the context of watershed health rather than solely carbon sequestration.

Five city parcels were identified for conversion with conversions being tailored to the unique characteristics and functions of the site along with the ability to optimize ecological benefits at the site. The cost-benefit analysis revealed that over an 8-year period, these conversions would prevent approximately 7,373 lbs. of $CO2$ per acre from being emitted. Meanwhile, saving the city a gross estimation of about $9,612 per 1 acre.

The StoryMap provides textual information along with spatial data, which will ensure a diverse audience can grasp the significance of this project.

This report not only helps the city reach its immediate CAP goals but also lays the groundwork for a resilient, eco-friendly future. By embracing recommendations set forth in the report, Bowie has the opportunity to be pioneers in sustainable urban development while contributing to regional and national efforts to combat climate change.

Introduction

Ecological landscaping, or sustainable landscaping, is the development and maintenance of landscapes that prioritize the ecology of a site with the aim to support and enhance local ecosystems (Ecopro, 2021). Currently, there are a large number of properties in the City of Bowie that primarily consist of turfgrass. Converting these landscapes into more ecologically sustainable alternatives can provide benefits to the local environment and to Bowie's citizens. Notably, it would aid the city in reaching the carbon sequestration goals outlined in its Climate Action Implementation Plan (CAP) and could potentially reduce the cost of maintaining landscapes within the city.

The City of Bowie currently lacks a comprehensive set of policies to guide landscape conversions and the management of landscapes within the city. Policy recommendations, when properly formulated, offer the opportunity to incentivize landscape conversions within the city as well as enforce the use of maintenance practices that will aid the city in reaching its carbon reduction goals. To inform the development of such policy recommendations, it would be beneficial to understand what other municipalities have done to foster landscape conversions that have aided in the attainment of their carbon reduction goals.

Landscape conversions offer the opportunity to not only increase carbon sequestration but to also mitigate the heat island effect, provide vital habitat for native species, and enhance overall biodiversity (Francoeur et al., 2021). Landscape conversions involving short growth plantings and increased canopy tree cover using native plants, for example, supports organismal biodiversity, elevates biomass leading to increased carbon sequestration and reduces runoff when compared to turfgrass (Ecopro, 2021). Landscapes where mowing is reduced or eliminated support canopy cover and plant root systems that stabilize soil, increase soil organic matter and retain nutrients, thus fostering healthier and more productive soils (Hanson et al., 2015). Landscapes that involve the integration of native trees, grasses, and pollinator plants support near continuous plant growth which is crucial for sustained carbon sequestration throughout the year. Such landscapes often operate as self-sufficient, resilient urban ecosystems.

The cost of implementing and maintaining landscape conversions will ultimately drive the pace at which conversions take place yet it is important to weigh the expected costs of conversions, and changes in maintenance, against the desired benefits. With such an analysis absent, it would be difficult to convey to city residents that landscape conversions are being done in a fiscally responsible manner and will have long term benefits to the residents.

Information that is presented in an aesthetically pleasing, concise way offers the opportunity to reach a broader audience than a formal report. One way this can be done is by summarizing the findings of this project in the form of a StoryMap. StoryMaps combine textual information with spatial data succinctly, so that is understandable and applicable to most audiences. Many agencies have begun utilizing StoryMaps as a method of delivering results of completed projects in an organized manner. This is because StoryMaps help teams plan and prioritize their most critical tasks and areas are an excellent way to walk a group or individual through the various steps of an analysis.

Objectives

1) To provide policy recommendations to the City of Bowie that will promote the use of sustainable eco-friendly landscape practices within the city.

2) To provide recommendations for converting specific public space turf areas within the city to more ecologically sustainable landscapes.

3) To conduct a cost-benefit analysis of the proposed landscape conversions that considers both the economic and environmental costs and benefits to the city.

4) To create a StoryMap that will summarize the primary factors that influenced recommended landscape conversions within the city and the recommendations for how these sites should be managed.

Methods

In order to obtain information that could be used to support recommendations that were provided to the city, a review of the literature was conducted. The University of Maryland online library was the main resource utilized for this review with key terms in the "ScienceDirect" database including "Ecological Landscape Conversion", "Carbon Sequestration" and "pollinator garden ecology" being used to guide the search. Key points and data of the outputs of the review were then organized in an outline compilation with citing the source. Research and analysis provided geospatial data, economic figures, and policy examples from other similar projects. Policy examples from areas that share similar environmental characteristics with Bowie were most beneficial for research. The city of Portland, Oregon was chosen as a key reference for the final policy recommendations taking into account differences between the two cities. Further literature was reviewed to determine the best management methods and techniques for land parcel conversions. This included research into environmental factors like the area size, soil makeup, soil health, native vegetation, or climate/weather conditions.

There are twenty-two parcels of land identified by the city for potential conversion. Five of these sites were selected to undergo suggested conversions (Sites 1, 11, 12, 18, 20) using the rationale that these areas would be among the easiest to provide enhanced beneficial functions to the city. In selecting factors to guide the conversion of land parcels, factors such as location, function of the space, and current land use were considered. Landscape conversion options for parks and around residential areas included short growth plantings and increased tree canopy cover to mitigate heat and sequester more carbon in residential areas. Pollinator gardens were an option for use where an improvement for wildlife habitat was deemed to be important or where an increase in aesthetic appeal of a site was deemed to be desirable. Buffer zones were considered for use near water bodies or to lessen the effects of anthropogenic impacts. Conversions that were driven by management practices focused on adoption of limited mowing were used in large open areas that were near tree lines, roads and areas receiving regular foot traffic.

The economic factors of different types of ecological conversions were considered in the cost-benefit analysis. This included calculating the cost of how the parcels are currently maintained through an interview with Rick Kellner, superintendent of the Parks and Grounds Division in Bowie (Appendix B). The cost of converting spaces took into account reductions in mowing, adding pollinator gardens and short growth plantings, and implementing buffer zones. The calculations for which are further described in Appendix C and D. The cost of converting areas to tree canopy cover was also considered in the analysis.

The StoryMap was constructed by organizing background information, best ecological landscaping practices for the areas of interest, proposed conversion recommendations, related works from other municipalities and the cost benefit analysis overview. The background information leads to best management practice options and the considerations that were used to make suggested conversions. Exploring further into the StoryMap leads to information about conversions that have taken place within other municipalities. The cost benefit analysis is placed before the conclusion to explain what monetary attributions are necessary to successfully plan and maintain these proposals. The StoryMap presents the factors hindering or enforcing the decision to convert an area, and spatial data in support of the recommendations.

Results

Policy Research

The City of Portland, Oregon, has a robust Climate Action Plan. The City of Bowie can adapt some of their strategies and apply them to its own strategies. The Bowie CAP emphasizes carbon sequestration but does not address ecological landscaping solutions beyond the expansion of the city's tree canopy. There are many other ecological landscaping strategies that could be employed, with multiple benefits potentially being derived. Increasing native biodiversity through native pollinator gardens or improving local water quality by incorporating riparian buffer zones to reduce nutrient pollution are two such examples. While carbon sequestration is a priority in the Bowie CAP, it only focuses on the expansion of the urban tree canopy as an action item.

Portland's CAP, which was created in 2015, outlines a specific strategy involving ecological landscaping initiatives. Their 2030 objectives focus on increasing green infrastructure, reducing impervious areas by 600 acres, and expanding the urban forest canopy to cover at least one-third of the city. Portland’s Parks and Recreation (PP&R) department, the Bureau of Environmental Services, and the Bureau of Planning and Sustainability lead some of these initiatives. Examples include Tree Programs and Tree Codes (Title 11, Trees), which include improvements adopted through the Citywide Tree Project. The Bureau of Development Services monitors tree canopy changes while encouraging native- and climate-resilient tree planting to help the city reach canopy targets. The city prioritizes financing these programs by evaluating and establishing innovative funding sources and financial strategies to maintain, sustain, and even expedite green infrastructure implementation and maintenance. Portland’s Bureau of

Planning and Sustainability has developed a Climate Emergency Work Plan that educates and encourages intersecting strategies and actions that sequester carbon in trees and sustainable green spaces (Bureau, 2022). An alternative example would be the Healthy Parks, Healthy Portland Ecologically Sustainable Landscaping Initiative (Portland, 2015). A report by Portland Parks and Recreation builds on established best management practices, identifies potential future landscapes, sets priorities for identifying enhancement areas, and suggests a process for working collaboratively. This report outlines two city-wide plans that address environmental concerns within different contexts and serve as guiding documents for their Sustainable Landscaping Initiative. One of these documents is the Portland Climate Action Plan. The other document is Portland's Watershed Management Plan, which outlines six strategies for a comprehensive approach to improving watershed health. This ordinance is broad and extends beyond the scope of Bowie's project, however it highlights revegetation and ecological landscaping as effective strategies. This document guides ecological landscaping initiatives by providing policy support within the context of watershed health as well as carbon sequestration (Portland, 2015). Portland Parks and Recreation go on to outline in this report their Nature Patches program. In this program, nature gardens are implemented in underutilized sections of developed parks, enhancing these areas with native plants, logs, boulders, and educational components. These patches function as sanctuaries for wildlife, specifically native pollinators, while offering opportunities for community engagement. Through community involvement and stewardship activities, the program seeks to improve soil and plant health, diversify park landscapes, and foster partnerships. Bowie can use Portland's experience to inform its own policies, emphasizing community engagement, inter-departmental collaboration, and innovative funding mechanisms for effective implementation. By adopting and customizing elements of Portland's approach, Bowie not only gains insights from a sustainability leader but also contributes to the broader national movement towards resilient urban landscapes.

Ecological Landscaping Practices & Possible Conversions

i. Pollinator Gardens

Pollinator gardens are one possible conversion strategy to lessen turfgrass use in Bowie. They are typically a mixture of native and non-native flowering plants designed to attract pollinators, which are helpful to plant and insect survival and aid in the growth and health of nearby plants (University of Maryland Extension, 2023b). To create a pollinator garden, there should be a variety of colors, shapes, heights, and flowering seasons present within the garden (University of Maryland Extension, 2023b). When deciding what plants to establish in a pollinator garden, using native plants is beneficial because, when placed in the right environment, they require less water, fertilizer and pesticides than traditional gardens and lawns (University of Maryland Extension, 2023b).

Native plants well suited for use in Maryland, include stiff leaf goldenrod (*Solidago rigida)*, Atlantic goldenrod (*Solidago arguta*), blue wood aster (*Symphyotrichum cordifolium*) or smooth aster *(Symphyotrichum laeve*), woodland sunflower (*Helianthus divaricatus*), and small woodland sunflower (*Helianthus microcephalus*) (National Wildlife Federation, n.d.).

Lawns can be transitioned to pollinator gardens without the use of herbicides. In such cases, a black tarp should be placed over the area where the garden is to be and remain there for at least four weeks, until all unwanted vegetation has been killed (University of Minnesota, n.d.b). When designing a pollinator garden, there should be several of the same species planted in groups of five or more to aid attracting pollinators to the site. Pest control, if needed, should be done in compliance with principles of integrated pest management. In most years, wildflower areas in Maryland will perform well without the need for irrigation (University of Minnesota, n.d.a). During the first 2-3 years, it is typical for a wildflower area to be mowed more than once a season (University of Minnesota, n.d.b). After this, mowing is then only performed at the end of the season. Reseeding may be necessary after the first year, and treatment may be needed for aggressive weeds or invasive species (Massachusetts Government, n.d.). Once established, pollinator gardens can serve as educational sites for the public to learn about the importance of native and pollinator plants and the need for ecologically favorable landscape designs. Signs and other educational materials explaining the importance of ecological landscaping are a feature of educational pollinator gardens.

ii. Limited Mowing

A no-mow management conversion strategy is designed to suppress weeds and turfgrass while transitioning an area into a meadow, while a limited mow area allows for turfgrass to stay as is with less mowing occurring (Beaver Watershed Alliance, n.d.). Limited mow areas help to increase biodiversity, improve stream health, reduce mowing costs, and create areas of elevated biomass. Higher biomass production can facilitate carbon sequestration since there is more organic matter that can store carbon (Beaver Watershed Alliance, n.d.). During the early transitional stages of establishing a no-mow zone, herbaceous weeds and invasive woody plants can become the dominant species at the site. If this happens, the area should be mowed every 2-3 weeks from spring to late summer until the woody invasive species are no longer a problem. To effectively eliminate problematic herbaceous weeds, rake them first, and then conduct a final mowing of the area to ensure the remaining weeds are eradicated (Prairie Nursery, n.d.). Once invasives and weeds are under control, native groundcovers such as wild ginger (*Asarum canadense*), alumroot (*Heuchera americana*), or green-and-gold (*Chrysogonum virginianum*) should be planted since these species do not grow tall and can exist with limited mowing practices (University of Maryland Extension, 2023a). Until these species are fully established, mulching and manual hand weeding may be necessary to prevent the reintroduction and encroachment of unwanted plant species (University of Maryland Extension, 2023a). At some point the introduction of native plant species in limited mow areas should become self-sustaining communities, requiring no inputs other than perhaps once or twice a year mowing and removal of the detritus. Based on Maryland's climate, planting of the aforementioned natives should occur between August 20th to October 20th for the most rapid rate of establishment of the desired landscape (Prairie Nursery, n.d.).

iii. Tree Canopy Cover

Tree canopy cover plays an integral role in sequestering carbon, mitigating the heat-island effect, and providing habitat for native pollinators. Generally, plants with large breast height or basal diameters have a high carbon sequestration efficiency. Temporal and spatial aspects of carbon sequestration are highly dependent on the plant species (Wang, 2021). Trees typically store about 97% of their carbon above ground while herbaceous vegetation stores less than 1% of their carbon in above-ground stocks (Ariluoma, 2023). Woody and herbaceous vegetation, particularly grasses, expend much energy, producing fine roots that are constantly being replaced, causing high levels of below-ground carbon storage, mainly in the form of soil organic matter. Picking suitable species for the location is critical as climate and surrounding vegetation ultimately determine if the desired plant species will survive when introduced to a site. Evergreen tree species have the highest mean carbon sequestration efficiency of all plant categories, followed by deciduous tree species. This is because evergreens have higher rates of photosynthesis and carbon sequestration efficiency in the winter than deciduous tree species.

While evergreens such as *Vitex lucens* have a lower photosynthetic capacity in the summer season, the rate in the winter seasons are more than tripled on average when compared to deciduous trees. Deciduous trees such as *Alectryon excelsus* have a much higher summer photosynthetic capacity than evergreens in the warmer seasons but halt photosynthesis in the winter due to the lack of leaves (Weissert et al., 2017). When planting trees for the purpose of carbon sequestration, they should be planted in rows spaced far enough apart to create open areas that are not shaded for the majority of the day (Ariluoma, 2023).

iv. Short Growth Planting

Short growth planting is the installation and care of plants that are between 1 and 10 feet in height. This landscape choice focuses on a blend of short growth plants such as herbs, shrubs, grasses, fragrant foliage, and other smaller plant organisms (Francoeur et al., 2021). Short growth planting in an urban setting benefits soil as it increases organic matter and boosts plant health. The use of short plants, particularly grasses that are infrequently mowed, in combination with practices such as irrigation and erosion control, has been shown to increase the average carbon sequestration by 7.7e-6 C·ac-1·yr-1 (Conant et al., 2001).

Short growth planting significantly reduces the heat island effect in suburban areas. When implemented near developed urban and suburban areas, short growth planting can help lower an area's temperature by roughly 5°C by absorbing shortwave radiation and decreasing localized albedo (Francoeur et al., 2021). Due to the height of the plants, short growth planting is ideal in places where visibility is important such as alongside roadways.

v. Buffer Zones

An ecological buffer serves as an area that lessens the shock of anthropogenic impacts on the surrounding environment. Vegetative buffer zones have a variety of benefits, including the capture of sediment and nutrients present in runoff. In a field monitoring study of watersheds in Japan and India, it was found that in streams with riparian buffer zones, nitrate levels were 43.7% less than that of the upland areas (Anbumozhi et al., 2005). Plant roots in vegetative buffer zones also prevent erosion by stabilizing the soil and reducing runoff flows (Zhou et al., 2008).

Implementing diverse native vegetation in buffer zones can positively impact biodiversity by aiding in maintaining nearby habitats and increasing insect populations, thereby attracting bird species (Tattari et al., 2003). Even narrow buffers have benefits. A thin strip of trees and shrubs, only a few meters wide near the water's edge, can establish important wildlife corridors (Owens, 2012). These corridors provide a habitat that offers food, water, and shelter for various species of birds, amphibians, reptiles, and small mammals. Buffer zones help to conserve wildlife, which is particularly important in the case of threatened or endangered species (Owens, 2012).

Buffer zones can be integrated into gardens. Garden buffer areas are portions of a garden or landscape designed to serve as a transitional zone between the garden and its surrounding environment. Maximizing the benefits of a garden buffer includes allowing appropriate spacing between garden and buffer zone plants (Owens, 2012). These techniques lower maintenance costs and increase the long-term survival of plants while providing water quality benefits. It is important to note that appropriate dense planting can also minimize weed encroachment and soil erosion losses. Below is a sample garden buffer that has the potential to work best in wetland or stream areas in Maryland.

Table 1: Possible plant species that can be incorporated into a garden buffer. Includes plant type as well as suggested total number or ratio of species. All plant species listed are native to Maryland. Adkins Arboretum & Critical Area Commission for the Chesapeake and Atlantic Coastal Bays "The Green Book Buffer".

Symbol	Common Name	Scientific Name	Size	Plant Type	Total Number	Credit
A	River Birch	*Betula nigra*	¾-inch caliper	Canopy tree	1	100
B	Sweetbay Magnolia	*Magnolia virginiana*	¾-inch caliper	Understory tree	2	150
C	Red Chokeberry	*Photinia pyrifolia*	3 feet	Large shrub	2	100
D	Sheep Laurel	*Kalmia angustifolia*	18 inches	Small shrub	3	75
E	Virginia Spiderwort	*Tradescantia virginiana*	1 quart	Herbaceous plant	6	12
F	New England Aster	*Symphyotrichum novae-angliae*	1 quart	Herbaceous plant	6	12
G	Helmet Flower	*Scutellaria integrifolia*	1 quart	Herbaceous plant	5	10
Actual Total Credit: 459 SF						
Notes: Passionflower *(Passiflora incarnate)* is a vine with lovely and unusual purple flowers that can be used as a spreading plant in place of some of the herbaceous plants. Blue-eyed grass *(Sisyrinchium angustifolium)* is another blue flowering alternative to the herbaceous plants.						

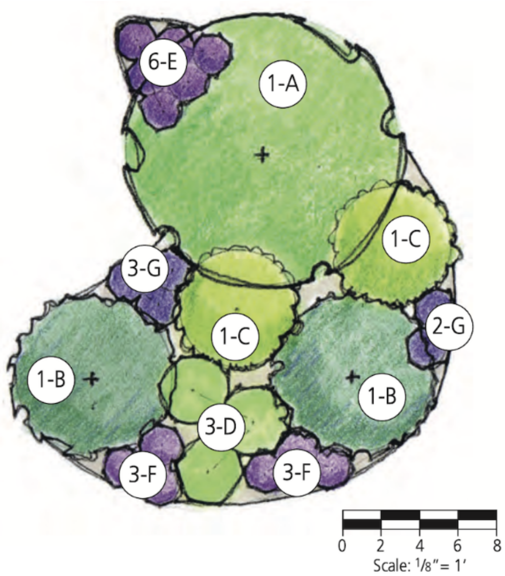


Figure 1: A garden buffer plan that incorporates the plant species listed above in Table 1. This small garden plan works well in low-lying or wet areas, such as a drainage swale. Figure from Adkins Arboretum & Critical Area Commission for the Chesapeake and Atlantic Coastal Bays "The Green Book Buffer".

vi. Proposed Landscape Conversions

The five areas selected for conversion using the above ecological landscaping practices within the City of Bowie are presented in figures 3 through 7. As provided by the City of Bowie, these are areas of interest 1, 11, 12, 18, and 20.

Two smaller parcels of land were selected for conversion in area 1 and are shown in Figures 2 and 3 respectively. The parcel shown in Figure 2 is located in a suburban neighborhood and currently consists of turfgrass and some electrical equipment. The recommended conversion at this site is to add a large section of limited mowing, increase tree canopy cover, and to implement a small buffer zone around the nearby tributary. The parcel shown in Figure 3 is also located in a suburban neighborhood, but it directly borders a local home. This may cause issues with the homeowner, so minimal changes have been suggested. The original land is primarily turfgrass, and it is recommended to increase the canopy cover from the existing tree line and to limit mowing closer to the road and sidewalk.

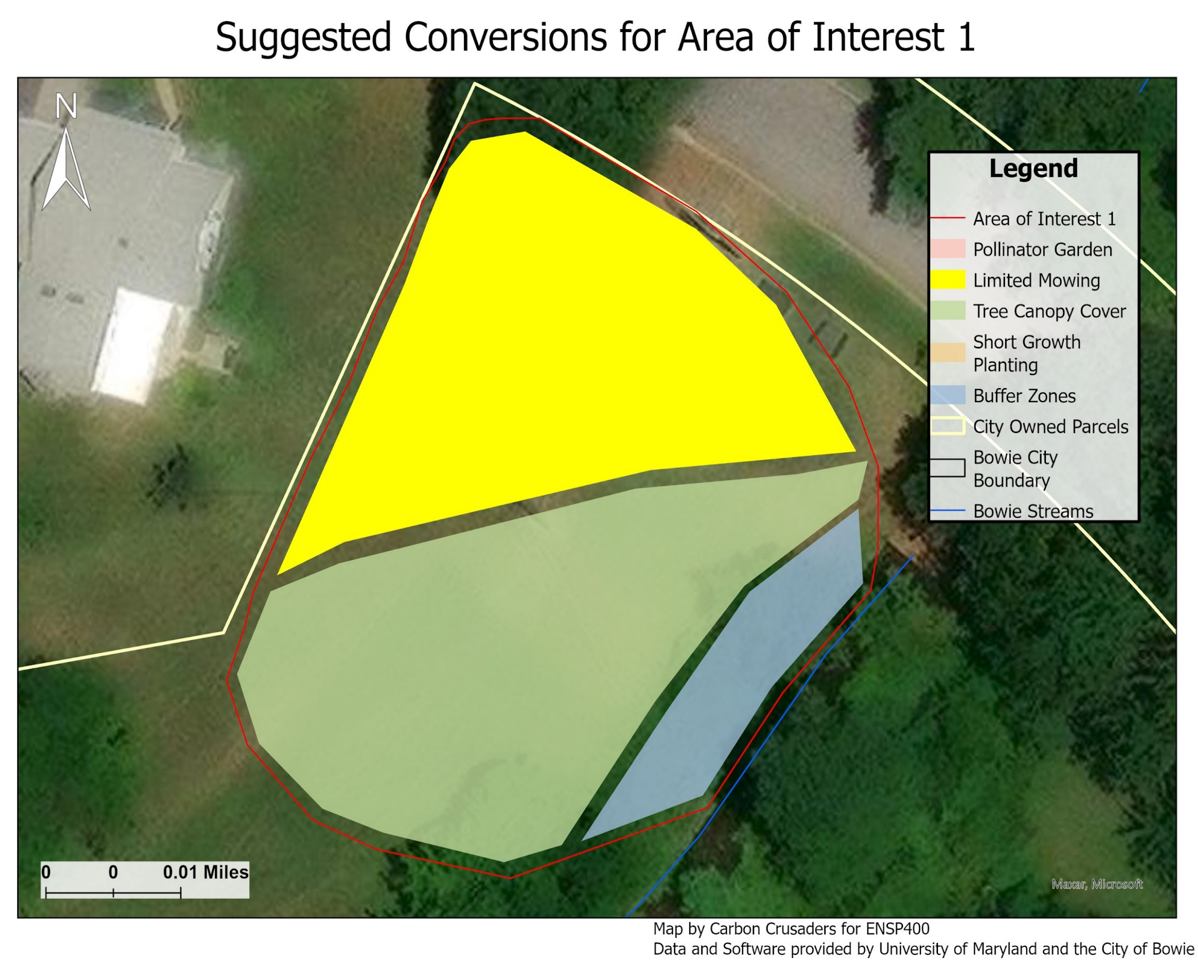


Figure 2: Suggested conversions for parcel one included within area of interest 1. Limited mowing, canopy cover, and buffer zones are the recommendations for this land.

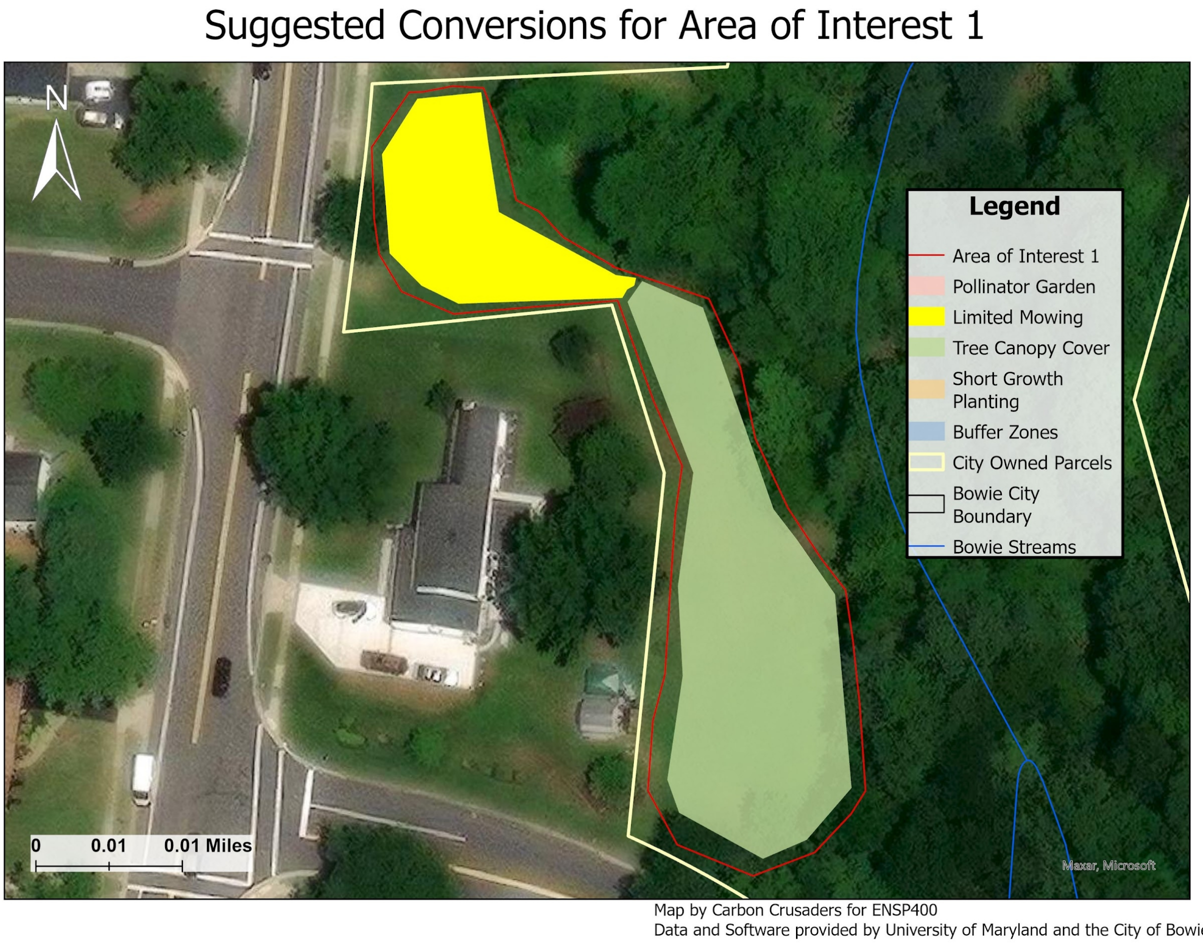
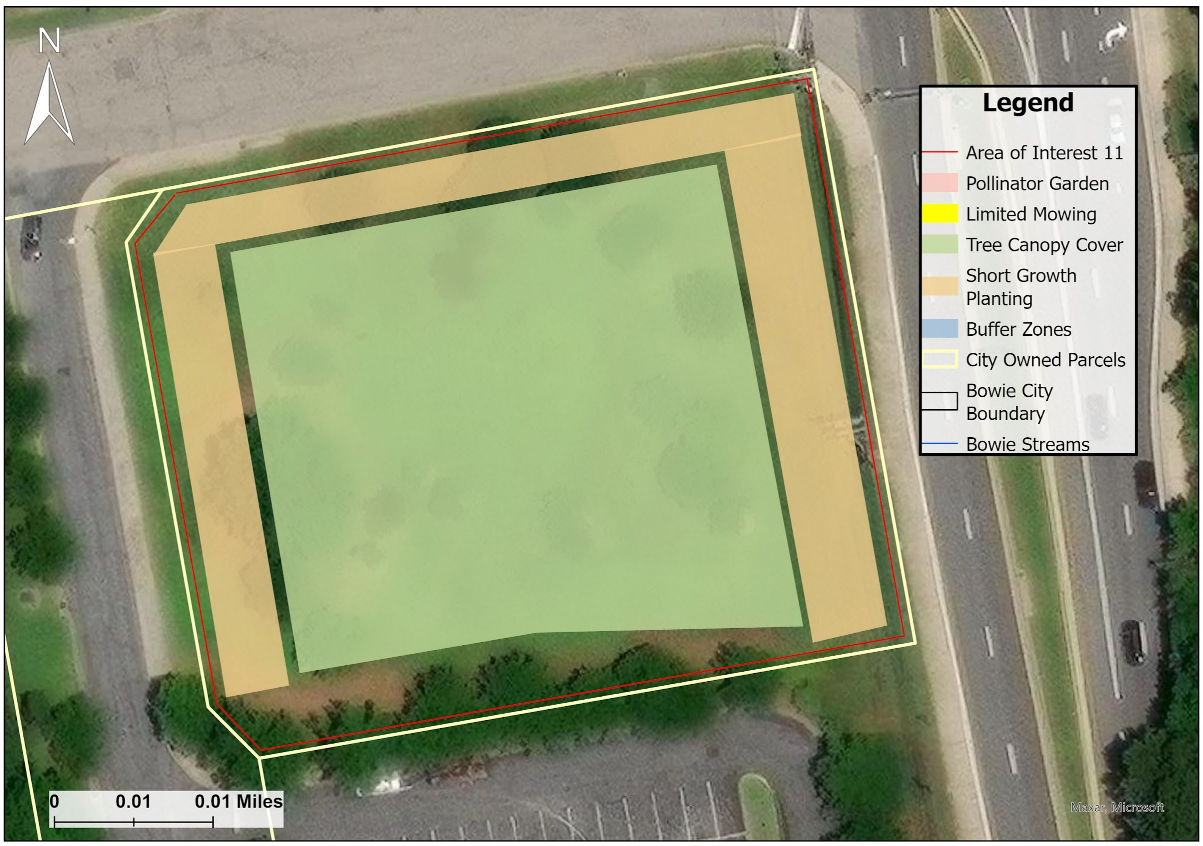


Figure 3: Suggested conversions for the second parcel within area 1 interest. Limited mowing and increased tree canopy cover are the ecological landscaping practices recommended here.

For the second conversion, area of interest 11, the space along Gallant Fox Lane is located near a commercial building, sidewalks, and a major road. Currently, there are trees sparsely planted throughout the parcel and on the southern border, adjacent to the parking lot, there is short growth planting. Seen in Figure 4, the proposed conversions are to increase canopy cover in the center and border the area with short growth plants.

Suggested Conversions for Area of Interest 11

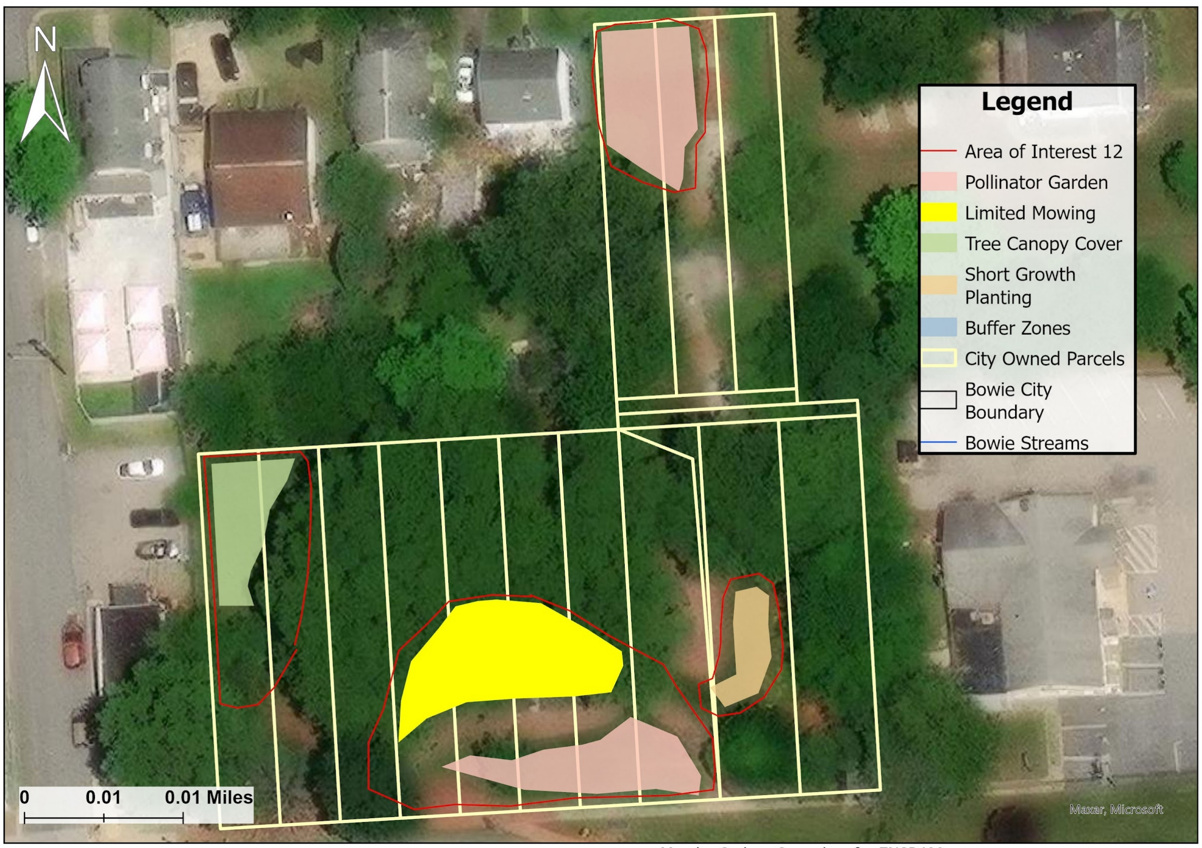


Map by Carbon Crusaders for ENSP400
Data and Software provided by University of Maryland and the City of Bowie

Figure 4: Suggested conversions for area of interest 11. Increasing canopy cover and short-growth plants is recommended.

Area of interest 12 is Town Green Park, which is situated in a residential area, but is used by residents as a small recreational park. There is a pathway through the park, with turfgrass and trees throughout the area. Pollinator gardens are suggested near the entrances to the park. Tree planting has been suggested in the western parcel. In the central part of the park, limited mowing is recommended. Lastly, in the eastern parcel, short growth planting can be added along the pathway, all seen below in Figure 5.

Suggested Conversions for Area of Interest 12



Map by Carbon Crusaders for ENSP400
Data and Software provided by University of Maryland and the City of Bowie

Figure 5: Suggested conversions for area of interest 12. The management strategies include adding pollinator gardens, limiting mowing, and increasing trees and short-growth plants.

The next site, area of interest 18, houses the Belair Stable Museum. With sites of historical significance, limited conversions are necessary, given that the function of the space needs to be maintained. Near the perimeter of the lot, there are many adult trees, but the canopy is not consistent across the lot. In the side yards of the museum, canopy cover can be increased by max two trees to create a cohesive canopy. Within the shape of the museum is turfgrass with a small garden in the center. As seen in Figure 6, a crescent-shaped pollinator garden has been recommended.

Suggested Conversions for Area of Interest 18

Map by Carbon Crusaders for ENSP400
Data and Software provided by University of Maryland and the City of Bowie

Figure 6: Suggested conversions for area of interest 18. Ecological landscaping practices include a pollinator garden and increasing canopy cover.

The last recommendation is for area of interest 20, along Science Drive. This site has many different functions and surrounding aspects that make it unique. The parcel is along a major road that leads to a large industrial park. There is also a large pond and wetland area, with a walking path surrounding it. Currently, just turfgrass and shrubbery are surrounding the pond. Due to these factors, every management practice is used to convert this space. Along the water, a buffer zone has been recommended, with a small pollinator garden nearby to educate on the conversion of the space. In the northeastern area, it is recommended to increase canopy cover, incorporate short growth planting along the pathway, and limit mowing on the eastern side of Tesla Drive, as shown in Figure 7 below.

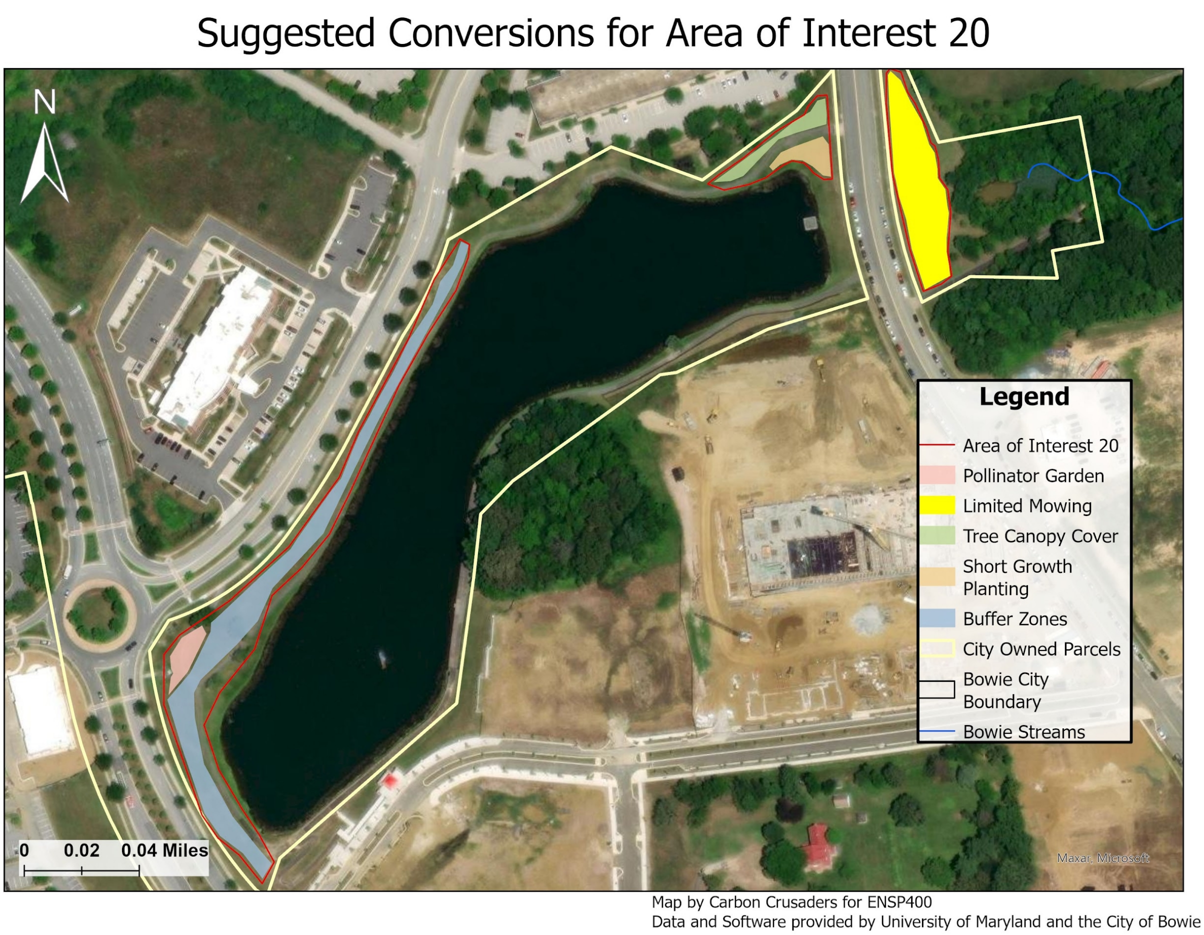


Figure 7: Area of interest 20 utilizes all of the management strategies, pollinator gardens, limited mowing, canopy cover, short growth planting, and buffer zones, which are strategically placed throughout the parcel.

Cost-Benefit Analysis

Rick Kellner, superintendent of the Parks and Grounds Division in Bowie, provided data to quantify the traditional yearly lawn maintenance by the city. Generally, these are the same costs every year because the initial costs have already occurred. Kellner answered questions to the best of his ability with knowledge and experience from working with the Parks and Grounds Division for many years. Some of the figures are approximate estimates and do not represent exact spending or savings.

The landscape categories considered in the cost-benefit analysis are the primary and secondary sites in Bowie and the five ecological landscaping methods. Turf at primary sites is present in highly visible areas and is maintained at a high level by the Parks and Grounds Division. Secondary sites are less visible, often near roadways, and usually considered for ecological conversion (see Appendix B). The mowing frequency of turf at primary and secondary sites, current materials associated with the maintenance of the turf, and labor costs in Bowie were acquired through the interview with Rick Kellner (see Appendix C). The results for the mowing frequency, removal and installation, and maintenance figures for the ecological landscaping conversions were discovered through research (Appendix D). Converting turfgrass to an ecological landscape can be done in three main steps. First, Parks and Grounds will remove the existing turf; second, plant seeds, trees, and native plants; and finally, ensure different levels of yearly maintenance. Table 2 shows a summary of the mowing frequency, upfront costs, maintenance for the first three years, and maintenance after three years for each of the landscape categories.

Table 2: Comparison of management intensity and installation practices for different landscape categories.

Practice	Landscape Category			
	Turf at Primary Sites in Bowie	Turf at Secondary Sites in Bowie	Reduced Mowing, Pollinator Gardens, Short Growth Planting, Buffer Zones	Canopy Cover
Mowing frequency once established	30-32 per year	20 per year	1 per year	N/A
Removal and installation	None	None	Remove turf [1] and plant desired species	Tree installation
Maintenance for the first three years	Mowing, pesticide and fertilizer treatment, seeding, mulching, irrigation, and leaf removal	Mowing, leaf removal, pesticide, and fertilizer treatment	Mowing three times per year in the first year. One time per year in the following two years.	Monitoring for signs of drought or disease before the tree is established.
Maintenance after three years	Mowing, pesticide and fertilizer treatment, seeding, mulching, irrigation, and leaf removal	Mowing, leaf removal, pesticide and fertilizer treatment	Mowing once a year to contain weeds.	Leaf removal[2]

[1] Three herbicide applications for turf removal (Bradbury et al., 2019).
[2] The cost of added leaf removal is negligible due to the frequency of leaf removal currently in Bowie. (See Appendix C)

The Lawn to Pollinator Habitat Savings Calculator was published by the Commonwealth of Massachusetts as part of the "Sustainable Landscaping at State Facilities". Pollinator habitat includes limited mow zones, management of meadows and grasslands, and pollinator gardens (Commonwealth of Massachusetts, 2020). These ecological landscaping practices are effectively equivalent to the limited mowing, pollinator garden, short growth planting, and buffer zone landscape categories. Assumptions for default data by the Commonwealth of Massachusetts incorporated into the Pollinator Habitat Savings Calculator were cross-referenced with the data received from the City of Bowie. Tables 3, 4 and 5 show the inputs to the Pollinator Habitat Calculator. Table 6, "Costs for One Acre of Turf and Pollinator Habitat" show business as usual mowed turf costs and pollinator habitat costs. Table 7 are the estimated pollinator habitat savings for one year and eight years. A graph showing the results of Table 7 can be found in Appendix E.

Table 3: Step 1 of Pollinator Habitat Savings Calculator

Site Details	**Data Input**
Parcel Size (acres)	1
Baseline # of Mows (annually)	20
Fuel Type for Mower	gasoline
Type of Change	till & seed
Include mowing labor costs in calculations?	yes

Table 4: Step 1.b of Pollinator Habitat Savings Calculator

Till & Seed Upfront Capital (Setup) Costs			
Preparation Costs (per acre)	**Default Data**[3]	**Use Default Data?**	**Data Input**
Tilling equipment amortized costs	$15.50	yes	

[3] Default data are the assumptions made by the Commonwealth of Massachusetts when publishing the Pollinator Habitat Calculator.

Seed Cost[4]		no	$325
Seeding equipment amortized costs	$19.50	yes	
Labor Cost	$259.77	yes	
Total Till & Seed Capital Cost (per acre)	$619.77		

Table 5: Step 2 of Pollinator Habitat Savings Calculator

Site Management Logistics	Default Data	Use Default Data?	Input Data
Mowing Time (hours per mow)	1.5	yes	
Fuel Cost (per gallon)[5]	$2.58	no	$3.32
Fuel Usage (gallons per mow)[6]	2.48	yes	
Annual Amortized Mower Maintenance Cost[7]	$51.00	yes	
Mowing Labor Cost (per hour)[8]	$37.11	no	$36.00

Table 6: Costs for one acre of Turf and Pollinator Habitat

	Business as Usual Mowed Turf Costs (per acre)	Pollinator Habitat Costs: Till & Seed (per acre)
Site Preparation Costs	$0	$619.77
Annual Fuel Cost	$164.34	$8.22
Annual Labor Cost	$1,080.00	$54.00
Annual Amortized Maintenance Cost	$20.40	$1.02
Annual Mowing Time (hrs)	30	1.5

[4] The seed cost is an estimate of seed mixtures for native species which range from $150 to $500/acre (Janke et al., 2021) (See Appendix D). The assumption is a mid range seed mixture.
[5] The gas price is the average gas price in Maryland on November 1, 2023.
[6] The fuel usage may vary depending on the type of lawn mower. The assumption is a 46”-inch mower width, 3-4 mph, using 1.65 gallons per hour (Commonwealth of Massachusetts, 2020).
[7] The assumption is a 300-hour mower life, one oil change per 50 hours, and tune-up every 100 hours (Commonwealth of Massachusetts, 2020).
[8] The assumption is using an entry-level laborer from City of Bowie Parks and Grounds.

Total Year 1 Cost	$1,264.74	$683.01
Total Annual Upkeep Cost	$1,264.74	$63.24
Greenhouse Gas Emissions (lb CO2)	970	48.51

Table 7: Estimated Pollinator Habitat Savings

	Annual	**Eight Years**
Year 1 Site Preparation Cost	$620	$620
Fuel Cost Savings	$156	$1,249
Labor Cost Savings	$1,026	$8,208
Amortized Maintenance Cost Savings	$19	$155
Total Gross Savings	$1,202	$9,612
Net Savings Over Lifetime	-	$8,992
Avoided GHG Emissions (lb CO2)	922	7,373
Mowing Time Savings (hrs)	28.5	228
Annual Upkeep: Percent Cost Reduction	95%	

In monetizing the value of tree canopy cover landscapes, it is important to take into account the benefits that are derived from the shelter that is generated by such landscapes. The cost of trees to implement a canopy cover is variable and depends on the nursery price and trunk circumference when purchased. River Birch, Red Maple, Eastern White Pine, and Redbud Eastern are four native trees to Maryland available at the Patuxent Nursery or Bowie Lowe's. Patuxent Nursery has larger trees available in 15-gallon pots. Bowie Lowe's has smaller trees available in 2-3 gallon pots. The cost ranges from $60 to $200. The native tree and plant selection can be done by the project planner. The shelter trees provide can benefit city residents and business owners through decreased cooling requirements that occur within buildings during the summer months. The shade from a "25-foot tree can reduce the annual cooling costs of a typical residence by 8 to 12 percent" (Danler & Langellotto-Rhodaback, 2015). The trees can also provide shelter from the wind. Danler and Langellotto-Rhodaback also found that "evergreens serving as windbreaks can save 10 to 50 percent on heating costs in the winter" (Danler & Langellotto-Rhodaback, 2015). Another benefit of canopy cover is the increase in home value. "In Portland, Oregon, street trees were found to add an average of $8,870 to housing prices" (Danler & Langellotto-Rhodaback, 2015). The overall benefit a tree can provide to a single family residential is calculated through the National Tree Benefit Calculator published by the Arbor Day Foundation and summarized in Table 8. These savings will quickly accumulate if many more trees are planted in ecological landscape conversions.

Table 8: Annual overall benefit to a single-family residential building calculated by the National Tree Benefit Calculator. (National Tree Benefit Calculator, n.d.)

Tree	**One Inch New Tree**	**Six Inch Grown Tree**	**Estimated Purchase Price**[9]	**Breakeven year**[10]
Eastern redbud	$4	$15	$73	Year 7
Eastern white pine	$3	$18	$53	Year 6
Red Maple	$1	$35	$40	Year 5

StoryMap

The StoryMap (Appendix A) provides visualization of geospatial data accompanied by explanatory text of the project findings and recommendations for the City of Bowie. Included in the StoryMap are policy recommendations that apply to each parcel of land that was examined in the report, per the first objective. There are many instances of related work done throughout the country in implementing ecological landscaping. Three related conversions, in Portland, Oregon,

[9] Estimated purchase price assumes the tree is bought from Bowie Lowe's as a one-inch new tree.
[10] The amount of years for the annual overall benefit to equal the estimated purchase price. Assumes the tree diameter increases one inch per year. Estimates may differ due to change in purchase price or tree growth rates.

College Park, Maryland, and Vienna, Virginia are shown in the StoryMap and can be used for governing entities, citizens and other municipalities to reference. Pertaining to the second objective of the project, the StoryMap allows for an interactive visualization of the different management strategies on the areas of interest, similar to the proposed landscape conversions reviewed in this report. The difference is that a viewer can move the map around to see the surrounding landscape and factors influencing the conversions. The StoryMap also provides an overview of the economic and ecological factors that were considered in the proposed conversions. Overall the StoryMap allows one to examine the physical and economic impacts that will result from the proposed ecological landscaping conversion of turfgrass in Bowie.

Discussion

Benefits of Ecological Landscaping

i. Official Policy Recommendation

Portland, Oregon has a national reputation for sustainable urban planning, as the city has a robust policy framework that has evolved over many years. This makes Portland an ideal candidate for the City of Bowie to use as a blueprint as it builds a foundation for ecological landscaping and land-use policy. The City of Bowie is advised to enhance its Climate Action Plan by incorporating and outlining more specific green infrastructure targets and strategies. A critical step involves amending the CAP to broaden its scope, aligning with Portland's approach that not only emphasizes tree canopy expansion but also incorporates natural and green infrastructure goals more generally. This would extend support to short-growth and groundcover planting. It would also promote urban design that incorporates natural systems and green infrastructure into public site improvements such as within rights of way, green corridors, etc. Additionally, Bowie is encouraged to formulate a Watershed Management Plan to potentially identify and prioritize ecological landscaping strategies aimed at improving watershed health. This would provide further support for ecological landscaping initiatives, as it outlines further benefits and strategies for ecological landscaping beyond carbon sequestration. This integrated plan should draw upon the experience outlined in Portland's Watershed Management Plan, emphasizing the effectiveness of revegetation and ecological landscaping practices. To guide these initiatives, Bowie should develop a supporting document or manual, akin to Portland's Climate Emergency Work Plan or PP&R’s Ecologically Sustainable Landscaping Initiative, fostering a cohesive and strategic framework for sustainable landscaping projects. By adopting these official recommendations, Bowie can elevate its commitment to ecological sustainability, fostering community engagement, and inter-departmental collaboration, ultimately contributing to the development of resilient and ecologically sound urban landscapes.

ii. Additional Environmental Benefits

In addition to local policy, the listed landscape conversions outlined in this report benefit other environmental aspects as well. The converted landscapes attract pollinators and other wildlife, boost ecosystem health, and protect the environment. By implementing these landscape changes ecosystems in Bowie can improve and become more biodiverse. Attracting pollinators and wildlife means that more animals have sources of food and protection and can carry out their ecosystem roles more effectively. Boosting ecosystem health means that the plants and animals can interact more cohesively and take the strain off of environments that have been damaged. Protecting the environment, specifically through buffer zones, aids in absorbing excess nutrients and prevents soil erosion from limiting environmental degradation. Overall, these strategies help create a better ecological habitat in implemented areas.

iii. Benefits to Residents

The identified landscape conversions will also provide economic advantages and benefits to the residents of Bowie. Ecological landscapes, specifically buffer zones and pollinator gardens, can serve as visually appealing green spaces for residents to enjoy. Creating scenic areas contributes to a sense of community pride and well-being. Several of the strategies also contribute to mitigating heat and providing shade, which is important as Maryland summers become hotter. For example, tree canopy cover and short-growth planting help reduce the heat island effect in cities by absorbing shortwave radiation from the sun and conducting photosynthesis. Additionally, tree canopy cover will provide shade for residents using walking trails or nearby roads. Limited mowing practices help to reduce noise pollution and air pollution. Lastly, the converted landscape conversions can be used as educational tools around the city. Providing signage and posters in converted areas helps residents understand their importance for the environment and how they benefit the community. Implementing these strategies would have a positive effect on residents, and highlighting these benefits may help to gain support from the community for future sustainable projects.

Proposed Landscape Conversions

Each of the five selected landscapes undergo a unique and effective conversion that helps the City of Bowie to achieve their CAP. As mentioned previously, each of the proposed conversions is effective at sequestering carbon, lowering local temperatures, and providing a habitat for biodiversity.

The first parcel of area of interest 1, shown in Figure 2, helps change the landscape from predominantly lawn turf into a productive area that can support increased wildlife and decrease runoff into the nearby stream. The presence of the stream and nearby trees indicated that adding a buffer zone and furthering the tree line would be beneficial to this area. Due to the presence of electrical equipment, limited mowing is suggested in a large part of the parcel, so that maintenance staff can still access the equipment needed safely. The second parcel in area of interest 1, shown in Figure 3, has the unique factor of being in close proximity to a residence. Since this land has been left alone by the city for an unknown amount of time, the homeowner would likely expect the parcel to stay the same. Thus, in the northern part of the parcel, limited mowing is recommended to keep the aesthetics and functionality of the landscape while still decreasing carbon emissions from mowing and other maintenance factors. In the lower part, it is recommended to plant trees to create a cohesive canopy.

Area of interest 11, shown in Figure 4, currently has a considerable amount of potential to be an ecologically productive parcel of land, but with how it is currently being managed, the land is utilized poorly. By extending the perimeter with short growth planting, one could beautify the land while increasing the amount of carbon sequestration. In the center of the parcel, there are many young, small trees, so the best recommendation is to continue to increase the number of trees.

Area of interest 12 is an important piece of land to the Bowie community. As it is a park, there are plenty of opportunities for educational sites and by implementing nonintrusive conversions to decrease carbon emissions, the functionality of the space is maintained. Ecological landscaping is still a relatively new idea, so by adding education on the concept, specifically to pollinator gardens, Bowie can educate a wide variety of age ranges on its importance. This is why two pollinator gardens have been added to this site, near both entrances to the park. The educational signs can also include information about the other ecological landscaping practices and where and why they are being used. Increased canopy cover, limited mowing, and short growth planting are recommended for this lot to enhance the natural beauty of the space and promote the concept of ecological landscaping, seen in Figure 5.

Area of interest 18 (Figure 6) is the Belair Stable Museum which is a historical site dedicated to two Bowie citizens who raised racehorses in the area in the late 1740's (City of Bowie). The functionality and management of the space specify that the conversions for this parcel should be minimal with the only aim to be increased beautification of the space. As there are many historical sites throughout Bowie, use of the same logic should be applied. Increasing the natural tree line is suggested on the perimeter of the space to provide shade to the museum. Within the shape of the building, a crescent shaped pollinator garden is recommended. Correctly designed and managed pollinator gardens offer the opportunity to beautify a natural space. With the presence of educational signs, visitors can learn more about what Bowie is doing to make their city more sustainable in primary and secondary sites.

Finally, area of interest 20, shown in Figure 7, utilizes all five of the landscape conversions discussed previously and thus, is a culmination of incorporating ecological landscaping throughout the city. The combination of pollinator gardens and buffer zones around the pond allows for an educational experience, similar to the Belair Stable Museum. By implementing short-growth planting, limited mowing areas, and by expanding the tree canopy in less used spaces, the parcel can be more sustainable and prevent pollution runoff into the tributary.

Cost-Benefit Analysis

The cost-benefit analysis results indicate considerable economic benefits to the ecological landscaping conversions. The calculations show an estimated annual savings of $1,202 per acre annually for pollinator habitats like reduced mowing, pollinator gardens, short growth planting, and buffer zones. The annual avoided greenhouse gas emissions are 922 lbs of CO_2 per acre annually for pollinator habitat. The gross savings is $9,612 for one acre of pollinator habitat over eight years. Over eight years, the total avoided greenhouse gas emissions are 7,373 lbs of CO_2 per acre for pollinator habitat. The avoided greenhouse gas emissions align with the goals of the City of Bowie's Climate Action Plan. The economic savings can go toward future conversions or other programs to benefit the city. The time to pay back upfront capital is one year in one-acre conversions of pollinator habitats. It is more likely that the City of Bowie will convert more than one acre throughout the project. When the model is adjusted to a twenty-acre conversion, the time to pay back upfront capital is six years (Commonwealth of Massachusetts, 2020). This makes sense because the more significant the area for conversion, the more equipment and labor are necessary. Bowie could start with one-acre conversions yearly to accumulate capital to pay back the initial investment while achieving climate change goals.

StoryMap

An easy and effective way to present information in a step-by-step analysis is through the use of visuals. The StoryMap is an aid to help understand such processes and in this project was used to show the how and why of the steps that lead to the recommendations for areas of interest in this project. The maps included within the StoryMap identify the sites of interest and type of changes that took place in each of five areas of interest. The accompanying text provides the rationale for the proposed changes at each of the sites. The StoryMap also includes summary information of the cost benefit analysis and a brief accounting.

Utilization of ecologically based landscapes has taken place at other locations including Seattle, Washington, College Park, Maryland and Washington, DC. Looking at other municipalities and how they have made similar conversions gives insight to what works and potential problems that may occur. Municipalities that have developed varying policies regarding implementing green infrastructure as it relates to greenhouse gas emission reductions can be informative when considering landscape conversions for a particular space.

Limitations

A limitation to this project is that it does not provide specific carbon sequestration values for the proposed changes at the five sites of interest. The reasons for this are that there is a lack of quantitative data on the carbon sequestration rates of native plants and that carbon sequestration is dependent on locational conditions. There is carbon sequestration data available for various tree species, but not for most other plant types other than turfgrass. In the case of the latter, carbon sequestration is highly dependent on how the turf is managed and where it is located (Selhorst and Lai, 2013). While an extensive literature search was not conducted on this topic, it is likely this is the case for other types of plants as well.

The Cost-Benefit analysis is limited by varying environmental conditions, scaling considerations, and dependency on initial estimates. The long-term viability of the cost-benefit analysis may be affected by uncertain ecological conditions. Drought, invasive species, or changing maintenance requirements may affect the long-term management and cost of maintaining the conversions. There are scaling considerations that would affect the cost of conversions. This study quantifies conversion done by one acre. Once scaled up to more acres, more logistic or operational challenges may increase the cost. A dependency on initial estimates also limits the cost-benefit analysis. There could be different staff, pay, or maintenance practices at the City of Bowie Parks and Grounds Division in a few years. The cost-benefit analysis provides the best estimates with the data available, however with these limitations, future conversions would quantify the actual costs.

Conclusion

Based on research conducted for the City of Bowie, recommendations have been provided to achieve the goal of boosting carbon sequestration and limiting turfgrass usage in the landscape. This report used policies from Portland, Oregon, to inform The City of Bowie's future policy framework. Practices such as the increased usage of pollinator gardens, limited mowing, increased tree canopy cover, short growth planting, and the use of buffer plantings are suggested for implementation on city properties to boost carbon sequestration rates. A cost-benefit analysis was conducted to understand the feasibility of implementation and upkeep of the converted parcels around the City of Bowie. The current cost for maintaining the turfgrass is $1,264.74 per acre annually. However, with conversions to pollinator habitat, the cost is reduced to a $683.01 upfront cost and $63.24 annual upkeep cost per acre. The annual savings for one area of conversion to pollinator habitat is an estimated $1,202 per acre. A StoryMap was created to display the recommendations outlined in the report visually. It is a tool to enhance community understanding and engagement in ecological landscaping. The recommendations outlined in this report will improve the ecological and economic aspects of the city's operations while moving the city towards its climate goal targets. It will also highlight the City of Bowie's commitment to pioneering the implementation of friendly, community-sustainable urban development within the region.

Appendix A

StoryMap

An ArcGIS online StoryMap that includes ecological landscaping practices, Ecological conversion areas of interest and environmental factors that influence recommendations for the City of Bowie. This includes features like economic figures and tables, ArcGIS Pro map layers and text to provide a summary of the outlined objectives:

https://storymaps.arcgis.com/stories/77200638bf5f4d5b836f226d1ecb398e

Appendix B

Primary and Secondary Turf in Bowie

The Parks and Grounds Division maintains 250 acres of parks and facilities. Bowie's public land parcels are divided into primary and secondary sites. Primary sites are areas that receive extra maintenance due to their high visibility. This can include increased mowing, fertilization, and irrigation. Primary sites are City Hall, historic sites, the Senior Center, etc. Secondary sites are less visible and require less maintenance for lower turf quality. This can signify less mowing or no irrigation. Secondary sites are areas near roadways or "right of way." They are visible but not used by people often. Kellner noted that Bowie has Memorandums of Understanding (MOU) with the state or county over maintaining the right of way. An MOU allows the county or state to develop the parcel into a more attractive, better site with the caveat that the city will be responsible for future maintenance. Kellner said the city likes the MOUs because they allow for increased beautification of the spaces for residents. For this cost-benefit analysis, secondary sites will primarily be the areas for ecological conversion.

Appendix C

Current Maintenance of Turf in Bowie

In the City of Bowie Parks and Grounds Division, 30 to 35 staff members are employed full-time for 40 hours a week. The work crew consists of crew leaders at $60/hr, senior laborers at $40/hr, and entry-level laborers at $36/hr, including base salary and benefits. Senior laborers have experience operating small equipment like zero-turn, hand, and walk-behind mowers. The entry-level laborers are employed with no experience.

Mowing is done by the work crew 30 to 32 times per year for primary sites. That is about once a week in the warmer months when grass grows. Based on the mowing frequency of primary sites, secondary sites are mowed about 20 times per year or every one or two weeks in the growing season. Mowing is weather-dependent, so in droughts, there is less mowing. The estimations for mowing are for average years without instances of significant drought that affects mowing practices.

The maintenance of primary sites includes yearly pesticide and fertilizer treatment, seeding, mulching, irrigation, and leaf removal. Fertilizer is used on the primary sites one or two times per year. Purchasing fertilizer and pesticides costs $500 to $550 per acre. Pre-emergent weed control is spread on the turfgrass to control the spread of weeds before they occur. If weeds arise, the city uses a post-emergence herbicide, which requires less labor but more cost, as often as necessary to maintain the space. The primary sites are also seeded once per year. It takes 200 pounds of grass seed per acre to maintain the turf. For labor, it is about $500 per acre to do the seeding once per year. The primary sites are mulched once per year. The primary sites have underground sprinkler systems that irrigate water during the growing season. The secondary sites are never irrigated, even in times of drought.

As for leaf removal, from the start of November to December 15th, there is an intensive leaf removal campaign. For about six weeks, thirty or so employees work on leaf removal in Bowie. Many of these days are spent helping residents remove leaves from their lawns so that cost is excluded from the cost-benefit analysis because it does not involve public land. One day of the work week, the crew maintains the public spaces. First, the leaves are removed from the primary sites and then the secondary sites. One day a week for six weeks means 48 hours of labor for leaf removal per person. Thirty crew members are getting paid a minimum of $36 per hour. There is no data on the number of each type of crew member, so the analysis assumes everyone gets paid a minimum of $36 per hour. That comes to a total cost of $51,840 a year on leaf removal. With 250 acres of land, leaf removal costs at least $207.36 per acre per year. All public land in Bowie is maintained with extensive leaf removal every year. Including more trees through ecological landscaping will not significantly alter the amount of time spent on leaf removal. The cost will stay the same before and after ecological landscaping. Therefore, leaf removal is not considered in the cost-benefit analysis.

Appendix D

Process of Converting Pollinator Habitat

One analysis of converting large areas of turf into pollinator gardens recommended using "multiple herbicide treatments (glyphosate or another [non selective], broad-spectrum, general-use herbicide) combined with some form of tillage are common and most appropriate for large-scale conversions" (Janke et al., 2021). Another analysis in Iowa recommends "applying herbicides throughout an entire growing season (three applications) and preceding fall (one application). Late fall is the best time to kill cool-season grasses by spraying" (Bradbury et al., 2019). In Maryland, the timing of applying herbicide to kill cool-season grasses shifts to early fall or September. The site preparation done by the Parks and Grounds Division is critical to the success of ecological landscaping.

The price for seeds is highly variable depending on what type of pollinator garden or native planting is desired. The cost of seeds will vary depending on the type and sourcing but typically fall around $150 to $500/acre. (Janke et al., 2021). A pollinator habitat area is usually mowed during establishment "to stimulate seedling establishment by reducing competition of annual weeds and grass" (Janke et al., 2021). The desired frequency of mowing during the first three years of a pollinator garden is three times per year in the first year and one time per year for the next two years (Bradbury et al., 2019). The pollinator garden will take 3-4 years to mature fully (Janke et al., 2021).

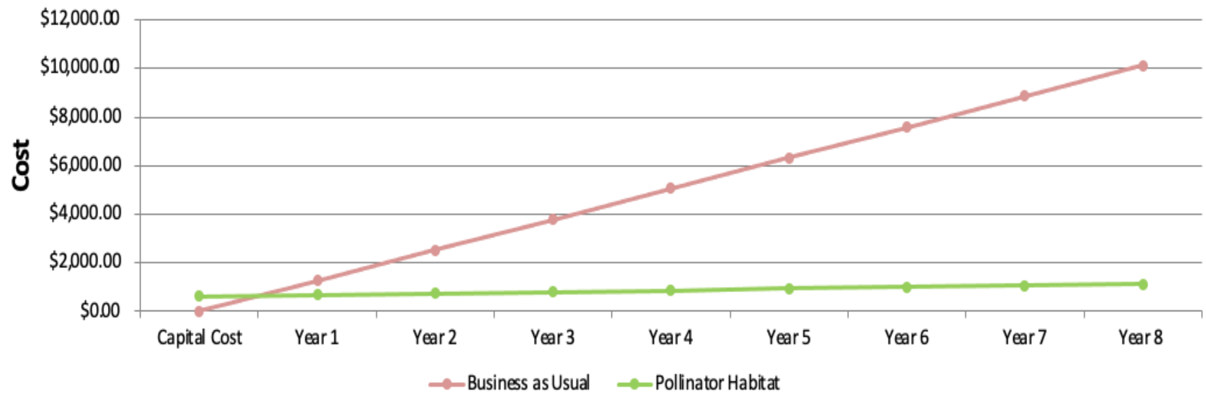
Appendix E

Visualization of Pollinator Habitat Savings over Time

This graph was created using the Lawn to Habitat Savings Calculator by the Commonwealth of Massachusetts. Inputs reflect the City of Bowie assumptions for ecological landscaping.

Cumulative Upkeep Costs: Business as Usual vs Pollinator Habitat

	Capital Cost	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Business as Usual	$0.00	$1,264.74	$2,529.48	$3,794.22	$5,058.96	$6,323.70	$7,588.44	$8,853.18	$10,117.92
Pollinator Habitat	$ 619.77	$683.01	$746.24	$809.48	$872.72	$935.96	$999.19	$1,062.43	$1,125.67
Net Savings	**($619.77)**	**$581.73**	**$1,783.24**	**$2,984.74**	**$4,186.24**	**$5,387.75**	**$6,589.25**	**$7,790.75**	**$8,992.25**



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