

# Stew-MAP: Geo-Visualization of Seattle Environmental Stewardship Organizations

Jim Goldsmith and Ian Price

Summer 2013

Professional Master's Program in G.I.S. (PMP-GIS)

University of Washington

Seattle, WA

## ***Table of Contents***

<i>1. Introduction</i>	<i>3</i>
<i>2. The Importance of Civic Environmental Stewardship</i>	<i>7</i>
<i>3. StewMAP Technology Design Considerations</i>	<i>13</i>
<i>1. Required Functionality of StewMAP</i>	<i>15</i>
<i>2. Required Data Components of StewMAP</i>	<i>17</i>
<i>3. Required Technological Components of StewMAP</i>	<i>20</i>
<i>4. A Minimal MySQL Database Design for StewMAP</i>	<i>25</i>
<i>4. Scoping and Alternatives</i>	<i>28</i>
<i>1. ArcGIS Server and ArcGIS API for Javascript</i>	<i>31</i>
<i>2. Google Maps API</i>	<i>33</i>
<i>3. OpenLayers</i>	<i>36</i>
<i>5. Business Considerations</i>	<i>41</i>
<i>1. Maintenance Needs for StewMAP</i>	<i>42</i>
<i>2. Implementation Estimates</i>	<i>43</i>
<i>6. Conclusion</i>	<i>45</i>
<i>Appendix A: USFS questionnaire for stewardship organizations</i>	<i>47</i>

# 1. INTRODUCTION

What is environmental stewardship and environmental stewardship mapping? What are their roots and why are the concepts and possibilities of both becoming a growing interest to scientists, government agencies, urban dwellers, and society as a whole? This research report is primarily focused on providing a path to constructing an interactive, user-sustained environmental stewardship mapping application (a.k.a. Stew-Map) using a participatory Geographic Information System (GIS) within a suitable delivery technology. However, in order to understand the desire to develop such an application, it is important to have a basic understanding of the foundation of environmental stewardship, and the human and societal drivers behind the concept.

Environmental stewardship is a concept that has been getting more attention with every passing year as the world population grows, the planet's natural resources are used and manipulated, and the world around us appears to be permeated with the effects of human influence. The idea seems simple: As beings that thrive off the natural environment, we must be mindful of the resilience of the natural resources we harvest and the resulting effects of our use and manipulation of those resources on the surrounding environment – the planet on which we live. However, "...the widely used concept of "environmental stewardship" is not readily defined by a few words or sentences, and is probably more complex than many would assume." (Romolini, Brinkley, & Wolf, 2012). The famed naturalist Aldo Leopold (1897-1948) defined the general concept through the term "**land ethics**" he coined in his book, "A Sand County Almanac". Land ethics is a philosophy that seeks to guide the actions when humans use or make changes to the land. Leopold wrote that there is a need for a "new ethic", an "ethic dealing with the human's relation to land and to the animals and plants which grow upon it" (Wikipedia, 2013a).

In 2009, the Green Cities Research Alliance (GCRA) was launched by the Pacific Northwest Research Station of the USDA Forest Service. "The purpose of the initiative is to facilitate natural resource research within urban areas of the Pacific Northwest region of the U.S., to coordinate science and community partners within the PNW region, and then, to link investigations to other U.S. regions." (Wolf, Blahna, Brinkley, & Romolini, 2011) Figure 1 shows a simplified overview of the evolution of Stew-Map.

## The Evolution of Stew-Map

### Social-ecological phenomena appears in urban areas

- Organizations in urban areas (cities) participate in "environmental stewardship" projects to care for their local environments.

### Questions arise about environmental stewardship activities

- What is Urban Environmental Stewardship?
- What is the "footprint" of urban environmental stewardship projects (number of organizations, all of their activities, and relative density of activity at various locations)?
- How do they relate to each other? Gaps and overlaps?
- What overall effect can they have on urban social-ecological systems and the urban "green infrastructure"?
- Can they help with overall urban environmental governance?

### Scientists, researchers, gov. agencies, and organizations interested in environmental governance and civic engagement

#### → The Stew-Map Concept begins to develop

- Helping to understand a civic environmental restoration resource in its totality (environmental stewardship in urban social-ecological systems).
- Use spatial tools such as GIS to assemble, visualize, and analyze the environmental stewardship restoration system.

### USDA Forest Service - Northern Research Station

New York City Urban Field Station and university researchers involved with environmental governance and civic engagement.

- Builds off of **2004** study of urban stewardship of 6 NE U.S. cities by the Urban Ecology Collaborative (UEC).
- Develop the concept of Stew-Map (The need for a common database of stewardship groups and a map of stewarded sites)
- Survey development
- First "turf" mapping (Area of stewardship activity)
- Organization network mapping

### 2009: USDA Forest Service - Pacific Northwest Research Station

- Launches the Green Cities Research Alliance (GRCA)
  - Facilitate natural resource research within urban areas of the Pacific NW (PNW).
  - Coordinate science and community partners within the PNW region.
  - Link investigations to other U.S. regions.
  - GRCA reached out to other U.S. cities involved in similar stewardship mapping and assessment projects. (i.e. New York, Chicago, and Baltimore)

### 2011-2013: Stew-Map: Phase 1

- Assemble a stewardship organization directory
- Collect attributes of each organization
- Collect text descriptions of turf
- Digitize one to multiple polygons representing turf

### 2013 → : Stew-Map: Phase 2

- Develop the concept and assess alternatives for stewardship mapping in participatory GIS
  - Organizations can enter or edit their own attributes
  - Organizations can enter or edit their own turf

### Stew-Map: Phase 3 (Consortium GIS Design)

- Public access to static and dynamic displays of stewardship organization information and turf.
- Administrative access by stewardship organizations to enter and/or update "turf" geography.
- Analytics to generate maps and overlays based on web-based queries.
- Links and displays of metro/regional organizational network analysis.

Figure 1: The Evolution of Stew-Map

Nearly 600 environmental stewardship organizations are operating in and around the two largest cities in the Puget Sound Basin. Their environmental stewardship activities may range from management of family forests to a neighborhood park clean up on a weekend. Initial census data of these organizations quickly exceeded one's capacity to comprehend the full implications of the assessment beyond simple descriptive statistics of the population. Engaging the use of a geospatial database would enable a cumulative estimation of environmental stewardship activities and their associated organizations in relation to place and ecological systems. ([Wolf et al., 2011](#)).

The GCRA reached out to other U.S. cities that had started conducting similar environmental stewardship mapping and assessment projects. These other cities include Chicago (<http://stewmap.cnt.org/>), New York ([http://www.nrs.fs.fed.us/nyc/focus/stewardship\\_mapping/history\\_intent/](http://www.nrs.fs.fed.us/nyc/focus/stewardship_mapping/history_intent/)) and ([http://www.nrs.fs.fed.us/nyc/focus/stewardship\\_mapping/](http://www.nrs.fs.fed.us/nyc/focus/stewardship_mapping/)), and Baltimore ([http://www.beslter.org/frame4-page\\_3d\\_28.html](http://www.beslter.org/frame4-page_3d_28.html)). The Environmental Stewardship mapping concept (a.k.a. Stew-Map) uses a GIS and geospatial database. Initial efforts to map environmental stewardship activities in the Seattle area were accomplished by conducting a survey of Seattle area environmental stewardship organizations which resulted in text descriptions of their organization and geographical area of activity. This information was digitized in a GIS by a GIS analyst to facilitate representing the data and analysis in maps; an example is shown in Figure 2 (Stewardship - Community Improvement (King County, WA 2011)) ([Palpuz, Farmer, & Tsoi, 2013](#)). This approach is obviously labor intensive initially and updates could be equally cumbersome. A next logical step in the Stew-Map project will be to transition stewardship mapping into a participatory GIS available via the internet. This leads to the primary purpose of this research paper; to develop the concept and implementation plan for a user-input mapping and display tool.

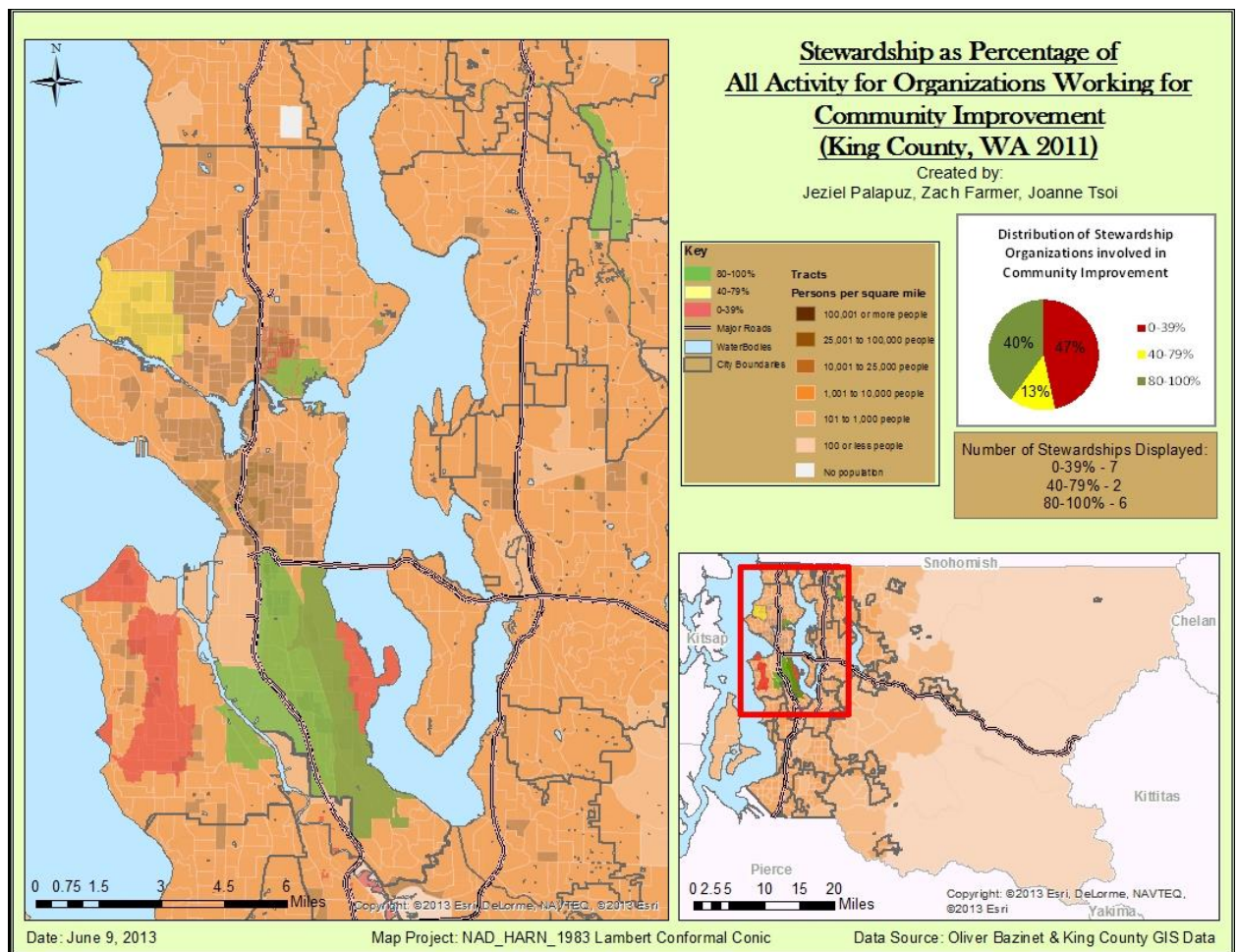


Figure 2: Stewardship - Community Improvement (King County, WA 2011)

There are a substantial number of stewardship organizations with unmapped “turf” or “areas of activity”; new organizations form every year adding to the aggregate of environmental stewardship activities. The Stew-Map website functionality needs to be extended to include a spatial data collections tool so that organizations new to Stew-Map can input their “turf” and organizational data, and those that are already part of the dataset can edit and update their information as needed. This expanded concept is considered participatory GIS. There is also an interest in having a system and designed workflow for integrating new information into the core dataset, web representations, and static map products.

The purpose of this project was to **develop the concept and assess alternatives for stewardship mapping with participatory GIS, a user-input mapping and display tool**. The goals/objectives/scope of the project includes:

- Assessing the pros and cons of potential delivery technologies for Stew-Map (i.e. ArcGIS Server, Google Maps API, Open Layers).
- Workflow needed to develop the tool.
- Determine and describe the management needs once the system is online.
- Options for creating a prototype.
- Then consider the capacity for future expansion of the project (i.e. local Stew-Map Lite for Seattle to a national scale).

## **2. The Importance of Civic Environmental Stewardship**

### **Population Growth**

The human population has grown at an unprecedented rate over the last few centuries. It reached one billion for the first time in 1804; it doubled to two billion by 1927, five billion in 1987, six billion in 1999, and seven billion in 2012 ([Wikipedia, 2013b](#)) – (see figure 3 - World population: 1800 to 2100). Although humans have ingeniously learned to harvest and manipulate the natural resources of our planet for the benefit of the human species, the planet has not increased in size and the natural resources available are limited. This is a large scale world-view of the human to natural environment interactions. What about the human interaction with our environment on a smaller scale, the urban environment?

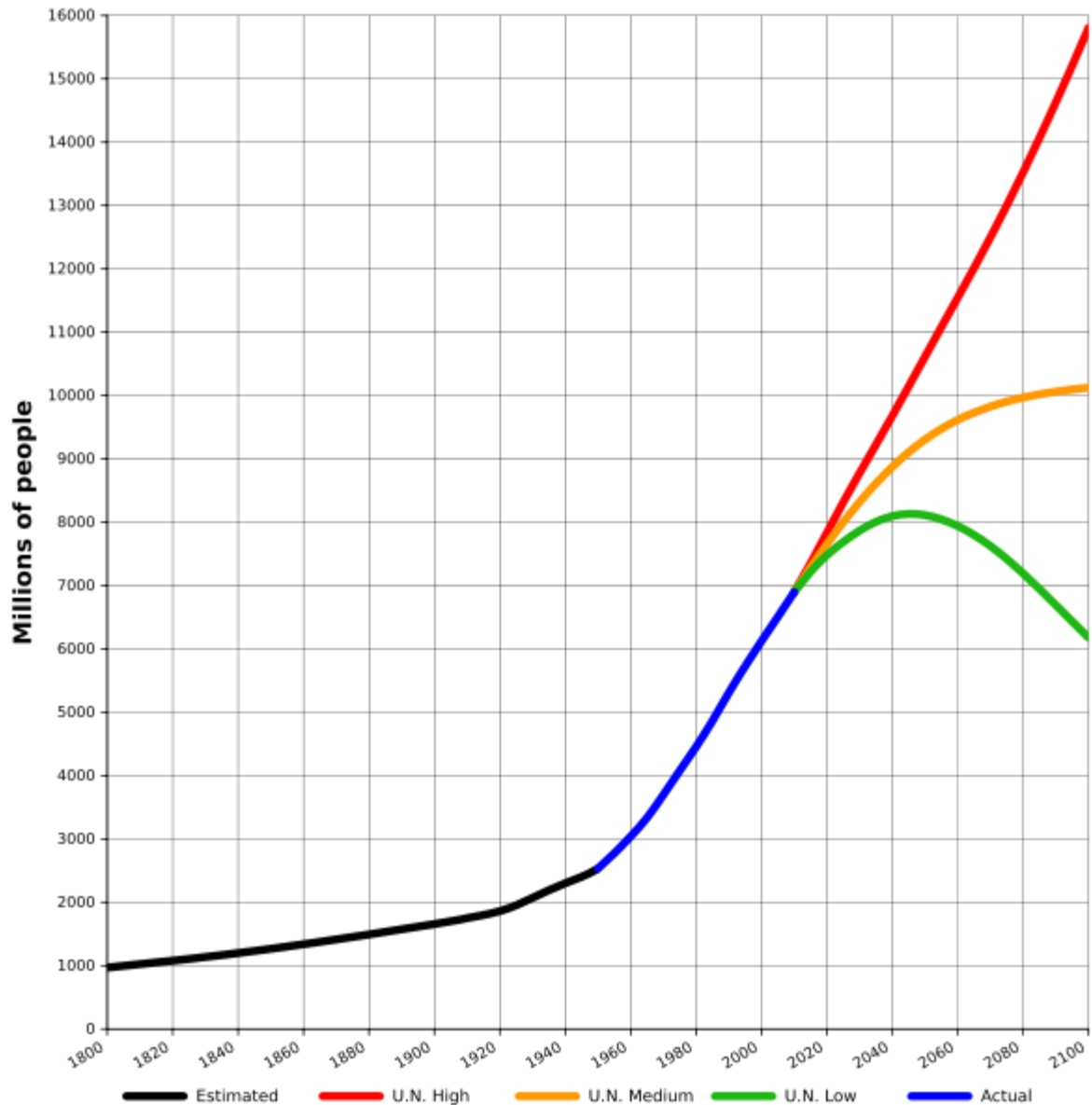


Figure 3: World population: 1800 to 2100 - based on UN 2010 projections and US Census Bureau historical estimates. Source: Wikimedia Commons ([Tga, 2012](#))

### **Population Migration: Rural to Urban**

In the United States, the human migration from rural to urban environments has been fairly consistent over the last few centuries. In 1800 6.1% of the population lived in urban areas and 93.9% in rural areas - in 1900 the percentages were 39.6% urban and 60.4% rural - 1990 demonstrated the migration continued with 75.2% urban and 24.8% rural ([US Census Bureau,](#)



[1990](#)). In 2010, urban areas accounted for 80.7% of the U.S. population, up from 79% in 2000 ([US Census Bureau, 2012](#)). With urbanization comes stress and change to the natural systems and balance that once existed in those areas. The stresses and changes to these natural systems brings to mind the concepts of sustainability and resilience.

### **Sustainability and Resilience**

As described by Thomas Elmqvist, a professor in Natural Resource Management at Stockholm University, “Sustainability is commonly misunderstood as being equal to self-sufficiency, but in a globalized world virtually nothing at a local scale is self-sufficient. To become meaningful, urban sustainability therefore has to address appropriate scales, which always would be larger than an individual city.” In terms of resilience thinking, complex systems are “rarely static and linear, instead they are often in constant flux, highly unpredictable and self-organizing, with feedbacks across time and space. A key feature of complex adaptive systems is that they can settle into a number of different stability domains.” ([Elmqvist, 2013](#)).

In the case of urbanization, the urbanized areas have been pushed beyond the tipping point of the original natural equilibrium or stability domain that once existed in those areas. The equilibrium state now includes humans along with all of the uses and modifications they impose on the surrounding environment. A basic principle in resilience thinking is that a slow variable like urbanization “may invisibly push the larger system closer and closer to a threshold (beyond which there would be radical change toward a new equilibrium) and that disturbances that previously could have been absorbed become the straws that break the camel’s back.” ([Elmqvist, 2013](#)). The new equilibrium may be one that we, as humans, don’t particularly care for, and it may be one that is less than ideal for our survival.

### **Human Responses to Disturbances in Natural Systems**

Since humans are creatures of the natural world, it makes intuitive sense that they may have a deep desire to bring back some elements of the natural system equilibrium that once existed where their urbanized environment now stands. Humans created these urban environments, but they are not always pleased with the separation from the complex natural systems from which they originated. Human responses or strategies to deal with disturbances like urbanization may fall into different

descriptive categories depending on the extent of the disturbance to the original natural system. These strategies are coping, adapting, and transforming.

A *coping strategy* is the ability at the local scale and possibly at the level of individuals to deal effectively with a single disturbance; the crisis is rare and temporary and the situation will normalize when the disturbance recedes. *Adapting* to change is an adjustment at a larger scale in natural and human systems, in response to actual or expected disturbances when frequencies tend to increase. *Transformation* strategies are employed when coping and adaptation strategies are insufficient and outcomes are perceived to be highly undesirable; a *transformation* is a response in which the decisions made and actions taken change the identity of the system itself, they create a fundamentally new system when ecological, economic, or social structures make the existing system untenable. (Elmqvist, 2013).

Note Box 1

Environmental stewardship (ES) is an acknowledged, though little understood, societal response to the decline of natural systems in built environments (Wolf et al., 2011). Environmental stewardship may fall into any of the human response strategies depending on the type and extent of the disturbances of the natural systems in which the people live or interact. Human use and manipulation of our natural resources and natural systems such as industrialization, land development, and the associated transportation systems may result in undesirable disturbances such as air and water pollution and loss of natural vegetation and habitat. Cycles in the planetary environment, such as climate change, may also result in undesirable disturbances for the human species (See Note Box 1). These disturbances may lead to human responses in the form of environmental stewardship – attempts to restore the disturbed natural systems to a new state of equilibrium that is acceptable to the human inhabitants.

**Climate change is a greatly debated topic with highly respected scientists and researchers on both sides of the debate.**

**For example:**

**The Physical Evidence of Earth's Unstoppable 1,500-Year Climate Cycle**  
“The Earth currently is experiencing a warming trend, but there is scientific evidence that human activities have little to do with it. Instead, the warming seems to be part of a 1,500-year cycle (plus or minus 500 years) of moderate temperature swings.”

**(Singer & Avery, 2005)**

Although science and policy [government] entities are responding to these [disturbances] threats to the natural systems with initiatives for knowledge building and action, fiscal shortfalls in local government and environmental resource organizations limit the capacity to address ecosystem needs and recovery. Environmental stewardship is an often overlooked intervention strategy, and the full potential of civic engagement by citizens on behalf of ecosystem health is little understood. ([Wolf et al., 2011](#)).

At first glance one might view environmental stewardship in urban areas as a nice way to green things up and make life more pleasant for the urban human inhabitants. While this perception is very true, “green” spaces within urban areas can come together to perform very important ecological functions. Governance needs to deal with the fact that the small size of green areas in urban areas increases the probability that organisms, including pollinators (bees) and seed dispersers (birds), will exhibit local extinction. This means that governance should work at improving local green area habitat and integrating each area into a larger landscape mosaic of green areas. This also means to recognize or to create city scale networks by planning for the best use and placement and/or protection of different green areas to increase the area of functionally connected habitats and spatial coverage of the desired ecosystem services. Lack of social ties between actor groups [environmental stewardship groups and green space managers] indicates a limited ability to synchronize management across space; for example, providing complementary habitats for functional groups such as pollinators and seed dispersers. ([Ernstson, Barthel, Andersson, & Borgstrom, 2010](#)). In order for governance to assess the overall geospatial and ecological relationships between the various types of green areas and environmental stewardship activities in urban areas, they must be able to view the “green area mosaic” as a whole with all of the relevant information (attributes) connected to each area.

Protecting, creating, and managing “green” areas in urban environments makes sense in the realm of sustainability management; however, it is also very important to be cognizant of the fact that we live in a country that constitutionally guarantees private property rights. “Reasonable” environmental rules and regulations that encourage or require wise stewardship and use of private property are necessary to prevent private property abuses that are unhealthy, dangerous, and/or have significant negative impacts on the surrounding environment or community. However, the pendulum should not

be allowed to swing too far in the direction of environmental and species protection if it amounts to the taking of private property or private property rights in order to “protect” the environment or some “threatened” or “endangered” species. We must all be aware of abuses on both sides of the debate and seek common ground that maintains private property rights while encouraging and/or rewarding good stewardship of the land, water, and surrounding environment. A case in point is brought forward by the U.S. Senate Committee on Environment and Public Works, “Vitter Warns Louisiana of EPA’s Secret “Sue and Settle” Deals, Could Impact State - Says EPA and U.S. Fish and Wildlife Service are colluding with environmental groups”

[\(US Senate Committee on Environment and Public Works, 2013\)](#). Well-meaning groups and agencies whose purpose is environmental stewardship, natural resource restoration, environmental protection, wildlife management, or a host of other similar purposes must be very sensitive to people and private property owners that are directly impacted by their activities and pursuit of restrictive land use rules and regulations. “The results of the regulatory approach often satisfy no one, divide communities, and inflame emotions. Conservationists are frustrated that regulations have little effect or are even counterproductive. Landowners are angry because species preservation is done at their expense and often with little regard for their families and businesses.” [Scott Roberts, Freedom Foundation Property Rights Director] [\(Blank, 2011\)](#)

# 3. STEW-MAP TECHNOLOGY

## DESIGN CONSIDERATIONS

Representing the world of environmental stewardship through StewMAP requires the manipulation and visualization of large amounts of data. In this era of exploding technologies and open-source solutions, there are more options than ever before in how to build databases and geographic data. The existing Seattle StewMAP data is but a skeleton of what the sponsors have asked that the project house. In the first section of this chapter we discuss the functional requirements of StewMAP. In turn, these functional requirements necessitate requirements of both data and of technological components. The pieces of data required to reach a final StewMAP solution and how they drive the technological components that will drive the application must satisfy the functional components. This approach to designing a working solution allows for expansion of StewMAP's capabilities over time while allowing for all core requirements to be met.

While our sponsors have suggested a StewMAP Light, a region-wide, scaled-back version with less functionality than desired of a nation-wide implementation, we have designed with the national level in mind. However, our version of StewMAP is, once implemented, simple enough to be used at a regional level. In fact, it is our hope that a single implementation of StewMAP could be used region-by-region, allowing for uneven development of regional data as may be needed. With organizations providing the majority of input data, only a low level of maintenance per region would be needed to sustain the project.

Through sponsor input and designing a data solution, we pinpointed the minimum requirements for the project in order to design efficient, scaled databases and technology solutions for implementing this project on a national level. We identified the necessary functionality, data requirements, and 5 technological components needed to create a functional, full StewMAP. From this we hope you, the reader, will walk away with a solid understanding of these components before we offer the technical limitations, maintenance requirements, up-front and ongoing costs, and usability of different integrated solutions which contain each of these components. The following components are

required to manage the interface, user levels, and data layer structure of a StewMAP web application.

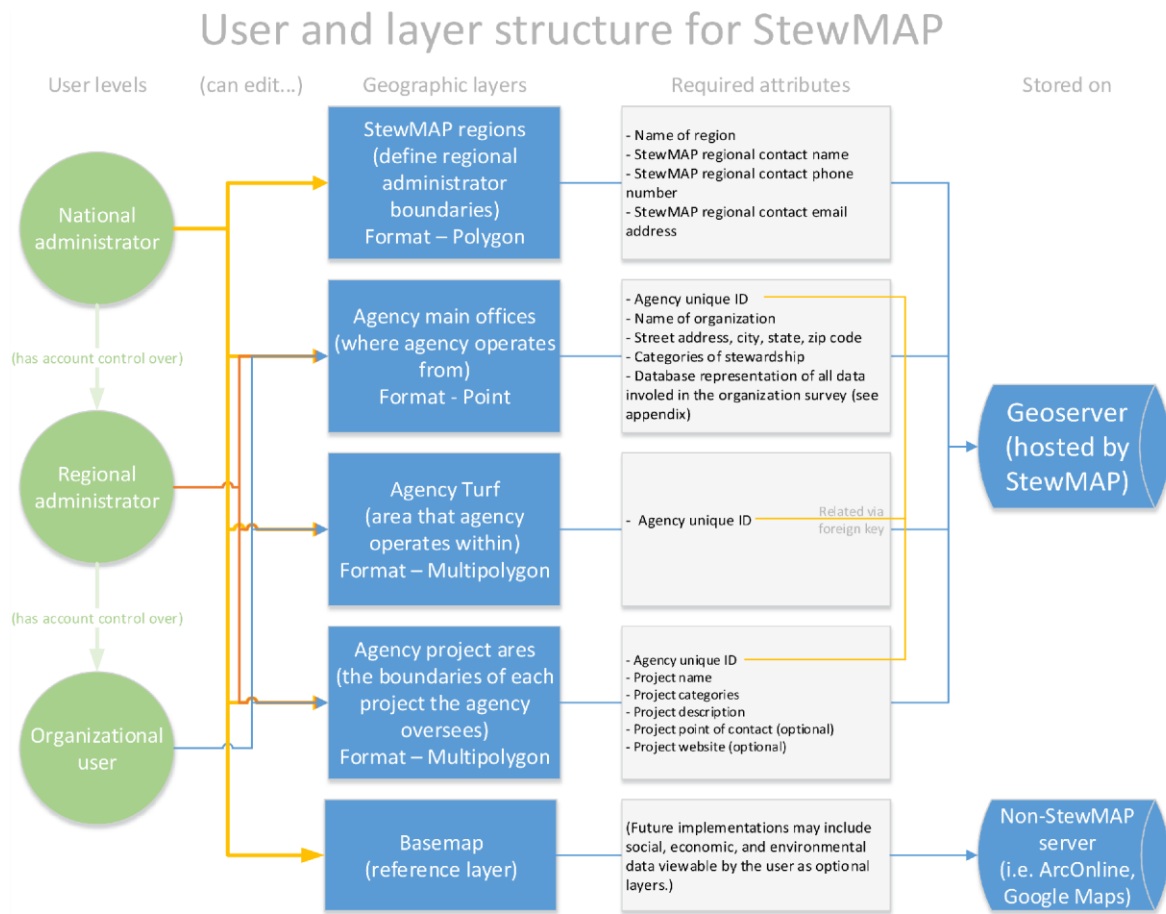


Figure 4- An initial conceptual representation of relationships between the minimal requirements for user-levels and datasets in an implementation of a national StewMAP.

## REQUIRED FUNCTIONALITY OF STEWMAP

At its core, a final design of StewMAP must provide a range of functionality that allows organizations to update data relating to the nature of the organization itself, the turf the organization operates throughout, and the extent of current and future projects the organization is completing. The design of StewMAP should also focus on making the use of these tools as intuitive and user-friendly as possible, as a confusing or overly complex interface could easily turn away organizations that would otherwise be willing to regularly update data pertaining to their activities. StewMAP must be able to provide a number of tasks to differing levels of users:

### *Visualization*

At the heart of StewMAP is the ability for anyone to seek out information on existing stewardship organizations and display both ‘turf’ and project boundaries. Ideally, anyone would be able to view these geographic areas across a whole region or extent of their choosing. Visualization must be automated to the point that default symbologies provide the user with an easily understood mapping interface coupled with display of textual information relating to organizations.

### *Filtering*

Since a nationwide implementation of StewMAP is bound to have huge amounts of data, visitors need the ability to filter what they see. We envision users being able to search out organizations within a given extent based on the categories of work performed, funding sources, and attributes such as the name of an organization. Should the ability for users to export information from StewMAP, these same criteria should be able to limit what is downloaded as well as what is displayed on a screen.

### *Editing*

Organizations need to be able to edit any data pertaining to themselves. When an organization signs up for an account, they should be asked a series of questions akin to the original StewMAP questionnaire (see **appendix A**). Furthermore, interactive editing of geographic boundaries for organizational ‘turf’ must be available to the organization. Organizations must also have ways in which to create, modify, and delete the projects that are displayed for them. The data for these

projects will consist of not only a geographic extent per project but information regarding the nature of the project (such as a start date, end date, name of project, and categories of stewardship that the project falls within).

***Administration***

Due to concerns about the accountability data provided per organization and the maintenance of this data over time, administrators must be able to edit organizational data when it is known to be inaccurate or outdated. Furthermore, ongoing contact with organizations must be maintained in order to motivate them to continually update their StewMAP data. As such, administrators should have control over all the organizational data within a given region, where they can edit boundaries of turf and project areas as well as the non-geographic data of any organization within their region. As regional administrators may change over time and regions must be created and maintained, a national administrator (or multiple) could be in charge of these tasks. These three levels of users (organizational users, regional administrators, and national administrators) each require secure logins and a specific, functional backend in order to meet all functional requirements.

***Backend Functionality***

For any functions that are to be performed only by users with some level of registered account (such as editing) there must be a functional backend only available after logging in. Backend functionality must be limited based on the type of account the user has logged in with (organizational user, regional administrator, and national administrator). See the table below for a basic overview of what the backend must provide to each level of user.

<b><i>Functionality</i></b>	<b><i>Users levels</i></b>
Editing of own turf/project boundaries	Organizational users
Editing of turf/project boundaries within region	Regional administrators
User account control over organizational users	Regional / National administrators
User account control over regional admins	National administrators
Mass emails to groups of users	Regional / National administrators
Bulk exporting of data and boundaries	Regional / National administrators

*Figure 5 – Connecting functionality to the user levels*



## REQUIRED DATA COMPONENTS OF STEWMAP

Collections of data are only as strong as the architecture that supports them. A robust database will not only suffice in storing the possibilities for data that exist within a system, but guard against inaccurate data from entering the system. As such, a well-designed database will limit the user in ways that help guide data input into a strict yet useful format.

Nonetheless, there's a difficulty in tamping down the exact nature of data in a project such as StewMAP. The technological options that may possibly be used to implement StewMAP do not process the same exact types of data, necessitating not only an analysis of the technologies themselves but the data structures they use in any worthwhile comparison of options. Although the average geographer may seek to use a geodatabase encompassing many layers and tables for a task, other data structures exist that are specifically geared for internet applications. We have attempted to capture how this could be done using MySQL databases, a lightweight yet extremely robust web-based SQL database.

As part of the initial implementation of the Seattle StewMAP, organizations were sent questionnaires to return to the project sponsors (see **Appendix A**). The questions within sought information such as the location of an organization, a written description of the organization's turf, categories of stewardship the organization is involved in, funding sources for the organization, and how to reach a point-of-contact for the organization. With this information returned by almost 150 organizations, boundaries for organizational turf were digitized by University of Washington undergraduate students. A limited amount of information relating to each organization was stored in shapefile attribute tables. Visitors to the Seattle StewMAP website could look at the turf of one organization at a time and view limited information about the organization itself. This limited functionality is now recognized as inadequate for StewMAP and caused far greater need for monitoring the data than desired.

In general terms, if we were to break down the minimum data requirements, per organization, to fulfill the requests of our sponsors, we would be looking at:

- **Organizational information** (containing all non-geographic questionnaire answers.)

- **Location of organization's main office** (a geographic point, used not only for informational purposes but to assign an organization to an administrative region.)
- **Organizational turf** (a multipolygon which represents the whole of the area the organization provides at least some form of stewardship within.)
- **Organizational project(s) area** (*per organizational project*, a multipolygon representing the geographic area the project encompasses.)
- **Organizational project information** (*per organizational project*, a small collection of data to represent non-geographic information needed per project area such as project name, project categories of stewardship, timeframe of project, and point-of-contact name, phone number, and email.)
- **User login information** (as each organization must be able to log in to the StewMAP backend to modify their general information, turf, and projects, information to authenticate users and allow access to the backend must be stored as well.)

In addition, there is non-organizational information that must be stored for the purposes of StewMAP:

- **Administrative regions** (in essence, if an organization's home office, represented by a point feature, falls within a particular administrative region then the administrator assigned to that region has power over the organization's data.)
- **Ecological regions** (using multipolygons, ecological regions could be defined as non-overlapping areas of similar environment/ecology, for which each could have extra content such as a news page for the Colorado Plateau region and an organization of the month.)
- **Administrator user login information** (our proposed design has both regional administrators and national administrators as part of the StewMAP user structure.)
- **Additional rich content** (data that can be explored by any visitors to StewMAP shouldn't be limited to the purely geographic, but have the capacity for educational and informational web content as well.)

With these data requirements in mind, it is clear that a simple, out-of-the-box technology delivery solution for StewMAP is unlikely to exist. The requirements for functionality and data capabilities of StewMAP requires a cohesive set of multiple technologies that work together.

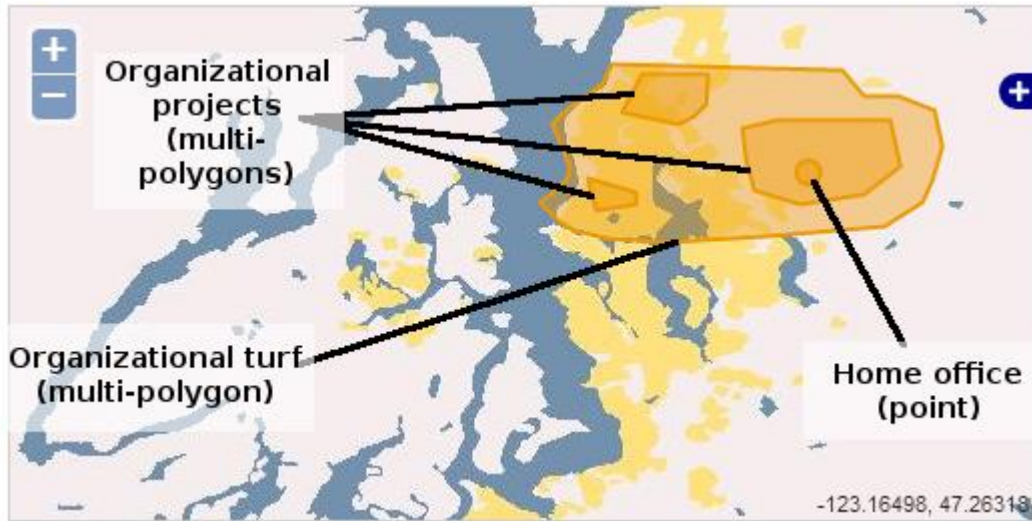


Figure 6 - A simple illustration of the types of geographies that exist for an organization within StewMAP.

# REQUIRED TECHNOLOGICAL COMPONENTS FOR STEWMAP

## *1. Web-based interactive front-end*

The StewMAP must have a publicly accessible presence on the internet so that the information within can be easily accessed by members of the public. Although seemingly simple in concept, this website must house all of the following capabilities so that visitors from any location, at any permission-level, may access the central databases that drive StewMAP. The web-based front-end may provide further pages to elaborate on whatever subjects the administrators of StewMAP find to be of interest to visitors. This front-end is the “public face” of StewMAP and, though it is available to all, should have a user login, so that organizations can navigate to the StewMAP, login, and proceed to edit their organizational information, turf, and ongoing projects.

## *2. Administrative back-end*

The StewMAP sponsors we worked with wanted a way for administrators to make changes to any of the information that organizations have entered. This includes general information (such as address, type of organization, etc) as well as geographic boundaries for organizational turf and the boundaries per organizational project.

Through this backend, the user structure will be controlled:

- One or more **National administrators** are needed to manage regional administrative accounts. Ideally, this role would be filled by someone who is responsible for the overall maintenance of StewMAP.
- **National administrators** (the 'super-users' of the StewMAP) can create accounts at any level, revoke privileges, and (with the click of a button) log in as any regional administrator or organizational user in order to edit that organizations attributes, turf, and project boundaries.

*It would advantageous for a national administrator to also have control over the data that is shown in any basemap, though this may be difficult to implement programmatically.*

- **Regional administrators** would be created and administered by national administrators. Their responsibility lies in acting as a contact for organizations, promoting the updating

of organizational data to participating organizations, and verifying the data entered by organizations.

- The regional administrators would have rights to edit any organization's information (including turf/project boundaries) as long as that organization's home office (a geographic point) falls within their assigned region (a polygon). The purpose of regional administrators is to monitor, verify, and update organizational turf and project boundaries. The regional administrators should also have the ability to contact the organizations within their defined region, both through mass emailing and individual contact.
- **Organizational users** would be used by the stewardship organizations that are participating in StewMAP. An organizational user, when signing up for an account, would fill out a web-based questionnaire (see **appendix A**) in order to . From there, they would create a single point feature that represents the location of the main office of their organization, their organization's turf (a multipolygon), and as many projects as they wish (each project being represented by a multipolygon).

Depending on the technologies used, this back-end may be web-based (for example, if a PHP/MySQL user authentication backend were used) or only accessible locally (such as if ArcGIS Server were used to control all user accounts).

#	Company	Name	Username	Status	Actions
1	Cummins Wagner Florida	Dan Orr	cummins-wagner-florida		
2	F & H Food Equipment	Chris Christiansen	chris christiansen		
3	Harvill Industries	Leon Maitre	leon maitre		
4	National Process Systems	Debbie Tracy	dt		
5	NCM International	Fernando Diaz	fenando		
6	Stainless Process	Jason Worrton	stainless process		
7	Thermaline	Rick Rohwer	idahodairy		
8	Thermaline, Inc.	Kaleb Simmons	ksimmons		
9	WALKER HI-TECH INC.	Stephen James	walker hi-tech		

1 - 9 9 Total

Shows whether account is active or not. Inactive accounts can not be logged in to.

View user account  
 Edit user account  
 Delete user account  
 Activate/DeActivate account  
 Log in to user's account

Figure 7 - An example of the user authentication back-end library UserCake  
 (source: Thermaline.com, upon company permission)

### ***3. Organizational information and feature-class editing (with user login)***

The focus on having web-based editing tools in StewMAP exists so that organizations may enter and edit their own geographic data. It is the organizational user who will do this, though they are the least likely of any user level to have a background in geography. As such, the tools provided to organizational users should ideally be as simple and user-friendly as possible.

The data that will be stored for each organization's survey questions, main office location, turf, and projects dictate what tools must be available. We envision that when an organizational user logs in to their account, they have a number of pages they can access that allow them to edit the different pieces of data stored for their organization:

- The organizational attributes (i.e. the answers to the initial organizational survey) need to be accessible for editing, by the organization, at any point. Realistically, when a new account is created this will be completed. A form-based web-page should provide all the functionality needed for users to edit this data.
- The organization's "turf" must be able to be edited by users. Any organization will only have one instance of their turf (encompassing the whole of the area that the organization provides stewardship throughout). Since the turf is stored as a single multi-polygon feature, any web-page with a dialog that allows the user to create and edit a single multi-polygon provides the functionality needed.
- The organization may have multiple project areas, representing the geographic extent of specific projects the organization is working on. If the organizational user logs in to their account and wants to edit project areas, they must be presented with a list of existing project areas and the option to create a new project area. In addition to multi-polygon geometry being entered per project, further information such as the project name, what categories of stewardship it falls into, a project website, and project point-of contact must be editable. These may be entered via forms (per project) while the project coverage would need a single multi-polygon editing dialog (with similar functionality to the dialog the organization would use to draw their turf). Each project should have a start and end date.

- The organization may wish to contact a StewMAP regional administrator with questions or concerns. We would suggest an email form that the organizational user may fill out and that would send an email directly to their regional administrator(s).

#### ***4. General user feature and data-viewing capabilities***

The general user of the StewMAP will be anyone who visits the StewMAP website and explores the data therein. They do not require the ability to edit data, but should be provided with useful tools for searching out and geovisualizing stewardship data. At its basic level, the user will have a map that they can change the extent of, zooming in and out or panning in different directions.

The ability to interact with data will be confined to the operations a visitor can perform. We suggest the following functionality be provided to visitors of StewMAP:

- The simplest data to visualize in StewMAP would be the main office locations per organization. As such, it is the geographic data layer that should be displayed by default when a user visits StewMAP. The visitor should have the ability to view a series of these points and click on one and see organizational information.
- The visitors should have the ability to view organizational turfs instead of main office locations. If the user turns on the data layer for turf, they should be able to view a list of the organizations that the map is showing and limit the selections by, at least, categories of stewardship and the type of organization.
- The visitors should be able to view stewardship project boundaries. If they click on a project boundary, further information about the selected project should be displayed (i.e. name of project, categories of stewardship, etc.). Projects should also be searchable and limitable by timeline of project, categories of stewardship, etc.

## ***5. (For future implementation) Interactive mapping capabilities***

The StewMAP sponsors wish for interactive mapping capabilities to be available to visitors. At a minimal level, this would mean visitors would be able to turn layers of social, environmental, or economic data on and off as they see fit. Whether this data is purely visual (and not limitable by queries) or highly interactive will depend on the time and expertise of those who are implementing the StewMAP.

If visitors were given the ability to query organizational data and export shapefiles of it, this would allow for a much greater level of analysis than would be provided by any interactive web mapping platform. Visitors would be able to analyze the StewMAP data against any geographic data they possess. This would be a great service to researchers and decision-makers who are seeking information on stewardship in a given area.

It is worth noting the capabilities discussed in this section are discussed to provided the minimal required functionality for StewMAP as defined by the project sponsors. Plans for added functionality, such as interactive mapping capabilities available to StewMAP viewers and tools that may help organizations collect feedback on projects, are not being discussed here. However, we believe that a well-designed database and object-oriented application for StewMAP would allow for wide expansion over the coming years.

Once again, we would like to stress that these requirements would allow for a nation-covering StewMAP to be established. The only difference between creating this StewMAP and a local, 'light' version would be that a local version would have no need for defined regions or regional administrators. If developing a local version of StewMAP with no division of regions, the database structure depicted in the following three pages would suffice for all data storage. Geo-widgets designed to edit, update, delete, and view this data would make requests in the extremely common and well-known SQL language, and any intermediate web programmer could approach the system post-implementation and easily figure out the structure of StewMAP.



# A Minimal MySQL Database Structure for StewMAP

## Translating organization-specific information to data

The StewMAP requires large amounts of data to be stored per organization. Following is a proposed database structure to store this information, regardless of platform used. It is worth noting that this data may exist independently of any geographic data within StewMAP (and related to geographic features by the omnipresent OrganizationID, a unique identifier to represent a specific, individual organization) or as tables joined/related to the geodata. It is the database administrator's duty to give each field a unique, representative name.

Table name		
Relationships	<b>PK</b> Primary key attribute/field	Data format
	Attribute/field	Data format
	★ Geographic data field	Data format

Further notes and information

Main contact information		
<b>PK</b>	OrganizationID	integer, auto-incremented
	Name	varchar/string
	Title	varchar/string
	Phone number	varchar/string
	Email address	varchar/string

Stewardship activities		
<b>PK</b>	OrganizationID	integer, auto-incremented
How often does the organization...	Conserve the local environment	Enum / Subtype&domain
	Monitor the quality of the local environment	Enum / Subtype&domain
	Take care of a specific place within local env.	Enum / Subtype&domain
	Restore or transfer local ecosystem(s)	Enum / Subtype&domain
	Advocate for the local environment	Enum / Subtype&domain

Legal values for these fields:  
**Never**  
**Sometimes**  
**Often**

The data type enum is a very useful construct within such databases as MySQL and SQLite. The database administrator defines a series of legal values. Any time a value is inserted into this field or updated, an error will rise if the value doesn't fall.

In geodatabases, subtypes and domains allow the administrator to define legal values, as well as abbreviations or representative values.

Organizational information	
<b>PK</b> OrganizationID	integer, auto-incremented
Organization name	varchar/string
Web site (optional)	varchar/string
Mailing address	varchar/string
City	varchar/string
State	varchar/string
Zip code	varchar/string
Organization email	varchar/string
Organization phone	integer
Year founded	varchar/string
Annual budget	integer
Legal designation	Enum / Subtype&domain
Percentage of org's effort put towards stewardship	Enum / Subtype&domain
Broadest scope of org's stewardship efforts	Enum / Subtype&domain
★ Main office location	Point (single)
★ "Turf" (region which the organization provides stewardship within)	Multi-polygon

Legal values for this field:  
 501(c)(3) or has applied  
 501(c)(4) or has applied  
 Community group/org.  
 School district  
 Federal government agency  
 State government agency  
 Local government agency  
 Public institution  
 Quasi governmental  
 Private firm/for-profit business

Legal values for this field:  
 0-19%  
 20-39%  
 40-59%  
 60-79%  
 80-100%

Legal values for this field:  
 International  
 National  
 Multiple states  
 State of Washington  
 Regional  
 County  
 City of operation  
 Local (i.e. single neighborhood)

Organizational purposes/functions		
PK	OrganizationID	integer, auto-incremented
	Publichealth	Enum / Subtype&domain
	Education	Enum / Subtype&domain
	Housing and shelter	Enum / Subtype&domain
	Community improvement	Enum / Subtype&domain
	Environment	Enum / Subtype&domain
	Toxics / pollution related	Enum / Subtype&domain
	Animal related	Enum / Subtype&domain
	Human services	Enum / Subtype&domain
	Youth development	Enum / Subtype&domain
	Economic / business development	Enum / Subtype&domain
	Employment / job related	Enum / Subtype&domain
	Legal services / civil rights	Enum / Subtype&domain
	Arts, culture, creative	Enum / Subtype&domain
	Recreation and sports	Enum / Subtype&domain
	Crime / criminal justice	Enum / Subtype&domain
	International / foreign affairs, national security	Enum / Subtype&domain
	Scientific / technological research	Enum / Subtype&domain
	Faith-based activities	Enum / Subtype&domain
	Electricity generation	Enum / Subtype&domain
	Energy efficiency	Enum / Subtype&domain
	Other	Varchar / string

How well does this organization provide the following function...

Legal values for these fields:

**Not at all**  
**Somewhat**  
**Often**

As is the case above, the enum data type would suffice in any data-delivery system utilizing a SQL variant database. However, in a purely GIS solution then subtypes and domain would have to be used to achieve the same functionality.

# 4. Scoping and Alternatives

The success of any implementation of StewMAP depends on how well the five technological components chosen are customized to address the needs for functionality at each of StewMAP's user levels. The many available solutions for each technological component each have limits for what they can provide to users and must be customized via programming, the specification of settings, and defining the interactivities between each technological component in an overall "technological delivery system". With this in mind, we have put together three complete solutions, each designed to address the needs of StewMAP. To keep the concept fresh in the reader's mind, the five technological components we have identified as necessary to the implementation of StewMAP are:

- Web-based interactive front-end
- Administrative back-end
- Organizational information and feature-class editing
- General user feature- and data-viewing capabilities
- Interactive mapping capabilities (for future development)

The three solutions we offer each use a collection of software to achieve a form of StewMAP, yet we will refer to them from here on out by the geographical data platform they use to complete their solution. The solutions (ArcGIS Server, Google Maps API, and OpenLayers) each share characteristics (such as Application Programming Interfaces that allow for customization through programming) while some offer out-of-the-box functionality (such as ArcGIS Server's web application publishing service) that we have found to be unsuitable for StewMAP due to lack of functionality without further specification. As such, we will not be discussing the overall nature of each solution available, but focusing on the parts of each that would be applicable towards a final StewMAP implementation.

In our research, it became apparent that there is no single solution that will work without a large amount of custom programming. The demands of StewMAP may seem relatively simple, but they are unique and will not be generating revenue that could be used to hire outside services.

We suggest anyone working with StewMAP to look outside this paper at the documentation available so they may better understand the full possibilities of each solution:

- ArcGIS Server: <http://resources.arcgis.com/en/help/main/10.1/index.html#//0154000002np000000>  
and ArcGIS API for Javascript: <https://developers.arcgis.com/en/javascript/>
- Google Maps API: <https://developers.google.com/maps/documentation/javascript/>
- OpenLayers: <http://dev.openlayers.org/apidocs/files/OpenLayers-js.html>

	Web-based interactive front-end	Administrative back-end	Organizational information and feature-class editing	General user feature- and data-viewing capabilities	Interactive mapping capabilities
ArcGIS Server	ArcGIS API for Javascript (APfj) allows for display and querying of geographic data. This allows for JS and PHP to be created around the widget to provide any other website content.	APfj custom programmed widgets/queries accessed via secure, password-protected pages would provide administrators with the needed functionality.	ArcGIS Server sharable-editing insufficient for this task. As with the organizational backend, editing would have to be provided via secure pages housing APfj widgets. Data created would be stored in a locally housed server.	APfj widgets could provide interactive geo-data display functionality while using JS/PHP to display attributes of features (such as Organization name).	Custom-programming would be necessary to provide complex query and display functions, but could be easily managed by the APfj API with user input managed by a JS/PHP interface.
Google Maps API	Like ArcGIS APfj, Google Maps API does not provide any website structure but functionality to build widgets within a website. Any javascript capable web scripting could support GM API.	APfj custom programmed widgets/queries accessed via secure, password-protected pages would provide administrators with the needed functionality.	Editing would have to be provided via secure pages housing APfj widgets. Data created would be stored in a Google-housed cloud server with fees to make data requests (for display or editing).	GM API widgets could provide interactive geo-data display functionality while using JS/PHP to display attributes of features. 2D and 3D visualization tools and data integration with Google Earth are available.	Custom-programming would be necessary to provide complex query and display functions. Data downloads would be in Google native formats (such as KML) unless conversion functions programmed.
Open Layers	OpenLayers widgets can be embedded in webpages via javascript. This allows for JS and PHP to be created around the widget to provide any other website content.	Many scalable options for a PHP-based solution (such as UserCake) could manage accounts and limit function per pages available at each user level.	Custom interface programmed using javascript utilizing existing OpenLayers widgets. Geo-data stored in MySQL or comparable database.	Custom interface programmed using javascript utilizing existing OpenLayers widgets. MySQL db would have to be queried via JS off-page function by PHP script.	With PHP scripts integrating JS for Openlayers widgets, users could submit queries to a MySQL db which would be returned via widgets. Less flexibility than the other options, but all necessary functions are provided for.

Figure 9 - A comparison table of the ways in which each solution addresses the technological components of StewMAP.

## ArcGIS Server / ArcGIS API for Javascript

Pros	Cons
Well-known in the geography world	Requires a running instance of ArcGIS Server for data delivery
Supports many data formats	Subject to licensing restrictions and depreciated functions
If licensing allowed, very simple data sharing of extra geographic layers and base-map features	Extra features and permissions to manage could create bloat
On-board analysis tools could provide built-in functionality when analysis features are built into StewMAP	Unusable features (such as an ill-fitted user account management system) could create bloat and confusion; a poorly-scaled product

## Google Maps API

Pros	Cons
Extremely strong visualization abilities (in both 2d and 3d)	Extremely limited data format support (.kml, .kmz, .csv, .dbf, .shp)
Ability to interface with ArcGIS Server (and all-Server supported data formats) using Google Maps API Link for ArcGIS Server	Link to ArcGIS Server requires a licensed, running instance of ArcGIS Server for data retrieval
Google-based cloud servers offer geographic data hosting plans	Using Google cloud servers is pay-per-web-request after a given limit
Provides all the geodata-related functions needed for the minimal requirements of StewMAP	Least amount of functionality of all three solutions compared; data can be removed by Google at any time

## OpenLayers

Pros	Cons
Strong open-source community with extensive documentation	No built-in tech support line to call, must rely on the OpenLayers community for help
Versatile, high-level functionality provided	No way to edit data outside of StewMAP (such as using ArcGIS Server/ArcGIS) without exporting
No danger of depreciated functions due to embedded release nature, no worry of expiring licenses	Requires user level control to be programmed through other means just like the other solutions
Offers the most flexibility in hosting abilities and data format support, including the usage of MySQL databases	Although generally considered very robust, open-source nature of OpenLayers could mean bugs take longer to fix

*Figure 10 - A list of pros and cons for each over-arching geo-technology component of StewMAP*

## **A. ArcGIS Server and ArcGIS API for Javascript**

ArcGIS Server is a software add-on for ArcGIS Desktop that expands functionality in sharing, publishing, and managing geographic data. Using ArcGIS Server allows for data layers to be published to a web service from ArcGIS Desktop, for administrators to define user groups, and for administrators to limit access (per group) to viewing, editing, creating, and deleting features per layer. From the multiple editions (Advanced, Standard, and Basic) and two levels (Enterprise and Workgroup) available, sifting through the options to figure out the best solution for a single project may be a harrowing experience.

For the purposes of StewMAP we will be discussing the functionality of the Advanced Enterprise version of ArcGIS Server. The Advanced edition allows for spatial analysis and data delivery via internet capabilities that are not available elsewhere, while the Enterprise level means that there is no limit to the number of connected users or amount of data that can be stored. These abilities may be very useful when StewMAP reaches a level where visitors would be able to analyze data on their own accord. Furthermore, the Standard and Basic editions of ArcGIS Server limit the ability to deploy data and applications over the internet.

Although ArcGIS Server provides a number of tools for publishing and sharing geographic data, the way in which user access to data is structured with these tools would prevent an out-of-the-box user access structure from ArcGIS Server to be applied to StewMAP. User permissions are applied per defined user groups, with access only occurring once an administrator or super-user invites a user. Managing a user set as large as could be expected from a nation-wide implementation of StewMAP would not only prove time-consuming, but the level of complication involved would make such an approach unmanageable. Instead, a programmed solution that defines the data accessible for any given user, via a dynamic server-side web-programming language such as PHP, would have to account for this shortcoming. This approach is suggested for the other solutions discussed in this chapter, but is worth noting that this is the first instance of a function provided by ArcGIS Server that may seem to be well-suited for StewMAP upon first glance but falls short of meeting the specific needs of StewMAP. From the standpoint of creating a properly scaled solution, these types of built-in functions that must be ignored or manually bypassed can lead to confusion and bloat.

However, all of this bloat has a purpose to the right user. The ArcGIS API for Javascript can call upon features stored on an ArcGIS Server instance and rely on the relationships within a complex geodatabase to limit results. If the administrators of StewMAP saw a need for doing complex analysis of the data on-hand, they would not have to attempt file conversions or complex operations before being able to use their data in a standard instance of ArcGIS Desktop.

The existing Seattle StewMAP has used, at least to some degree, ArcOnline for data entry and management. While this solution is useful in enterprise business situations, once again the user structure of StewMAP is such that ArcOnline provides insufficient security limitations for organizations. To limit an organizational user of StewMAP to editing only features they've created, no permissions available within ArcOnline or ArcGIS Server will suffice.

### **Creating StewMAP with ArcGIS Server**

In order to create StewMAP with ArcGIS Server and the ArcGIS API for Javascript, there's a large amount of customization needed. Of the many challenges presented in this approach, the biggest hurdle would be the control of user access. With native ArcGIS Server user control structure, groups of people are given control of features classes by administrative controls. StewMAP, on the other hand, requires that organizations be able to create accounts, add features, and edit their own data while not being able to edit features throughout a region or category as part of a group. Regional administrators must be able to edit any features within a region while having account control, being able to deactivate accounts and edit features association with any organizations within a region.

The process of creating StewMAP using any of the available options will following the same general wireframe: create a sitemap and general interface for the website, create the necessary databases/geodatabases as dictated by the platform, create the widgets to display and edit geographic data with the expectation of passing organization/user ID's to a function so that reusable code exists in each page, and install and customize a backend (preferably php-based, allowing for server-side creation of dynamic javascript and html pages) for organizations and administrators to do editing of geodata and general data. These steps can be done, mostly, in parallel by developers if what functionality must exist per division (such as whether data will be displayed solely in the geo-widgets or outside in the GUI when a general user is exploring organizations) is explicitly stated.



## B. Google Maps API

The Google Maps API provides a language for interacting with geographic data based upon the widely used web-based Google Maps platform. Google's cloud-storage technologies can work with many data types and are free to call server requests upon to a stated limit. After this limit, a cost per thousand web requests can occur. Whereas the ArcGIS Server API appears to be geared towards large agencies and enterprise organizations, the Google Maps API's strongest suit may be the wide amount of user-accessible geographic features. Not only does this allow for the use of basemaps with a detailed collection of physical and human features as could be found in other options, but extensive collections of business locations, user-submitted features, and strong built-in visualization tools.

When we speak of visualization tools, this does not only mean that a wide array of 2-dimensional basemaps are available. Through the Google Maps API, users could load the collection of StewMAP geography, served through Google's storage technology, into Google Earth and explore it with the ease of a lightweight yet very visually stimulating interface. As most environmental stewardship organization do not likely have advanced-level GIS analysts on their team, this would create a user-friendly way for StewMAP visitors to explore the stewardship efforts in their area with little hassle and no need for technical expertise.

However, this solution has limitations that the others do not. A Google Maps API authorization key must be maintained in order to use the Google Maps API coding in any webpage and, while free at the current time, may be subject to usage fees and restrictions in the future. Google reserves the right to revoke the a license at any given time which, should this occur to StewMAP, would mean that not only a re-design of the project would be necessary but that data loss could occur. However, the latest release of the Google Maps API now provides an "ArcGIS Server link" that provides a platform for using the API to load data from an ArcGIS Server instance.

This means that using the Google Maps API for its strong visualization and easy-of-use is an option without remotely storing data and relegating it's rights to another organization's ownership (<http://help.arcgis.com/en/webapi/javascript/gmaps/>). The analysis options offered by this API are nowhere near as in-depth as the ArcGIS API for Javascript coupled with ArcGIS Server. If not using an extension to work with external data formats, support is only available for .shp, .kml, (strictly Goldsmith & Price

formatted) .csv, and .kmz data formats to store geodata.

(<http://support.google.com/mapsengine/bin/answer.py?hl=en&answer=1272933#vectorFiles>) These are not designed to store large amounts of data with varying data types, nor are they suitable for complex relationships between feature classes.

These drawbacks certainly could impact the ability of StewMAP to provide tools for users to analyze the relationships between stewardship organizations and their regions in addition to limiting future data expansion for the project.

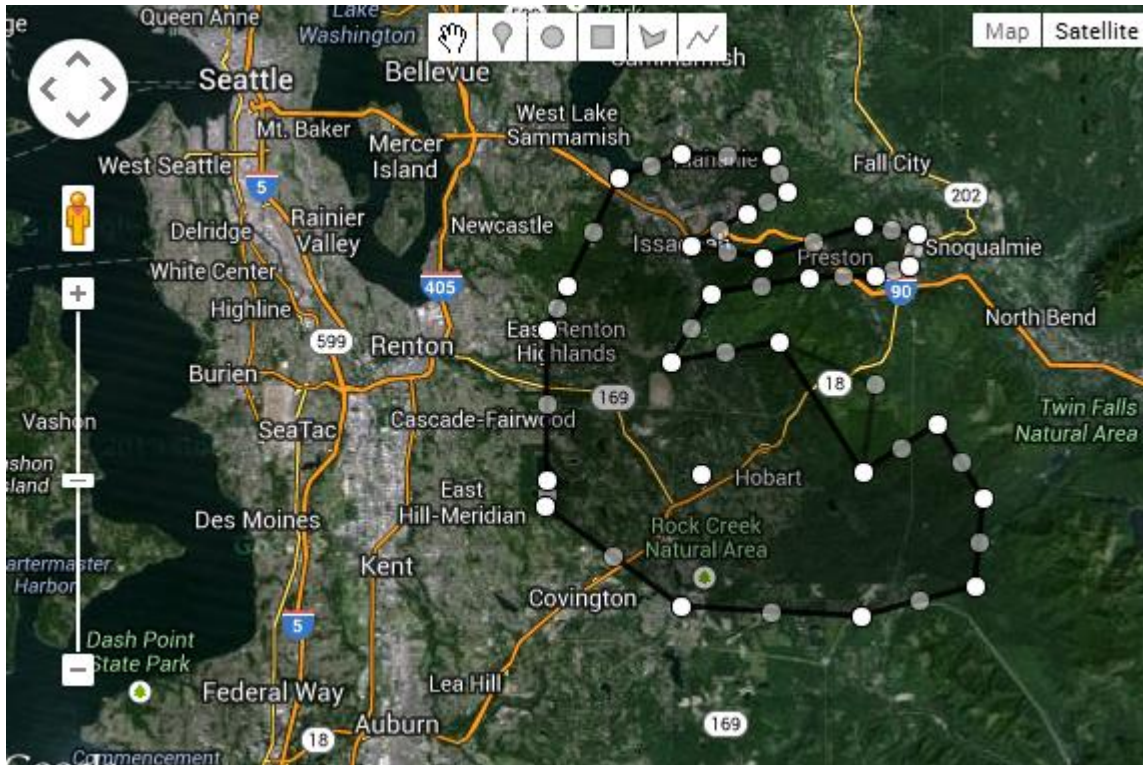
### **Creating StewMAP with Google Maps API**

The big question with using Google Maps API is what data format will be used for the geographies. The limitations to data formats as listed above mean that features that are available using, say, geodatabases would not be accessible unless the Google Maps API utilized the recently released Google Maps API Link for ArcGIS Server. However, editing features via the link for ArcGIS Server is not yet supported, so the data format used to store editable geographies in StewMAP must be of the limited, Google Maps API-supported formats (.shp, .csv, .kml, .kmz, .dbf). (<http://google-maps-utility-library-v3.googlecode.com/svn/trunk/arcgislink/docs/reference.html>)

This limitation notwithstanding, using Google Maps API with its supported data formats would provide all the editing and visualization functionality desired. Further down the line when interactive analysis becomes a part of StewMAP, the data formats may limit the ability to study outside data against that stored in StewMAP. While it is our team's opinion that the visualization tools offered by Google Maps API are the best out of all the options studied, these limitations alone would set the tool at the bottom of the list in terms of long-term feasibility of meeting the goals of StewMAP. Nonetheless, let's consider building StewMAP with the Google Maps API and *not* using the link for ArcGIS Server for a few moments.

As with the previous example of building StewMAP using ArcGIS Server and ArcGIS API for Javascript, the Google Maps API would be used for nothing more than creating widgets that would display and provide editing functionality for users. What they would be able to view and edit would have to be managed by outside code and other languages and APIs. In fact, Google Maps API is a

javascript-based library just like ArcGIS API for Javascript, so the differences between implementing each solution are, first, that Google Maps API would have to serve geographic data via Google's cloud service or an online geoserver and, second, that any non-web-based usage of StewMAP data would have to be downloaded via this outside source and, possibly, converted to a data format more useful in whatever GIS package would be used.



*Figure 11-- An example of a widget with polygon editing capabilities built with Google Maps API  
(Source- Blitz Gmap Editor, <http://www.geocodezip.com/blitz-gmap-editor/test5.html> )*

## C. OpenLayers

Developed as an open-source Javascript library for working with geographic data, OpenLayers is a flexible, highly-customizable platform for developing mapping applications. With the ability to work with many of the most widespread data types and software packages, OpenLayer's strength is bolstered by its set of interactive, online features. With a large user-community, open-source licensing, and thorough documentation, it seems that programming dynamic web applications utilizing the OpenLayers framework is within the capabilities of any geographer with experience writing code.

A very common question that occurs often when discussing open-source software is "Is it future-proof?" The fears of having a technician work with StewMAP in a few years and have no experience with a defunct OpenLayers architecture is well worth investigating. However, there is also a significant advantage to the open-source, community-developed world of OpenLayers in that it requires no external software to provide the data. While the Google Maps API can host geodata on the web via multiple data formats, the developer has the right to suspend the needed Google Maps API license for any user at any time. ArcGIS Server requires hardware running the software to host data. OpenLayers is, in this regard, the most future-proof solution.

OpenLayers supports an extremely wide array of geographic data formats including the ability to use MySQL database geometry fields. This is our preferred method of data storage due to it's robust yet lightweight nature. MySQL is one of the most widespread database platforms on the internet and has many powerful tools built to assist in back-end data maintenance (such as phpMyAdmin). While ArcGIS Server allows for data operations to be performed on ArcGIS Desktop and in Server, it requires a running instance to provide data to the web and may even be serving dozens of other data operations, meaning that anyone working with the data would have to be careful and knowledgeable to the whole server system.

Perhaps most importantly, OpenLayers hosts a large range of functions. The user community has taken advantage of OL's open-source nature and has many developers offering extra, non-native functionality through their own library additions. Basemaps are available from sources across the web including BingMaps, GoogleMaps, and others. OpenLayers even has the ability to serve data

from ArcGIS Server, so should StewMAP be built using MySQL as suggested but the desire to migrate data to an on-site ArcGIS Server instance, very little programming would have to be changed.

There is no fear of losing the ability to work with OpenLayers code in the future and no danger of fees or depreciated features. Web-hosting services could house the data with no further interface to the data needed. OpenLayers, post-development, would be the most “portable” of the options discussed. There is no license to maintain or needed hardware link from data to the web. Furthermore, agencies appear to be increasingly relying on OpenLayers to provide the customization they need in their web apps.

### **Creating StewMAP with OpenLayers**

OpenLayers is, like the two technologies previously discussed, a javascript-based API. With support for serving data from ArcGIS Server as well as external web-based geo-servers, data format handling in OpenLayers is comparable with ArcGIS Server. The OpenLayers API itself not only provides a large array of visualization tools and editing functions, but requires no ongoing licenses to be managed.

Like the previous examples, OpenLayers would be used to develop widgets within StewMAP to perform the heavy lifting needed to display and edit geodata. A programmer would have to use a platform to allow users into the StewMAP backend to edit features and limit based on the user. Creating programmatic functions that allow for the passing of features when they meet certain criteria (such as limiting visibility and editability of features to those attributed to whatever organization is logged in to the backend) would be necessary to create a fully functioning StewMAP. This does not differ from ArcGIS Server/API for Javascript or Google Maps API.

The open-source nature of OpenLayers means that licensing or support would never be an issue, that once a suitable online geoserver was established there would be no need for a self-hosted hardware solution, and that analysis tools would be available but would require programming in order to achieve results. Most comparisons (ease of programming and use, documentation, visualization capabilities) between ArcGIS Server/API for Javascript and OpenLayers do not yield notable

differences. However, OpenLayers has a definite advantage in being able to be used indefinitely, regardless of license fees or depreciated features. On the other hand, ArcGIS Server would provide analysis tools for use without hard-coding that may provide useful in the future.

In the end, OpenLayers provides all the functionality needed and is geared towards creating custom geotechnology solutions. ArcGIS Server/API for Javascript is the overarching enterprise GIS solution for any use imaginable, but would also supply far more than is possibly needed by StewMAP. Working with ArcGIS Server may mean navigating through many unwanted features and functionality, creating bloat and confusion after the initial programming phase. OpenLayers provides a platform that, if built well the first time, would provide a streamlined, well-scaled StewMAP solution with all needed functionality accessible through the internet.

It is for these reasons that we suggest using OpenLayers to build the final implementation of StewMAP with an online geoserver, allowing for organizations to easily edit features and information while providing the tools to build on StewMAP into the future. With a customized website utilizing OpenLayers for geo-widgets, MySQL databases for all data storage, a PHP-module for user authentication, and outside-hosted server space, StewMAP would have the greatest likelihood in functioning as envisioned with as little fuss as possible after implementation.

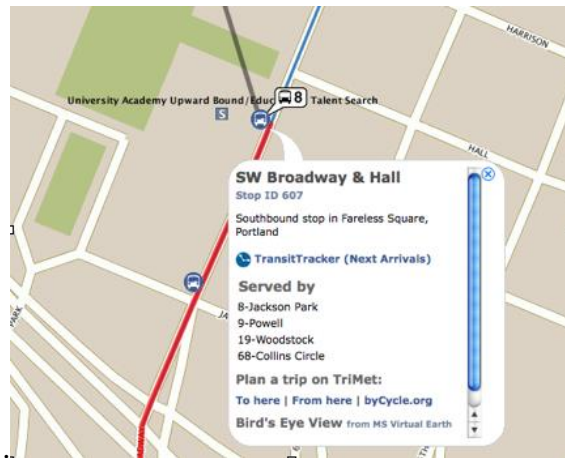


Figure 12-- An example of a javascript-coded information bubble in OpenLayers, displayed when a point feature is clicked on. (Source- TriMet Interactive TripPlanner, <http://ride.trimet.org>)

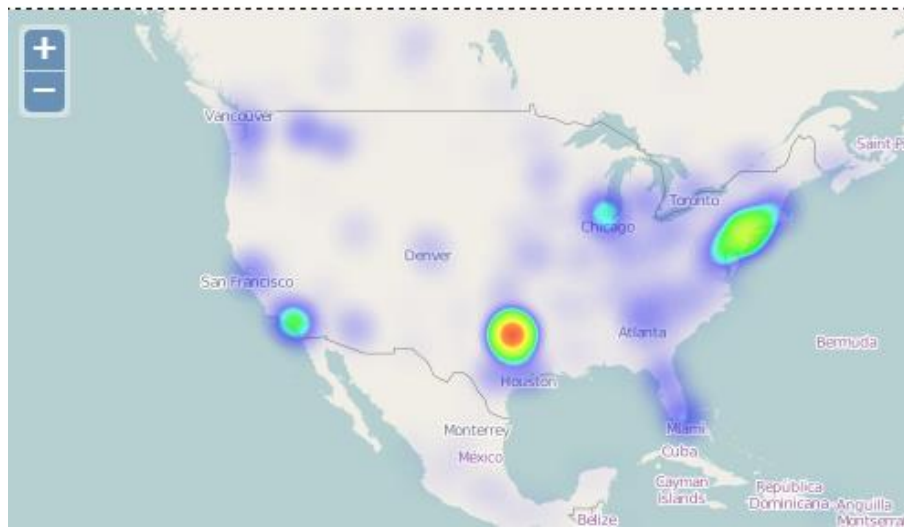


Figure 13-- OpenLayers using the HeatMAP.js library, displaying a static layer  
(Source- OpenLayers Heatmap Overlay;

[http://www.patrick-wied.at/static/heatmapsjs/demo/maps\\_heatmap\\_layer/openlayers.php](http://www.patrick-wied.at/static/heatmapsjs/demo/maps_heatmap_layer/openlayers.php) )



Figure 14-- A theoretical sitemap of StewMAP as a full web-site/web-application.



# 5. A Business Case for StewMAP

Stewardship mapping in a participatory GIS (Stew-Map) is a geospatial information technology (GIT) project. Stew-Map will be an enterprise level GIS that will be designed to accommodate a large number of users that can manage, share, and use spatial data and associated information. The implementation of a GIT project can take a significant amount of time, effort, and money. It can take up to five years for an organization to see a return on investment (ROI) for a GIT program if there is going to be a financial ROI. Building a business case for Stew-Map must consist of a project definition, financial analysis, and strategic analysis. ([Lerner, Ancel, Stewart, & DiSera, 2007](#)). A financial analysis would include estimates of tangible benefits, costs, cash flows, opportunity cost, and inflation. It would calculate financial metrics such as net present value (NPV) and return on investment (ROI). However, at this juncture in the Stew-Map project, it seems to fall more into a strategic analysis justification. A strategic analysis would address the relationship between advancement of Stew-Map into a participatory GIS and the mission and goals of its sponsors. A strategic analysis would present costs and benefits that may be very difficult to quantify; thus they would be ignored in a financial analysis. However, the financial cost of the desired presentation technology alternative would need to be accurately estimated so that the funding source could decide if the strategic benefits exceeded the financial costs. Generally speaking, strategic benefits might include:

- Public access to static and dynamic displays of stewardship organization information and turf.
- Administrative access by stewardship organizations to enter and/or update “turf” geography.
- Analytics to generate maps and overlays based on web-based queries.
- Links and displays of metro/regional organizational network analysis.
- Promote broader public involvement in environmental work.
- Promote partnerships between people and groups involved in urban environmental sustainability.
- Quality of life improvement in urban environments due to environmental stewardship

activities.

- Urban environmental governance, including environmental management and land management, may be enhanced by having access to comprehensive maps of environmental stewardship projects along with information about the associated stewardship organizations.

## **Maintenance needs for StewMAP**

Any design of StewMAP will require at least some level of human maintenance. With the back-end functionality of StewMAP built as we have designed it, we believe the time needed for verifying and editing data and accounts will be minimal.

The user structure as we have designed houses merely three levels of authenticated users: national administrators, regional administrators, and organizational users. The national administrator(s) would have full control over all regional administrator accounts. The regional administrators would have full control over all the organizational users within their geographically defined region and be in charge to changing the region-specific data as needed. The amount of time needed to perform these tasks will vary widely depending on the number of organizational users within a region. By far the most time-consuming task for an administrator would be to edit organizations' turf and project areas after they found the organization's delineation inaccurate.

If there was a singular nation-wide StewMAP to maintain, the first step would be create a polygon feature-class of defined regions within the US. Assuming these regions would not be re-defined, at least one regional administrator per region would be responsible for verifying organizational user-input data. We think this would require very little time. Regional administrators could potentially server as points-of-contact for the organizations within their region, allowing for mass-emails to be sent as reminders to update StewMAP and answering questions.

In order for region-specific informational panels, regional administrators could have access to forms that edit a few simple MySQL fields:

- ▲ Image (base64-encoding could convert to text and back)
- ▲ Body (text)

Using these fields alone, a simple region-specific html-panel could be created easily. When a user is exploring Stewmap, the centroid of their viewport could see if it is within a region (by using the `.polygonContains()` function of OpenLayers). If the function was triggered when viewport scrolling halted, a signal that sets the region-specific info based on these MySQL fields could be programmed to update.

If these were stored as MySQL data fields they could be shown per region, defined by which region the centroid of the map's viewport rests within.

As an example of the amount of time needed to maintain StewMAP, we would estimate the amount of time spent per week per regional administrator overseeing a region with 500 organizational users to be 1-2 hours per week. National administrators would have very little responsibilities outside of managing regional administrators and their accounts, but would have the ability to edit organizational geo-data or information as needed.

## **The costs of implementing StewMAP**

Implementing StewMAP as it is described in this paper may not seem like an easy task, but a single full-time web developer with PHP/MySQL/Javascript *and* geographic application programming experience (a common combination of skills) and a part-time geographer (to review data format and editing functionality) would likely be able to build the application in 1-3 months.

As of the time of writing (August 2013), PHP Web Developers made an average of \$89,000 per year salary while geographic developers brought in an average of \$85,000 per year (source: Indeed.com, August 21<sup>st</sup>, 2013). We used these figures to construct high- and low-end estimates for the implementation of a *minimal*, nation-wide-capable StewMAP.

<b>Labor, Web Programmer (40 hours)</b>	\$1,711.54
<b>Labor, Geographic Programmer (10 hours)</b>	\$408.65
<b>Number of weeks to develop StewMAP (low estimate)</b>	5
<b>Number of weeks to develop StewMAP (high estimate)</b>	13
<b>Total development cost (low estimate)</b>	\$10,600.96
<b>Total development cost (high estimate)</b>	\$27,562.50

Ongoing costs for web-hosting are heavily dependent on bandwidth use and the number of visitors to a site. For hosting alone with the configuration we have specified, we believe hosting and a domain-name for StewMAP could be as little as \$30/month, though we'd expect over \$50 a month would be the norm. Once built and tested, we would not expect re-programming to be needed without a desire to add additional functionality.

# 6. Final Recommendations

Regardless of which technology is chosen, it is important to design and implement a usable system. Systems that users find difficult to learn and complicated to operate are likely to be under used, misused, or fall into nonuse. Human Centered Design (HCD) is an approach to design that incorporates the user's perspective into the development process. The strategic activity of usability planning and scoping is performed by identifying and bringing together stakeholders relevant to the project development to create a common vision for how usability can support the project objectives. High-level information should be collected and agreed upon such as:

- Why is the system being developed? What are the overall objectives?
- Who are the intended users and what are their tasks? Why will they use the system? What is their experience and expertise? What other stakeholders will benefit or be impacted by the system?
- What are the technical constraints?
- What key functionality is needed to support the user needs?
- How will the system be used?
- What is the overall workflow? What are the typical scenarios of how and why users will interact with the system?
- What are the usability goals? How important is ease of use and ease of learning? How long should it take users to complete their tasks? Is it important to minimize user errors? What graphical-user interface (GUI) style guide should be used?
- How will users obtain assistance in using the system?
- Are there any other initial design concepts?

Prior to implementation, usability evaluations should be conducted to improve the product as part of the development process by identifying and fixing usability problems (“formative testing”), and to find out whether people can use the product successfully (“summative testing”). ([Maguire, 2001](#))

With all this in mind, we believe that the best option for building StewMAP is to design the system as has been stated in this report using OpenLayers as the over-arching geographic technology to provide the needed functionality. There are multiple reasons for this suggestion; OpenLayers exists free of licenses and the possibility of regular fees for use, OpenLayers offers an extremely wide-range of available functions and supported data formats, OpenLayers can interface with many server types to store and retrieve data, and OpenLayers does not appear to be any more difficult to program with than the other two options. Coupled with a MySQL database for storing text information and even point and multipolygon geographies (<http://dev.mysql.com/doc/refman/5.0/en/mysql-spatial-datatypes.html>), a complete web application could be relatively quickly assembled that provides all requested functionality for StewMAP with little to no bloat. All functionality could be hosted via the web application, eliminating the need to have a physical server or ongoing license. The software could be configured to the exact scale that suits the users' needs.

Regardless of the method chosen to build StewMAP, this paper lists many design and implementation considerations that can help guide those who work on it next. It is our belief that StewMAP will help connect communities and be built into an extremely strong tool, driving polycentric governance through participatory GIS, and look forward to that day.

# Appendix A- **USFS questionnaire for stewardship organizations**

## **USDA Forest Service – Stewardship Mapping**

developed in cooperation with USFS collaborators in New York, Chicago & Baltimore

Kathleen Wolf, Ph.D. (kwolf@uw.edu)

Michele Romolini, Ph.D. candidate, U of VT

final version: January 7, 2011

survey was administered online through June 2011; data reduction to reduce categories was done January 2013

## SEATTLE AREA ENVIRONMENTAL STEWARDSHIP SURVEY

Does your organization work on behalf of the environment in some way? This may include planting trees, advocating against toxics, restoring a riparian area, gardening in a schoolyard, or some other stewardship activity. We would like to learn about these activities, including what your organization does, where, and why.

The intent of this study is to understand environmental stewardship in the Seattle region. We define **stewardship as conserving, managing, caring for, monitoring, advocating for, and educating the public about local environments**. Based on the information we collect, we will develop maps to show where and how people work together to improve the environment of the region.

A similar study was conducted in New York City, and it has helped stewardship groups connect with each other, obtain new resources and partners, and the results support citizens as they work on behalf of their local environment.

This survey should take about **20-30 minutes** to complete. It includes questions about your organization and about its stewardship programs or projects. Please complete this yourself, or route to the person who is qualified and has the authority to respond.

Thanks in advance for completing the survey; your input will help us to develop a complete picture of stewardship in the Seattle area.

### **1. Please enter your contact information to get started.**

Your personal information is confidential. We will not share any of the identifying information with anyone outside of the research team. We are asking for this information as we may contact you if we have questions about information you provide on this survey.

Your name:

UW IRB #39921 EC :: January 7, 2011

Page 1

Your title or position description:

Your phone number:

Your email:

**From this point on you will be asked a series of questions about your group or organization. Please try to provide responses that indicate the conditions or situations of the entire organization or group, rather than just your own personal experience or preferences.**

**2. Basic Information about your group/organization.**

Group/organization name:

Web site (if available):

Mailing Address (with City, State, ZIP):

Group/organization Email:

Group/organization Phone:

Does your group/organization wish to be listed in a public, online stewardship database? In other cities, this database allows stewards who share interests to find each other and collaborate if they wish. YES/NO

**3. Please tell us about your group/organization's environmental stewardship activities:**

How often does your organization do the following types of stewardship activities?	Never	Sometimes	Often
Conserve the local environment? Take care of a place in the local environment (for example, a community garden, a block of street trees, an empty lot, a riverbank, a schoolyard, a forest preserve)? Restore or transform local ecosystem (for example, daylighting a stream, brownfield recovery, or habitat restoration) Monitor the quality of the local environment? (for example,			



monitoring air or water quality, or species monitoring)?			
Advocate for the local environment?			
Educate the public about the local environment?			

\*Skip logic: If anyone answers “never” to all questions, jump to a page that says:

Thank you for your interest in filling out this survey. Based on your response to the last question, your group/organization's activities do not fit into our research definition.

If you made a mistake while filling out the last question(s), please click the Back arrow (below) to update your response.

**Please tell us about your group/organization . . . . .**

**4. What is your group/organization’s legal designation? (Please choose the most appropriate response).**

- 501(c)(3) (or has applied)
- 501 (c)(4) (or has applied)
- Community group/organization without 501(c)(3) or 501(c)(4) status (such as a block club)
- School district
- Federal government agency
- State government agency
- Local government agency
- Public institution (not an agency)
- Quasi governmental (such as a port authority)
- Private firm, for-profit business → If checked, then pop-up with a note that says, “For this survey, please answer stewardship questions based only on the stewardship work that your business does that is volunteer or pro bono.”
- Other (please specify) \_\_\_\_\_

<b>5. Below is a list of possible purposes and functions of organizations. How well does each of the following describe the purpose or function of your group or organization?</b>			
	not at all	somewhat	very well

Public health (including mental health, food, crisis intervention, health care)			
Education			
Housing and shelter			
Community improvement and capacity building			
Environment (including gardening, forestry, ecological restoration, water and air protection)			•
Toxics/pollution related			
Animal related			
Human services (including day care, family services)			
Youth development			
Economic or business development			
Employment, job related			
Legal services, civil rights			
Arts, culture, creative practices			
Recreation and sports (including birding and fishing)			
Crime, criminal justice			
International, foreign affairs, and national security			
Research in science and/or technology			
Faith-based activities			
Power/electricity generation			
Energy Efficiency			
Other _____			

**6. Considering all of the programs, activities, and services your group/organization does, what percentage of your effort is for stewardship?**

0 – 19%	20 – 39%	40 – 59%	60 – 79%	80 – 100%
---------	----------	----------	----------	-----------

<b>7. Below are possible project sites/settings for stewardship. In the past year, how often did your group or organization do stewardship work at each of the site types?</b>			
	never	sometimes	often

<p>WATER &amp; WATER-RELATED</p> <ul style="list-style-type: none"> <li>Watershed / Sewershed</li> <li>Stream / River / Canal</li> <li>Waterfront / Beach / Shoreline</li> <li>Wetland</li> </ul> <p>OPEN SPACES &amp; NATURAL AREAS</p> <ul style="list-style-type: none"> <li>Prairie/Savanna</li> <li>Forest/Woodland</li> <li>Park</li> <li>Community garden</li> <li>Urban farm</li> <li>Playing field / Ball field</li> <li>Dog run or dog park</li> <li>Public garden (botanical garden, arboretum, etc.)</li> <li>Trails / Bike paths / Greenway / Rail-trail</li> </ul> <p>NATURE IN BUILT PLACES</p> <ul style="list-style-type: none"> <li>Residential building grounds (apartment courtyard, back yard, etc.)</li> <li>Vacant Land / Vacant Lot</li> <li>Brownfield property</li> <li>School yard or grounds / Outdoor classroom</li> <li>Grounds of public building other than school (city hall, library, hospital, etc.)</li> <li>Courtyard / Atrium / Plaza</li> <li>Street trees / Boulevard/ traffic island / greenstreet / parkway (Public right of way)</li> <li>Rain gardens / rain barrels / permeable pavement / bioswales</li> <li>Green buildings</li> <li>Green roofs</li> <li>Flower box / Planter</li> </ul>			
--	--	--	--

Other _____			
-------------	--	--	--

**8. Please tell us why your group/organization does stewardship work. [Freeform answer.]**

**Where your group/organization conducts stewardship activities . . . .**

**9.-What is the broadest geographic scope of your group or organization's stewardship activities?**

International

National

Multiple states

State of Washington

Regional (e.g. several neighboring counties, a landscape element such as the Puget Sound, etc.)

County

City of Seattle

Local (e.g. one or more neighborhoods, specific greenspaces within the city, etc.)

**10. Please describe in detail the boundaries of where your group/organization has done work in the last year. Be as specific as possible. You can list multiple locations.**

For example:

“Interlaken Park” – “All of King County” – “the traffic circle on Belmont and E Thomas” –

“The Puget Sound” – “along the Duwamish River” – “the Bradner Gardens P-Patch”

**11. Please identify all Seattle neighborhoods in which you work. Click on the neighborhood name for a map. If you are still unsure, please visit the City Clerk's website for additional maps: <http://clerk.ci.seattle.wa.us/~public/nmaps/neiglist.htm>.**

*[LIST OF NEIGHBORHOODS HOTLINKED TO CITY CLERK'S NEIGHBORHOOD MAPS]*

**Structure and administration of your group/organization . . . .**

**12. Approximately what year was your group/organization founded? \_\_\_\_\_**

Note: for national or regional groups/organizations please tell us the approximate year your chapter was founded.

**13. Approximately how many of the following does your group/organization have:**

Full-time staff: \_\_\_\_\_

Part-time staff: \_\_\_\_\_

Members: \_\_\_\_\_

Regular Volunteers: \_\_\_\_\_ (note regular volunteers are those who routinely volunteer in your group/organization’s activities. This is different from volunteers who may come out for a single work day).

For those volunteers who come out occasionally, can you estimate how many hours they contribute? per . . . . week \_\_\_\_\_ or month \_\_\_\_\_ or year \_\_\_\_\_

<b>14. How often does your group/organization use the following methods to share information with the public?</b>	never	sometimes	often
N/A, we don’t share information			
National media			
Local media			
Direct mailing / newsletters			
Door-to-door outreach			
Flyers / signs			
Website			
Listserv			
Social media (e.g. blog, Facebook, Twitter)			
National conferences/meetings			
Regional conferences/meetings			
City conferences/meetings			
Neighborhood-based conferences/meetings			
Radio			

TV			
Other (please specify) _____			

**15. What is your group/organization’s estimated annual budget for the current year?**

\_\_\_\_\_

Check box: Prefer not to answer

<b>16. Please indicate the level of funding your group/organization has received in the last year from the following sources.</b>	no funding	minor funding	major funding
Corporate giving/sponsorship			
Local foundation			
National foundation			
Endowment			
Fees/program Income			
Fundraisers (events, dinners, etc.)			
Individual donations			
Memberships			
Federal government			
State government			
Municipal government			
Other (Please Specify) _____			

**Relationships among groups and organizations . . . .**

In the final section of the survey, please tell us about your group or organization’s relationship to other groups and organizations.

For all questions in this section, we are interested in hearing about all possible collaborations. These may include federal, state, and local government; private companies; nonprofits, schools, or community group/organizations; etc.

**17. In the past year, did you seek information, advice, or expertise from other groups or organizations?**

**Please list up to ten groups/organizations from whom you received information, advice, or expertise related to environmental stewardship:**


**18. In the past year, did you offer information, advice, or expertise to other groups or organizations?**

**Please list up to ten group/organizations to whom you provided information, advice, or expertise related to environmental stewardship:**


**19. This question and the next are about funding. Please list up to ten group/organizations from whom you received funding related to environmental stewardship in the past year:**


**20. Please list up to ten group/organizations to whom you provided funding related to environmental stewardship in the past year:**



**21. Does your group/organization belong to any coalitions, partnerships, or working groups to share information, plan strategy, or coordinate activities? Yes/No**

If yes, please list the coalition(s) your group/organization is active in.

**22. Is there anything else you would like to tell us about your group/organization or this survey?**

This concludes the Seattle stewardship survey. Thank you for your participation. We will send you an announcement when our report and stewardship maps are available.

Feel free to contact us with any questions or comments at: [stewards@u.washington.edu](mailto:stewards@u.washington.edu)



# References

Blank, M. (2011). Common Sense Conservation - Saving Species Without Hurting People (URL - [http://www.myfreedomfoundation.com/docLib/20121128\\_CommonSenseConservation.pdf](http://www.myfreedomfoundation.com/docLib/20121128_CommonSenseConservation.pdf)) - A Publication of the Freedom Foundation.

Elmqvist, T. (2013). Urban Sustainability and Resilience—Why We Need to Focus on Scales (URL: <http://www.thenatureofcities.com/2013/03/27/urban-sustainability-and-resilience-why-we-need-to-focus-on-scales/>).

Ernstson, H., Barthel, S., Andersson, E., & Borgstrom, S. (2010). Scale-Crossing Brokers and Network Governance of Urban Ecosystem Services: The Case of Stockholm – URL: <http://www.ecologyandsociety.org/vol15/iss4/art28/> *Ecology and Society*, 15(NO. 4, Art. 28).

Esri (2013). ArcGIS Extension for the Google Maps API (URL: <http://help.arcgis.com/en/webapi/javascript/gmaps/>)

Google (2013). Google Maps API Documentation (URL: <http://google-maps-utility-library-v3.googlecode.com/svn/trunk/arcgislink/docs/reference.html>)

Lerner, N., Ancel, S., Stewart, M. A., & DiSera, D. (2007). Building a Business Case for Geospatial Information Technology - A practitioners Guide to Financial and Strategic Analysis.

Maguire, M. (2001). Methods to support human-centred design ,URL - <http://www.cse.chalmers.se/research/group/idc/ituniv/kurser/06/ucd/papers/maguire%202001a.pdf>.

MySQL (2013) MySQL Database Documentation (URL: <http://dev.mysql.com/doc/refman/5.0/en/mysql-spatial-datatypes.html>)

Palpuz, J., Farmer, Z., & Tsoi, J. (2013). Stewardship as Percentage of All Activity for Organizations Working for Community Improvement (King County, WA 2011) - Data Source: Oliver Bazinet & King County GIS Data, Copyright as shown on map.

Romolini, M., Brinkley, W., & Wolf, K. L. (2012). What is Urban Environmental Stewardship? Constructing a Practitioner-Derived Framework.

Singer, F. S., & Avery, D. T. (2005). The Physical Evidence of Earth's Unstoppable 1,500-Year Climate Cycle – URL <http://www.ncpa.org/pub/st279> - Retrieved: August 10, 2013.

TriMet (2013). Generic search on TriMet.org (URL: <http://ride.trimet.org>)

US\_Census\_Bureau. (1990). US Urban and Rural Population: 1790 to 1990 (URL: <http://www.census.gov/population/www/censusdata/files/table-4.pdf>) - Retrieved: August 6, 2013.

US\_Census\_Bureau. (2012). Growth in Urban Population Outpaces Rest of Nation, Census Bureau Reports - (URL: [http://www.census.gov/newsroom/releases/archives/2010\\_census/cb12-50.html](http://www.census.gov/newsroom/releases/archives/2010_census/cb12-50.html)) - Retrieved: August 6, 2013.

US\_Senate\_Committee\_on\_Environment\_and\_Public\_Works. (2013). Vitter Warns Louisiana of EPA's Secret "Sue and Settle" Deals, Could Impact State - Says EPA and U.S. Fish and Wildlife Service are colluding with environmental groups - (URL - [http://www.epw.senate.gov/public/index.cfm?FuseAction=PressRoom.PressReleases&ContentRecord\\_id=644862c0-f95a-e23f-b506-828fbd0cab86](http://www.epw.senate.gov/public/index.cfm?FuseAction=PressRoom.PressReleases&ContentRecord_id=644862c0-f95a-e23f-b506-828fbd0cab86))

Wikipedia. (2013a). Land Ethic - (URL: [http://en.wikipedia.org/wiki/Land\\_ethic](http://en.wikipedia.org/wiki/Land_ethic)) - Retrieved August 6, 2013.

Wikipedia. (2013b). World Population (URL: [http://en.wikipedia.org/wiki/World\\_population](http://en.wikipedia.org/wiki/World_population)) - Retrieved August 6, 2013.

Wolf, K. L., Blahna, D. J., Brinkley, W., & Romolini, M. (2011). Environmental stewardship footprint research: linking human agency and ecosystem health in the Puget Sound region (URL: <http://www.naturewithin.info/CivicEco/UrbanEcosystems.Stewardship.Apr2011online.pdf>). *Urban Ecosystems*, 16(1), 13-32. doi: 10.1007/s11252-011-0175-6