USING ARCGIS PRO (V3.1) AND ARCGIS ONLINE TO SUPPORT TOWN-LEVEL LAND AND WILDLIFE CONSERVATION EFFORTS IN THE STATE OF MASSACHUSETTS, USA

by
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Abstract

This study considers how ArcGIS Pro tools and ArcGIS Online web applications can be applied to assist small, under-resourced, town-level land-conservation groups with land acquisition and land management. The Land Preservation Society (LPS) of Norton, Massachusetts is studied as an example land-conservation group, and data pertaining to the project were saved through the LPS ArcGIS Online organizational account. Models were created using ArcGIS Pro (v3.1) ModelBuilder to perform least-cost and buffer analyses. The least-cost analysis connects core species habitats, and tax parcels that are near those connections are selected as a proxy for wildlife corridors. The buffer analysis quantifies the likelihood of habitats to become fragmented based on the distance from infrastructure features. QuickCapture was used to generate a point collection mobile application that may be used to collect data such as trash, hazards, and wildlife features. These features are added to a single map layer which may be viewed and used to prioritize land maintenance of conservation properties. The results of the analysis on the Town of Norton suggest tax parcels for future acquisition, provide a way to measure the likelihood of habitat fragmentation, and enable LPS members to collect and review point data on their land. A method for predicting wildlife corridors using a least-cost analysis is also presented. The models produced in ArcGIS Pro were shared to the LPS ArcGIS Online Organizational account and made public for LPS members and similar land groups to use. ArcGIS StoryMaps was used to present this study to a public audience, and to provide links to download the ModelBuilder models for use in ArcGIS Pro.

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1 Introduction

1.1 Introduction

As urban areas expand their footprint and as climate patterns shift, wildlife habitats change in response. Land conservation is a central means of preserving the health and extent of wildlife and natural areas for the future. Research in this area has shown that conservation efforts which focus on the benefits to the ecosystem are “superior to approaches that simply maximize the size of land acquired within an available budget” (Samiappan et al., 2022). To understand how wildlife responds and how land conservation can be better implemented with respect to ecology, it is essential to consider the spatial relationships between wildlife and human civilization. GIS (Geographic Information Systems) is a collection of computer-based tools that is used to produce, manage, analyze, and present spatial data. As such, GIS can be used to map the spatial relationships between wildlife and civilization, and to draw insights that can help conservation groups to strategize land acquisition and land management. ArcGIS Pro is a popular enterprise-level GIS software and is used as the software platform for this project to develop tools that help town-level land groups to manage their land holdings.

1.2 Statement of Problem

Approaching conservation at the town level is an important way to achieve local preservation of natural areas. Land conservation organizations exist in most towns in Massachusetts, some of which use GIS to map the extent of their properties and to share trail maps and interesting sights or natural features with the public. The problem for many of these town-level organizations is that they operate with limited resources such as budget, number of members, and technical/GIS proficiency. The Land Preservation Society (LPS) of Norton is a group that exemplifies the challenges faced by resource-limited land organizations in Massachusetts. These smaller town-level groups may be described as having a ‘low-capacity', and many of them lack digital geospatial records (Rissman et al., 2019). These limitations create a bottleneck for smaller land groups, who are then challenged to produce geospatial insights about their land. The LPS and the Town of Norton are investigated as a case study in this project, using the ArcGIS tools that are developed. The study area is explained in detail in Chapter 2.

1.3 GIS for Town-Level Land Conservation

To set the context for this study, it is important to review tools that currently exist to assist conservation efforts in Massachusetts. Many of these tools are available through the Massachusetts State website and are intended for use by town-level conservation groups. One major statewide effort to unite local conservation groups and promote the conservation of open spaces is the Massachusetts Land Trust Coalition (MassLand). The mission of MassLand is to "advance land conservation across Massachusetts by providing education, tools, networking and advocacy for land trusts and their partners" (massland.org). MassLand offers a handful of web-based geospatial tools to Massachusetts land groups to help inform land acquisition and land-use planning. The following sections provide a brief overview of each tool available through the MassLand website.

1.3.1 Mass Audubon MAPPR

One of the tools available through MassLand is the Massachusetts Audubon Society's Mapping and Prioritizing Parcels for Resilience (MAPPR) tool. This is a web-based tool that has several options to select, such as type of model (biological, aquatic, or resilience), individual model values (town for analysis. This tool identifies the likelihood of each tax parcel in the selected town to contribute to the resiliency of natural systems. The result of this tool is the tax parcels in the selected town symbolized as graduated colors and ranked in terms of their priority for conservation.

1.3.2 The Nature Conservancy RLMT

The Nature Conservancy (TNC) has a webmap viewer application that allows users to view and download interesting layers. The Resilient Land Mapping Tool (RLMT) focuses on ecoregions and includes layers that show the spatial distribution of metrics which quantify biodiversity, resiliency, carbon estimates, and ecosystem extents.

1.3.3 MassGIS MassMapper

The MassGIS MassMapper is also a webmap viewer application and has a broader selection of layers than the TNC webmap. It focuses mainly on physical/cultural resources, and infrastructure.

1.3.4 MassGIS BioMap

The MassGIS BioMap project is a geospatial conservation effort to host and share ecological data in Massachusetts with conservation and land groups. BioMap has an online map viewer, and a MassGIS webpage where data layers may be downloaded separately.

While the TNC and MassLand web tools are a good source for data, they do not allow the user to do much GIS analysis. The Mass Audubon MAPPR tool provides the end user with some analysis capabilities, but it does not allow for much fine-tuning in terms of input parameters, changing the way the model executes analysis, or symbolizing the final output. It would help the end user to have access to tools that complement a MAPPR analysis, but allow a finer degree of control over the analysis within a GIS software like ArcGIS Pro.

1.4 Objectives

The concerns of land conservation organizations fall generally into two categories: land acquisition, and land management (Rissman et al., 2012). The objective of this project is to provide low-capacity land groups with ArcGIS tools they can use to produce analyses that help to forecast the consequences of land use. These geospatial tools focus on identifying: 1) desirable land for acquisition, and 2) land which requires the most maintenance. The tools are in the form of an ArcGIS Pro (v3.1) Toolbox, and ArcGIS Online QuickCapture mobile application. The ArcGIS Pro Toolbox focuses on land acquisition, and it contains tools that allow stakeholders to conduct spatial analyses of their land. The Toolbox tools can help to answer the question "What land is most desirable for acquisition?". The QuickCapture mobile application focuses on land management, and it allows stakeholders to collect points and photographs of features on their land. The QuickCapture application can help to answer the question "Which properties require the most maintenance?" The deliverables of this project are the ArcGIS Pro Toolbox tools and the QuickCapture application. These tools are intended for use by all-volunteer organizations like LPS, and sample analyses of using these tools for the Town of Norton are provided.

From an ecological perspective, the preservation of wildlife corridors is of high concern. Wildlife corridors are areas of land that connect fragmented wildlife habitats and provide forage and cover for the species that inhabit them (Conine et al., 2004). For this reason, a LAND ACQUISITION Model was developed. This tool identifies potential wildlife corridors and properties near them. A FRAGMENTATION POTENTIAL Model was also developed. This tool identifies the potential for habitats to become fragmented. Human civilization can cause habitat fragmentation to occur when parts of a habitat are destroyed through processes like development, pollution, or deforestation. This leaves the remaining habitats isolated from each other. It is therefore of high concern for land groups to focus on preserving wildlife corridors by strategizing land acquisition and predicting habitat fragmentation before it happens.

2 Study Area

2.1 Overview of Study Area

The LPS is a small, non-profit land trust organization that uses GIS to help manage their land holdings. LPS has an ArcGIS Online-based map viewer and historical map archive that illustrates land holdings at the parcel level. LPS has few GIS-literate members, and they require a more self-sufficient approach to manage their GIS routinely. With little GIS experience, LPS needs to perform efficient and routine spatial analyses of their land and keep their geospatial products up to date.

In terms of access to resources and technical proficiency, LPS is not a unique land organization in Massachusetts, and other such groups can benefit from simplifying how they implement GIS. LPS is an example of a low-capacity land group. Lower capacity groups are less likely to share their data, and they tend to have a less robust digital data record than higher-capacity land groups. The role that smaller land groups play in terms of producing digital records for public consumption is limited by their ability to employ geospatial technology, and they may therefore benefit from having a simpler approach to producing insightful spatial data (Rissman et al., 2019). This project looks specifically at the geospatial needs of LPS as an example of a low-capacity land group in Massachusetts. While the tools presented in this project are tested on data specific to Norton and LPS, they are designed to be implementable and shareable with other groups who may benefit from using custom conservation tools in ArcGIS Pro.

2.2 Map of Study Area

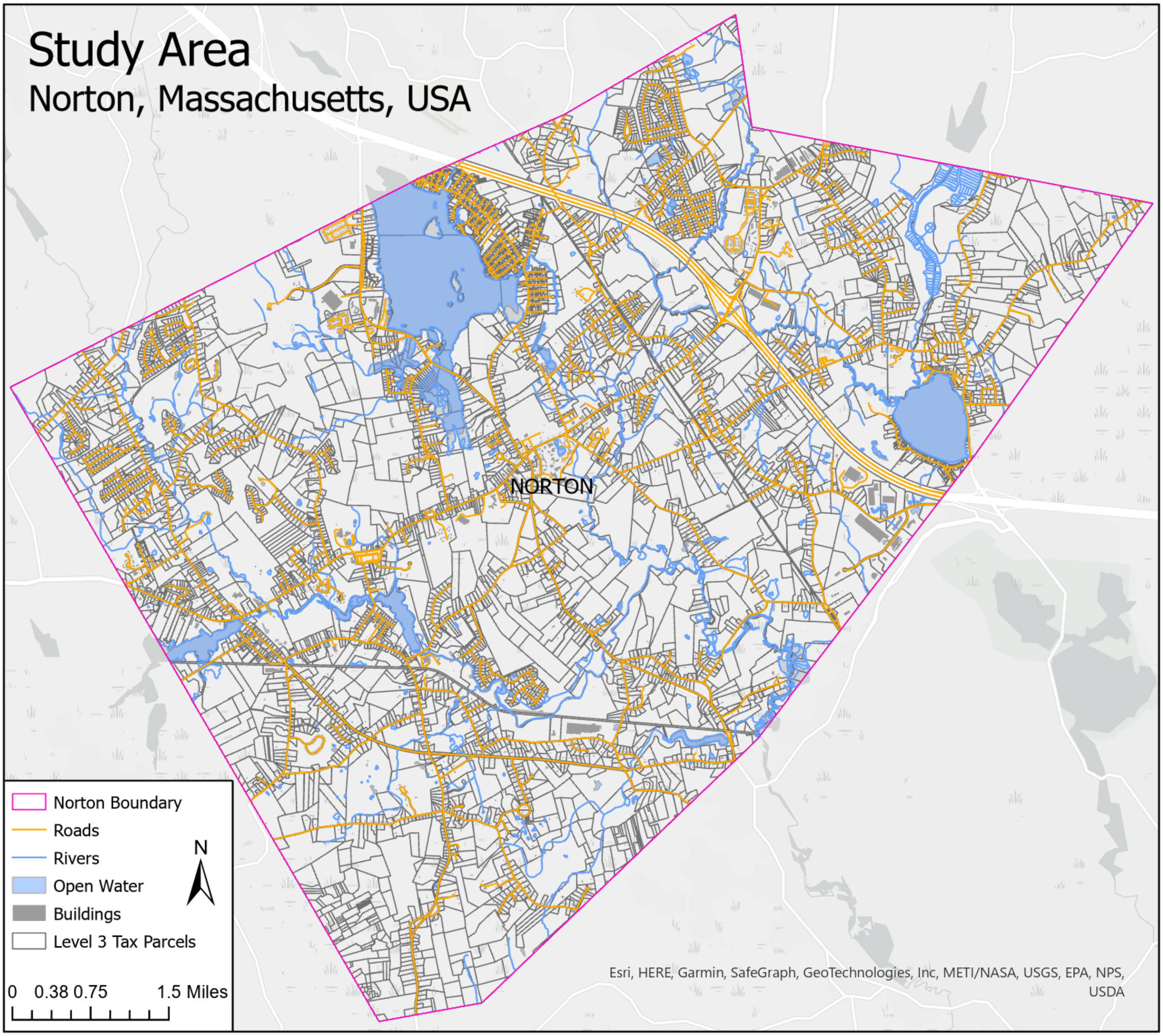


Figure 1: Map of study area - Norton, Massachusetts.

3 Data

3.1 Introduction to Data

All data used in this project were downloaded from the MassGIS website and incorporated into two geodatabases called *Conservation* and *Rasters* in ArcGIS Pro. The BioMap3 project contains habitat data and was downloaded from the MassGIS BioMap website. A 'Data' directory was created to store unique subdirectories for each type of data downloaded (*figure 2*). The 'Data' directory was added as a folder connection in ArcGIS Pro and used to bring layers into the project. Some initial preprocessing operations were done to standardize the spatial reference to *Web Mercator (Auxiliary Sphere)* and remove irrelevant attributes, and each layer was exported to the *Conservation* geodatabase.

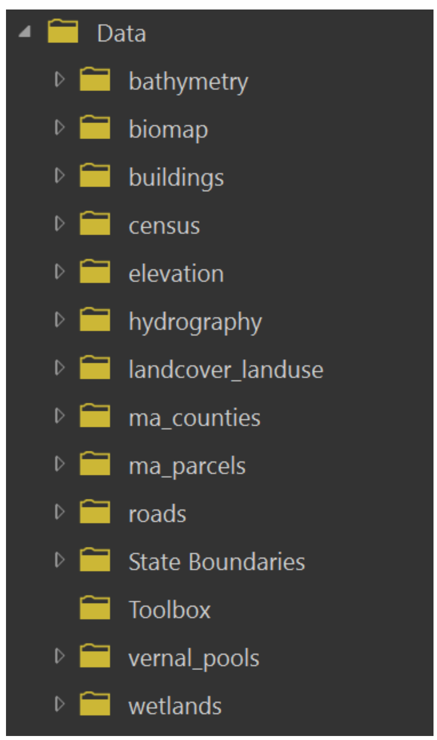


Figure 2: Structure of the folder that contains the initial datasets as they were downloaded from MassGIS.

3.2 Summary of Datasets

Table 1: Initial and final data layers by data type. 'Final Data' refers to data that is ready for analysis after preprocessing.

Accessed	Initial Data	Type	Final Data	Type
3/15/23	BioMap3	Polygon Feature Class (GDB)	Core_Habitats	Polygon Feature Class (GDB)
			Core_Habitat_Points	Point Feature Class (GDB)
3/8/23	Buildings	Shapefile	Buildings	Polygon Feature Class (GDB)
3/20/23	Census	Shapefile	Towns	Polygon Feature Class (GDB)
3/20/23	Counties	Shapefile	Counties	Polygon Feature Class (GDB)
3/15/23	Elevation from LiDAR	Raster (GDB)	Slope	Raster Dataset (GDB)
3/20/23	Hydrography	Shapefile	Water_Lines	Line Feature Class (GDB)
3/14/23	Landcover	Polygon Feature Class (GDB)	Landcover	Polygon Feature Class (GDB)
			Landcover_Raster	Raster Dataset (GDB)
3/8/23	Roads	Line Feature Class (GDB)	Roads	Line Feature Class (GDB)
3/8/23	Level 3 Tax Parcels	Polygon Feature Class (GDB)	L3_Parcels	Polygon Feature Class (GDB)
3/20/23	Vernal Pools	Shapefile	Vernal_Pools	Point Feature Class (GDB)
3/8/23	Wetlands	Shapefile	Open_Water	Polygon Feature Class (GDB)

			Wetlands	Polygon Feature Class (GDB)

3.3 Description of Datasets

The following list of data includes a brief description of the initial data from the relevant metadata, as downloaded from MassGIS. The purpose of each item and its usage is described.

<u>BioMap3</u>

The *BioMap3* geodatabase was downloaded and added as a database connection in ArcGIS Pro. The 'Core Habitats' layer was added to the Contents pane and exported to a geodatabase polygon feature class inside the *Conservation* geodatabase as 'Core Habitats'. A point feature class was generated from 'Core Habitats' using the *Feature to Point* tool and was saved to the *Conservation* geodatabase as 'Core Habitat Points'. This layer is used for land acquisition analysis, and for general map display.

<u>Buildings</u>

A Buildings geodatabase was downloaded and added as a database connection in ArcGIS Pro. The 'Buildings' polygon layer was added to the Contents pane and exported to a geodatabase polygon feature class inside the *Conservation* geodatabase as 'Buildings'. Data were derived from 2011-2012 orthoimagery. This layer is used for habitat fragmentation potential analysis, and for general map display.

<u>Census</u>

Census data by town were downloaded as a shapefile, added to the Contents pane, and exported to a geodatabase polygon feature class inside the *Conservation* geodatabase as 'Towns'. This layer is used in the land acquisition and fragmentation potential analyses to query an individual town and to set processing and mask extents.

Counties

County boundary data were downloaded as a shapefile, added to the Contents pane, and exported to a geodatabase polygon feature class inside the *Conservation* geodatabase as 'Counties'. This layer is included as an option to replace the 'Towns' layer for processing if a county-level analysis is more desirable than a town-level analysis.

Elevation

'Elevation from LiDAR' was downloaded as a geodatabase raster, added to the Contents pane, and exported to the *Rasters* geodatabase as 'elevation raster'.

Hydrography

Hydrography data were downloaded as line shapefile feature classes (water lines and freshwater boundaries) and added to the Contents pane. The features were exported to a line feature class inside the *Conservation* geodatabase as 'Water Lines'. The water lines feature class is used for land acquisition analysis and general map display.

Landcover / Land Use

Landcover data were downloaded as a polygon geodatabase feature class and added to the Contents pane. The features were exported to a polygon geodatabase feature class inside the *Conservation* geodatabase as 'Landcover'.

Roads

A Major Roads geodatabase from MassDOT was downloaded and added as a database connection in ArcGIS Pro. The 'Major Roads' layer was added to the Contents pane and exported to a geodatabase line feature class inside the *Conservation* geodatabase as ‘Roads’. This layer is used for the land acquisition and fragmentation potential analyses, and for general map display.

Tax Parcels

A level 3 tax parcels geodatabase was downloaded and added as a database connection in ArcGIS Pro. The ‘Level 3 Parcels’ layer was added to the Contents pane and exported to a geodatabase polygon feature class inside the *Conservation* geodatabase as ‘L3 Parcels’. A table including owner name, property value, and address was also exported to a geodatabase table inside the *Conservation* geodatabase as ‘L3 Parcels Assess’. The layer is used for land acquisition analysis and general map display, and the table may be referenced for additional information about tax parcels in a study area.

Vernal Pools

‘Confirmed Vernal Pools’ were downloaded as a shapefile point feature class, added to the Contents pane, and exported to a geodatabase point feature class inside the *Conservation* geodatabase as ‘Vernal Pools’. This layer is used for general map display and is not used for analysis in this project.

Wetlands

Wetlands data were downloaded as a shapefile polygon feature class, added to the Contents pane, and exported to polygon feature classes inside the *Conservation* geodatabase as ‘Wetlands’ and ‘Open Water’. The ‘Wetlands’ feature class contains swamps, marshes and bogs, and the ‘Open Water’ feature class contains lakes and ponds. These layers are used for general map display and are not used for analysis in this project.

4 Geospatial Methods

4.1 Introduction to Methods

A new ArcGIS Pro project was created, and the environments were configured before bringing data into the project. A scratch workspace geodatabase was created and set in the global project environments, and the output coordinate system was set to *Web Mercator (Auxiliary Sphere)*. The *Towns* layer and a state boundary layer were brought in. The *Towns* layer was used to create a new layer for the boundaries of Norton by exporting the layer to the scratch workspace with a query on the town-name attribute field for Norton. The state boundary was used to set the processing extent for initial preprocessing of data and was later changed to *Norton* during the model testing phase. The *Norton* boundary was used to clip the *Roads, Buildings, Open Water, and L3 Tax Parcels* layers for cleaner display in map layouts. A mask was also set to *Norton* in the Raster Analysis environments while testing the models.

After preparing the data, models were produced and tested for the case of Norton and the LPS. The models perform LEAST-COST and BUFFER analyses. The LEAST-COST analysis produces a layer that predicts the location of wildlife corridors, and a selection of tax parcels nearest to those corridors, but not near roads. These parcels are desirable for land acquisition. The BUFFER analysis produces layers that predict the potential of wildlife habitats to become fragmented based on their distance from roads and buildings. Each model was configured for use in the geoprocessing pane. They are stored within an ArcGIS Pro Toolbox called *Conservation Tools*.

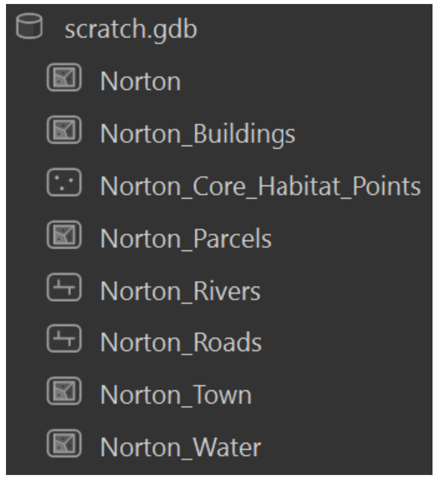


Figure 3: Scratch geodatabase with features classes that pertain to the study area.

4.2 Data Preparation

Each data layer was reprojected to *WGS 1984 Web Mercator (Auxiliary Sphere)* and exported to the *Conservation* geodatabase. Web Mercator was chosen as the projection format for these layers because it is a widely used standard for web maps. All raster datalayers are reclassified from 1 to 10 during model runtime so that they are transformed into the same scale for analysis. Some data layers required further processing before export. The following list includes brief descriptions of the processing that was done to each layer.

<u>BioMap3</u>

The core habitats polygon layer was added to the map from the *BioMap3* geodatabase and exported to the *Conservation* geodatabase with the name *Core_Habitat*. The new *Core_Habitat* layer was added to the map and used to generate center points for each of the core habitat polygons using the *Feature to Point* tool. The resulting layer *Core_Habitat_Points* is used by the PARCEL ACQUISITION model.

Hydrography

The hydrography layer is a grouped layer that contains linear features (rivers and water boundaries), and polygon features (ponds, lakes, wetlands etc.). To store these layers individually in the *Conservation* geodatabase, it was desirable to split this grouped layer into two separate layers: linear features (*Water_Lines*), and water bodies (*Wetlands*). It is important to note that the *Hydrography* layer contains wetland data, and therefore overlaps with the *Wetlands* layer. The *Hydrography* layer contains the line features and wetland polygons.

Landcover / Land Use

The *Landcover / Land Use* layer was downloaded as a polygon feature layer. To be used by the *Land Acquisition* tool, it needed to be transformed into a raster dataset. This was done with the *Feature to Raster* tool and the output was saved to the *Rasters* geodatabase as 'landcover raster'. This layer is used for land acquisition analysis and general map display.

Wetlands

The *Wetlands* layer contains attributes for *Open Water*. The layer was queried to display the *Open Water* features and was exported to the *Conservation* geodatabase as *Open_Water*. This layer contains the lakes, ponds, reservoirs, and large rivers in Massachusetts.

When preprocessing was complete, all feature layers were exported to the *Conservation* geodatabase (Figure 5), and all raster layers were exported to a folder called *Rasters* (Figure 4). This is the data schema that will be seen in ArcGIS Pro by the end user.

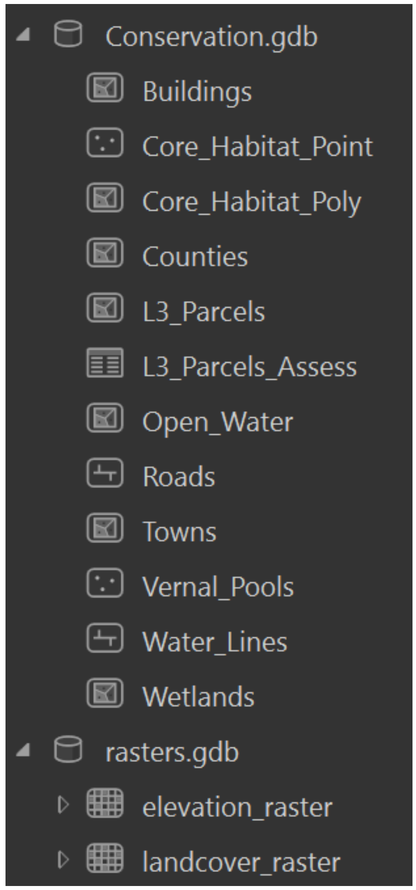


Figure 4: Conservation and rasters geodatabases with the feature classes and rasters used by the models.

4.3 Production of Models

This section describes the creation of conservation models developed in ArcGIS Pro ModelBuilder. The purpose of these models is to help conservation groups make informed decisions about property acquisition in terms of the location of wildlife corridors, and habitat fragmentation potential. The models were configured for use in the geoprocessing window by right clicking the required ModelBuilder nodes and selecting ‘Parameter’. A description of each parameter is provided in the metadata of each tool. The descriptions explain what data is required for the tool to run. The models are named PARCEL ACQUISITION and FRAGMENTATION POTENTIAL.

4.3.1 Parcel Acquisition Model

The PARCEL ACQUISITION model determines which tax parcels in a town are most desirable for acquisition, with respect to preserving wildlife corridors. It performs a least-cost analysis by generating a cost-surface and least-cost paths between points in the *Core_Habitat_Points* layer. ‘Least-cost’ refers to the amount of effort that an entity must expend to travel from point A to point B across a surface. These least-cost paths represent the easiest paths between core habitats, and they can be used to map strips of land that would best serve as wildlife corridors. Parcels that fall within a user-specified search distance from the least-cost paths are selected and exported to a new layer called *Acquisition_Parcels* in the project workspace. *Acquisition_Parcels* may be added to the map and used to determine parcels that are desirable for the purpose of constructing wildlife corridors. Figures 5 and 6 show the input/output data schema, and PARCEL ACQUISITION geoprocessing tool respectively. See Appendix B-1 for a full-sized image of the PARCEL ACQUISITION model.

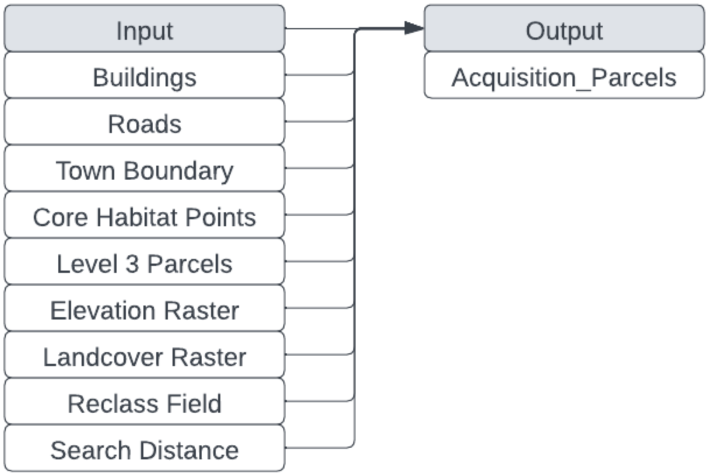


Figure 5: Input/Output schema for the Parcel Acquisition tool.

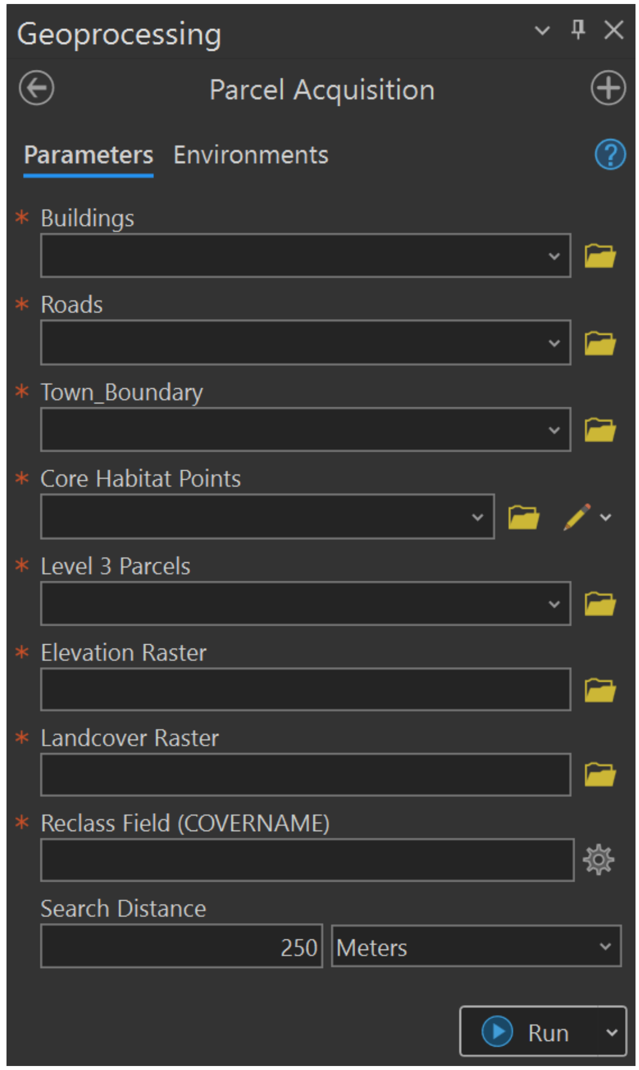


Figure 6: Parcel Acquisition model opened as a tool in the geoprocessing window.

4.3.1.1 Geoprocessing Tools Used by Parcel Acquisition

Clip

The CLIP tool is used to clip *Roads* and *Building_Structures* to a user-defined *Clip_Extent*. The *Clip_Extent* must be an individual town or county from the *Towns* layer. Data is clipped from statewide data layers to an individual town to improve processing speed of the tool.

Euclidean Distance

The EUCLIDEAN DISTANCE tool is used to produce two raster layers that describe the distance from *Roads* and *Building_Structures*.

Rescale by Function

The RESCALE BY FUNCTION tool is used to rescale the distance from roads and buildings raster layers. It is desirable for this analysis to consider distances that are further from roads and buildings as representing a lower cost. For this reason, the distance from roads and buildings raster layers were rescaled from 10 to 1, and not 1 to 10, because distances further from roads and buildings represent a lower cost to the mobility of wildlife.

Reclassify

The RECLASSIFY tool is used to reclassify the *Landcover* raster from 1 to 10. The *Landcover_Raster* contains a field for unique attribute values of landcover type. Desirable landcover types for wildlife corridors (forest, open land etc.) are assigned lower values, which represent a lower cost to the mobility of wildlife. Less desirable landcover types for wildlife corridors (impervious surface, water etc.) are assigned higher values, which represent a higher cost to the mobility of wildlife. Each of the landcover types in this raster are reclassified during tool runtime, and they may be changed by the end user by opening the tool in the ModelBuilder window and selecting new values for the RECLASSIFY tool.

Weighted Sum

The WEIGHTED SUM tool is used to generate a 'cost surface' from the input raster layers. The layers may be weighted based on the importance of each input raster. The cost-surface quantifies the cost of each cell in the raster, with 1 representing a low cost and 10 representing a high cost.

Cost Connectivity

The COST CONNECTIVITY tool is used to connect points in the *Core_Habitat_Points* layer with respect to the cost surface. It draws a path of least resistance over the *Core_Habitat_Points* in the *Clip_Extent*. The result is a line feature called *Core_Connections*.

Select Layer by Location

The SELECT LAYER BY LOCATION tool is used to perform a selection on the *L3_Parcels* layer. Parcels that fall within a user-specified, orthogonal distance from the *Core_Connections* line feature are selected.

Copy Features

The COPY FEATURES tool copies the parcels selected by the *Select Layer by Location* tool to a new geodatabase feature class called *Acquisition_Parcels*.

4.3.2 Habitat Fragmentation Potential Model

The FRAGMENTATION POTENTIAL tool determines which areas have a higher fragmentation potential than others. The *Roads* and *Buildings* layers are merged, and a Euclidean distance and buffer analysis are performed on the merged layer. The result is a gradient, *Frag_Potential*, and a line feature class, *Frag_Distance*. *Frag_Potential* describes habitat fragmentation potential with respect to the location of roads and buildings. Points that are closer to roads and buildings have a lower fragmentation potential because those areas are already developed, and further development would be unlikely to fragment core habitats. Points that are further from roads and buildings have a higher fragmentation potential because those areas are less developed, and development of them would be more likely to fragment core habitats (Lathrop et al., 1998). *Frag_Distance* describes the distance from roads and buildings in 100-meter intervals. *Frag_Potential* and *Frag_Distance* may be added to the map to inform land acquisition by showing areas that are at high risk for habitat fragmentation. Figures 7 and 8 show the input/output data schema, and HABITAT FRAGMENTATION POTENTIAL geoprocessing tool respectively. See Appendix B-2 for a full-sized image of the FRAGMENTATION POTENTIAL model.

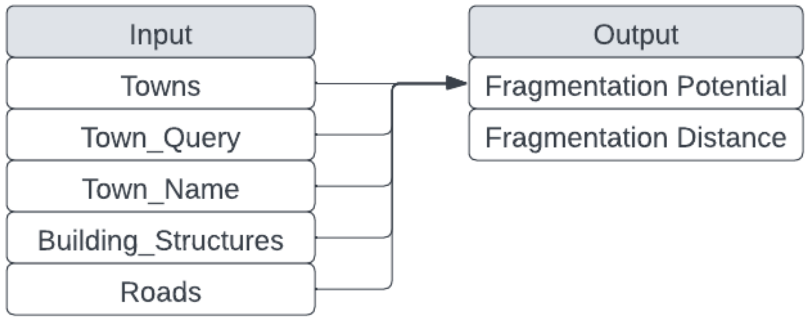


Figure 7: Input/Output schema for the Habitat Fragmentation Potential Tool.

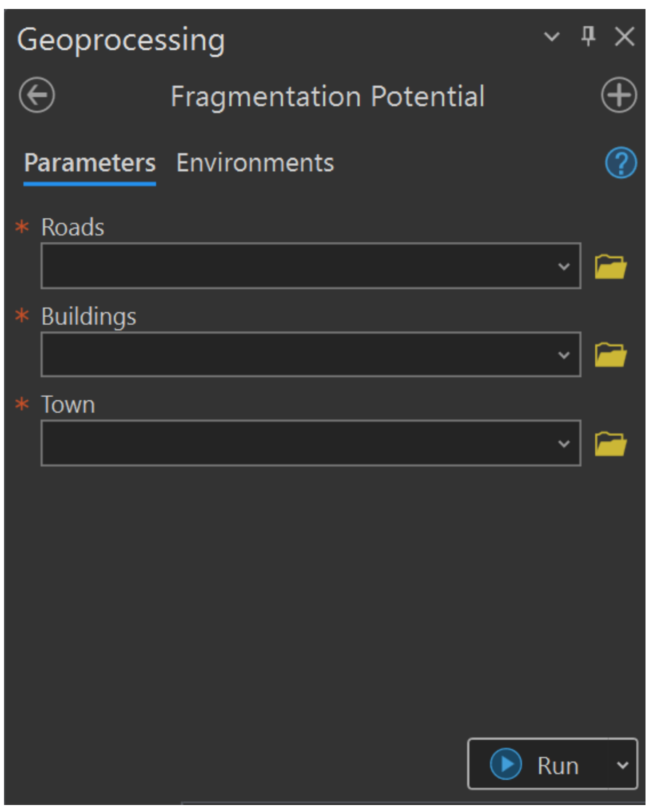


Figure 8: Habitat Fragmentation Potential model opened as a tool in the geoprocessing window.

4.3.2.1 Geoprocessing Tools Used by Fragmentation Potential

<u>Feature Class to Feature Class</u>

The FEATURE CLASS TO FEATURE CLASS tool is used to create a new layer for the desired town. The *Towns* layer is queried to select the town desired for analysis.

<u>Clip</u>

The CLIP tool is used three times in this model. It clips *Buildings*, *Roads*, and *Frag_Distance* to the town queried by the *Feature Class to Feature Class* tool.

<u>Merge</u>

The MERGE tool is used to merge *Buildings* and *Roads* into a single layer.

<u>Multiple Ring Buffer</u>

The MULTIPLE RING BUFFER tool is used to generate a series of buffers around the merged buildings and roads layer. Successive buffers are 100 meters apart.

<u>Polygon to Line</u>

The POLYGON TO LINE tool is used twice in this model. It converts the *Buildings* polygon feature class to a line feature class so that it can be merged with the *Roads* line feature class. It also converts the multiple ring buffer to a line feature class for easier display.

<u>Euclidean Distance</u>

The EUCLIDEAN DISTANCE tool is used to generate a raster layer that symbolizes the distance from roads and buildings with a gradient.

The final products were published to ArcGIS Online and shared with the public. The ArcGIS Online content is hosted through the LPS ArcGIS Online organizational account. This Project Package contains the *Conservation* geodatabase with the data layers, the *Rasters* folder, and the *Conservation Tools* Toolbox. To produce the project package, a new ArcGIS Pro project was created. The *Conservation* geodatabase, *Rasters* folder, and *Conservation Tools* Toolbox were brought into the new project, relevant layers were added to a Map, and the Project Package was produced and uploaded to the LPS ArcGIS Online organizational account. The final products are also available for download individually.

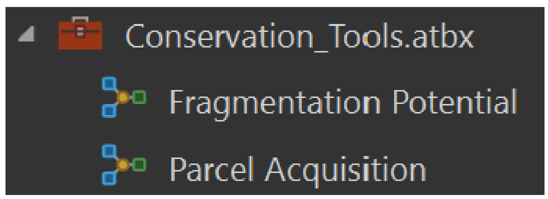


Figure 9: Conservation Tools toolbox.

4.4 Configuration of QuickCapture

A QuickCapture mobile application was configured through the LPS ArcGIS Online account. The purpose of this application is to collect point data in the field to help manage conservation properties by identifying important features on them. A new point feature layer was created in ArcGIS Online and configured to be used with the QuickCapture app. A string field for *Capture* and an attachment field for *Photos* were created in the point feature layer attribute table. Symbology for the *Capture* field was configured in the ArcGIS Online Map Viewer. The features in the *Capture* field of the *QuickCapture Points* layer are broadly categorized into 'Trail Blocks', 'Concerns', and 'Other'. Table 2 lists the types of features within the Capture field that may be collected with the application.

Table 2: Types of features that may be collected with the QuickCapture application.

Trail Blocks	Concerns	Other
Fallen Tree	Vandalism	Rock
Leaning Tree	Ice	Wildlife
Flood	Fire	Vegetation
	Trash/Litter	Vernal Pool
	Hazard	Structure
		Other

A web map was created for use with the QuickCapture application, and contains layers for *Towns, Tax Parcels, LPS Properties, LPS Trails,* and *QuickCapture Points*. This webmap may be referenced in real time through the QuickCapture application. It may also be used after data collection to configure the data points that were collected, and as a reference for decision making. This application was tested on LPS properties.

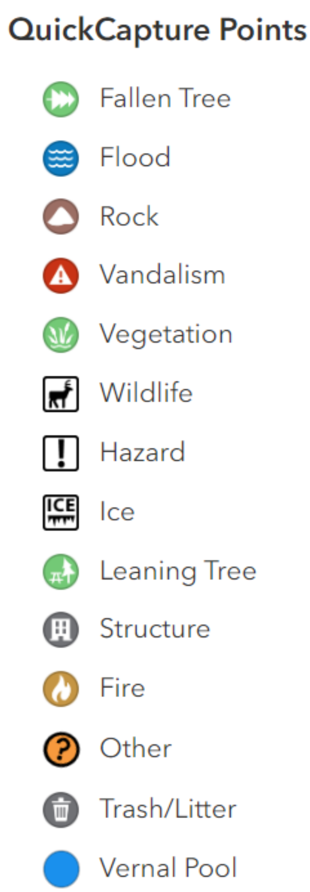


Figure 10: Symbology for QuickCapture Points point layer.

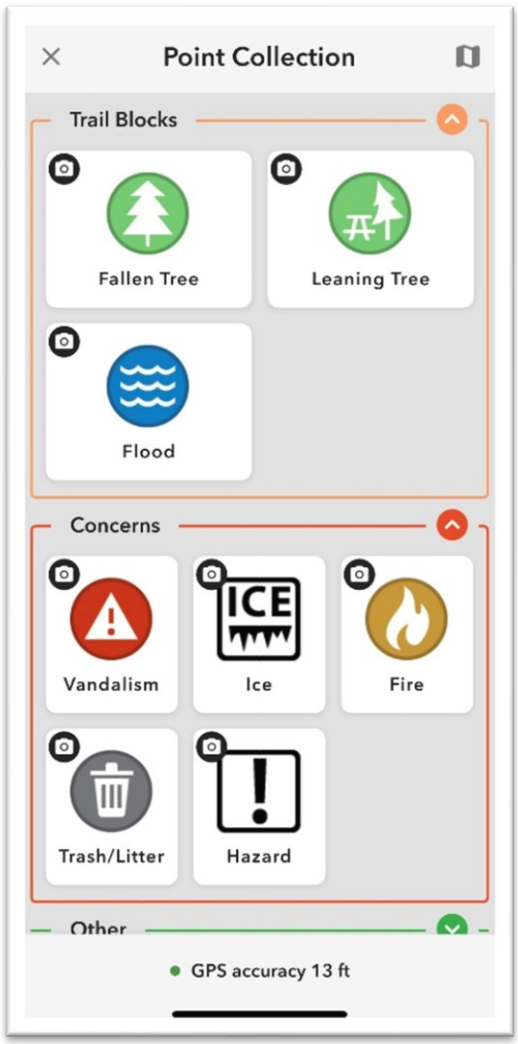


Figure 11: Screenshot of the QuickCapture app as viewed on an iPhone.

4.5 Methods Workflows

ArcGIS Pro Workflows

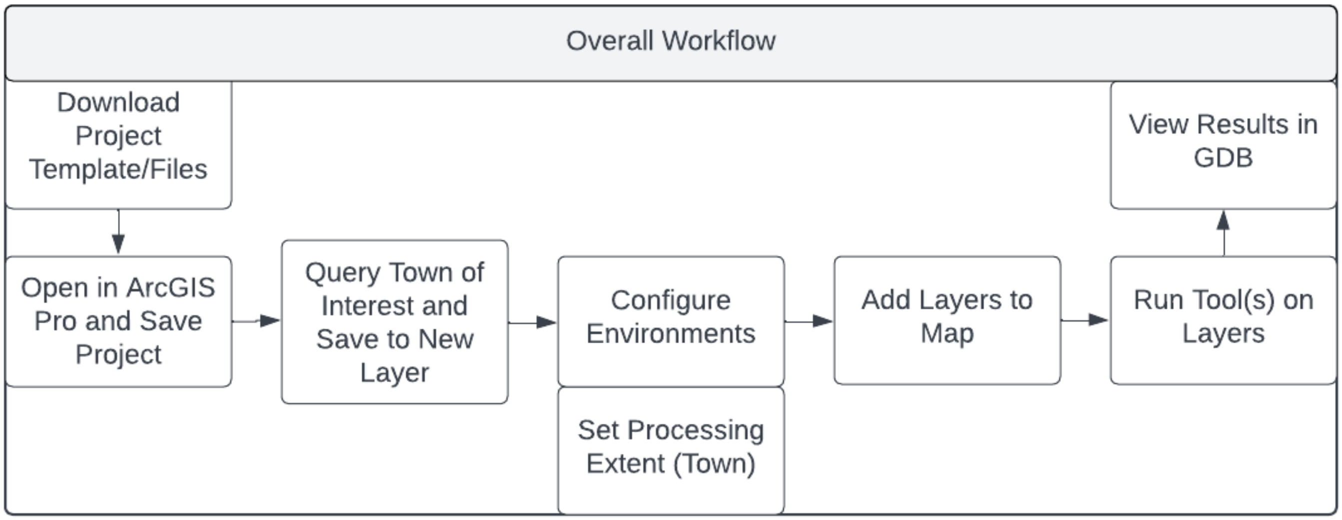


Figure 12: Overall workflow for downloading and using the Conservation Tools toolbox.

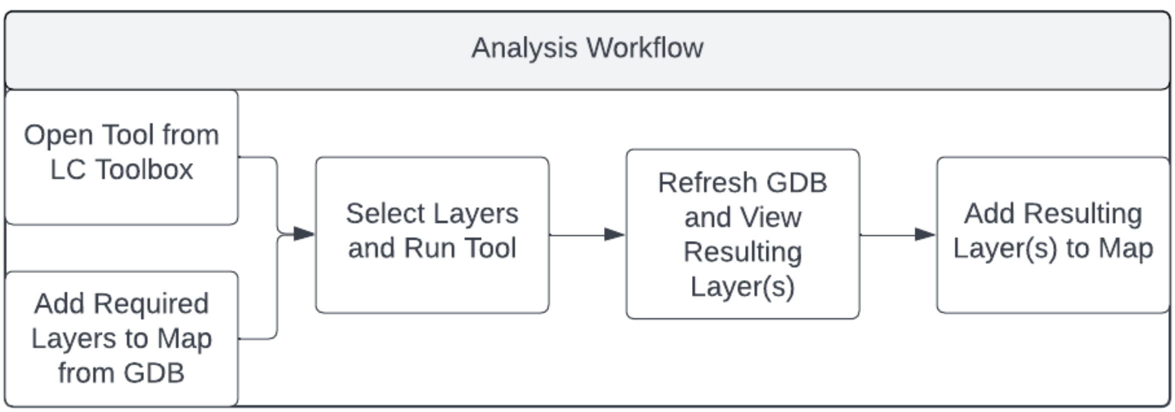


Figure 13: Analysis workflow for using the tools in the Conservation Tools toolbox.

QuickCapture Workflow

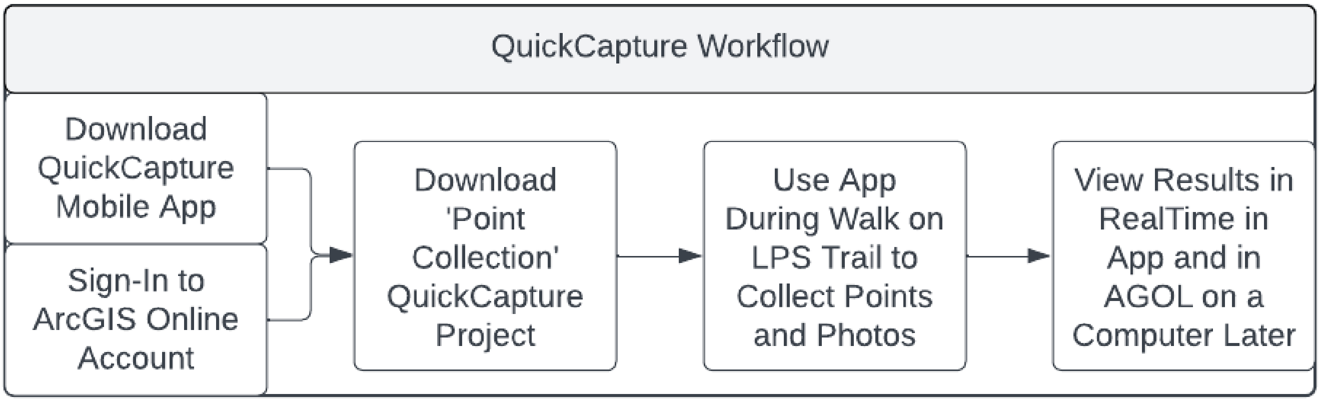


Figure 14: Workflow for using QuickCapture to collect data points and photos.

5 Results

5.1 Results of Study

Sample analyses were conducted using the Town of Norton and LPS land as an example. The results are presented below for each of the tools.

5.1.1 Land Acquisition Analysis

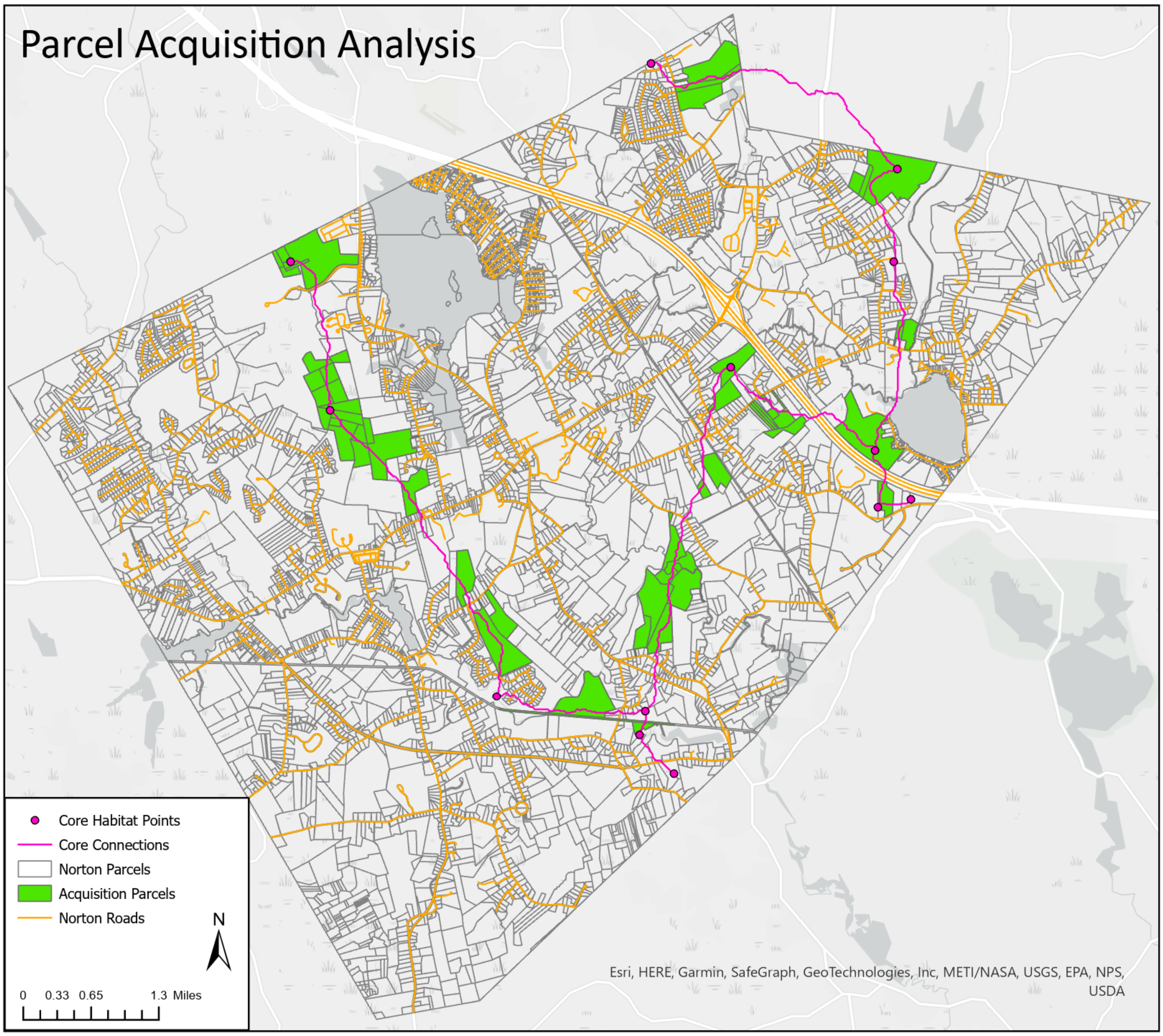


Figure 15: Map showing the results of running the Parcel Acquisition tool for the town of Norton with the default tool inputs.

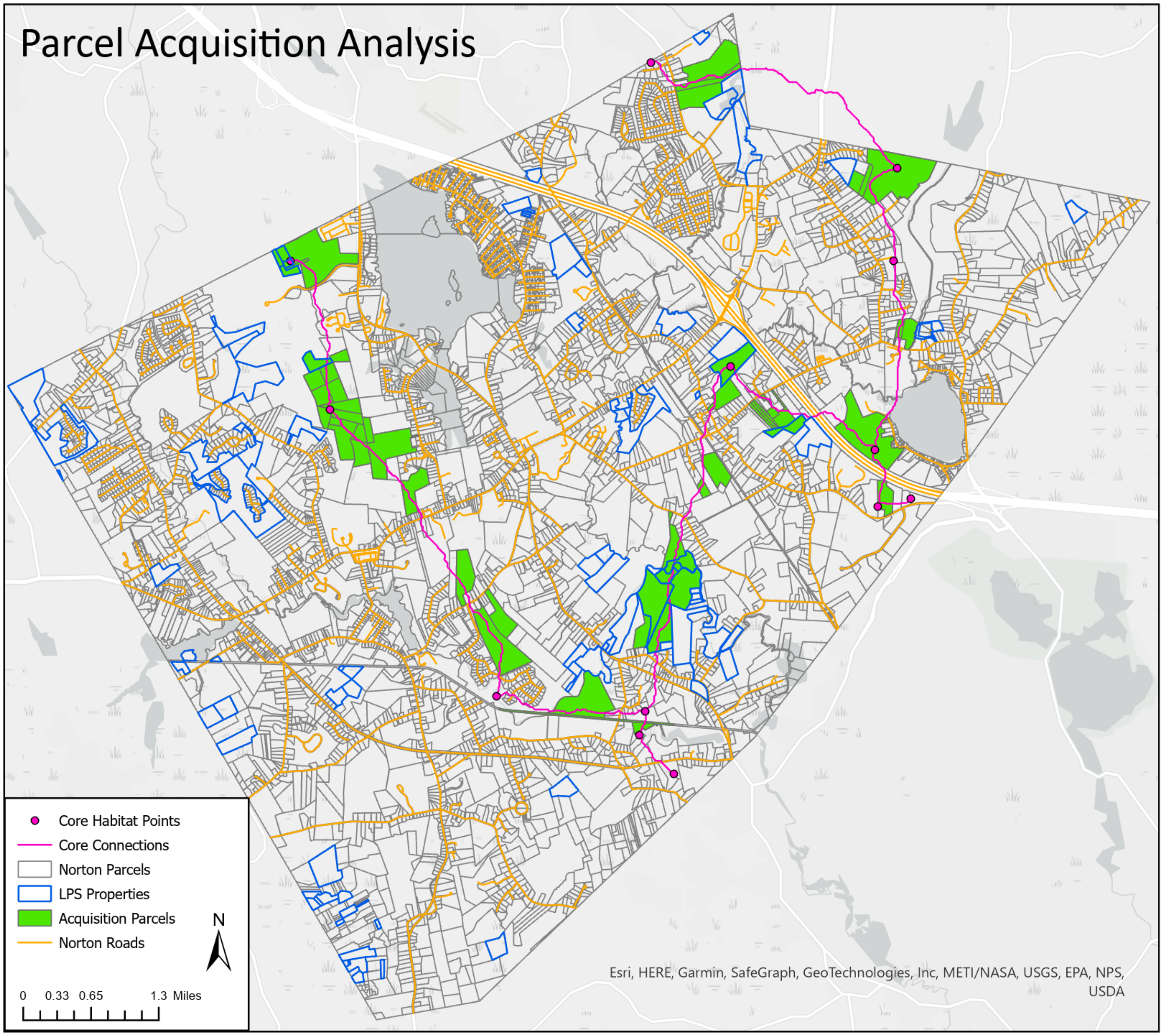


Figure 16: Map showing results of Parcel Acquisition analysis, overlayed with LPS property boundaries.

5.1.2 Habitat Fragmentation Potential Analysis

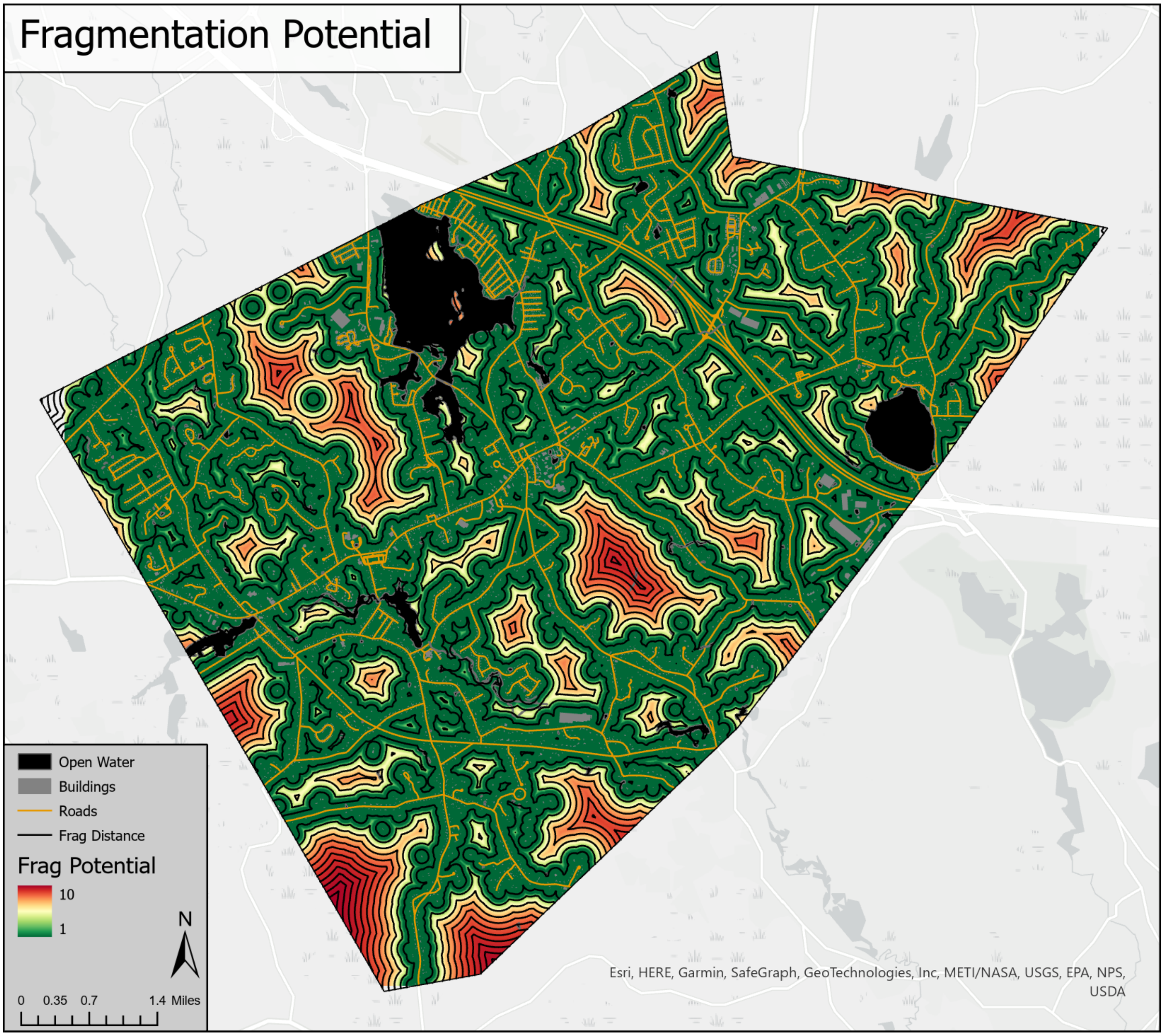


Figure 17: Map showing the results of running the Habitat Fragmentation Potential tool for the town of Norton with the default tool inputs.

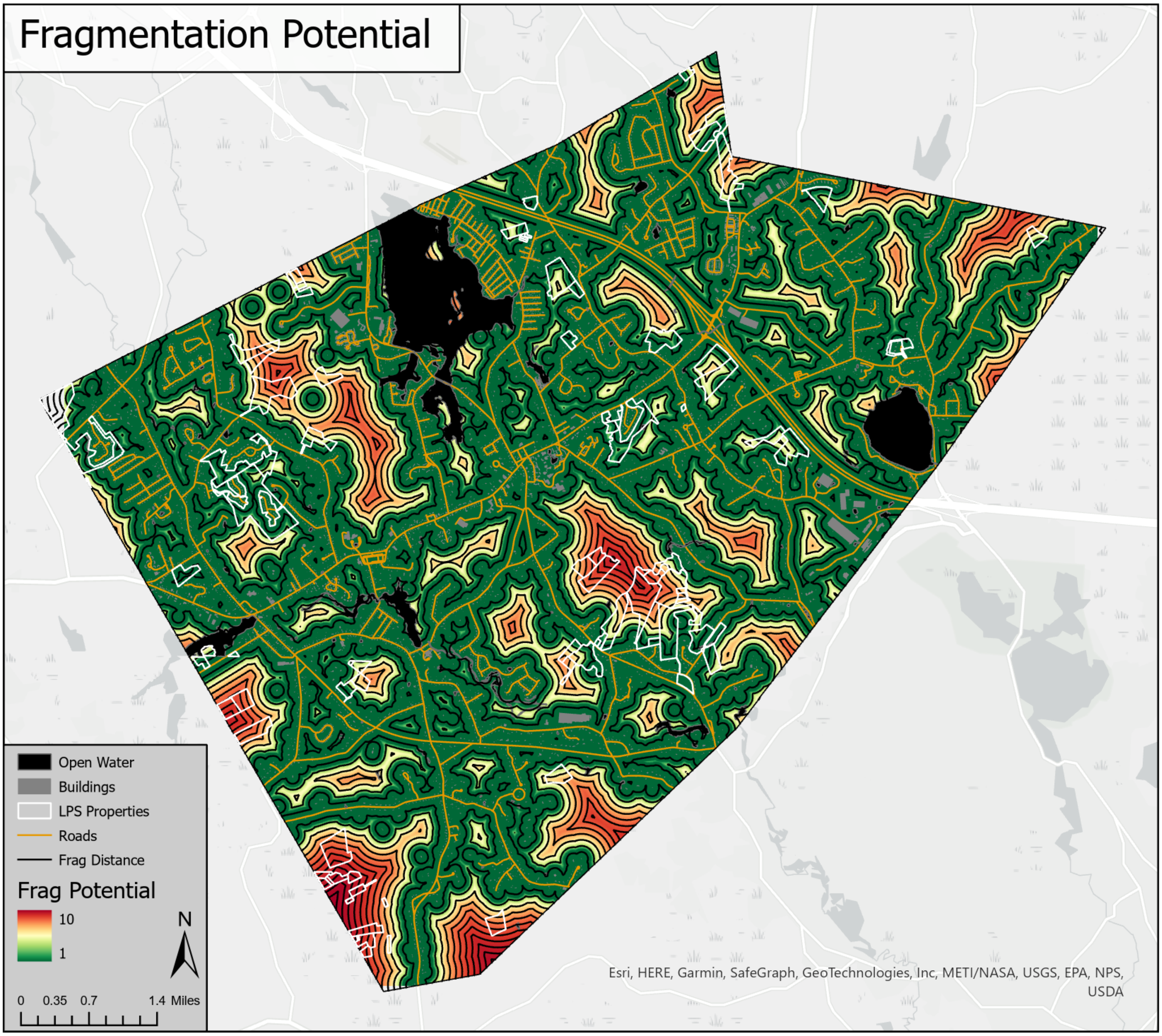


Figure 18: Map showing results of Habitat Fragmentation Potential analysis, overlayed with LPS property boundaries.

5.1.3 QuickCapture Data Point Retrieval

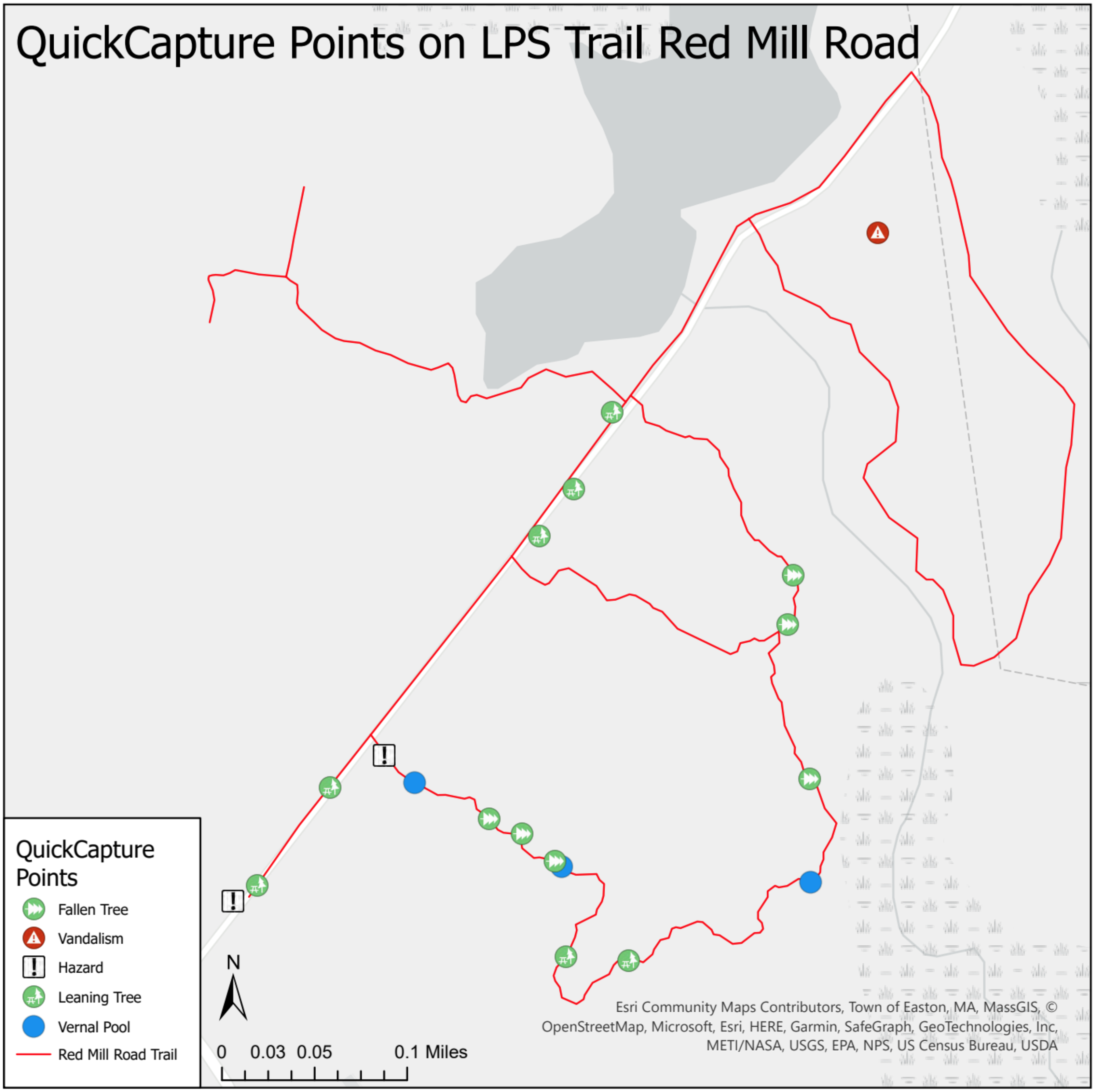


Figure 19: Map showing the results of a sample collection using the QuickCapture app at one of the LPS trail sites.

5.2 ArcGIS Online StoryMap and Final Deliverables

An ArcGIS Online StoryMap provides an overview of this project. The StoryMap reviews the need for small, low-capacity land groups to have access to GIS tools that can make land acquisition and land management easier. It reviews the data that was used in this project, the tools that were made available through this project, example analyses of how to access and use the tools, and what the results of mean.

StoryMap

https://storymaps.arcgis.com/stories/1acc2410f0b0482aa81a561451dd8a90

Massachusetts Conservation Project Package

https://nlps.maps.arcgis.com/home/item.html?id=05b8a562142944918ac4b3070c373dac

Conservation Geodatabase

https://nlps.maps.arcgis.com/home/item.html?id=b03ecb9e56904985a427461202746db7

Rasters Geodatabase

https://nlps.maps.arcgis.com/home/item.html?id=ff058ee2b08841789d9e773703d22bda

5.3 User-Endpoint Data Schema

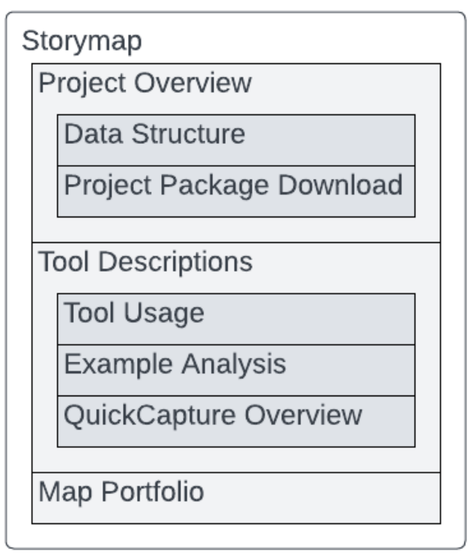


Figure 20: StoryMap data schema available to the end user.

6 Conclusion

6.1 Limitations

The results of the tools and workflows presented in this project demonstrate types of analysis that may be employed by town-level conservation groups to manage their land holdings with relatively little effort. While these tools are designed to be easily modifiable as data and available geoprocessing tools change over time, there are some limitations to what the tools allow the user to accomplish. One limitation to the PARCEL ACQUISITION analysis for example is that the wildlife corridors that are predicted by the model are based on the *Core Habitat Points* layer, which will change over time. The extent of wildlife habitat cores itself changes, so the geographic center depicted by the *Core Habitat Points* will change over time as well, and the connections between them will also change. This may in turn change the parcels that the tool determines to be most desirable for acquisition, and each analysis should be considered with this in mind. It is important for the end user to understand this, so that the model may be ran with the most up-to-date data available.

The FRAGMENTATION POTENTIAL analysis also has a limitation. While the locations of *Roads* and *Buildings* is a good proxy for determining fragmentation potential, they are not the only determiner. Pollution potential is also an important factor that is not accounted for in this analysis. It would be advantageous for this model to include some metric for pollution potential in the future.

6.2 Discussion

The purpose of this study was to develop GIS tools that can be used to assist small land groups. It was discovered that the GIS tools currently available through the MassGIS and MassLand websites do not provide adequate geospatial analysis capabilities for low-capacity groups to manage their land holdings. The tools presented in this project complement the MassGIS tools by allowing the user to perform more substantial spatial analysis and land management with ArcGIS Pro and QuickCapture. In addition, this project presents a method for identifying wildlife corridors. By considering the location of wildlife corridors, the PARCEL ACQUISITION analysis provides a strategic approach to identifying land that is desirable for preservation. The tools are easy to maintain over time and are usable by other land groups, making them robust and scalable. They are also usable by land groups in other states, if they have access to data layers like the ones in the *Conservation* and *Rasters* geodatabases.

Further research in this area should consider the model limitations previously mentioned and seek to minimize them. The development of a tool to work with the point data retrieved from the QuickCapture mobile application would also advance this research. It would be interesting to see the development of a tool that would accept the *QuickCapture Points* layer as an input and generate useful statistics about how those points are distributed among the properties they were collected on. The output of such a tool could be used as a reference to determine which properties are of higher concern than others in terms of managing a particular issue (floods or leaning trees for example). In the future, it would also be advantageous to include a video walkthrough in the StoryMap for completing the presented workflows.

While the limitations of this study may be minimized by future work, this project serves as a starting point for low-capacity land groups to begin implementing geospatial analysis more effectively to manage their land holdings. It is hoped that these tools and workflows are used by groups like LPS to make better-informed decisions regarding land acquisition and strategic land management.

Appendices

Appendix A: Full-Size Models

Description of Model Colors

- Turquoise bubbles stand for parameter from variable. This is a parameter that is derived from the tool it is connected to, and allows the user to specify an input other than the default value.

- Light Blue bubbles stand for an output that is not a layer (i.e. numerical value).

- Blue bubbles are inputs.

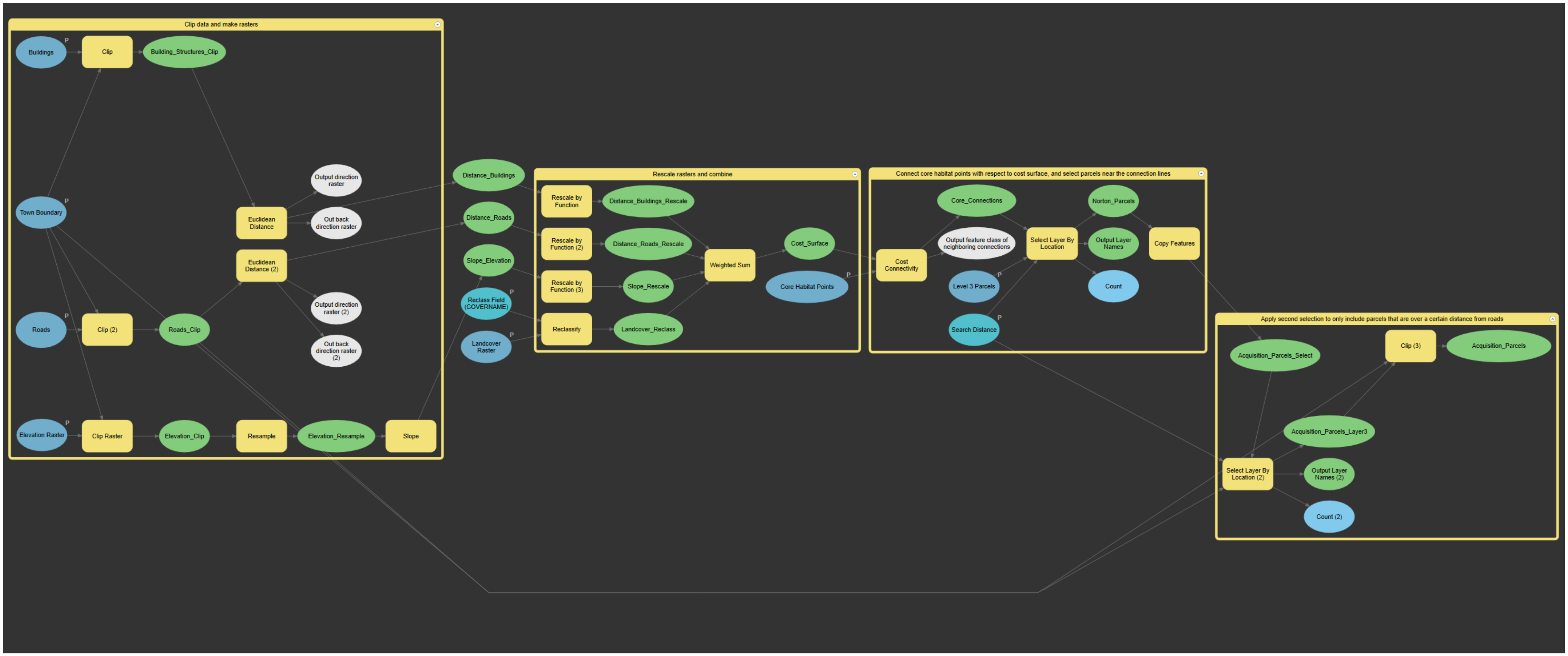
- Yellow bubbles are geoprocessing tools.

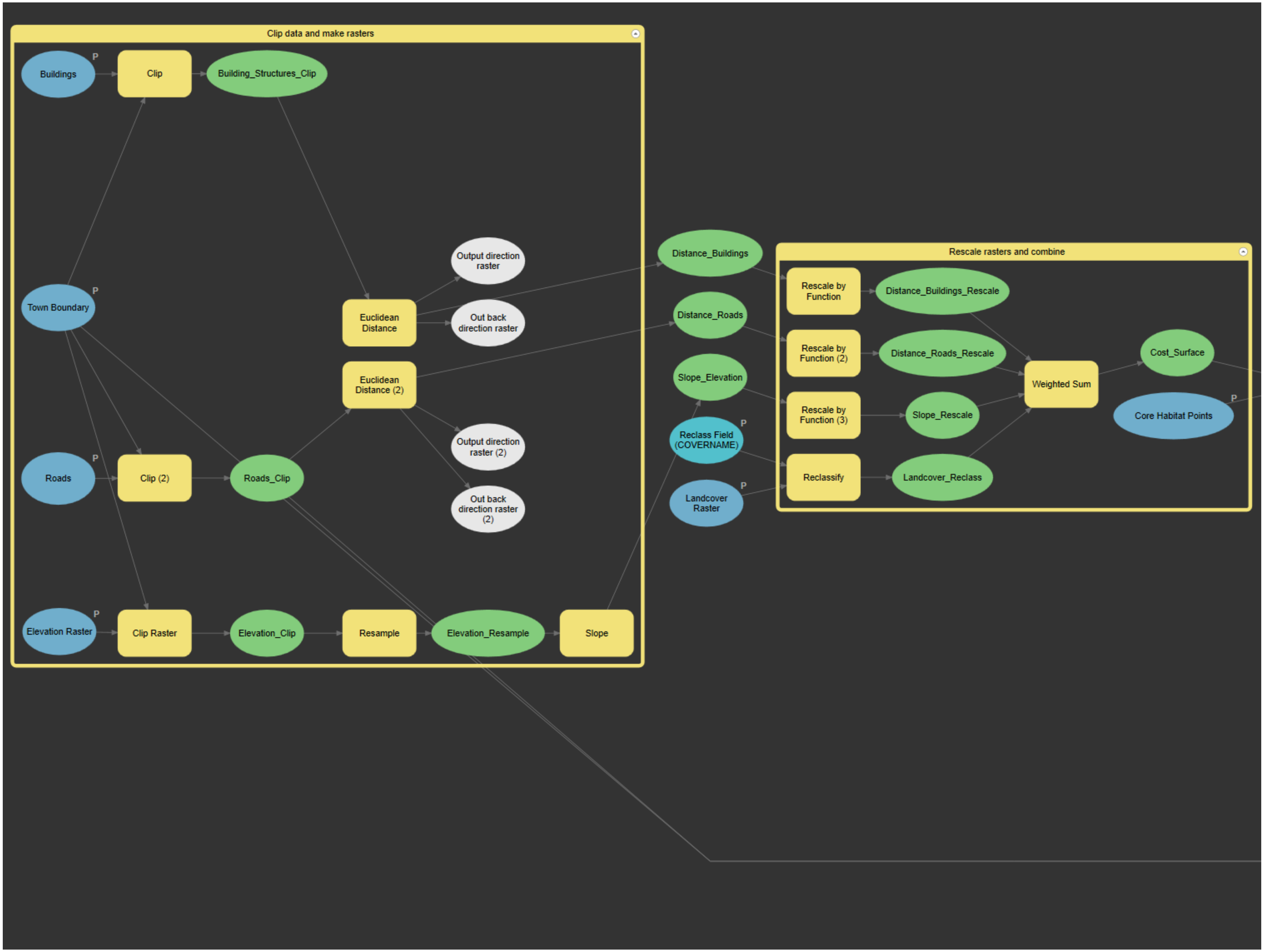
- Green bubbles are outputs.

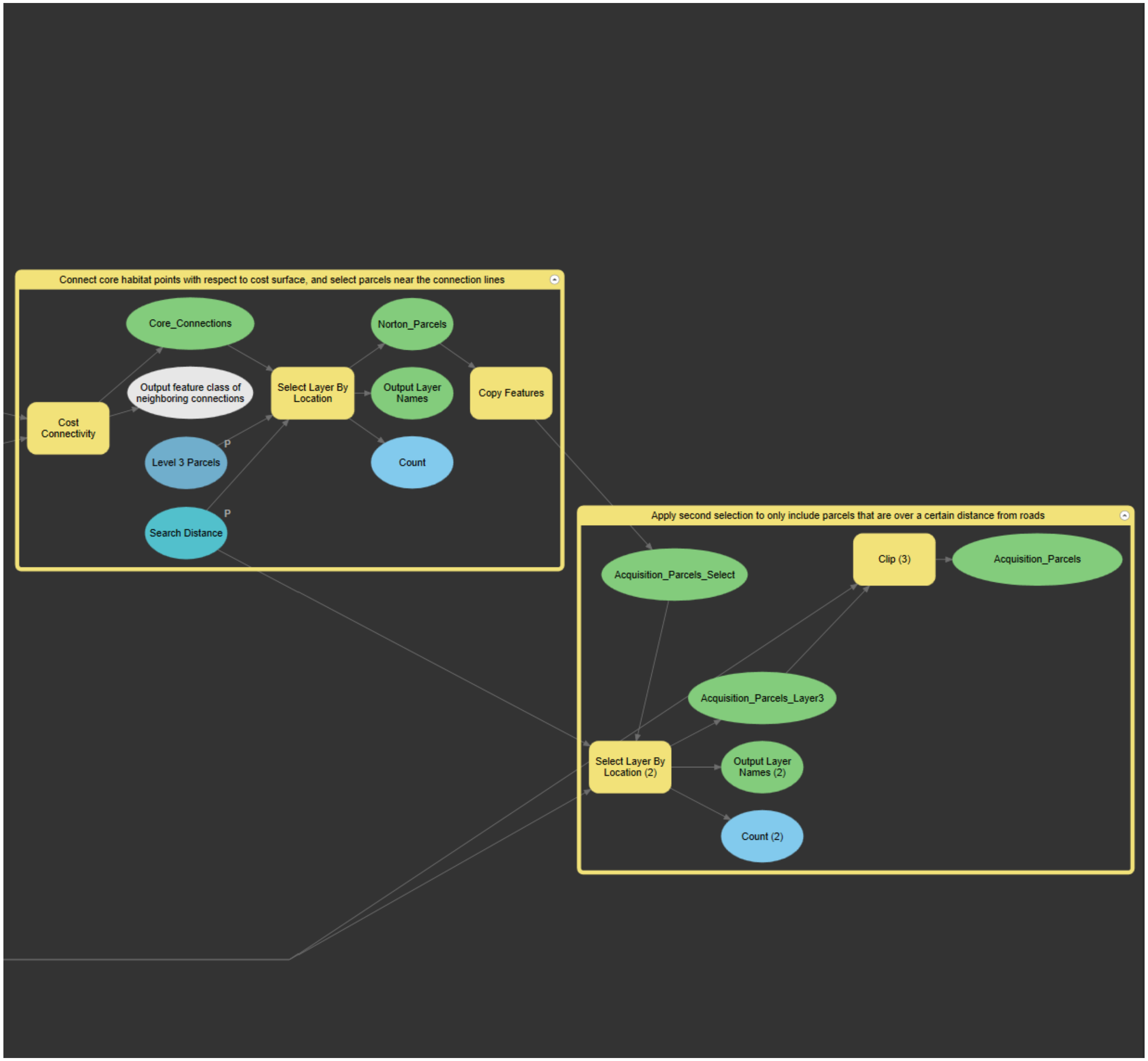
- Grey bubbles are optional outputs that are not generated.

- P stands for parameter. Inputs a P next to it will show as a parameter when the model is opened in the geoprocessing pane

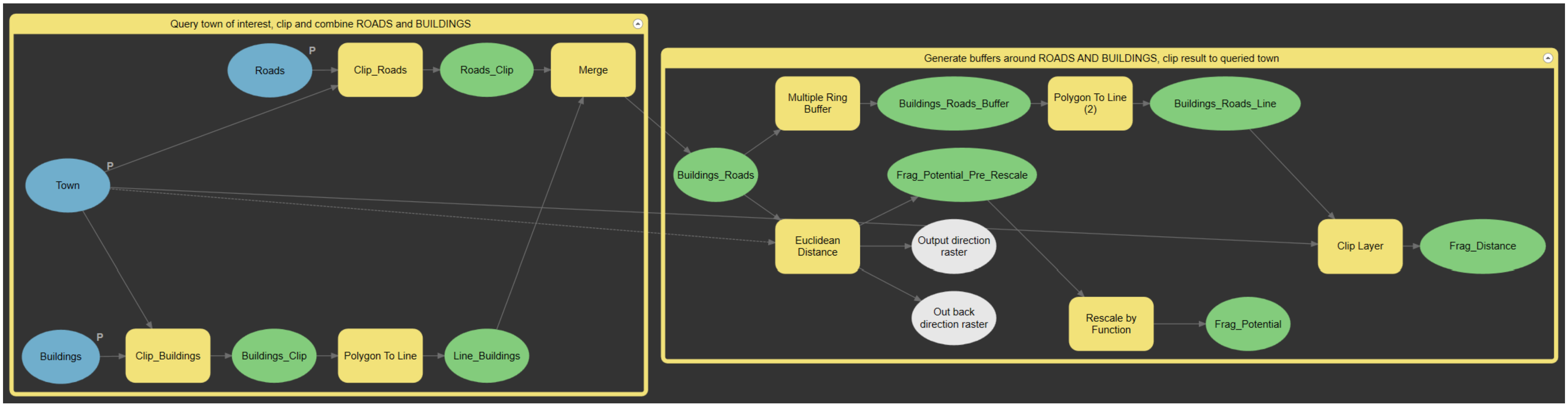
1. Parcel Acquisition Model




Clip data and make rasters
Buildings
P
Clip
Building_Structures_Clip
Town Boundary
P
Output direction raster
Euclidean Distance
Out back direction raster
Euclidean Distance (2)
Output direction raster (2)
Out back direction raster (2)
Roads
P
Clip (2)
Roads_Clip
Elevation Raster
P
Clip Raster
Elevation_Clip
Resample
Elevation_Resample
Slope
Distance_Buildings
Distance_Roads
Slope_Elevation
Reclass Field (COVERNAME)
P
Landcover Raster
P
Rescale rasters and combine
Rescale by Function
Distance_Buildings_Rescale
Rescale by Function (2)
Distance_Roads_Rescale
Rescale by Function (3)
Slope_Rescale
Reclassify
Landcover_Reclass
Weighted Sum
Cost_Surface
Core Habitat Points
P


Connect core habitat points with respect to cost surface, and select parcels near the connection lines
Core_Connections
Norton_Parcels
Output feature class of neighboring connections
Select Layer By Location
Output Layer Names
Copy Features
Cost Connectivity
Level 3 Parcels
Count
Search Distance
Apply second selection to only include parcels that are over a certain distance from roads
Clip (3)
Acquisition_Parcels
Acquisition_Parcels_Select
Acquisition_Parcels_Layer3
Select Layer By Location (2)
Output Layer Names (2)
Count (2)

2. Habitat Fragmentation Potential Model



Appendix B: Terms and Definitions

GIS Terms as Defined by ESRI

ArcGIS StoryMap – ArcGIS StoryMaps is a story authoring web-based application that allows you to share your maps in the context of narrative text and other multimedia content.

ArcGIS QuickCapture – ArcGIS QuickCapture is a field data capture app that allows you to capture data quickly. You can capture both the location and attributes of assets or incidents as you travel.

Buffer – A zone around a map feature measured in units of distance or time.

Feature Class – homogeneous collections of common features, each having the same spatial representation, such as points, lines, or polygons, and a common set of attribute columns

Feature Layer – A feature layer is a grouping of similar geographic features, for example, buildings, parcels, cities, roads, and store locations.

Geoprocessing – Geoprocessing is the processing of geographic information, one of the basic functions of a geographic information system (GIS).

Least-Cost Path – The least-cost path travels from the destination to the source. This path is one cell wide, travels from the destination to the source, and is guaranteed to be the cheapest route relative to the cost units defined by the original cost raster that was input into the weighted-distance tool.

Raster – In its simplest form, a raster consists of a matrix of pixels (or cells) organized into rows and columns (or a grid) in which each pixel contains a value representing information, such as image reflectance or temperature.

Other Terms

Fragmentation Potential – Habitat fragmentation is defined as the process during which a large expanse of habitat is transformed into (several) smaller patches of smaller total area isolated from each other by a matrix of habitats unlike the original (Fahrig, 2003)

Wildlife Corridor – a strip of natural habitat connecting populations of wildlife otherwise separated by cultivated land, roads, etc.

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- Conine, A., Xiang, W. N., Young, J., & Whitley, D. (2004). Planning for multi-purpose greenways in Concord, North Carolina. Landscape and urban planning, 68(2-3), 271-287.

- Jackson, H. B., & Fahrig, L. (2013). Habitat loss and fragmentation.

Data

- MassGIS

  Bureau of Geographic Information (MassGIS), Commonwealth of Massachusetts, Executive Office of Technology and Security Services
  https://www.mass.gov/info-details/massgis-data-layers

- BioMap3
  NHESP/TNC BioMap
  https://www.mass.gov/info-details/massgis-data-biomap-the-future-of-conservation

Websites

- Massachusetts Land Trust Coalition (MassLand)

  https://massland.org/

- Massachusetts Audubon Society MAPPR Tool

  https://www.massaudubon.org/our-conservation-work/policy-advocacy/local-climate-resilient-communities/mappr-project/mappr-tool

ESRI Documentation for Geoprocessing Tools Used in Models

- Buffer
- Clip
- Copy Features
- Cost Connectivity
- Euclidean Distance
- Feature Class to Feature Class
- Merge
- Multiple Ring Buffer
- Polygon to Line
- Reclassify
- Rescale by Function
- Select Layer by Location
- Weighted Sum