Farmland Prioritization Plan
for Bainbridge Island, Washington

Capstone Project

University of Washington's
Professional Masters Program for GIS and Sustainability Management
Geography 569 – GIS Workshop

by Scott Stcherbinine and Bryan Palmer
August 2013

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List of Acronyms

FOF – Friends of the Farms

BILT – Bainbridge Island Land Trust

COBI – City of Bainbridge Island

GIS – Geographical Information Systems

LTA – Land Trust Alliance

Acknowledgements

I. Introduction

Background

Bainbridge Island is an island-city located near the Kitsap Peninsula in the southern Puget Sound region of Washington State and is accessible by both bridge and ferry as shown in Map 1. Like most areas of Kitsap County, Bainbridge Island has been experiencing significant residential growth. Many acres of historic farmlands have been lost in recent decades' (FOF 2010). Bainbridge Island has a rich farming history dating back over 100 years and for many Bainbridge Island residents the loss of farmland is synonymous with the loss of the island's culture and identity. Friends of the Farms (FOF), a non-profit organization located on the island spawned with the intent of protecting existing farmland, has identified the "availability of land for commercial and community farming as the primary need to ensure the viability of local food production on Bainbridge Island" (FOF 2010). The ''local food movement' has increased the appreciation and demand for local foods with residents. This desire to consume locally grown food and protect existing farmland has led to a militia of volunteers willing to support FOF and their ambitions.

Study Area Bainbridge Island, WA

Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet
Projection: Lambert Conformal Conic
Data Sources: USGS NAIP 2011 orthophotos; City of Bainbridge Island GIS Department, WA

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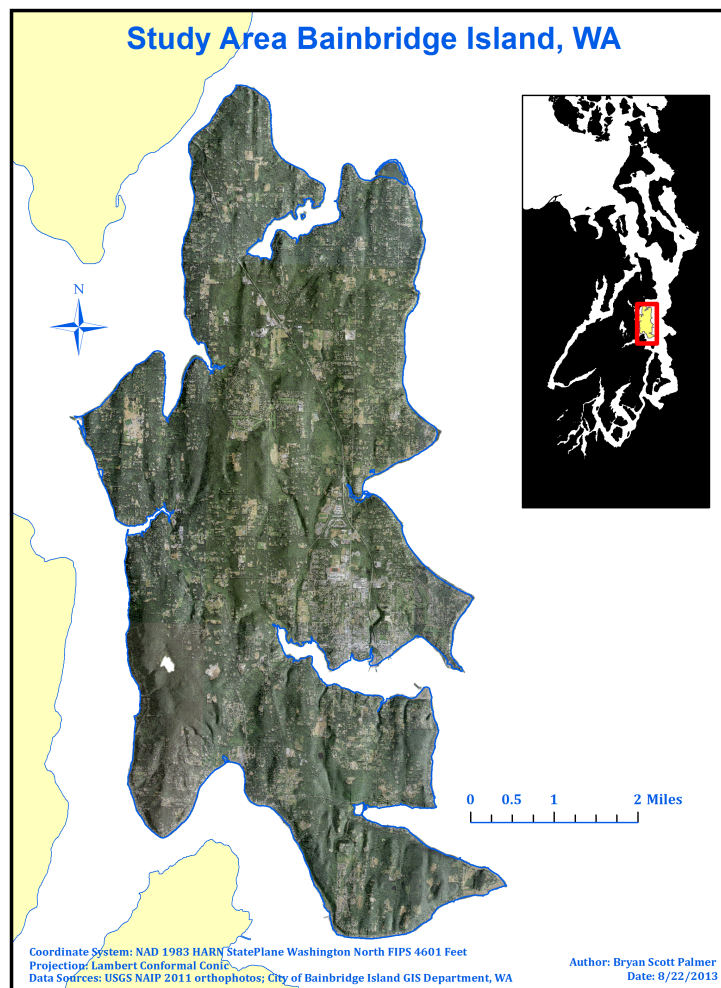
Map 1 – Study Area

Access to affordable land is the most experienced challenge for farmers on the island. Even with the existing social and natural infrastructures developed over the last century, the success of local farmers and farmland is declining due to two main reasons; the high

cost of real estate on Bainbridge Island and urban fringe encroachment caused by development. Bainbridge Island's farm loss trends are proportionally parallel to that of the rest of Kitsap County as a whole, losing over 180 acres of undeveloped/unprotected land every year for the last 15 years (Carr 2012).

There are a number of reasons that Bainbridge Island farmlands are worth protecting and committing time to developing protection strategies for. The combination of existing farming infrastructure paired with a legion of local food and farm enthusiasts make Bainbridge Island the ideal setting for stewarding the next generation of farmers. Bainbridge Island has the most concentrated areas of agricultural activities in Kitsap County with 10 farming areas on the island including NE Bainbridge, Manzanita, Day, Island Center, Battle Point, High School Road, Rolling Bay, Sportsman, Lynwood Center and Eagle Harbor. Within these ten areas forty-six farm businesses and nine properties all claim agricultural property tax status. Soils on Bainbridge are predominantly all prime for agricultural uses, while some are more fertile than others. All farmland needs to be irrigated so access to water is a major primary concern. Bainbridge Island has an adequate number of accessible water-wells. The density of large-scale agricultural activities occurring on Bainbridge Island are higher than other areas of Kitsap County; however, Bainbridge has the fewest number of documented agricultural support sites in the county (Kitsap County Assessor 2010). This demonstrates its resilience as a farming community.

This capstone project has been devoted to working closely with FOF to create an ArcGIS File Geodatabase consisting of current and potential farmland parcels ranked for their protection priority and potential future farming feasibility. This product will be used as a tool for educating partnering agencies as well as the public on farmland community needs and trends occurring on the island. This product will also be used to create supporting maps and arguments for grant funding applications. As graduate students studying GIS and Sustainability Management we have the technological capabilities to take the ideas of FOF and turn them into reality. Creating an inventory of current land being farmed as well as future potential farmable land and open space are necessary pieces for FOF to possess before they can reach the goals programmed in their 5-Year Strategic Plan.

Friends of the Farms

Friends of the Farms (FOF) was the primary sponsor for this project and the point-person representing them was FOF past president, past board member, and current active member Christi Carr. FOF is a non-profit agency located on Bainbridge Island that consists primarily of volunteers divided up between a board of directors, an executive committee of officers, 5 specialized committees and one part time employee acting as the FOF executive director. The 5 specialized committees consist of the Projects Committee, the Outreach Committee, the Agricultural Lands Committee, the Site Committee, and the Finance Committee. This project was inspired and initiated through the Agricultural Lands committee by Christi Carr and Bart Berg.

The mission of FOF is to 'Preserve and Enhance Local Farming' and their primary goal is to 'Ensure availability of land for sustainable commercial and community farming' (FOF 2010). FOF partners up with other various local agencies including the City of Bainbridge Island (COBI), the Bainbridge Island Land Trust, Kitsap County, Kitsap Conservation District, Bainbridge Island Metropolitan Parks and Recreation District, Bainbridge Island Housing Resources Board, Kitsap Community Agriculture Alliance and Bainbridge Island School District. Understanding the dynamics of FOF's internal and external workflow was a key component to the process of this project. Determining how these workflows function was essential for deciding where our capstone project would fit into their workflow.

FOF currently holds a five year contract with the City of Bainbridge Island to manage City-owned agricultural lands. These farmlands are used as public farmlands and are intended to provide access for farmers to raise crops on land with affordable leasing prices, increase community awareness of and access to city agricultural lands, repair and upkeep structures on these agricultural lands, conduct basic land maintenance, develop cooperative neighbor relations, educate youth, conduct outreach and steward a new generation of local citizens interested in farming.

The current focus of Friends of the Farms is to increase the acreage of permanently protected farmland on Bainbridge Island. In order to do this, they need to know what farmland is available presently and might be in the future. FOF is aware of the capabilities

of a Geographic Information System, but lacks the technological experience or the budget to explore its potential. FOF made the decision to partner with University of Washington and create a potential capstone project for graduate students in the Professional Master's Program in GIS and Sustainability Management.

Supporting Agencies Background
Bainbridge Island Land Trust

Bainbridge Island Land Trust is a state private nonprofit corporation whose mission is 'to preserve and steward the diverse natural environment of Bainbridge Island for the benefit of all' (Bainbridge 2012). To achieve this goal, the Bainbridge Island Land Trust acquires interests in land having significant or potentially significant conservation values such as scenic vistas, forestlands, wetlands, open spaces, tidelands, unique plant and animal habitats, agricultural lands, trails, open spaces, shorelines, riparian corridors, streams and wildlife corridors (Bainbridge 2012). Almost all current BILT owned lands and easements are predominantly forested. BILT is able to acquire land, and create easements by working with private landowners and using land protection agreements called conservation easements. BILT also partners with a variety of agencies to acquire and protect lands for more active uses like parks, trails and land that can be utilized by the public. Data provided to us by BILT for this project consisted of a file geodatabase titled by them, UW Capstone.gdb.

BILT reports that 'there is a moderate percentage (17.8%) but high acreage (2,798 acres) of agricultural soils that remain 'Undeveloped & Unprotected''. A large percentage and a large amount of acreage have already received some level of protection. A large portion of agricultural soils that are unprotected are currently covered by forestlands, which could present BILT with the dilemma of choosing to protect one resource over another. Soil typing data, based on farming suitability and productivity analysis, shows a significant amount of agricultural soils are expected to require either drainage or irrigation in order to be highly productive, which could also present BILT with a dilemma regarding water resources.

City of Bainbridge Island

The City of Bainbridge Island owns 60 acres of what is considered to be public farmland. Five farms exist on these 60 acres including the Johnson Farm, M+E Property, Crawford Property, Morales Farm and Suyematsu-Bentryn Farm at Day Road. The city purchased these lands with the hopes of providing healthy, local food for its residents and to continue what they believe to be a viable livelihood for both present and future island farmers. The land is currently leased to Friends of the Farms through a 5-year contract. FOF manages and maintains these 60 acres of public farmland as part of this contract. The farmland is then sub-leased to farmers. FOF also dedicates time to community efforts including education, farmland improvement projects, and mentoring apprentice farmers. FOF participates in monthly work parties and farm walks. Data provided to us by COBI for this project came in the form of a folder of shapefiles titled by them 'Farm Data Request'.

Kitsap County

Until recently Bainbridge Island was a part of unincorporated Kitsap County. Since Bainbridge Island was part of unincorporated county for so long, Kitsap County's GIS department has a good amount of GIS data for Bainbridge Island. Data provided to us by Kitsap County for this project came in the form of us downloading spatial data on-line from Kitsap County's GIS department data download.

Project Purpose and Objectives

Friends of the Farms, a non-profit organization composed of local agriculture enthusiasts was formed as a reaction to Bainbridge Island losing open space and farmland at a rapid rate due to development. Friends of the Farms connected with the University of Washington in hopes to utilize the technical skills of graduate students with a focus on GIS and sustainability management to create product for them that will inventory and prioritize current and future potential farmable land. The product being created will serve as an invaluable tool for generating supporting documents to be included in grant writing applications and other educational purposes. Being that FOF are a non-profit agency, most of the money they receive finds them through the grant writing process.

Project objectives include the creation of a file geodatabase containing appropriate spatial and non-spatial data files for agricultural farmland assessment on Bainbridge Island. Within this geodatabase, feature datasets will be created, where individual feature classes will be kept. We will also create a single dataset containing a cohesive current inventory of both publicly and privately owned open space and farmland and a protection prioritization score chart highlighting our scoring criteria for agricultural land characteristics. We will also create a prioritization plan, highlighting protection priority for the dataset of current publicly and privately owned farmland and open space, and provide the sponsor a bulleted list of guidelines for storing, managing, and updating the geodatabase we are creating for them.

One of our preliminary tasks was to create a comprehensive farmland and open space inventory of Bainbridge Island. The GIS workflow for this project incorporates devising an inventory of these parcels as well as including land characteristics for them such as soil, geohazards, and water sources. An initial prioritization of properties will be conducted using the GIS database and spatial analysis capabilities. The GIS work will also provide visual tools (maps) of existing and potential future farmland properties that will be very useful to the organization in education and outreach efforts related to farmland protection.

Out of Scope

During our many interactions with sponsors and supporting agencies many great ideas came to the surface about how to make this analysis as productive as possible. Due to unavoidable constraints such as time and money, some of these great ideas were forced to dwell outside of our scope of work for this capstone project. Areas of analysis that were out of scope included specific water rights data, recently developed lands, land use change, or planned future land developments.

Organization (FOF) Benefits

Numerous benefits to the FOF organization were apparent before this project began with other benefits being discovered along the way. The organization will gain its own private inventory of farmland that they can utilize as an extremely valuable tool for farmland protection efforts. The maps and data generated from the project will be used in

grant funding applications. The information will assist the organization in its prioritization efforts for farmland protection and, as importantly, provide essential foundational information. One benefit that became apparent was the possibility to build on this work. Each cohort graduating from the University of Washington's GIS and Sustainability Management program must complete capstone projects. Many of these projects are built upon work completed by past cohorts. This project could be used as a foundation for future capstone projects and expanded upon to incorporate current data or items that were deemed out of scope for this project.

Student Benefits

Numerous benefits to the students became evident while completing this project as well. Working with a small non-profit agency on an agricultural land management project was a great opportunity to get an insider's perspective into how bottom up land planning and management functions in a real world situation. Working with local agencies gives students the opportunity to see how city, county and non-profits work together, and form partnerships. Students also gained direct experience in determining positive agricultural land characteristics. This was accomplished by working closely with FOF representatives and local farmers. Students worked closely with sponsors in creating valid weighting criteria for evaluating agricultural farmland characteristics. One unique benefit realized was that this type of work is largely unprecedented in this region especially considering that the work being done is on the city scale and on an island. Students were given the opportunity to essentially run their own ship for this pilot study in terms of how we created the desired products articulated by FOF. The work done can be used as a template for other small organizations that have a need for farmland inventory and protection strategies. The work done could also be expanded on to incorporate Kitsap County or the Puget Sound region as a whole.

II. Design Considerations

Sustainability Management/Resilience thinking

There are a number of obvious reasons validating why this project fits well under the umbrella of sustainability management. The protection of open space is crucial during these times of high development trends. Development often means increased hardscape and impervious surfaces, equaling higher rates of urban heat island effects like increased energy use, elevated emissions of air pollutants and greenhouse gases, and impaired water quality. The overarching pressures to conduct farming in a sustainable manner make the adverse affects of cultivating agricultural lands practically non-existent. Consuming locally grown foods means less fossil fuel spent on transporting agricultural products and far less preservatives being used to keep tomatoes red for months at a time.

There are also a number of veiled reasons that further validate why this project fits well under the umbrella of sustainability management. One example is knowledge of water well proximity to parcels being transformed to agricultural lands. Choosing to cultivate new farmland near existing water wells will cut costs, but also limit adverse environmental effects while constructing new farmland infrastructure. Pumping water for irrigation often include the construction of underground piping systems. Piping materials often needs to be transported to site and machines are often used for trenching and backfilling, both relying on the use of fossil fuels. The same could be said about creating new farmland in proximity to any existing infrastructure. The more existing resources that can be utilized the less that will have to be constructed. Irrigation is essential to productive farming. All soils on Bainbridge Island are prime for agricultural purposes; however, some contain more water than others. Knowing where the dry soils are located helps the selection process to choosing appropriate sites for drip irrigation systems which conserve far more water than traditional rotor or spray irrigation systems.

Scales

Focal Scale

The geographical focal scale of this project is Bainbridge Island. There is a possibility that the work being done by FOF could expand to the mainland and begin advocating for farmland protection and future farmer stewardship programs across Kitsap County. The model created for FOF has the potential to be used on a larger scale if this expansion

occurs. If this is the case it is very possible that FOF will have more employees, ideally one of which possessing GIS capabilities.

Temporal Scale

The geodatabase and .mxd set created for FOF will be used over the next one to five years to create maps that will be used in grant applications. Maps created will assist greatly in graphically displaying parcels of interest and the land characteristics that accompany them. The current contract that FOF holds with the City of Bainbridge Island is a five year contract with the potential to be extended.

Organizational Scale

Friends of the Farms approached the University of Washington with a proposal to have graduate students assist in the creation of a farmland inventory and prioritization plan for Bainbridge Island as their capstone project. As students we selected our top three choices from a list of potential capstone projects. Professors then matched students up with their selections as best they could.

Alternative Design Methodologies / Literature Review
Dane County, Wisconsin

It was suggested by both our professors as well as our sponsors that we review a Land Information Bulletin put out by the Land Information and Computer Graphics Facility at the University of Wisconsin-Madison, titled Farmland Preservation and GIS, A Model for Deriving Farmland Priority Zones. The geographical scale of this case study was Dane County, Wisconsin where 3,000 farms produce a variety of agricultural products. There were many similarities between this project and what we were trying to accomplish with ours. Both areas have very rich farming histories and fear losing their cultural identity just as much as they fear losing valued open space and losing the privilege of having locally grown food. After dissecting the process they went through in Dane County, we were able to extract valuable information on how to prioritize existing farmland for our project. We referenced this bulletin frequently when selecting which feature classes were appropriate for the various proximity analyses that we planned to conduct.

Creating farmland priority zones, like those in the Dane county project, made less sense for our project for a number of reasons. The difference in geographical extents was the first discrepancy between scopes that we noticed. Bainbridge Island measures only 3.5 miles wide by 10 miles long, and existing farmland forms a patchwork across the island rather than occurring in clusters like the farmland of Dane County. Clustering of farmland occurred in Dane County largely due to its ridge and valley terrain and high variation of adequate agricultural soil deposits, left during the last glaciation. Another major difference between the two projects is the scale of farming occurring. Most products grown on Dane County farmland are grown on a commercial scale for export, where most products grown on Bainbridge Island are grown on a more local scale for local consumption.

Friends of the Farms 5-Year Strategic Plan

The FOF wrote a 5-Year Strategic Plan as a means to prioritize their work over the 5-year contract that they hold with COBI to manage city-owned farmland. Their primary goal is to ensure the availability of land for sustainable commercial and community farming. Primary objectives include providing contractual and/or lease management of public or private working lands, developing a network between private land owners interested in promoting agricultural activities on their property and farming, provide consulting services such as feasibility studies, strategic planning, and other expert advice regarding management of commercial and community farms, and lastly seeking property ownership. This plan also spells out in detail the FOF governance organization and organization development goals, staff operations, marketing strategies financial management plans and partnerships. FOF partnerships include Bainbridge Island Metropolitan Parks and Recreation District, Bainbridge Island Land Trust, Housing Resources Board, Kitsap Conservation District, Kitsap Economic Development Alliance, Bainbridge Island School District, Kitsap Community & Agriculture Alliance, The Bainbridge Island Grange, Global Source Education and Sound Food (FOF 2010).

Kitsap County Strategic Agricultural Plan and Inventory

This strategic plan was created as a reaction to the counties resident's strong connection with farmlands and the other natural environments that surround Kitsap

County. A $25,000 grant from the Washington State Conservation Commission of Kitsap County was provided to assist in the efforts of putting this strategic plan together. Findings of this plan include that land available for agricultural uses has been shrinking, farms have grown in number but reduced in size over the last 100 years, economies of scale have been lost for farms as their sizes and the number of farmers reduced, sources of support for farmland preservation and the local food system are well-known throughout the community, new farmers, including youth, are important to the long-term growth of farming in Kitsap county, increased technical assistance opportunities are needed for farm management and other food system sectors, small farms can provide nutritious products and services tailored to the growing local community food system, and lastly farms can increase the value of their products through modest value-added processing. The authors of this plan recognize that their situation is commonplace. Farmland is disappearing across the nation. Multiple strategies were reviewed including the varying transfer of development rights programs existing in King, Thurston and Snohomish counties. The plan goes into detail about the positive and negative aspects of all three programs. The number one noted strategy in this is to expand Comprehensive Plan policies and development regulations regarding local farming and food including adopting a right to farm ordinance, refocusing the transfer of development rights program and the review of other regulatory reform like selling and processing product on-site (Kitsap 2011).

Bainbridge Island Land Trust Conservation Plan

This plan was devised as a reaction to the diminishing supply of conservation lands on Bainbridge Island. The purpose of the Conservation Plan is to bring more strategic focus to BILT's conservation efforts, and to identify BILT's potential conservation priorities for the next five to ten years. In this plan resource priorities are identified bas on a list of criteria. Agricultural soils are considered to be a resource. After gathering data on agricultural soils it was discovered that agricultural soils cover 90.3% of Bainbridge Island acres, baseline regulatory protections are absent, and surprisingly it states that ecosystem health is irrelevant. BILT is in the initial stages of developing a framework for agricultural easements that may help guide future expansion and protection of working landscape, many agricultural soils exist in areas with forest resources and other habitat types.

Conservation of some areas for active agricultural use may result is the conversion of habitat to agricultural use creating a debatable situation. In this plan BILT lists the Friends of the Farms as a potential partner for farm preservation and agricultural land management (Bainbridge Island Land Trust 2012).
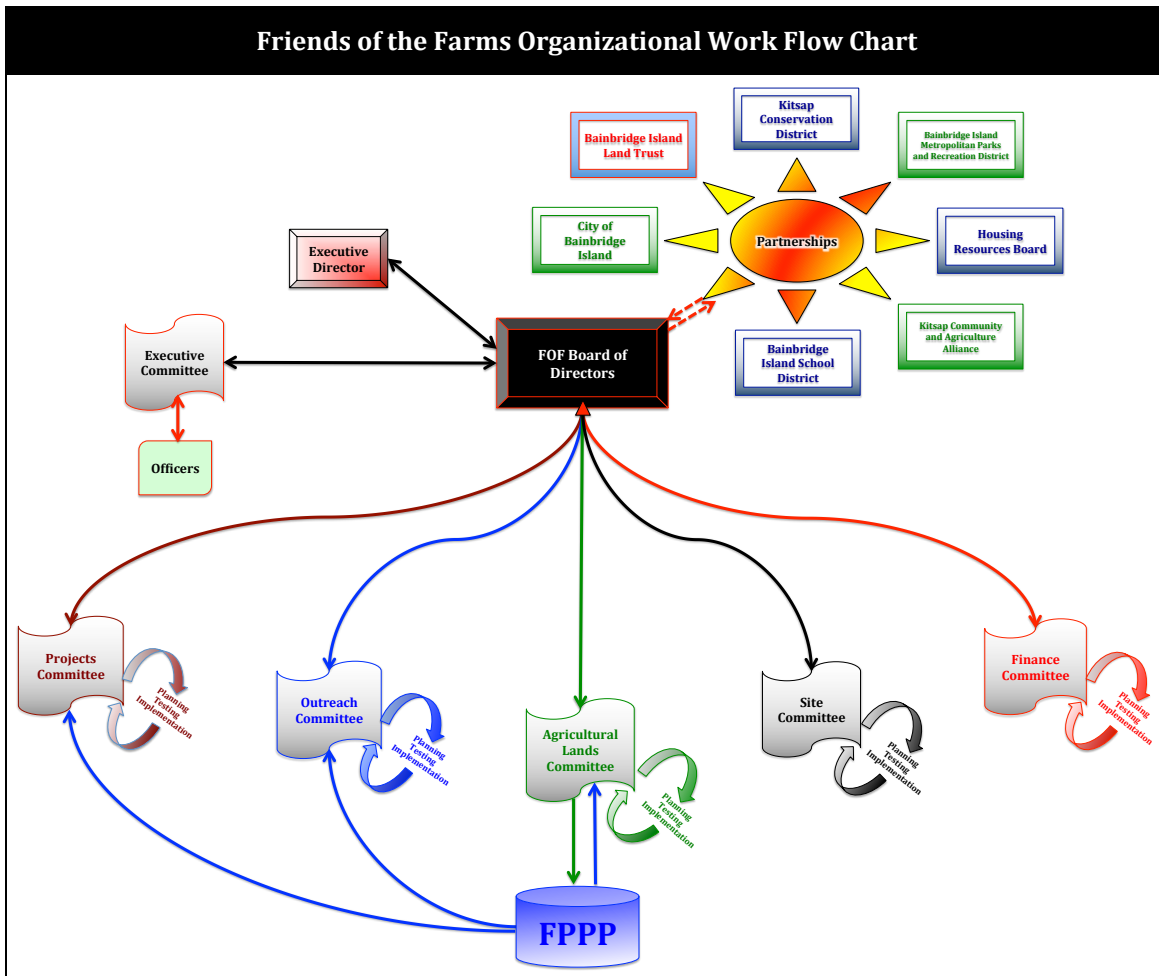

Figure 1 – Friends of the Farm Organizational Workflow

III. Workflows

Friends of the Farms Organizational Workflow

In the PMPGIS program at the University of Washington the building of workflows is an important part of the curriculum. Before any project begins a workflow model of some sort should be drafted. As the project continues it is important to have steps that iterate to

improve the project building process. In week seven of the Farmland Prioritization Plan Project we had a long discussion with our sponsor, Christy Carr, about their organizational workflow. We gave our sponsor an insight into our program and decided to develop a general workflow template that illustrated the Friends of the Farm organizational workflow. The end result was presented to our sponsor, and she felt it was a very accurate portrayal of their organization. It was gratifying to see that as we complete our capstone project that we now have mastered the workflow creation process. See Figure 1. It was interesting to take note on how our workflow for this project will end up creating a tool, which in the end will expand the organizational workflow for Friends of the Farm.

Farmland Prioritization Plan for Bainbridge Island Workflow

Our capstone project workflow spans a nine-week time period from initial project design considerations to the final products including a geodatabase, many predefined ArcMap files (.mxds), a PowerPoint presentation, and a capstone white paper (Farmland Prioritization Plan for Bainbridge Island) as shown in Figure 2. In the first week of our workflow we conducted a broad base literature review including various organizational reports from the City of Bainbridge Island, the Bainbridge Island Land Trust, Kitsap County, and the Friends of the Farm. In the first three weeks of the workflow we initiated a few site visits to farms to survey the geographical context and to the Saturday morning Bainbridge Island Farmer's Market to comprehend the unique farming culture of our project. In week three we met with our sponsor for a guided tour and extensive question and answer session discussing the intended products of our Farmland Prioritization Plan for Bainbridge Island. In the meeting we discussed the various criteria that would influence the final scores in our analysis. Friends of Farms furnished us with contact information for GIS data retrieval. GIS Data was collected from Gretchen Brown at the City of Bainbridge Island GIS Department, Brenda Padgham at the Bainbridge Island Land Trust, and the Kitsap County GIS Department towards the end week 4. We accepted an invitation to attend the next Friends of the Farm Agricultural Committee meeting and agreed to give a small presentation on the merits of a proximity analysis in week four. Shortly after concluding our presentation at the Agricultural Lands Committee we were able to obtain feedback on our preliminary scoring process suggestions for our multi-criteria analysis. Week four also
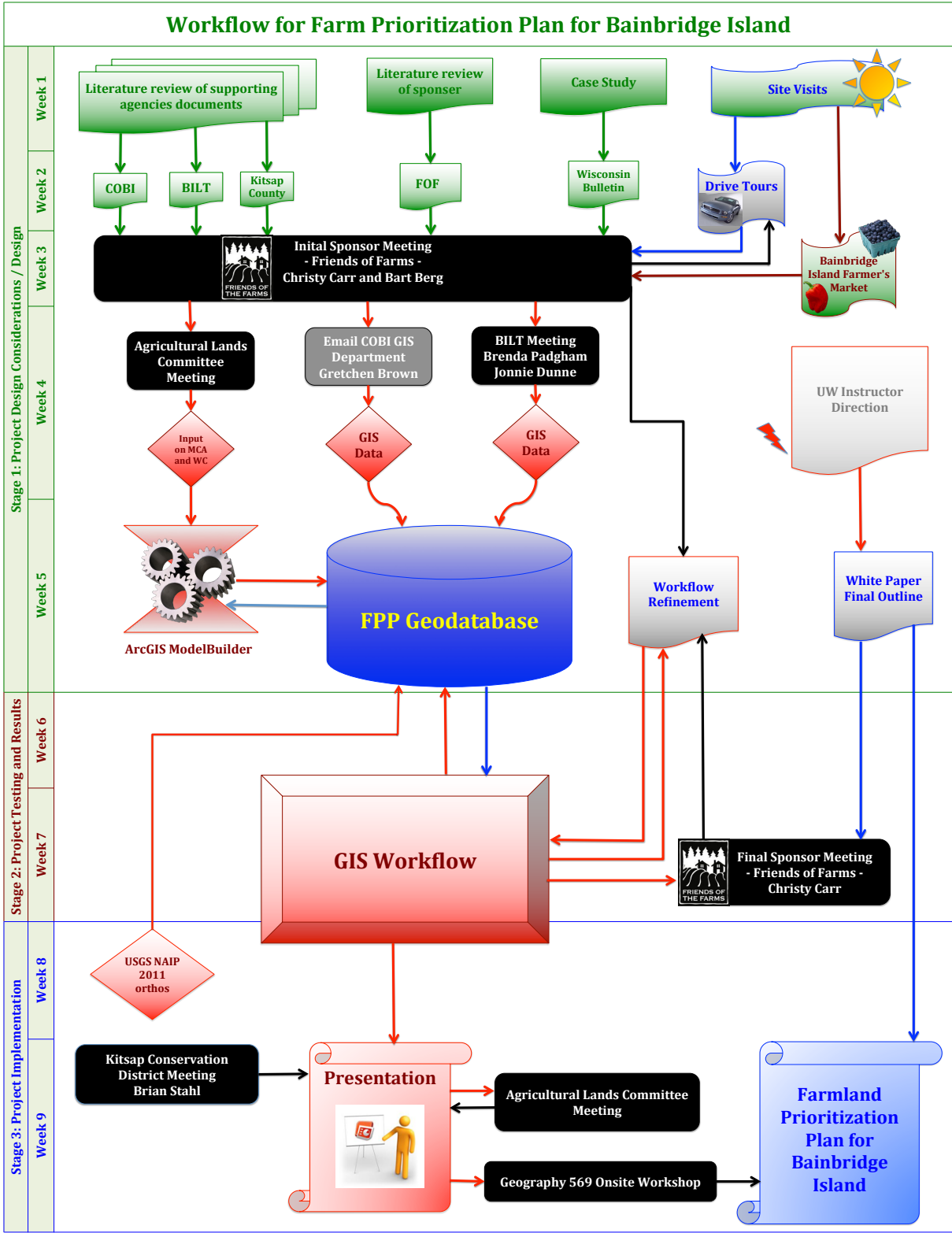
Figure 2 – Workflow for Farm Prioritization Plan for Bainbridge Island

included an evaluation from our Geography-569 course instructors on our capstone project. This evaluation helped guide our endeavors on finalizing an acceptable project workflow. During week 5 we created a working Farmland Prioritization Plan Project geodatabase for all GIS datasets received. During this process we shaped and organized our datasets to meet our future designed geoprocessing workflow plans. A final outline for capstone project paper was completed. This ended the first stage of our workflow process, Stage 1: Project Design Considerations/Design.

In week 6 we started the second stage of our project workflow, Stage 2: Project Testing and Results. The GIS workflow started to take shape from its initial design. It expanded significantly as we started the many geoprocessing operations on the newly acquired GIS datasets residing in the geodatabase. All major geoprocessing operation's products were stored in the geodatabase. Some check-step operations were excluded such as minor raster and intermediate polygon proofing. It was during this week that our testing revealed the limitations of our computers with the software we were utilizing, ArcGIS 10.1. Some of our initially designed near proximity analyses from the ArcToolbox proved to be too taxing on the CPU for our computer and resulted in incomplete or failed empty datasets. This was due to an ArcToolbox tool near proximity analysis between the farmland datasets and the Bainbridge Island datasets trying to create a matrix of 11,000 by a few hundred. We instituted a design change that replaced the ArcToolbox tool near proximity analyses with basic buffer and multi-ring buffer analyses along with the addition of various select by location methods. During the testing phase we confirmed our original scoring suggestions of our multi-criteria analysis with our sponsor Christy Carr in a final meeting. In this meeting we discussed our concern with the need for orthophotos to complete the designed remote sensing analysis for finding open-space parcels. Unfortunately, all of the supporting agencies of the GIS datasets were unable to supply us with a current set of orthophotos of Bainbridge Island due to special licensing requirements. This led to great disappointment, frustration, and a source of great concern for the project authors during week 6.

During stage three, Stage 3: Project Implementation, the project authors were informed by their peers in a week 8 Cohort 2013 Meeting that we research and obtain free orthophotos from U.S. Geological Survey (USGS) online if available. After the week 8 Cohort 2013 Meeting, National Agriculture Imagery Program (NAIP) orthophotos from 2011 were

discovered and downloaded from a USGS website link. Although it was very late in our project timeline and the orthophotos were 2 years old, the authors of this project decided to revise the GIS Workflow with one last refinement. It was also decided to initiate and complete a remote sensing survey in search of open-spaced parcels to add-to and enhance our farmland dataset into a better-quality farmland and open space dataset. We completed our final steps to our GIS workflow by running the multi-criteria analysis, tabulating the resulting scores, and then totaling the results in a final prioritization list. After the analysis was complete we had a meeting with Brian Stahl at the Kitsap Conservation District (KCD). Brian Stahl provided us with PDFs of 2002 and 2013 parcel farmland maps. After georeferencing these PDF maps in ArcGIS we were able to compare our results to the 2013 KCD comprehensive proprietary farms parcel dataset. It turns out for the most part our analysis was successful even with our incomplete tax farm parcel dataset from COBI and our added remote sensing analysis to discover farmable open-space land.

Farmland 2002 - 2013 Bainbridge Island
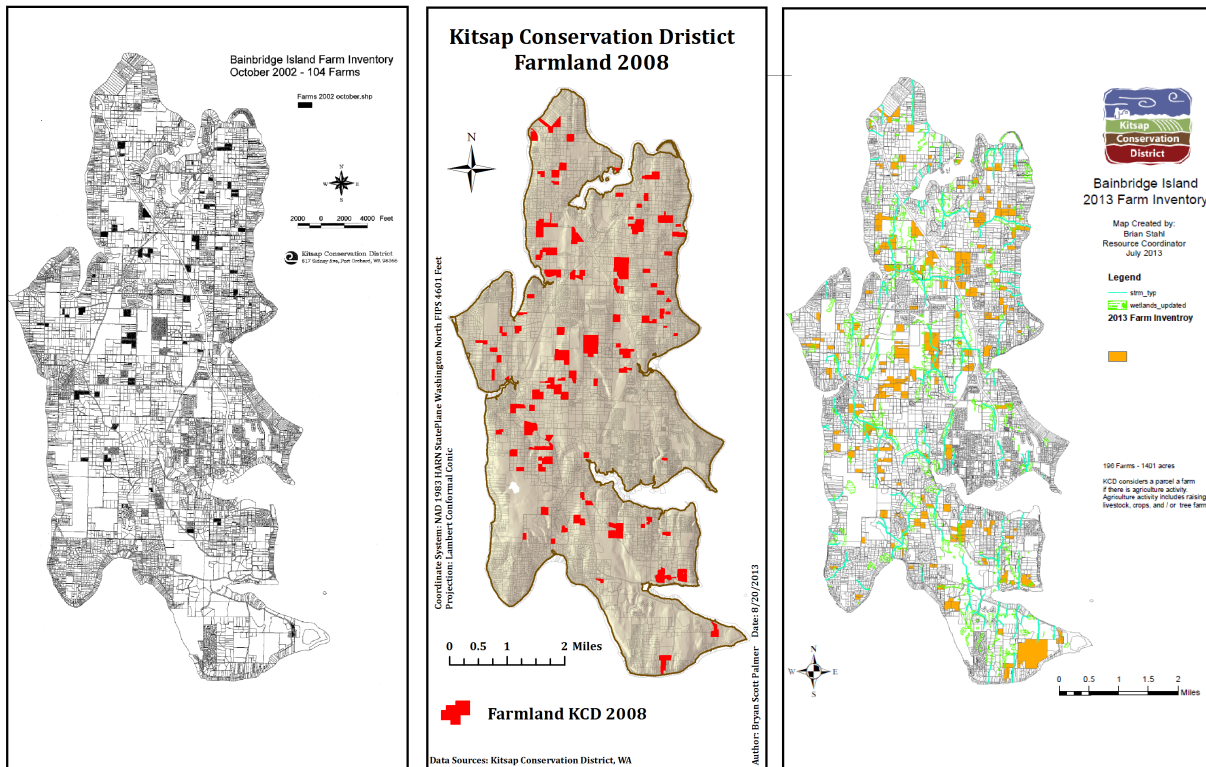
IV. Design/Testing/Implementation

Geodatabase (FPP.gdb)

It was noted in the beginning that the Friends of the Farms organization would be at a disadvantage to most of the major players in an open land consensus of Bainbridge Island. The City of Bainbridge Island, the Bainbridge Island Land Trust, and the Kitsap Conservation District all have a GIS. After this project is completed the Friends of the Farms will be able to level the playing field with their new geodatabase. The Farmland Prioritization Plan geodatabase consists of GIS datasets that were obtained from the City of Bainbridge Island's GIS Department, the Bainbridge Island Land Trust, and the Kitsap County GIS Department. NAIP 2011 orthophotos were obtained from the U.S. Geological Survey. Maps depicting 2002 and 2013 farmland on Bainbridge Island were obtained from the Kitsap Conservation District. The geodatabase also includes a great deal of this project's generated geoprocessed datasets as shown in appendix A.
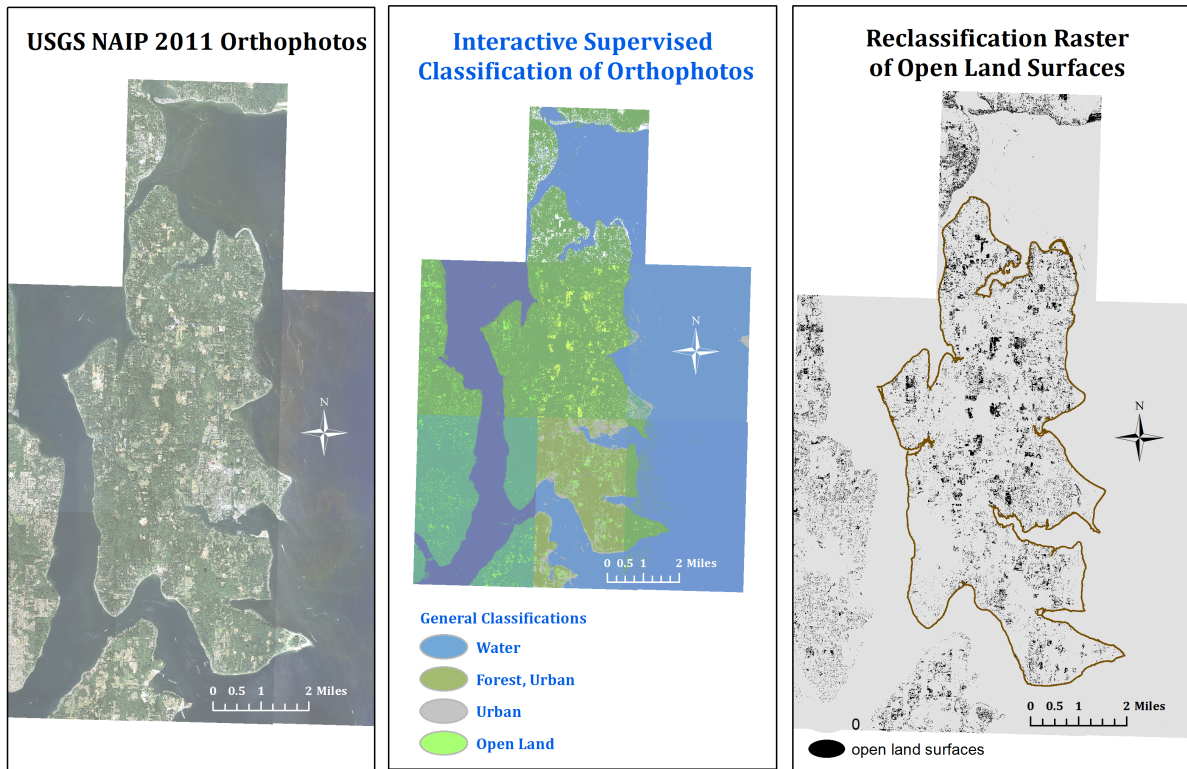
Remote Sensing Analysis

Our sponsor was hoping for a new parcel open space dataset apart from the standard farm_parcel dataset. This dataset would encompass all farmable lands that are considered at the moment as just open space. Friends of the Farm expressed interest in our preliminary meetings that they would like to concentrate more effort in identifying these open spaces with hopes of matching them up with farmers. To do this we had to devise a remote sensing analysis that would identify parcels with these open spaces. The datasets that we chose for the remote sensing analysis were free NAIP 2011 orthophotos obtained from a USGS download website. Using ArcGIS as our primary analysis tool we created a nine-step process that was based on an interactive classification of the pixels of an orthophoto.

In the first step of the remote sensing analysis four regions of interest (ROIs) were selected, water (Puget Sound), forest cover, urban (everything else), and open spaces. From

this we created an interactive classification raster. In the second step this raster was reclassified with the creation a new raster with just two pixel classifications, open spaces and everything else. In the third step the seven-reclassification rasters created from the orthophotos were mosaicked into just one raster dataset. Open-space raster data from nearby Kitsap Peninsula was removed.

Remote Sensing Workflow for Open Lands Creation

USGS NAIP 2011 Orthophotos

0   0.5   1   2 Miles

Interactive Supervised Classification of Orthophotos

0 0.5 1   2 Miles

General Classifications
- Water
- Forest, Urban
- Urban
- Open Land

Reclassification Raster of Open Land Surfaces

0 0.5 1   2 Miles

0   open land surfaces

Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet
Projection: Lambert Conformal Conic
Data Sources: USGS NAIP 2011 Orthophotos

Author: Bryan Scott Palmer
Date: 8/19/2013

Map 2 – Remote Sensing

In the fifth step the cleaned-up reclassification raster was converted to a polygon feature dataset. Using a Bainbridge Island polygon feature dataset as a mask, we clipped the new open space polygon feature dataset. In the sixth step the new open space polygon feature dataset then was compared to farm_parcels, BILT parcel datasets, COBI open space parcels, parks parcels, road parcels, wetlands, and prime dry soils. Polygons showing a centroid within in any of these datasets were removed.

The seventh step was to compare the new open-space polygon dataset with all parcels on Bainbridge Island. A new open-space parcel dataset was created from a select by location of the parcels containing the open-space polygons. The eighth step was to eliminate all parcels less than 0.9 acres in area. Our sponsor suggested that an acre would be the smallest parcel that they would have an interest. After surveying the results it was noted that there were quite a few parcels in the 0.9 to 1 acre range. So, it was decided to include them. The final step included one last comparison of the new open-parcel data set to the orthophotos to eliminate parcels such as school ball fields, golf courses, and cemeteries. The final product was a new open-space parcel dataset.
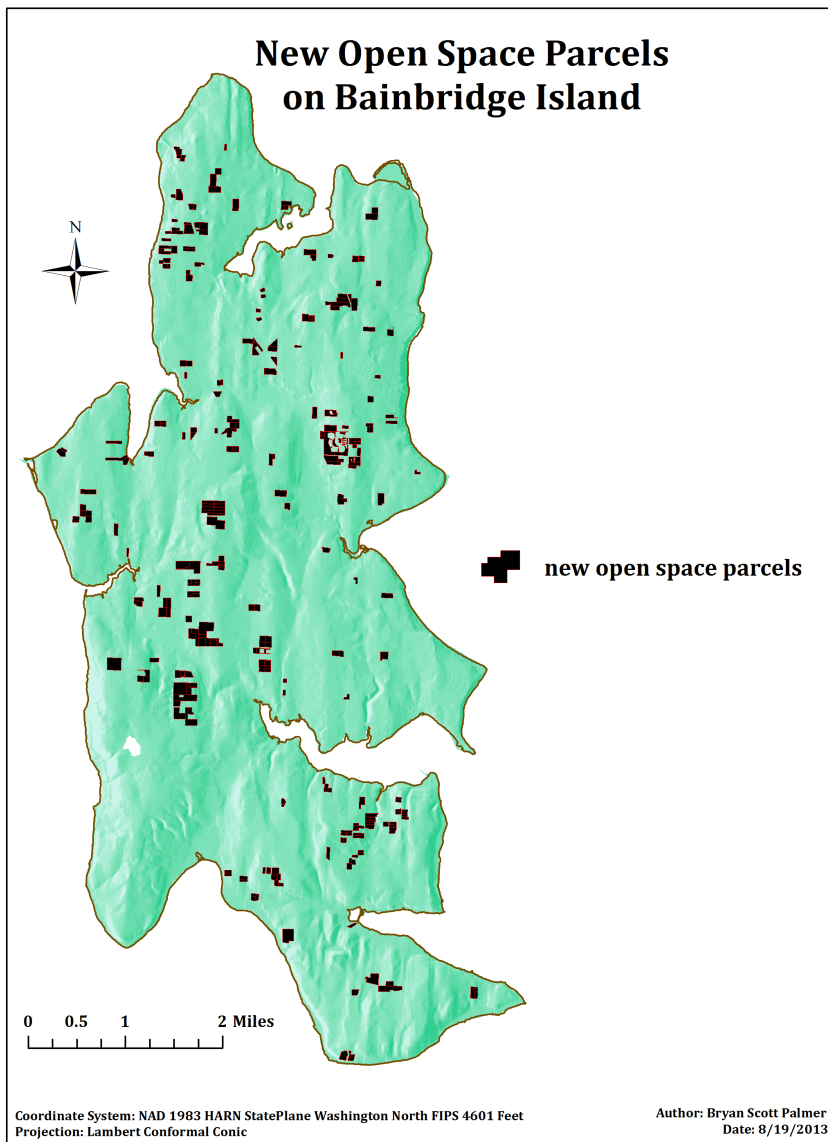
Map 3 – New Open Space Parcels

Dry Prime Soils Analysis

The creation of the prime dry soils dataset was a challenge. Borrowing a map from the Bainbridge Island Conservation Plan of 2012 labeled Agricultural Soils Survey, Map 11, we were able to extract a dry prime soils dataset as shown in Map 3. This was done by georeferencing the PDF map in ArcGIS and converting it to a raster dataset. Using an interactive classification analysis we are able to extract the dry prime soils dataset. This was then converted to a polygon (vector) feature class and added to the geodatabase. All parcels whose centroid was within the dry prime soils polygons received a score of -500 in the dry prime soils proximity analysis. The dry prime soils proximity analysis included a select by location of all parcels whose centroid was within a dry prime soil polygon.
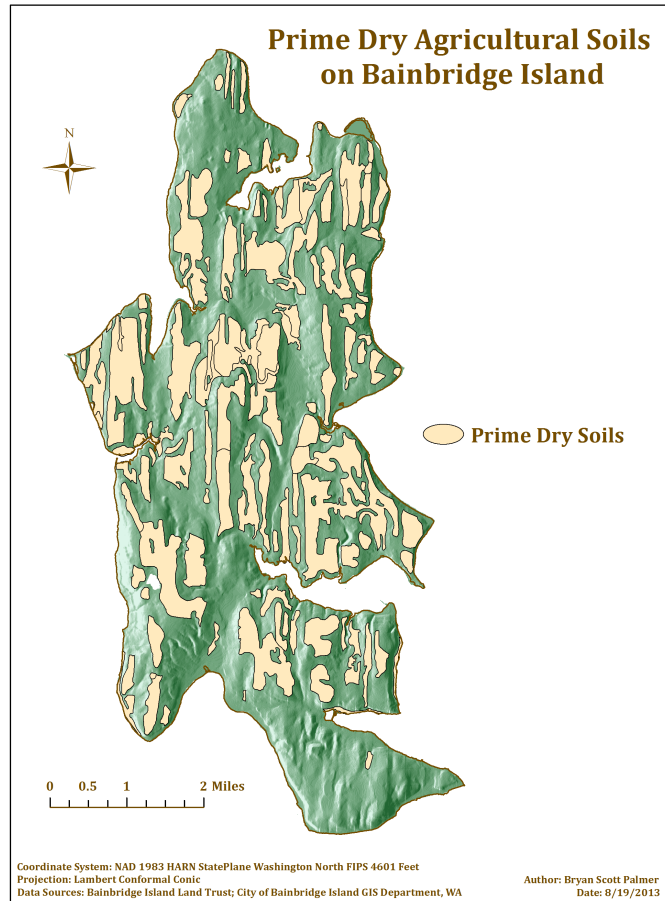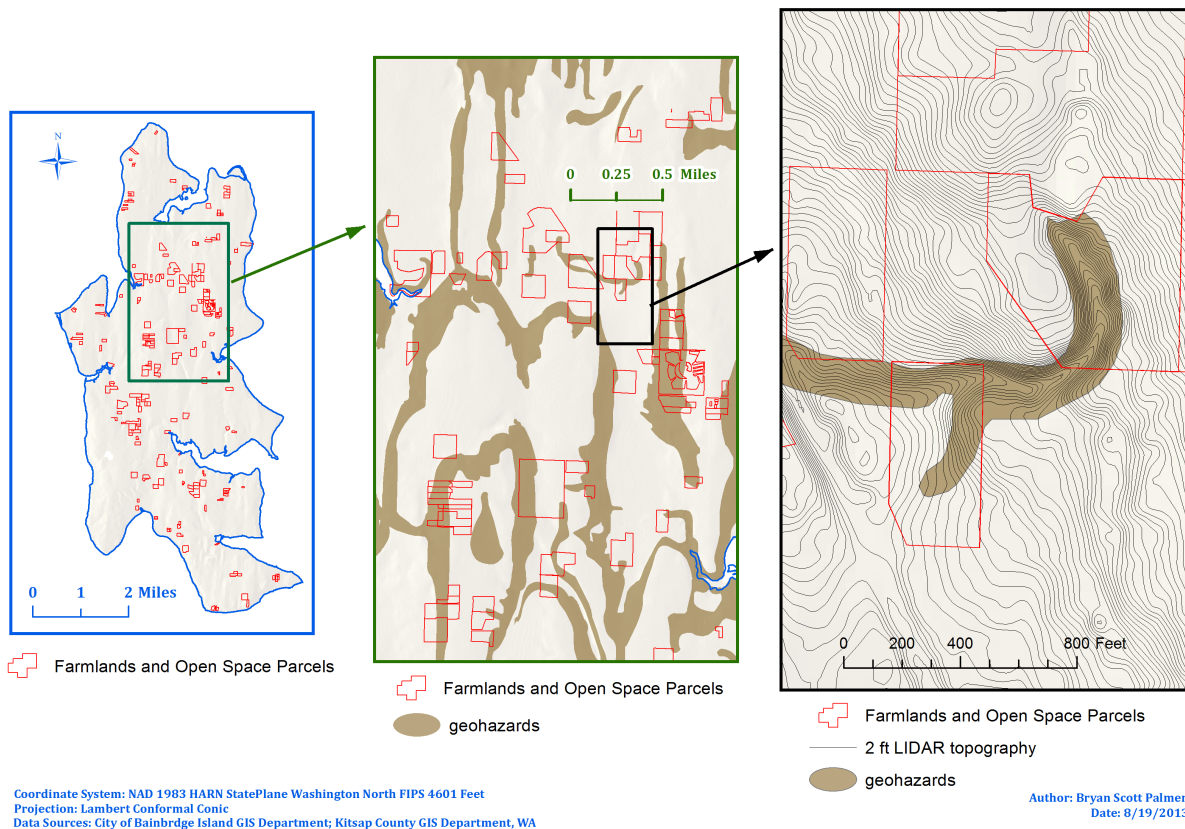
Map 4 – Dry Prime Soils

Geohazards (aspect) Analysis

Our sponsor was very concerned with the aspect of farms and open lands. Aspect was to mean the topography of the landscape present. It was decided that a geohazards dataset produced by Kitsap County would be ideal to represent unsuitable landscape for farming. The geohazards dataset was downloaded from the Kitsap County GIS Department's website. The dataset was clipped to match the area extent of Bainbridge Island. All parcels that shared a boundary within a geohazard received a score of -1000 in the geohazards proximity analysis.

# Geoprocessing Farmlands and Open Parcels with Geohazards

Farmlands and Open Space Parcels

Farmlands and Open Space Parcels

geohazards

Farmlands and Open Space Parcels

2 ft LIDAR topography

geohazards

0   0.25   0.5 Miles

0   1   2 Miles

0   200   400   800 Feet

Map 5 – Geohazards Analysis

Wetlands Analysis

The City of Bainbridge Island GIS Department provided the wetlands dataset. Our sponsor for the project was eager to have the different categories of wetlands and their respective regulated buffer distances contemplated with the wetlands proximity analysis. Within the wetland dataset we were able to find and symbolize wetlands into their respective four categories, I, II, III, and IV. Agriculture is deemed as a high impact land use. Washington State regulations for high impact use are as follows. Categories I and II wetlands have buffers of 300 feet. Category III wetlands have a buffer of 150, and category IV wetlands have a buffer 50. Wetlands and their associated buffers were combined into a single polygon feature class and added to the geodatabase. Parcels whose centroid was within this single polygon feature class received a score of -2000 for the wetlands

proximity analysis. The wetland proximity analysis included a select by location of all parcels whose centroid was within a wetland.

## Geoprocessing Workflow for Wetlands on Bainbridge Island
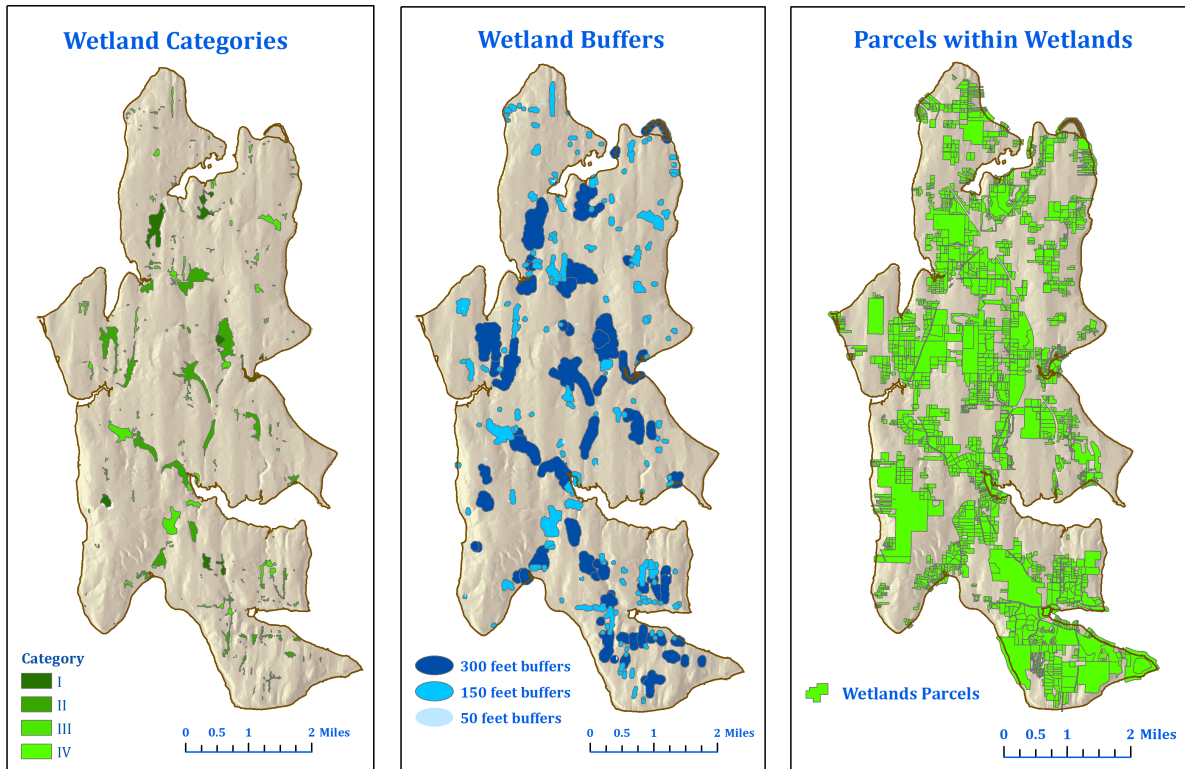
Map 6 – Wetlands Analysis

Water Well Sources Analysis

Bainbridge Island is a very small island measuring 3.5 X 10 miles. Most water sources are drilled wells extending into an aquifer directly below the island. Since large bodies of water are absent on Bainbridge Island, it was assumed and confirmed in conversation with our sponsor that most water for farming is based on drilled wells or shared irrigation from nearby wells. Water well datasets for Kitsap County were obtained from the Washington State Department of Health. The dataset was clipped to match the area extent of Bainbridge Island. A buffer polygon feature dataset was created at a ¼-mile distance from the wells for the water source proximity analysis and added to the geodatabase. Parcels containing a well received a score of 1000 and parcels whose centroid was within the ¼ mile buffer

received a score of 100. The water source proximity analysis included a select by location of all parcels containing the wells and a separate select by location of parcels within the ¼-mile buffer.

Geoprocessing Workflow for Water Source Buffer Analysis
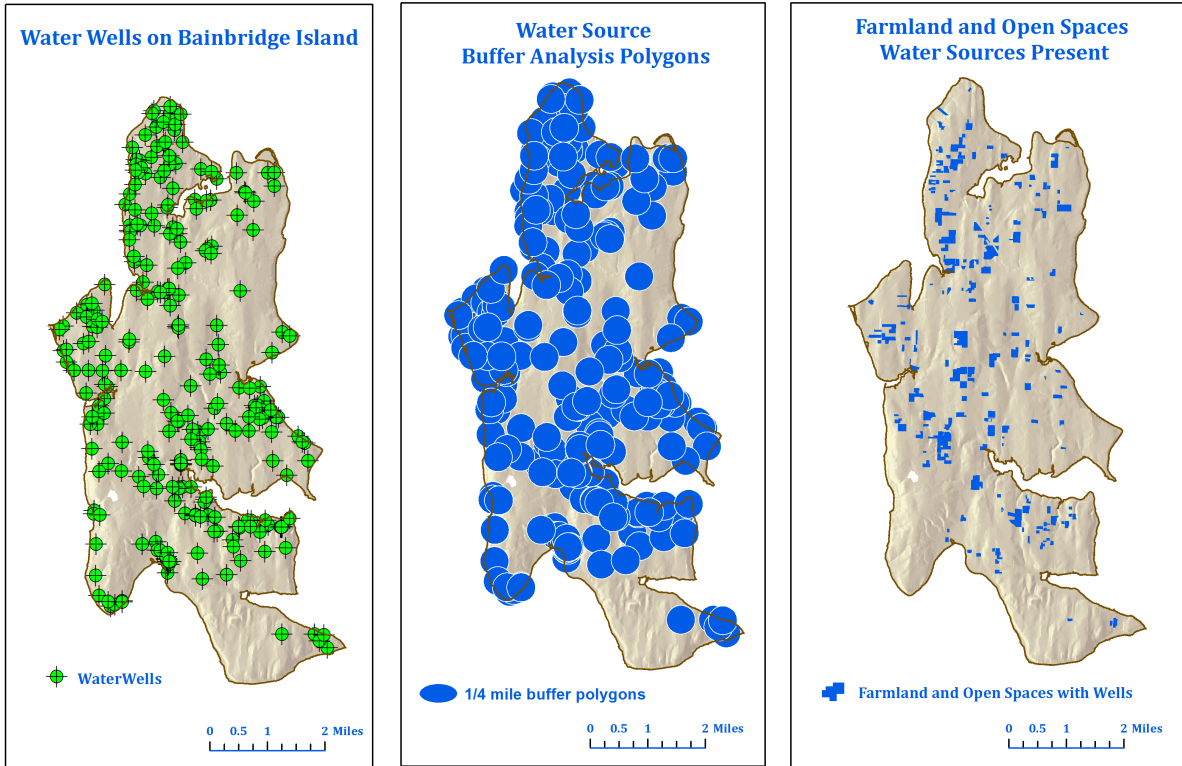
Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet
Projection: Lambert Conformal Conic
Data Sources: Washington State Department of Health; City of Bainbridge Island GIS Department, WA
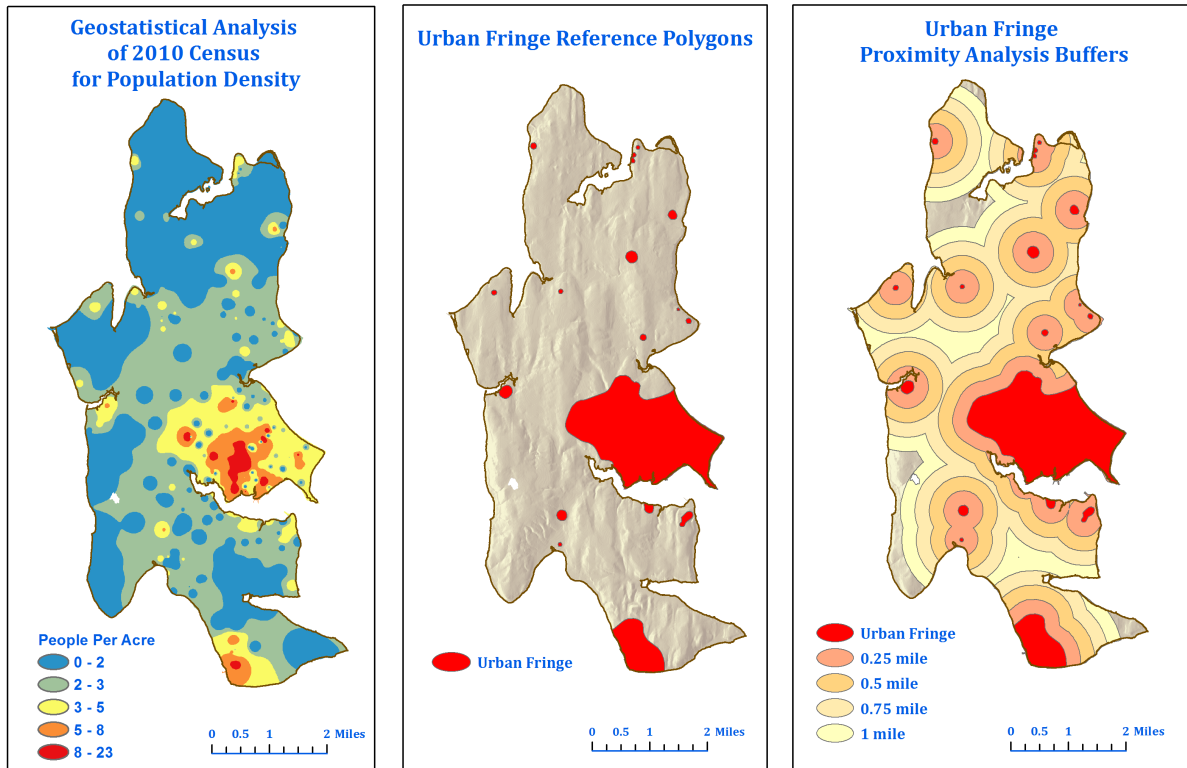
Author: Bryan Scott Palmer
Date: 8/19/2013

Map 7 – Water Source Analysis

Urban Fringe Analysis

Since farming's greatest danger is from the encroachment of urban and suburban development, it was decided early in the design process that an urban fringe boundary would be an important dataset in this multi-criteria analysis. Farms or open spaces located in the urban fringe or close to it would have a higher priority status than those farther away. Farms within the urban fringe received a score of 500, 400 at ¼-mile, 300 at ½-mile, 200 at ¾-mile, and 100 at a distance of one mile from the urban fringe boundary. An urban fringe dataset was constructed from 2010 census block data. It is defined as the area of density of three or more people per acre. The geoprocessing workflow for creating the

Geoprocessing Workflow for Urban Fringe Creation

Geostatistical Analysis of 2010 Census for Population Density

People Per Acre
- 0 - 2
- 2 - 3
- 3 - 5
- 5 - 8
- 8 - 23

0 0.5 1 2 Miles

Urban Fringe Reference Polygons

Urban Fringe

0 0.5 1 2 Miles

Urban Fringe Proximity Analysis Buffers

- Urban Fringe
- 0.25 mile
- 0.5 mile
- 0.75 mile
- 1 mile

0 0.5 1 2 Miles

Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet
Projection: Lambert Conformal Conic
Data Sources: City of BainBridge Island GIS Department, WA

Author: Bryan Scott Palmer
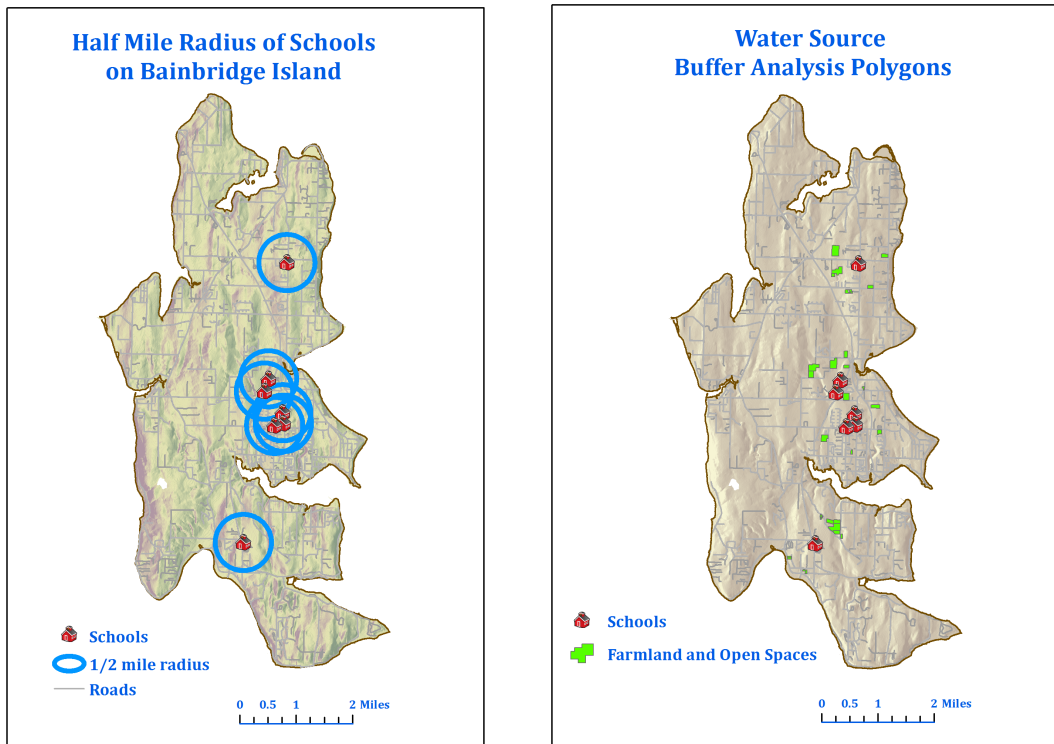Date: 8/19/2013

Map 8 – Urban Fringe Analysis

urban fringe dataset included the density calculation of people per acre, a geostatistical analysis of the density, creation of raster showing the area of density, and the conversion of this raster dataset to a polygon (vector) dataset. Buffer polygons at ¼ mile intervals were constructed using the multi-ring buffer tool. The proximity analysis for urban fringe included a selection by location of all parcels whose centroid was inside one of the zones (urban fringe, ¼-mile, ½-mile, ½-mile, and 1-mile) and received its score value respectively.

Schools Analysis

Our sponsor was very interested in knowing the distance a farm parcel was from local education. The Friends of the Farms promote field trips for local schools as an outreach

program to steward young minds on the merits of farming. It was decided in the early design process that a ½-mile walk for children would be an acceptable field trip length. The schools dataset was downloaded from the Kitsap County GIS Department's website. The dataset was clipped to match the area extent of Bainbridge Island. A ½-mile buffer was created polygon dataset was created. All farm parcels that shared area within a ½-mile buffer were given a score of 50 in the school proximity analysis. The school proximity analysis included a select by location of all parcels within the ½-mile buffer as shown in Map .

Geoprocessing Workflow for School Buffer Analysis

Map 9 – Schools Analysis

COBI Farmland (infrastructure) Analysis

   Our sponsor suggested that farms and future open land farming located near existing farms and their respect infrastructure would have a greater chance of succeeding with

shared resources and knowledge. It was decided early in the design process of this project to include a proximity analysis of the distance a farm or open space parcel was to farmland managed by the Friends of the Farms. Farms next to this managed farmland received a score of 100, 75 at ¼-mile, 50 at ½-mile, and 25 at a distance of one mile. A simple parcel dataset representing the farmland managed by the Friends of the Farms was extracted from the farms_parcel dataset provided by the City of Bainbridge Island. Buffer polygons at a ¼ mile, ½-mile, and 1-mile distance were constructed using the multi-ring buffer tool. The managed farmland proximity analysis included a selection by location of all parcels that shared a common boundary or whose centroid was inside one of the zones (¼-mile, ½-mile, and 1-mile) and received its score value respectively.
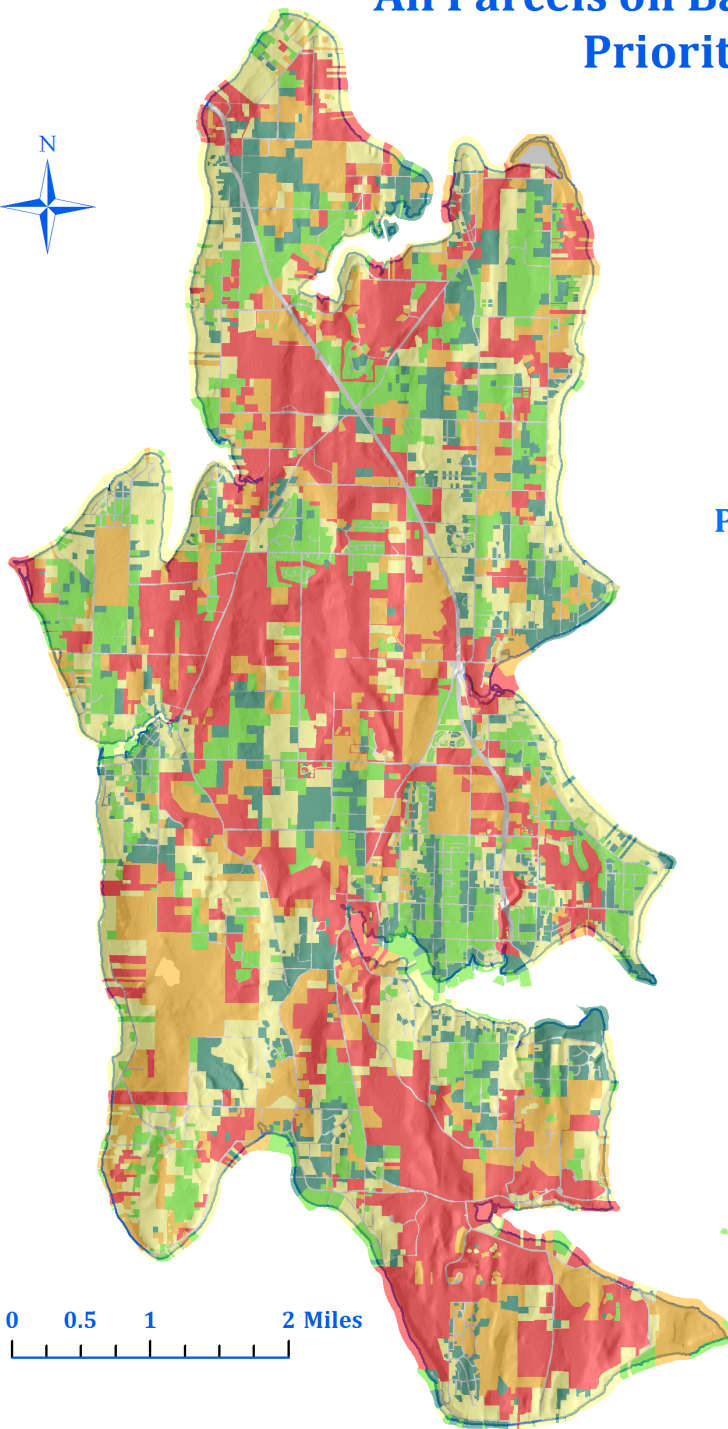
Existing Farmland Analysis

There are quite a few farms on Bainbridge Island. It was decided early in the design process most farms had existing infrastructure. Even though they have yet to be affiliated with the Friends if the Farm organization, it was decided that proximity to these farms might be beneficial. Parcels shared a boundary next to other existing farmlands received a score of 25, 15 at ¼-mile, and 10 at a distance of ½-mile. The existing farmland dataset was obtained from the City of Bainbridge Island. Buffer polygons at a ¼ mile and ½-mile were constructed using the multi-ring buffer tool. The existing farmland proximity analysis included a selection by location of all parcels that shared a common boundary or whose centroid was inside one of the zones (¼-mile and ½-mile) and received its score value respectively.

Multi-criteria Analysis

The multi-criteria analysis for this project included evaluating the following criteria: dry prime soils, water sources, wetlands, schools, urban fringe, COBI reference farms, and farms in general. The resulting scores for each of these criteria were summed in a total score. Two parcel datasets were run through this multi-criteria analysis, the Bainbridge Island parcel dataset (all parcels) and a combined farm and open-space parcel dataset. The total scores ascending or descending from these two lists are the prioritization numbers

All Parcels on Bainbridge Island Prioritization

Protection Priority

High

Moderate

Low

0   0.5   1   2 Miles

Map 10 – All Parcels Prioritization

**Farms and Open Space Parcels
on Bainbridge Island**

N

Protection Priority

High

Moderate

Low

0   0.5   1   2 Miles

Coordinate System: NAD 1983 HARN StatePlane Washington North FIPS 4601 Feet
Projection: Lambert Conformal Conic
Data Source: City of Bainbridge Island GIS Department, WA

Author: Scott Stcherbinine
Date: 8/19/2013

Map 11 – Farmland and Open Spaces Prioritization

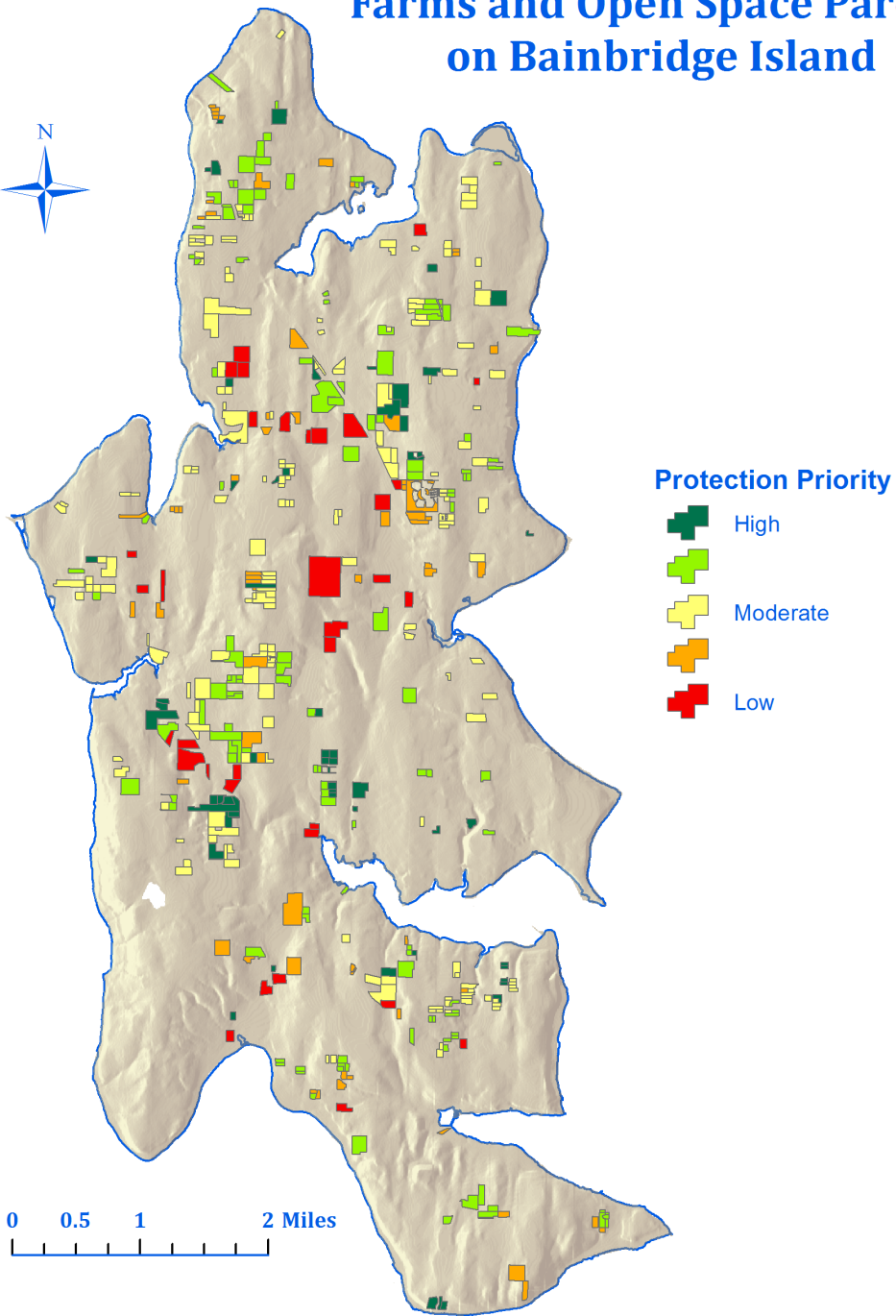that our sponsor initially requested as a final product in creating a Farmland Prioritization Plan for Bainbridge Island.

V. Financial Analysis

Creating a financial analysis for this project posed many challenges. Firstly many of the benefits noted in the section of this report titled 'Sustainability Management / Resilience Thinking' are intangible benefits. Being that parcels vary in size and proximity to necessary agricultural land elements like water soil or canopy coverage, both tangible and intangible benefits will reveal themselves on a case-by-case basis. Secondly Friends of the Farms is primarily a volunteer run organization and this is the first example of services being provided without money changing hands. FOF employs a single part time employee that serves as their executive director. All members of their board and their sub-committees are volunteers, who contribute intermittent hours to FOF dealings. Thirdly many of the partnerships that FOF has created are based on handshakes and the agreement to help each other when possible. This presents another example of services being exchanged without money changing hands. Lastly many farmers who lease land from private land owners use the barter system rather than money to pay for the land they are leasing. Farmers will often simply provide their landlords a percentage of their harvest for payment. This is another example of no money changing hands as well as an example of differing payment methods based on a case-by-case scenario. One recommendation suggested by the authors of this project is that the Geodatabase, .mxds, and all data be kept at BILT, a partner of FOF. BILT utilizes Americore GIS volunteers for technical support dealing with spatial data. This is yet another example of a non-traditional employer/employee relationship with no money changing hands. Furthermore the capacity of each volunteer will be different so deciphering how long it will take one versus another to complete GIS analysis tasks is impossible to estimate.

We were able to determine how much money it would have cost FOF to pay consultants to complete the work that we have done for this project. For this number we took into account hours spent by students, hours spent by sponsor, cost of ArcGIS software with necessary extensions, and price/per hour for GIS consulting. As students we committed

approximately 4 hours a day for 9 weeks giving a total of 252 hours for each student and with two students we have a total of 504 labor hours spent. Multiplying this total number of hours by an approximation for GIS consultant fees of $40.00 per hour, we came up with a total labor cost of $20,160.00. We also needed to take into account the cost of the ArcGIS software and appropriate extensions, which cost approximately $15,000.00. Our sponsor with FOF committed approximately 20 hours of coordination time with the University of Washington prior to students getting involved, approximately 20 hours of email dialogue with students and approximately 10 hours of in-person meeting time. For the purposes of this financial analysis we will assume that our primary sponsor is receiving the same consulting wage as the students, $40.00. Giving us a total of 2,000.00 for sponsor time committed to project. Taking all of these into account we come up with a grand total of $37,160.00 being spent on student and sponsor labor hours and software requirements.

VI. Recommendations (If Needed-Blanket Statement for FPP)

Storage of Geodatabase

We recommend that the products being turned over to FOF for this project be kept with one of their partnering agencies possessing GIS technological capabilities; however we feel that housing the geodatabase at a public agency like the City of Bainbridge Island or Kitsap County would create issues in regards to access. It has been our experiences that public agencies are much more protective of the GIS data they possess because of proprietary rights. It is our suggestion that the geodatabase reside at the Bainbridge Island Land Trust. Brenda Padgham with the Bainbridge Island Land Trust seemed very receptive to the idea of housing, maintaining and updating the geodatabase we have created. Furthermore BILT employs AmeriCorps volunteers that possess GIS capabilities, making them the perfect holder of the geodatabase because they have very little out of pocket expenses for these services. If possible it would also make sense for FOF to obtain ArcGIS ArcView software, which is often sold to non-profit agencies at a reduced price. This software would allow FOF to create maps using the geodatabase we provide.

Use of geodatabase

Within the geodatabase provided to FOF there is a collection of pre-made ArcMap (,mxd) documents for each multi-criteria analysis that was conducted. These maps can be used for quick reference to trends occurring across the island. We encourage the user to create maps of their own, that zoom into the individual parcel or parcels of interest, to get a zoomed –in, more detailed look at patterns and processes occurring.

Future Analysis Expansion

We suggest that FOF approach the University of Washington's Geography department again for future analysis expansion. Each year students must complete capstone projects prior to graduating from the Professional Masters in GIS program and we see this as an excellent opportunity for this mutual-beneficiary relationship to continue. Suggested additions to this project include replacing outdated data with the most current data available, the incorporation of an ArcGIS ModelBuilder model to automate the proximity analysis, and a Python script using data driven pages to create a Bainbridge Island agricultural land characteristic map book.

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Land Information and Computer Graphics Facility (LICGF) Niemann J. Bernard Jr., Ventura Stephen, Miskowiak, Douglas and Heinzel, Math (2000). Farmland Preservation and GIS – A Model for Deriving Farmland Priority Zones. Funding was provided by the College of Agricultural and Life Sciences, School of Natural Resources, University of Wisconsin-Madison.

Appendix A

Catalog Tree		
☐ 🗄 FPP.gdb		
⊞ 🗂 Bainbridge_Island		
⊞ 🗂 BILT_Parcels		
⊞ 🗂 COBI_Parcels		
⊞ 🗂 Farm_Parcels		
⊞ 🗂 Geology		
⊞ 🗂 Water_Sources		
⊞ 🗂 WorkingParcels		
⊞ ▦ BI_Pop_Dens		
⊞ ▦ Bidem		
⊞ ▦ Extract_kits11		
⊞ ▦ HillSha_Extr51		
⊞ ▦ HillSha_Extr52		
⊞ ▦ Hillshade		
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⊞ ▦ m_4712220_nw_10_1_20110826_20111007		
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⊞ ▦ ortho_2		
⊞ ▦ ortho_3		
⊞ ▦ ortho41		
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⊞ ▦ ortho65		
⊞ ▦ ortho72		
⊞ ▦ PeoplePerAce_Clip		
⊞ ▦ PeoplePerAcre		
⊞ ▦ Pop_Dens_Full_extent		
⊞ ▦ Reclass_1st		
⊞ ▦ Reclass_2nd1		
⊞ ▦ Reclass_3rd1		
⊞ ▦ Reclass_4th1		
⊞ ▦ Reclass_5th1		
⊞ ▦ Reclass_6th1		
⊞ ▦ Reclass_7th1		
⊞ ▦ ReclassPeoplePerAcre		

Contents | Preview | Description

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blocks_2010	File Geodatabase Feature Class
Cummunity_Centers	File Geodatabase Feature Class
Lidar2ft3dtopo	File Geodatabase Feature Class
OrthoOpenFinal_10	File Geodatabase Feature Class
Parks	File Geodatabase Feature Class
Parks_BIMPRD	File Geodatabase Feature Class
Roads_BI	File Geodatabase Feature Class
Roads_Hwy	File Geodatabase Feature Class
Schools	File Geodatabase Feature Class
Schools_buffer	File Geodatabase Feature Class
Schools_farmParcels_near	File Geodatabase Feature Class
Shorelines	File Geodatabase Feature Class
UF_1_mile_polygon	File Geodatabase Feature Class
UF_half_mile_polygon	File Geodatabase Feature Class
UF_quarter_mile_polygon	File Geodatabase Feature Class
UF_quarter_mile_polygon_SymDif	File Geodatabase Feature Class
UF_quarter_mile_polygon_SymDif_Final	File Geodatabase Feature Class
UF_threequarter_mile_polygon	File Geodatabase Feature Class
UrbanFringe	File Geodatabase Feature Class
UrbanFringeFinal	File Geodatabase Feature Class
UrbanFringeFinal_clip	File Geodatabase Feature Class
UrbanFringeParcels	File Geodatabase Feature Class
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Wetlands_parcels_2	File Geodatabase Feature Class
Wetlands_Union	File Geodatabase Feature Class

Catalog Tree		
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⊞ 🗂 Bainbridge_Island		
⊞ 🗂 BILT_Parcels		
⊞ 🗂 COBI_Parcels		
⊞ 🗂 Farm_Parcels		
⊞ 🗂 Geology		
⊞ 🗂 Water_Sources		
⊞ 🗂 WorkingParcels		

Contents | Preview | Desc

Name
BILT_Esmts
BILT_fee_owned
OTHER_easements

Catalog Tree — FPP.gdb (COBI_Parcels selected)

Catalog Tree

- FPP.gdb
  - Bainbridge_Island
  - BILT_Parcels
  - COBI_Parcels
  - Farm_Parcels
  - Geology
  - Water_Sources
  - WorkingParcels
  - BI_Pop_Dens
  - Bidem
  - Extract_kits11
  - HillSha_Extr51
  - HillSha_Fxtr52

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- COBI_half_mile_polygon
- COBI_Owned_OpenSpace
- COBI_quarter_mile_polygon
- COBI_Reference_farm_parcels
- COBI_Ring_buffers
- COBI_Ring_Buffers_clip
- parcels
- Parcels_Current

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Catalog Tree

- FPP.gdb
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  - BILT_Parcels
  - COBI_Parcels
  - Farm_Parcels
  - Geology
  - Water_Sources
  - WorkingParcels
  - BI_Pop_Dens
  - Bidem

Contents | Preview | Description

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Catalog Tree

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  - COBI_Parcels
  - Farm_Parcels
  - Geology
  - Water_Sources
  - WorkingParcels
  - BI_Pop_Dens
  - Bidem

Contents | Preview | Description

Name
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- openSpaceparcels_geohazards
- PrimeDrySoils
- Soils_General
- stability
- stabsoil
- surgeo

Catalog Tree ⊐ ✕

- ⊟ 🗄 FPP.gdb
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  - ⊞ 🗂 BILT_Parcels
  - ⊞ 🗂 COBI_Parcels
  - ⊞ 🗂 Farm_Parcels
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Contents | Preview | Description

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- Ⓐ cwspAnno_old
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- ▦ TOT5yr_Clip
- ▦ TOT6mo_Clip
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- ▦ uncontested_overlap
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- ▦ WaterSource_parcels
- ▦ WaterSource_parcels_OpenSpaces_Farmland
- ⦂ WaterWells
- ⦂ Well_Logs

Catalog Tree ⊐ ✕

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  - ⊞ 🗂 COBI_Parcels
  - ⊞ 🗂 Farm_Parcels
  - ⊞ 🗂 Geology
  - ⊞ 🗂 Water_Sources
  - ⊞ 🗂 WorkingParcels

Contents | Preview | ◄ ►

Name

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- ▦ FuturePotential_5