THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF GEOGRAPHY

# DESIGNING A TRADITIONAL STATIC PAPER MAP USING DYNAMIC TECHNOLOGY AND BIG DATA

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SUMMER 2016

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Geography
with honors in Geography

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# ABSTRACT

To add knowledge to the production and distribution of independently created large-scale maps, this research seeks to understand heritage and recreation maps in the folded paper format. Jim Thorpe, Pennsylvania and the surrounding area is used as the case study to test this procedure. The research explains why the paper map is still important in an increasingly digital world. The goal is to create a workflow to efficiently and accurately design a recreation map that focuses on outdoor activities and cultural heritage. The research establishes the criteria for an area to be mapped by reviewing its heritage and recreation potential. A detailed account is given of the data, software, and hardware used to create such a map. Through the case-study, a framework is developed that can be used to produce and publish recreation maps. This framework is not specific to the case, and can be used in other regions of the country and the world. No proprietary data is used in the production of this map and the framework is based on Volunteered Geographic Information (VGI) and data in the public domain. Preference is given toward using Free and Open Source Software (FOSS), although some proprietary software was used. This investigation is useful to anyone interested in large-scale map production, geographic information systems (GIS) software, cartographic design, open-source data, and large datasets.

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## ACKNOWLEDGEMENTS

My first thanks goes to all of the random people that have had to listen to me talk about both this research and map project. There are too many faces too remember, but the bits of advice that these people have given were essential to this research. These random thanks go to chance encounters at conferences like NACIS, professors and students at Penn State, residents of the Jim Thorpe Area who have insider knowledge on trails and history, and all of my friends who have helped me both with on the ground research and design!

A special thanks to Deryck Holdsworth and Roger Downs for helping in the editing of this paper. Deryck again, for being a wealth of knowledge when it comes to maps of these types. Roger, another special thanks for always encouraging me to see the world through a geographic lens and pushing me into joining Schreyers. Cindy Brewer for her class on cartography, which both taught and inspired me to make my own. Michael Hermann for running Purple Lizard maps, which both helped me explore the beauty of Central Pennsylvania and proved that large scale paper maps still have a place in this world.

# Chapter 1

## Finding Purpose for a Paper Map in a Digital World

This research seeks to add more information to the design and publication of recreationally and historically themed maps. Recreation and history are two topics that in most circumstances deserve their own respective maps. However, there are circumstances that permit the conjoining of these two subjects into one map. In particular, the map discussed in this research, The Jim Thorpe Map, combines these two themes, Recreation and History, in order to satisfy the demands of a particular audience, namely the tourists who visit the town of Jim Thorpe. When visiting the town, it is usually a dual-purposed trip. Tourists visit the town to view the historical aspects, a frame that is often captured in the label 'heritage tourism", and also to enjoy outdoor activities in the natural terrain in which the town is set. Those visiting the town often need a guide for both the historical and recreational elements the area has to offer, demanding cartography at multiple scales.

The purpose of the research is to understand how this type of map should be created. Cartography is, more so than ever, a rapidly changing discipline. There are more and more methods, tools, and mediums for cartographic representation in this digital era. This research will investigate the most appropriate methods, tools, and mediums to produce a traditional static paper map using the most up-to-date technology.

In years past, when a cartographer imagined making a map, there was a clearer view of the process and the final product: a paper map of some specific size and with a likely limited palette of colors and text. Now, the majority of people who imagine using a map will anticipate

using that map in the digital form. Not only do users expect maps to be in the digital form, but they expect them to be interactive, containing hyperlinks to take the user to other information if needed. Cartographers of our time must be trained not only in classic cartography, but also in web development. Additionally, there is an expectation of being able to carry the map with you at any moment. Cartography is shifting toward designing and producing web maps that should all be at the touch of your fingers. Mobile compatibility is expected of web cartographers working in a professional environment.


**Figure 1: An example of Mapbox GL shown on an iPhone 3GS (Halperin 2014)**

Given that we currently live in a world with interactive maps and three-dimensional maps available on affordable smartphones (see Figure 1), what is the motivation for producing a framework for designing a static map? Why should anyone spend time designing paper maps when the industry is making a dramatic shift toward the digital realm?

The answer to this is quite simple. Paper maps and digital maps are two entirely different tools that serve different purposes. One is not better than the other, and one should not replace the other. They must simply coexist and complement one another. In order to decide which of these cartographic media should be selected, the end use of the map itself must be identified. It is not the tool that decides the use, but the use that decides the tool.

The classic cartography argument about paper versus digital must be considered before starting on this map. In order to resolve this argument, we must look at the end purpose of this map. In order to better understand the expectations for this map, the "end use" has been broken up into three sections. The first, and most important, is audience: Who will be using this map? The second, intrinsically tied to the first, is purpose: How and for what purposes will the audience be using this map? The third, describes technical limitations: through which media will the map be used and what are the advantages and disadvantages of each of these media?

## 1.1 Audience

The primary audience for this map will be tourists visiting the town of Jim Thorpe and the surrounding area. The majority of these visitors are from New York City, many parts of New Jersey, and the Philadelphia region. They visit the town to view historical architecture, see remnants of the coal industry, and to imagine life in a quaint town of less than 5000 residents.

Their other motivation is the outdoor activities the area has to offer. There are many outfitters and resort owners in the area whose livelihoods depend on visitors coming to enjoy these activities. The area offers hiking, biking, rafting, paintballing, and many more opportunities to enjoy the natural environment in and around Jim Thorpe.

However, it is also important to take into consideration the local residents of the area, as they are often core promoters of the area's attractions. Therefore, although locals will not be the primary audience, their needs should be reviewed when making the map for several reasons.

First, for a cartographer, mapping an area where people live, work, and play is not a simple issue. People perceive space differently and may not agree with choices made on spatial features that are represented in the map. More importantly, without knowing it, a cartographer may very well be mapping land that is owned by the map user. It is important to not create negative relationships between map designers and land owners. Second, they may want to be featured on the map. A map that represents river rapids could also represent an outfitter that will allow map users to enjoy those rapids. When creating this style of map, it is not simply to represent phenomena, but to enable people to experience those phenomena.

## 1.2 Purpose

How the audience might use the map depends on the needs of the audience. Tourists visit the area in order to appreciate the history and explore the natural environment. The map acts as both a navigation aid and information tool for these users. They can see the locations of points of interest and how they can get to them. The map also needs to make navigation possible through expanses of previously unmapped areas. Locals are likely to use the map more as a navigation tool than an information tool. The map has to satisfy the needs of all the intended audiences simultaneously.

This map of Jim Thorpe and the Lehigh Gorge is made focusing on the end-user. It is helpful to actually imagine those who will be using the map, where they will be using the map, and through what medium will they be using the map. Of course, the first image to come to mind is that users will be using this map to locate themselves once they are physically within the extent of the map. This however, is not the only location where the map could be used. Maps can

work to advertise and attract people to an area just as well as they can allow users to understand where they are in an area. Maps are an excellent medium for advertisement. This map will not be distributed solely in the area in which it describes, but also in areas of prospective audiences.


**Figure 2: Tourists in Jim Thorpe for the annual Fall Foliage Festival (Drury 2013)**

The majority of tourists that visit the Jim Thorpe area come from an array of cities within about one hundred miles. Ideally, in addition to focusing on users locating themselves within the context of the map, we can imagine users wanting to experience the area that the map represents. Visitors to the mapped area can bring their touristic experience home with them to explain to friends and family through the map.

It is important that the map, due to the intended use for distant audiences as well as those nearby, tries to cultivate a sense of place. The goal is not to design a basic reference map of the area with a stock color palette that can be transferred to any other American town. The goal is to create a map that enables users to experience an impressive place without being within that physical space. If the end use was simply a reference map, then Google Maps would be

sufficient. For the purposes of this project, therefore, the map should enable "sense of place" for users who are located both within and outside the extent of the map.

### 1.3 Technical Limitations

Both audience and purpose are abstract concepts that need to be enabled through some physical tool, the map itself. The goal is to enable a sense of place through the map. Yet, this does not answer through which medium this sense of place should be represented.

Historic and Recreation maps are typically in paper form, but even with these themes, there is a movement toward the digital realm. Digital historical "story maps" are often animated, interactive, or a combination of both. Digital recreation maps are a bit more ambiguous. Smartphone GPS applications are popular for recording outdoor recreation like cycling and trail running. Users can upload their GPS traces onto digital base maps of their choice. This is something typically done at home, on a computer, or in an area with cellular service.

When users are within the mapped area, computers and cellular service may not be available. The audience, as described above, will likely not be from the area of interest and, therefore, may be separated from their personal computers. Even if they do bring personal computers, it may not be useful only to view the map within the constraints of their hotel's Wi-Fi service or the limitation of their laptop's battery. Little justification is needed to explain why this tourist/recreational map should not only be published as a web map.

There is, however, a more robust argument to be said for designing a mobile map. People readily trust the directions given by their mobile devices to get from their homes to their final destinations. This largely negates the need for a paper locator map with any kind of directions.

Once in those locations, there are a number of spatially enabled mobile applications to help guide visitors. Yelp, Zomato, and Foursquare are just a few applications available at no cost. These applications provide locations, descriptions, reviews, and contact information for points of interest across the country. It could be argued that any historical points of interest will be sufficiently covered by mobile applications.

Mobile applications are also becoming increasingly popular for outdoor recreation and navigation. Cellular service coverage is increasing. Strava and MapMyRide are just two of hundreds of mobile applications that allow users to view and download GPS traces of other user's walks, hikes, rides, and more. These applications can serve as both a GPS recording and navigational tool. Strava currently has a tool in beta called "Route Builder." This tool allows users to input two locations and Strava will automatically deliver a route using the most popular trail routes between the two input points. It is the equivalent to a Google Map's navigation tool where the data is input and used directly by users.

Considering the map technologies available today, it might seem difficult to argue for traditional paper maps. The functionality of a paper map is limited simply to a two-dimensional form, with no user interaction, no automatic updates, no future potential, etc. The list of functionalities that a paper map does not contain goes on.

Often overlooked, however, are the functionalities that a paper map *does* have, and will always have. First and foremost, the paper map requires no source of power and can function indefinitely, unlike powered devices. The traditional paper map is not limited to the size of a screen. The entire extent described can be seen with an unfolded map. The traditional map cannot be broken, at least in the ways a device can. New paper and printing technologies have developed paper types that are extremely resistant to water, ripping, and overall wear.

And, perhaps the most overlooked advantage of the paper map, is the cartographer behind the map itself. Paper maps are often made by professionals trained in the art and science of cartography. Web maps often rely on user input that can be added from anyone with an account. Web maps also rely heavily on algorithms that automate placement of geometry and text. Web maps rarely are designed specifically for a single area and with a specific theme. Although most web mapping firms have cartographers or GIS analysts employed, they cannot filter the volume of data on their applications.

The cartographer behind the map has many duties that often go unnoticed in a world where maps are shifting to automated digital platforms. Cartography is an art form, and the aesthetic taste of the cartographer for the subtle changes in spatial placement and styling cannot be replaced through automation. There is no form of technology that can experience the place being mapped in a way that can be translated to the map itself. Perhaps for the first time, we live in a world where too much data can be a problem. The cartographer acts as a data filter for all the elements that should appear on a traditional paper map.

Static maps are also more accessible than the other two mediums. Not everyone has a computer, mobile device, and access to the internet. Even if everyone did have access to such technology, it cannot be assumed that everyone knows how to use digital maps. Of course, the static map is not the all-encompassing solution to accessibility, but overall it is more accessible than digital maps. The only obstacle between a user and a traditional paper map is the ability to see and read the map. Digital maps have the same seeing and reading obstacle plus additional technological obstacles.

The argument for web vs static maps is alive and well. The argument will continue until everyone comes to the consensus that the two mediums should coexist. Again, it is the end use

that defines the tool to be used. Both mediums have their advantages and disadvantages. In order to understand where the focus of the efforts of the Jim Thorpe Map should be placed, the advantages and disadvantages of each medium are listed below (Table 1).

**Table 1: The advantages and disadvantages of web, mobile, and paper maps.**

| Medium | Advantages | Disadvantages |
|---|---|---|
| **Desktop Web Map** | Highest degree of interactivity<br>Automatic data updates | Requires to be plugged in or to be charged<br>Requires internet service in most applications<br>Cannot be used mobile<br>Limited to screen size |
| **Mobile Map Application** | Moderate degree of interactivity<br>Automatic data updates<br>Mobile ability | Requires to be plugged in or charged<br>Requires cellular data service in most applications<br>Can be easily broken<br>Limited to screen size |
| **Traditional Paper Map** | Mobile Ability<br>Cannot be broken<br>Does not require internet connection<br>Cartographer design and data filtering<br>Not limited to size of screen<br>Accessible to all | Lowest degree of interactivity<br>Slow update process (Requires redesign and reprint) |

# Chapter 2

## Chapter 3 Review of Potential Software and Hardware Products

The audience of the map, the purpose of the map, and the advantages/disadvantages of technology should be resolved before beginning the cartographic process. The next step, and it is important that this be given all due consideration, is to decide on the software that should be used to compile and style geographic information. For a project of this nature, there is no single software tool that should be used. No matter what procedure is taken, multiple tools and software will be used throughout the process. Still, there may be a best choice when taking into consideration the elements described in the purpose of the map. *The best procedure will use the fewest tools to get the most output.*

It can be argued that any tool that can be used to improve the quality of the product, should be used. However, this is a difficult argument to make when describing map production. Geospatial software is highly complex. There is a steep learning curve associated with most geospatial software. Aside from the learning curve, there are a variety of different file types used for certain products that may not easily transfer to other products. Some software may not support importing the only file type that another software source exports.

Aside from the complexity of using many different types of software, there is a cost associated with each of these. Fortunately, there is a movement toward Free and Open Source Software (FOSS). Developers are opening the gates to creativity by making non-proprietary, high quality software that can be altered to the advantage of the user. With this being said, the best procedure can be slightly modified. *The best procedure will use fewer tools and spend less funds to get the most output.*

## 2.1 Mapbox Studio and TileMill

Mapbox makes some of the most popular free geospatial software available. There is a caveat to the phrase “free geospatial software” in this example. Mapbox designs software that is free to download and use for creating maps. Hosting maps and data online, however, is proprietary. The primary function of the software is to compile geospatial information, style that information, and then generate vector tiles that can be used for web mapping. The end product usually consists of a base map and custom layers styled in Mapbox Studio or TileMill. Users can freely use the software to create as many maps as desired, but must purchase a specific plan in order to host the map and data online.

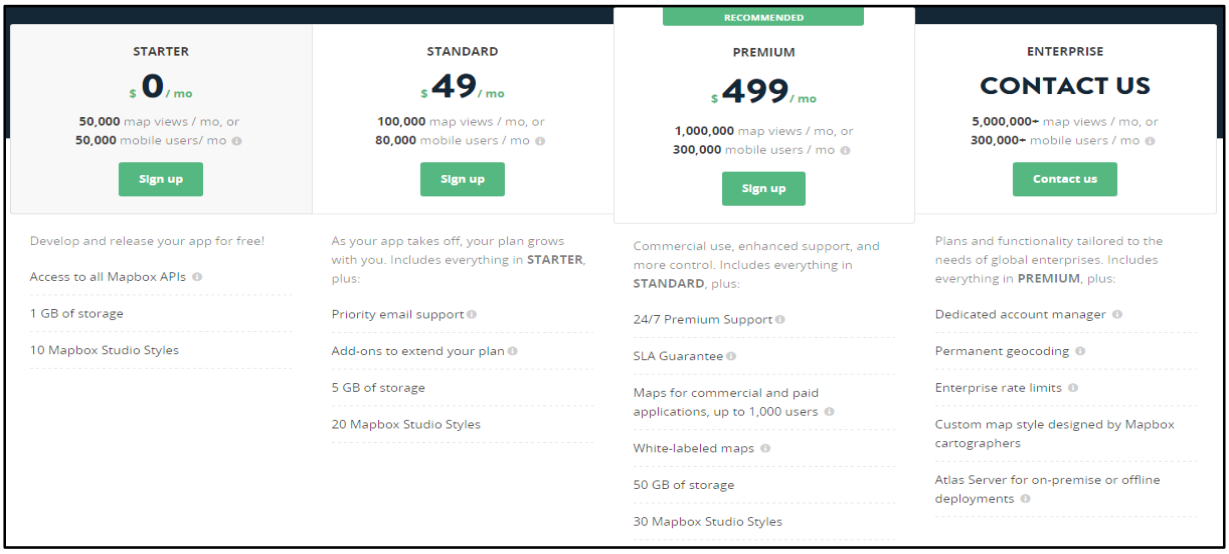



**Figure 3: Mapbox plans and pricing (Mapbox Enterprise 2016)**

There are minor differences between Mapbox Studio and TileMill that need explanation. TileMill is an earlier software created by the company Mapbox. TileMill is essentially the earlier version of the Mapbox Studio software. Again, like its successor Mapbox Studio, the primary function of TileMill is to compile geospatial information, style that information, and then generate vector tiles that can be used for web mapping. TileMill, although it is an older version

of the software, provides the functionality to export static maps as Scalable Vector Graphics (.svg); Mapbox Studio does not support this functionality.

Scalable Vector Graphics are the file-type of choice for professional map design. Most professional GIS software are designed to export to .svg files. SVGs are important because they are typically the best way to store spatial data that must be edited within vector design software. They prevent the pixelated effect that is typical among raster type features. Raster type files have a defined resolution for which they work, while SVGs can be used at any scale. Adobe Illustrator is the most popular vector design software used by cartographers to create static maps. Adobe Illustrator supports importing SVGs and is the industry standard for editing them.

Mapbox and TileMill *were* to be used for this map in particular due to the flexibility of their outputs. If done correctly, Mapbox products can be used to nearly simultaneously create a map fit for both the web (desktop and mobile) and paper form. All geospatial elements can be organized and styled in Mapbox Studio. The Mapbox Studio output can then be uploaded to Mapbox and hosted on a personal webpage. Also, although it should be saved for future work, this same map could be made mobile friendly using other Mapbox tools.

Both products, Mapbox Studio and TileMill, use Cartographic Cascading Style Sheets (Carto-CSS) to style geospatial features. This is a text-based styling system that can be easily transferred between the Mapbox Studio and TileMill. As long as the files that refer to the geospatial elements remain the same, the styling can literally be copy-pasted from one software to the other.

This is advantageous because after the map is compiled and designed in Mapbox Studio for web map output, it can easily be transferred to TileMill to be exported as an SVG. As mentioned above, SVG is the file-type of choice for importing into vector design software like

Adobe Illustrator. Once the map is exported into Adobe Illustrator, final stylistic changes can be made to the map. Afterwards, the map can be integrated into a folded map design template and a static map, in addition to a web map, will be produced.

Using Mapbox Studio and TileMill *would* have been preferred throughout this process. The advantages of having two pieces of software that can be so easily intertwined to simultaneously produce a web map and a static map cannot be overlooked. With this method done successfully, one does not have to choose between a web or static map. Rather, both mediums will be available to complement one another.

There is an additional advantage to using CSS for the styling of data. If, in the future, a similar thematic map is to be made with similar style, the style from this project can be directly added to a new map of a different location. This would work as long as the files are named in a similar manner. There would be some manual changing required, but it would be minimal compared to using alternative software.

For this project in particular, the static map will be the focus. The goal will be to produce both a static and a web map, but the web map will be a secondary focus. Web mapping allows for a near-infinite degree of interactivity, not all of which can be described within the constraints of this project. The goal of this project in regards to web mapping is to design a map that is similar to the static version, but is hosted on a web page rather than printed on paper. As with the paper map, the audience's end-use of the map will be used to determine features in the web map.

The only interactive web map elements to be included is the ability to pan. This is done so that no additional styling or coding is necessary. If a secondary functionality, such as zooming, was added, then the map design would become much more complicated. If the ability to zoom was added, all features of the map would have to be redesigned for different zoom

levels. This would be the next step for designing an interactive map. Future work could add many types of interactivity to the web map. There could be many useful features added. For example, pop-ups containing contact information for the businesses featured on the map.

After adding data and styling data a test was done to export a sample map as an SVG in TileMill. Unfortunately, TileMill cannot successfully export a map with labels as an SVG. After scouring online forums, Mapbox's help pages, and TileMill's help pages, it was found that this is a common bug in the software. Although still available for download, TileMill is no longer a software supported by Mapbox so this bug will not be addressed. Also, Mapbox has yet to include the ability to export any map using their software as an Adobe Illustrator project or an SVG.

In conclusion, Mapbox and TileMill cannot be used to design both the static and digital map simultaneously. The purpose of this study is to design a traditional paper map, and so this software will no longer be used. However, if in the future Mapbox supports exporting to an Adobe Illustrator project or as SVG, then it may be a good choice for this type of map design.

## 2.2 Pyramid Shader

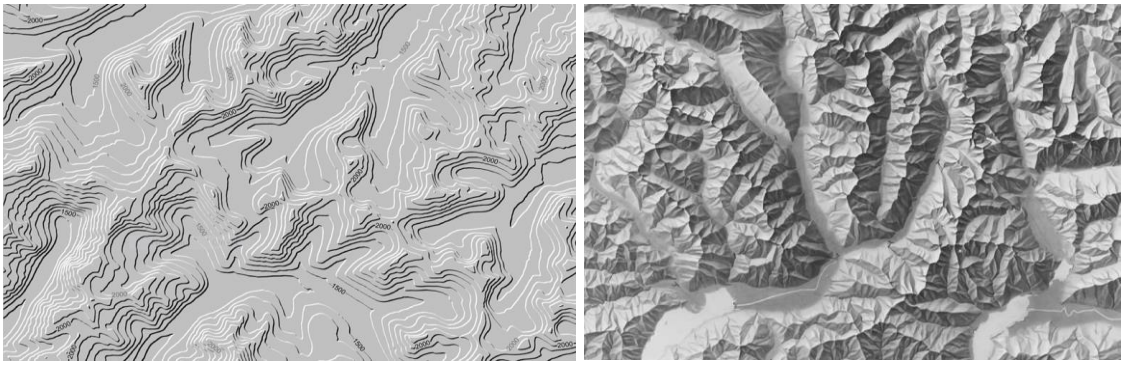


**Figure 4: Illuminated contours (left) and relief shading (right) made using Pyramid Shader software (Jenny et al. 2015)**

Although Mapbox products provide a wide array of geospatial tools, they are missing some key functions. Mapbox products have the ability to import background raster information, but the ability to edit this type of information is limited. One of the most essential elements to a map of this type is to have an excellent representation of topography. The raw elevation data for this map is currently in Digital Elevation Model (DEM) format. This is a raster type image with pixels referring to specific elevations. Mapbox products do not support tools that can turn a DEM into contour lines - an essential background element to this map given the importance of the Lehigh River Gorge, whitewater conditions, and bike-path terrain.

Pyramid Shader is the free and open source solution to Mapbox's inability to do sophisticated processes with raster elevation data. Pyramid Shader is a software product designed by Bernhard Jenny, Charles Preppernau and James Eynard at Oregon State University. This software is free to download at http://terraincartography.com/PyramidShader/. Below is the official description of Pyramid Shader and its functionalities:

> *Pyramid Shader is a specialized application for visualizing terrain models and other digital raster data. Pyramid Shader can create:*
>
> - *Shaded relief*
> - *Illuminated and shadowed contour lines ("Tanaka contours")*
> - *Hypsometric colors*
> - *Local hypsometric colors*
> - *Exposition colors*
> - *Bivariate colors*
> - *Slope*
> - *Aspect*
> - *Profile curvature*
> - *Pyramid Shader can generalize terrain by removing small high-frequency details and/or large landforms.*

Unfortunately, this software cannot be used for this project. The software is functional, but in its current state cannot support the size of the Digital Elevation Model. The extent and resolution of the data is simply too large. This is an excellent example of the limitations FOSS can have. However, through testing smaller datasets, Pyramid Shader is an excellent software to use for elevation representation. If future updates support larger DEM datasets, it should be used.

### 2.3 ArcMap

ESRI GIS products such as ArcMap are the most popular tool used for paper map production. ArcGIS products allow for spatial compilation, analyses, editing, and design. The software is versatile and is able to handle many different formats and allows high user control and interaction with data. It even provides a moderate degree of graphic design.

Typically, for high quality map production, maps made with ArcMap will be exported as Adobe Illustrator projects for vector design. This can be labeled as the "Arc to Illustrator" method. The advantage of this is that files can remain geospatially accurate within the ArcMap product. Then, after the project is exported to Illustrator, the true geometry can be changed for stylistic purposes without affecting the original geospatial data.

ArcMap is probably the most powerful software choice for editing geospatial data and will best prepare the data for the vector export to Adobe Illustrator where the map layout will be prepared. ArcMap can handle nearly all data types that will be used with little need for external pieces of software. Despite these valuable advantages, there are a few dramatic disadvantages to the ESRI's ArcGIS products. ArcMap is an extremely expensive product. A single basic license currently costs $1500 (esri 2015) with prices dramatically rising for additional features.

However, ESRI does offer a free license to students. Due to this, ArcMap will be the primary geospatial software used for the production of this map.

### 2.4 Adobe Illustrator, Photoshop, and InDesign

Adobe products are the *de facto* standard of the cartography industry for post-geospatial editing. Illustrator is used to edit vector elements exported from whichever geospatial software is used; Photoshop is used for some raster editing and photo editing; and InDesign is typically where the final product would be edited before being submitted for publishing.

Adobe Creative Cloud is the source from which all Adobe products can be paid for and downloaded. The payment structure is either $19.99/month per software or $49.99/month for all Adobe software. There are many free sources available that have similar functionality: Inkscape is a free equivalent to Illustrator; Gimp is a free equivalent to Photoshop; and LucidPress is a free equivalent to InDesign.

### 2.5 OSMIQ

OSMIQ is a Free and Open Source Software designed by Danish Geospatial Engineer Marco Bradtke. OSMIQ allows users to isolate data of interest that has been downloaded from OSM. When users initially download a map from OSM the data is “locked in” and cannot be accessed. OSMIQ allows users to import .osm files (maps that have been downloaded from OSM), filter through the data according to tags, and then export this data in a variety of formats. The primary file type that will be exported is the shapefile. A detailed tutorial of this process is given in section *7.2 Data Collection, Processing, and Representation* section of this paper.

## 2.6 Software Selected

After much trial and error with all of the software mentioned above, only a few were used for this project. OSMIQ was used to extract and organize data from OpenStreetMap. ArcMap was used to further organize data, style data, and label data. The finishing touches were done with Adobe Illustrator, which was used to modify small changes in labels, lines, and icons. Adobe Illustrator was also used to design the marginalia and other non-map elements of the completed product.

## Hardware Used for Data Collection and Ground Truth

The only hardware or field equipment used during the process of this map production is an Apple iPhone 4S. As will be described in section 7.2 *Data Collection, Processing, and Representation*, most of the data has not been directly gathered. The data that would typically require a traditional GPS unit is being replaced by openly available data from Strava and OpenStreetMap. The iPhone 4S will be used simply to confirm the accuracy of some of the most remote trails that have the lowest aggregate GPS points in Strava's Global Heat Map. Traces with low aggregate GPS points may not be navigable trails at all. These traces may occur to GPS error or the user simply going off the beaten-path. Due to the nature of the heatmap, a measurable threshold cannot be used to define what a low aggregate GPS trace is. This is done simply by eye.

Since the majority of data is coming from Strava, it is important to briefly mention the types of hardware supported by Strava to record GPS traces. Many devices are automatically compatible with Strava, allowing users to directly upload their data. If their device is not compatible, data can be uploaded in the following file formats: GPX, TCX, and FIT. Below is the list provided by Strava describing compatible and non-compatible devices:

**Table 2: Devices and their compatibility with Strava (Rosie 2015)**

| Compatible | Not Compatible |
|---|---|
| CATEYE | HTC Hero |
| Fitbit (Fitbit Surge) | HTC Hero S |
| Garmin | Nexus One |
| Microsoft Band | |
| Soleus | |
| Suunto | |
| Timex (Run Trainer 2.0) | |
| TomTom | |
| iPhone (iOS 7.0 and above: 4, 4s, 5, 5s, 5c, 6, 6+) | |
| Android | |

# Chapter 3

## A Modern Workflow for Map Production

The workflow for this project will be similar to that followed for the creation of other maps of a similar theme. This chapter dissects individual parts of the cartographic process in order to better understand map production as a whole. The first step involves defining the need for it to take place. In other words, why should a map be created for this area in particular? Also, what should the particular theme of this map be? These two concepts, area of interest and theme of interest, are the foundations for the cartographic process.

To understand the theme and area concepts better, the background and history of the area of interest will be examined. Understanding the history of any area up to the current time period is essential for framing the kinds of elements that should be represented in a current map of that area. For this map, the coal era will be the time period of core focus since the coal industry is responsible for many of the historical features that are to be mapped, such as canals, mines, mining trails, inclines, and abandoned railroads. Historical photos are to be included to add a sense of place to the map. Photos, older maps, and historical text are essential to developing a map that will be able to convey salient elements of this coal history theme. These non-map elements add to the sense of place where the cartographic components of the map fall short.

The other core focus of the map is recreation, or more specifically, outdoor recreation. Understanding the natural environment of the area is required before beginning the cartographic process. This brings up questions concerning why the area may be a destination for outdoor recreation, such as: why is this area as remote as it is? Are there land areas that are dedicated to outdoor recreation such as state parks, state game lands, state forests, etc. within the extent?

After an overview is completed of these two background topics, history and recreation, an investigation of their respective data can be considered. The examination of background information gives insights into the types of data sources that should be collected and how this data can be collected. Once a decision is made on what data is to be collected, it must be filtered and stored. A thorough explanation of data to be collected, the method for collecting data, and the storage of that data is described throughout the text.

The data collection process for this map in particular is unique. The focus is to rely heavily on Volunteered Geographic Information, or VGI. This VGI data will be collected through two primary means: OpenStreetMap (OSM) and Strava Global Heatmap data. OpenStreetMap is similar to a wiki site where users with an account can add and attribute geographic data. Anyone with an account can add, edit, or delete geometry or attribution from the OSM database. This works both for and against the system as a whole. Fewer restrictions to the ability to edit the database means that more people are likely to contribute. However, this also means that the accuracy of the data goes unchecked by professionals. There is also the occasional user who will intentionally vandalize data for a variety of reasons (Ballatore 2014). Despite these possible flaws in the OSM database, many professional companies use OSM data as a data source.

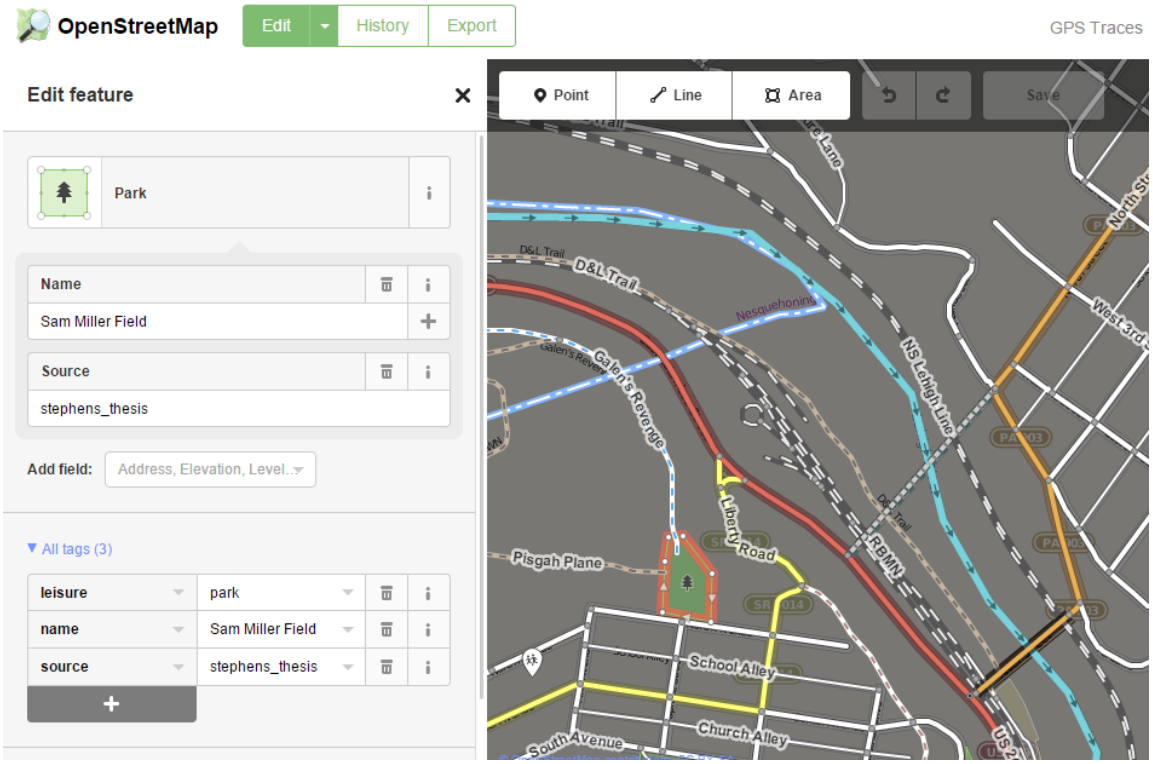



**Figure 5: The OpenStreetMap interface open to edit a park feature (openstreetmap.org 2015)**

Although it can be edited by anyone with an account, using OSM should not be seen as a subversive practice. Many government agencies are using data from OSM. For example, the Oregon Department of Transportation is using OSM as a data repository for city infrastructure improvement regarding bicycle transportation (Maus 2014). Users of the Strava application are voluntarily contributing GPS data in aggregate. This aggregate data does not show the individual traces of users, but combines the data points of many users into one larger feature. Strava is an application that tracks user fitness by recording their GPS track during different kinds of activities, the most popular being cycling and running. A division of Strava, Strava - Metro has been aggregating this data and selling it to city governments. The city, in turn, can find insights such as volume of traffic or type of traffic on certain roads, etc. This data is also available to the

public in aggregate via the Strava Global Heatmap, which will be used to correct and add trail geometry to the map in this project.

Another method of VGI that will be used for the addition of information to the map is quite indirect, but practiced frequently among cartographers who are mapping where quantitative data of the area of interest is insufficient. The final VGI method to be described is the Skeleton Map. A Skeleton Map is a basic reference map of the area to be mapped. The idea is to provide local residents with a skeleton of a map where they can add their own kind of data. This allows locals to contribute data without being restricted to technology or the OSM interface. Skeleton maps will not be used during the creating of this map due to time and academic authorization constraints, but they could be helpful in future work.

Once the data has been filtered and organized, cartographic representation of that data can be explored. It is best to have all the data available before attempting to style specific pieces of that data. A main principle of cartography is to ensure that balance exists among all the elements featured in the map. In order to find this balance, all data must be present before finalizing style. However, it is possible to use “dummy” data to have a grasp on all the elements that will eventually be represented.

The design process of the map will be broken up into a bottom-to-top approach in regards to the map layers. For example, the simplified orthoimagery that serves as a background will be described before vector layers like points of interest. The design of the layers of the map will be described as follows: raster background data, vector polygon data, vector line data, and finally vector point data. In other words, the data that covers to most map area on the paper will be described first, and the data covering the least area will be discussed last.

There are subcategories that belong to each of the four broader categories mentioned above. These subcategories will also be described in the layer order in which they are placed on the map. For example, hillshade raster data will be beneath semi-transparent orthoimagery and vector contour lines will be beneath streamlines. Although this is the order in which the design of these layers is described, it is different from the priority given to each layer. This is a historic and recreationally themed map, and therefore features like trails and historic points of interest should be given the highest priority. The other features of the map should serve to enhance the recreation and historic elements of the map.

Once all of the geometry and labels have been added and designed, other map elements can be added and designed. Other elements include text boxes, orients, pictures, and scales. These elements are sometimes referred to as marginalia. Marginalia can be a misleading term, as some of these elements are sometimes placed within the margins of the map. In fact, it often works to the benefit of the map if these elements are included within the margins. Marginal items can sometimes have a spatial aspect to them and work well to fill in negative space.

There will be three main goals when developing a color palette for this map: to properly represent the terrain, to develop a sense of place for map users, and to match these colors to the overall branding color. Of course, there must also be a balance among these three elements. The background raster elements, vector foreground elements, and overall brochure design should complement each other. Also, it is important for the color scheme to reflect the theme of the map itself. The color scheme for this map will follow the general theme of historic and recreationally themed maps reviewed in section *6.2 Thematic Benchmark Maps.*

There is another unique method for creating a color scheme that is not a common practice. In order to develop the most realistic sense of place, one can extract the exact colors

from local photography and use them in the map design. For example, if building polygons are to be represented in a walking map, the cartographer can take pictures of those buildings to find the exact colors to be used. Map users will more easily be able to relate features on the map with the real spatial phenomena if this is done.

Aside from properly representing the terrain and features within the terrain, it is important to develop a color scheme that can be consistent throughout a number of products. The most notable cartographic firm to use this is ideology is National Geographic. National Geographic has a signature yellow color that is used on almost all of their products. The yellow frame to their magazine and maps is easily recognized (Figure 6).

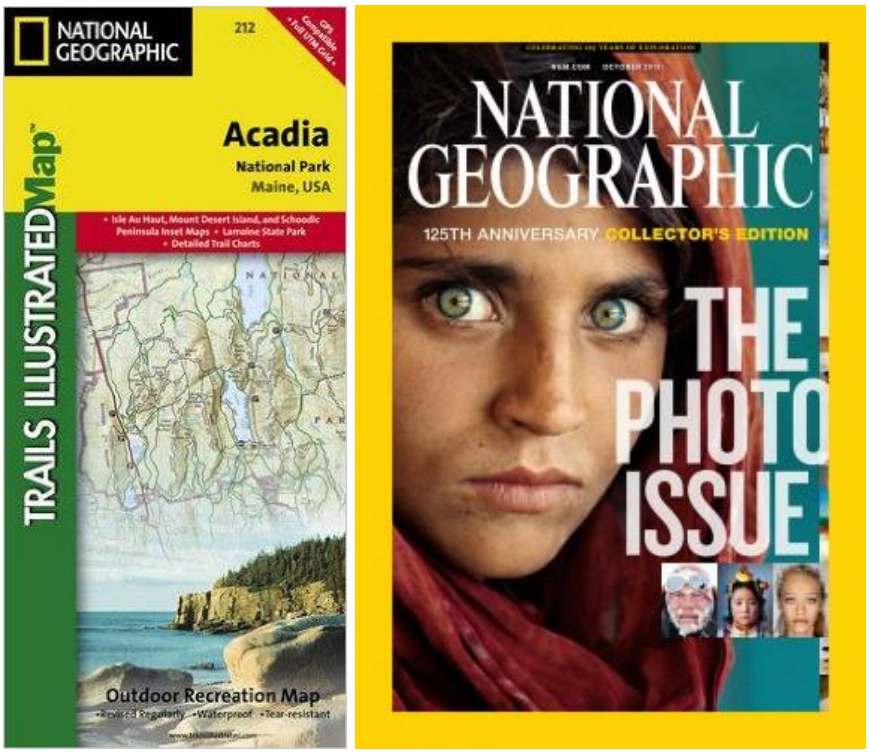



**Figure 6: Two publications from National Geographic exhibiting their trademark color scheme (Foster 2013)**

# Chapter 4

## What Makes a Location Worthy of Mapping?

### 4.1 Area of Interest

Jim Thorpe, Pennsylvania and the surrounding area have a rich history, an extensive (and unmapped) trail system, and a small business community willing to sponsor and sell the product. Currently there is not a prolific recreational or historical map of the area. Visitors come to the area to explore the small towns that have succeeded in retaining their small-town charm and Victorian architecture. In addition to visitors enjoying the picturesque built environment, the area has large swathes of forests, rivers, and valleys (Figure 7). Many of these features mentioned, both in the built and natural environment, go unseen by residents and tourists alike. Mapping the area will be beneficial to both the community and to its visitors.

**Figure 7: The Lehigh Gorge seen from Mt. Pisgah (Patrick Stephens 2015)**

The history of Jim Thorpe stands out among other small towns in Pennsylvania. Its natural and cultural history adds map value, tourism value, and residential value to the area. Jim Thorpe is located at the southern extent of the Anthracite Coal Region in Eastern Pennsylvania. The town, which is the seat of Carbon County, sits at the base of a valley through which the Lehigh River runs. Its location was essential to the development of the town in the early part of the nineteenth century.

Jim Thorpe was founded in 1818 by the Lehigh Coal and Navigation Company under the town's original Lenape name, *Mauch Chunk.* Once anthracite coal had been found in regions just to the west, the area known as Mauch Chunk began its evolution into a coal transportation hub. Mauch Chunk, situated at the base of the mountains where coal mining took place and adjacent to the Lehigh River, made it the perfect location for the coordination of logistics for shipping coal to more densely populated areas to the southeast, especially Philadelphia. Coal was initially shipped by rafts, which were hard to control in the fast-flowing Lehigh River. The same year that the town was founded, 1818, Josiah White of the Lehigh Coal and Navigation Company started construction of the Lehigh Canal, which involved the construction of 52 locks to move coal-laden barges down the valley. The Lehigh Canal paralleled the Lehigh River and fed the industrial cities of Allentown and Bethlehem with coal to fuel mills and factories. Additional coal could be sent farther downstream to Philadelphia and Atlantic trade routes via the Delaware river.

By the 1860s steam locomotives became efficient enough to replace canals as the primary mode of coal transportation. This was the beginning of Mauch Chunk's transformation from a coal town to a rail and coal town. This transformation only increased the wealth and popularity of Mauch Chunk.

A gravity railroad, the first of its kind, was built in 1850 to improve efficiency in the extraction of coal on Mt. Pisgah. The gravity railroad was laid over 1200 feet and rose over 450 feet of vertical terrain between Mauch Chunk and Summit Hill, a small mining town to the northwest of Mauch Chunk (Rabenold 2014). At the time, the gravity railroad was such an interesting feat of engineering that it served as a tourist attraction resembling modern-day amusement park "roller-coasters." The area was advertised as the "Switzerland of America" for tourists using the railroad on Sundays when the coal was not being moved (Figure 8).

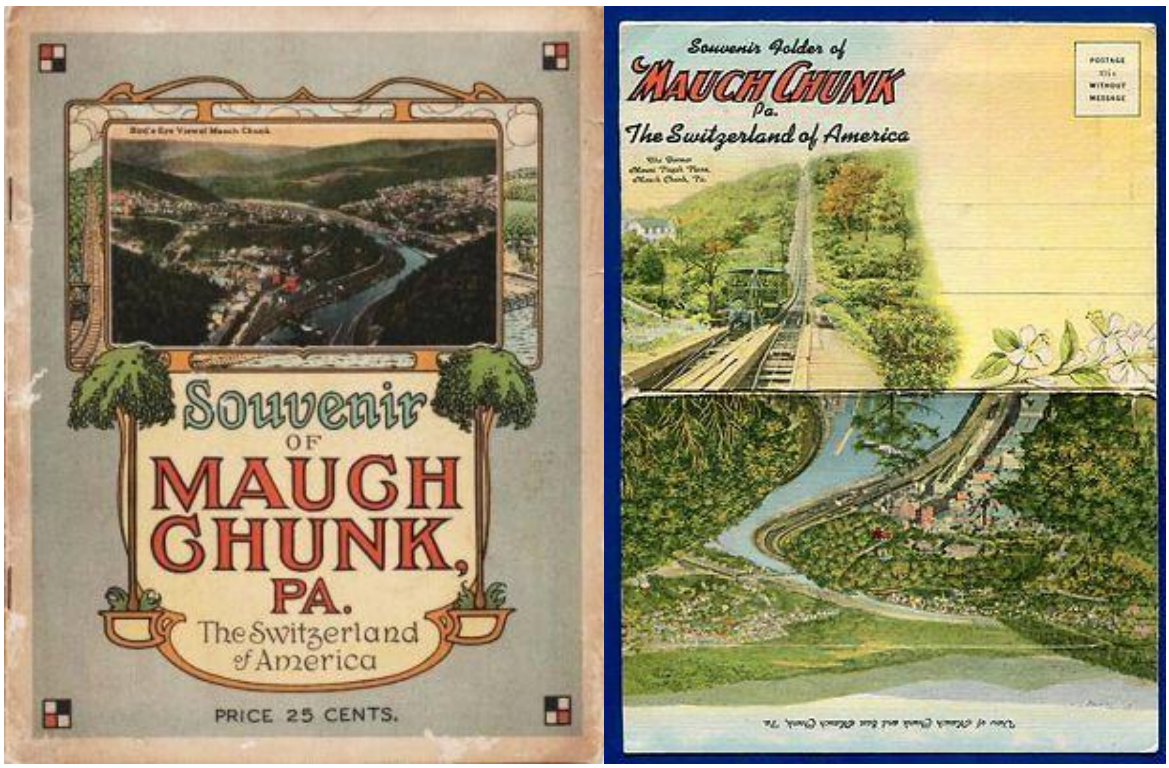



**Figure 8: Two antique postcards displaying the touristic nature of Jim Thorpe in the early 1900s (Petrilla 2015)**

The Lehigh River corridor also underwent a radical transformation during the growing popularity of the steam locomotive. Railways were laid parallel to the canal. These railways extended north and westward deeper into the coal region and connected that area to the industrial

furnaces of the Lehigh Valley. Mauch Chunk again served as a portal connecting these two areas, with the town profiting as a result.

Mauch Chunk transformed from relative wilderness to a wealthy small town over the course of the next 100 years due to the coal extraction and transportation infrastructure. The concentration of wealth in the town lead to more interesting developments in the built environment. Some Mauch Chunk residents began constructing ornate Victorian mansions aside the steep valleys. Many of the buildings constructed during Mauch Chunk's peak still exist today, with coal baron Asa Packer's house being one of the most prominent.

> *"Jim Thorpe's famous mansions and Victorian architecture support the claim that Mauch Chunk was once the home to 13 millionaires. During its golden era in the late 1800s the town was known as the wealthiest town per capita in America. The industry of tourism grew in importance alongside coal and railroads, and Mauch Chunk boasted seven grand hotels to handle all the visitors."* (MCHS 2014)

Unfortunately, this wealth was to be short lived and Mauch Chunk experienced a fate similar to other Boom and Bust towns. In the 1920s, oil started to become the nation's primary energy source and the coal industry weakened. By 1932, the last shipment of coal was transported down the Lehigh Canal and by 1933 the Switchback Rail System was dismantled. As the industry the town depended on began to collapse, so did the economy of the town. From the 1920s to the early 1950s little economic progress had been made in the town of Mauch Chunk. With the lack of its primary industrial base, the town shrunk economically.

It was not until 1954 that Mauch Chunk began to transform from an old-coal town to what it is today. In 1954 the remains of the renowned athlete, Jim Thorpe, were moved from Oklahoma to the area and a memorial for the fallen athlete was constructed. Not only did the

town of Mauch Chunk elect to host this memorial, but the name of the town itself was changed to its current name - Jim Thorpe, Pennsylvania.

Jim Thorpe, the athlete, is important to American history due to his heritage and athletic ability. Jim Thorpe, who was half Caucasian and half Native-American, achieved many of his athletic accomplishments during a period of relatively extreme racism in the United States. In 1912 Thorpe won the Olympic gold medals for the pentathlon and the decathlon. Thorpe also played football, basketball, and baseball professionally. His abilities decreed him by many the *Greatest Athlete of the Twentieth Century* (Salgado 2008).

With this new name and memorial for the "greatest athlete of the twentieth century," the town of Jim Thorpe began its transition into a tourist destination. It was not long after the renaming of the town that the Asa Packer Mansion, one of the most toured sites in the area, reopened for touring in 1956. By 1962 the Jim Thorpe Tourist Bureau opened and by 1968 the film, *The Molly Maguires,* was filmed on-site, bringing national attention to both the area and its history. Vintage steam locomotives were brought to the area for scenic railroad tourist events, and the old train station became a model railroad museum. The Northeast Extension of the PA Turnpike, and especially the Long Pond Interstate exit, made the area more accessible for car-driving tourists from Philadelphia, Southeast Pennsylvania, and Southwest New Jersey.

From the year the town gained its new name to today, the community has done even more to boost its annual tourist revenue. Many tourist oriented businesses are listed in the top 50 employers of the entire county such as Blue Mountain Ski Area, Split Rock Resort, Jack Frost Big Boulder Ski Areas, Pocono WhiteWater Rafting, Penn's Peak, The Inn at Jim Thorpe, and more (Center for Workforce Information & Analysis 2015). Currently the town and area is seen as a mecca for historical tours, whitewater rafting, paintball, cycling, camping, boating, and other

outdoor activities. In short, the area currently hosts a plethora of both *natural* and *built features* to be mapped.

### 4.2 Features to Map: The Built Environment

The coal era left an interesting imprint across the area that the proposed map will encompass. The downtown area includes rail stations and Victorian mansions and the countryside is dotted with canals, canal locks, mines, and railway right-of-way features. These built features, both in downtown areas and the countryside, will be both interesting and challenging to represent cartographically. For the purpose of the explanation of these features, they have been categorized into *town* and *country* features.

This classification is needed because it will help to filter which features should be represented on an inset map versus the main map. For example, the Victorian homes and many rail features will be located very near to each other. Therefore, an inset of Downtown Jim Thorpe will be necessary in order to map those features, which would otherwise be clustered on a small scale map.

**Figure 9: Downtown Jim Thorpe seen from Flagstaff Mountain (Lewandowski 2010)**

Downtown Jim Thorpe is a relatively densely built area for the size of the town itself (Figure 9). This is one of the charms that has remained from the coal era that provides an allure for many of the town's visitors. Within the dense downtown area there are a disproportionately high number of visitor sites, restaurants, hotels, and other historic features. There are enough of these features that many "walking tour" maps have been created for the downtown area.

There are a significant number of people who visit the area simply to visit downtown Jim Thorpe. Therefore, including a walking guide to Jim Thorpe highlighting key areas will increase the customer base. The downtown inset will provide spatial reference for many of the historical photos that could be included within the map. Also, many of the businesses that may want to be promoted on the map will be located within this inset. Establishing a method for including both the historical feature and current business may be difficult. The downtown includes many historical buildings that double as retail stores and restaurants. These businesses may close and reopen in less than one year and they are not always related to the history of the building itself.

One solution to this may be to tell the history of a specific historical feature and include in this story the current business that exists there today. For example, this would work well for the *Inn at Jim Thorpe,* built in 1849 as an inn and which remains one today.

A list of features that could be highlighted in this inset include: *houses of Victorian architecture, The Harry Packer Mansion, The Asa Packer Mansion, Kemmerer Park, Josiah White Park, The Anthracite Coal Lump, The Train Station, The Old Jail, The Inn at Jim Thorpe, Restaurants, Hotels, Features businesses, The Dimmick Memorial Library, The Carbon County Courthouse, St. Paul's Episcopal Church, Millionaire's Row on Race Street, and The Castle of Packer's Doctor.* All of the above features would translate well to the digital medium. The majority of these features have complementary websites. If a digital map were to be made, pop-ups could be added - linking the spatial features to the website.

The Lehigh Gorge was the main corridor for transporting coal during the late 18th century and early 19th century. It also served as the source of water that paralleled the Lehigh Canal. When railways became the primary mode of transportation, those tracks were laid along the Lehigh Gorge and paralleled the Lehigh River. The railways and canal left behind many elements that should be included in a heritage map.

The canal itself can still be seen along the side of the Lehigh River in certain areas - specifically near Weissport. The canal is a separate water feature that attracts attention and it should be represented on the map. The canal is one of the most interesting features users visit along the *Delaware and Lehigh National Heritage Corridor*. The locks of the canal are of specific interest, reinforcing the change in elevation along the river, and should be featured.

The story of the railway along the Lehigh River is similar to that of many other railways along the East Coast and in the Rust Belt. When the nation moved toward interstate highways as

the primary mode of transport, for both freight and for passengers, the use of these railways diminished. A recent trend has been the conversion of these railways into recreational trails. The ground leveled for the railway, low slope, and leftover gravel provide a head start for constructing a cycling trail. This trail provides the perfect mode of access for many of the canal features mentioned above. The railway, like the canal, also left many interesting features that can be included in the map. Rail stations, rail bridges, and other rail elements are historical features worth representing.

### 4.3 Features to Map: The Natural Environment

Visitors seek this area for its history, but also for the natural environment of the area. The area hosts a significant number of state parks, state game lands, state forests, and private tracts of forest. The topography is picturesquely mountainous compared to the rest of Eastern Pennsylvania. Moreover, the area acts as the "forest playground" for the metropolitan area that stretches from New York City to Philadelphia.

In this "forest playground" exist many different features that can be mapped. These features are likely to be the key purpose of this map. As mentioned above, many of the historical features above have been mapped and extensive attention has been given to them. There is only one recreation guide for this area, David Matsinko's *Jim Thorpe Adventure Guide,* which is both out of date and out of print. Also, features in the natural environment are inherently more difficult to find, further justifying their need for mapping.

The primary natural features to be represented are typical of most recreational maps. The area has an extensive trail network that can be used for hiking, biking, motorsports, and cross

country skiing. The area once hosted many natural wetlands that have been dammed and converted to lakes. These lakes and the activities and the activities they host are also worthy of being mapped. The Lehigh River is also as popular now as it was during the coal era, but its use has changed. The Lehigh River may be the most popular river on the East Coast for whitewater activities like rafting, kayaking, and canoeing. All of these elements contain features related to them that should be mapped.

The Jim Thorpe area has trails running through the majority of its natural areas. Mt. Pisgah, the peak nearest to Jim Thorpe, has miles of old coal paths that have been turned into hiking, cycling, and motorcycling trails. Many of these trails lead to ridge vistas, Lehigh Gorge overviews, and relics of the coal industry. The trails on Mt. Pisgah are a cause of some concern due to the dangerous features near the trails. There are active and inactive mines that are still in this area that could pose a potential hazard to trail users. Also, the abandoned mines were strip mined. This means that there are vertical cliffs, some over 100 feet, covering the mountain. Due to the danger of this area, the disclaimer should highlight taking caution in this area.

In the 1990s the Broad Mountain was nationally known for hosting some of the greatest mountain biking trails in the country. One trail loop, American Standard, was featured in one of the discipline's most respected publications, *DirtRag Magazine*.

Around the Jim Thorpe Area there are more than five lakes open for public/semi-public use. Many of these lakes have activities associated with them for recreation like boat rentals, swimming, and camping. It would be useful to map users if all of these lakes were featured so that differences can be seen between them quickly and easily.

One of the most interesting natural features to be mapped will be The Lehigh River. As mentioned above, the river will be shown in detail on an inset in order to display all of the

information relevant to it. The primary natural features on the river to represent will be the rapids. It is important for whitewater boaters to know the location and difficulty of rapids. Also, put-in and take-out points are essential locations to know for boaters. These put-in and take-out points, which require different boating permits, can be represented on the map.

### 4.4 Naming the Map

It should be noted that although Jim Thorpe is the focus of this map, it is not the largest town featured in the map. Also, many of the trails featured in this map are located outside the boundaries of the town. As such, it may seem counter-intuitive to use Jim Thorpe as the primary location label for this map. There are multiple reasons for selecting this name and not the names of the surrounding areas. The town of Jim Thorpe is fully featured and is located near the center of the map extent. Jim Thorpe is likely the area where the map will be both hosted and sold in the greatest volume. There are many small retail businesses in the town that sell similar merchandise to customers with historic and recreational interests. Jim Thorpe is the area with which visitors will associate the majority of natural and historic features represented in the map.

Naming a map after the town or feature located within its center is hardly a reason for deciding on a definite name. Town location, however, does bring up suggestions on how *not* to name a map after locations it represents. There are many other names after which the map could be labeled. *Southern Poconos, Carbon County, The Broad Mountain, Eastern Anthracite Coal Region* and many others could be possible names when basing a map label on geographic location.

*Southern Poconos* is not a robust choice because there currently are not other maps that would distinguish this specific map as *Southern.* There is not a *Northern, Eastern, or Western Poconos* map in print. This map is not part of a series, and so this choice has been removed. *Carbon County* would provide a decent title, but the county is not well-known to visitors from New York or New Jersey. When tourists visit the area, they visit specific towns, not the county itself. Also, county maps typically provide general road information and are not based on history or recreation. *The Broad Mountain* contains the majority of the trails, but not all of them and so this option is not sufficient. *Eastern Anthracite Coal Region* is simply too vague and does not invoke recreational and historic aspects of the map that a name like *Jim Thorpe* does.

Although the above options will not be featured as the main title, it is important that the reader knows the map also includes detailed information about the general areas mentioned above. These general areas and the detailed insets should be listed somewhere on the title page of the map. The list of these "subtitle" areas will be the following: *Mt. Pisgah, Broad Mountain, Beltzville Lake, Weizer State Forest, Downtown Jim Thorpe, Lehigh Gorge Trail and Rapid Map.*

# Chapter 5

# The Use of Other Maps

## 5.1 Current Maps of the Area

Currently, there is not a map of the area that matches the theme and extent of the map described throughout this project. However, there are a number of maps with similar themes and smaller extents that will be useful to review. These maps range from professional state park maps produced by the Pennsylvania Department of Conservation and Resources (DCNR) to spatially abstract cartoon advertising maps to hand-drawn trail maps drawn on top of USGS topographical maps. The list is long and varied, but each map contains data and styling techniques that can be extracted for use within this project.

All of the maps described in this section are in static form. There are no area specific web maps of the area to be reviewed. Still, the area does exist within the context of larger scale web maps like the Pennsylvania DCNR Map Viewer (http://www.gis.dcnr.state.pa.us/maps/index.html) and the Pennsylvania Game Commission Mapping Center (http://pgcmaps.pa.gov/pgcpublicviewer/). These web maps were designed so that data that can be downloaded from them. There are some interactive elements that could be drawn upon, but that is a focus point for future work.

Each of the maps in this section will undergo a standardized review process. This will provide a systematic approach for data extraction and style standards. The goal of this process is to be able to designate a review of these maps "Complete." A map is considered "Complete," when its style, source, data, extent, and use have been extracted in a way that will help the design of the case study map.  It is important to keep a separate document where a written account of

notes and data taken from each map can be recorded. Illustrated below is an example of how this process will take place using the Lehigh River Gorge Map as an example (Figure 11). *Appendix A* provides a complete list of the current maps of the area.

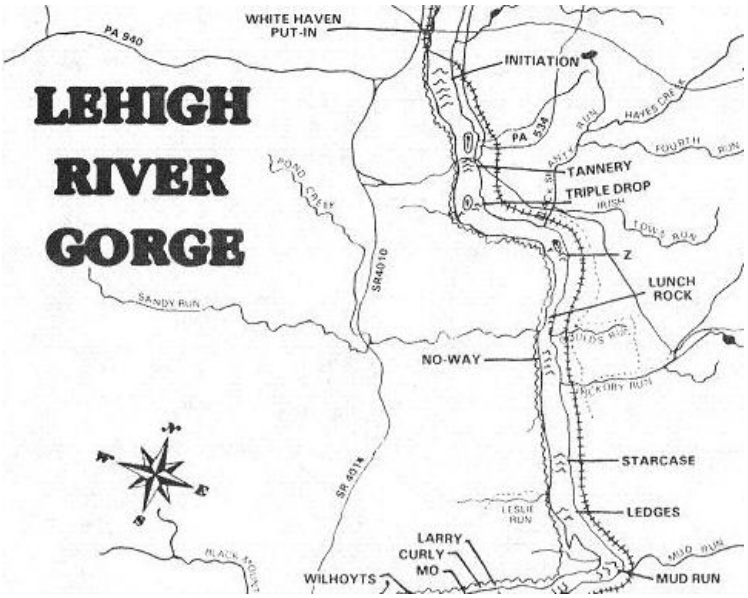



**Figure 10: Lehigh River Gorge Map (Jim Thorpe River Adventures)**

- Who designed the map? What is the map theme? What is the extent that the map covers? Where can the map be found?
  - Unknown Cartographer
  - Recreation map
  - Extent covers the Lehigh River Gorge from White Haven to Jim Thorpe
  - *http://www.jtraft.com/river-description-and-map/*
- What is the intended audience and purpose of this map?
  - Recreationalists wanting to navigate the Lehigh River Gorge via the Lehigh River or the Lehigh Gorge Rail Trail. Recreationalists could be rafters, kayakers, canoers, bikers, or hikers.
- What are the types of data that can be extracted from this map (that cannot be more easily extracted from other sources), what is the data type, and under what label would it be in the Jim Thorpe Map?
  - Boating put-ins and take outs **point**
  - Rapids **point**
  - Access roads **line**
  - Hiking trails **line**
- Are there any additional notes that should be taken in regards to style, additional text, or graphics?

    - The map has a specific method for balancing three linear elements that are parallel and close to one another: The Lehigh River, the railway that parallels the river, and the trail that parallels the river. This could give insights on how to deal with this densely area.
- Has the map gone under the complete review and has all the data been extracted and added to the database?
    - The map review is: complete October 29, 2015
    - The data extraction is: complete December 5, 2015

## 5.2 Thematic Benchmark Maps

The current maps of the area provide a great deal of information about the area. As noted above, this information can be used for both data extraction and styling purposes. Still, none of the maps above contain all of the information that is conveyed on the Jim Thorpe Map. They do not satisfy the intended theme, contain all the data desired, or satisfy the cartographic standard of The Jim Thorpe Map. The cartographic standard being a durable map that is aesthetically pleasing and providing functionality to the intended users.

In order to fill these voids, maps of other areas will be reviewed. These maps have been chosen due to their similar theme or similar data representation. These maps may be drawn on from well-known cartographic journals, from renowned cartographic firms, or from map competitions. The standards for the map quality for the intended map should match, if not exceed, the map standards of the maps described in this section.

This section describes a simple review process that each map should undergo. This review process will highlight the best design elements from each map. These design methods can then be emulated or used for inspiration in the Jim Thorpe Map. The review process will be similar to the review given in *Current Maps of the Area*, but with less of a stress on data

extraction and more stress on notes and style. Illustrated below is an example of how this process will take place using the Sawtooth Wilderness Map as an example (Figure 12). *Appendix B provides* a complete list of Thematic Benchmark Maps.

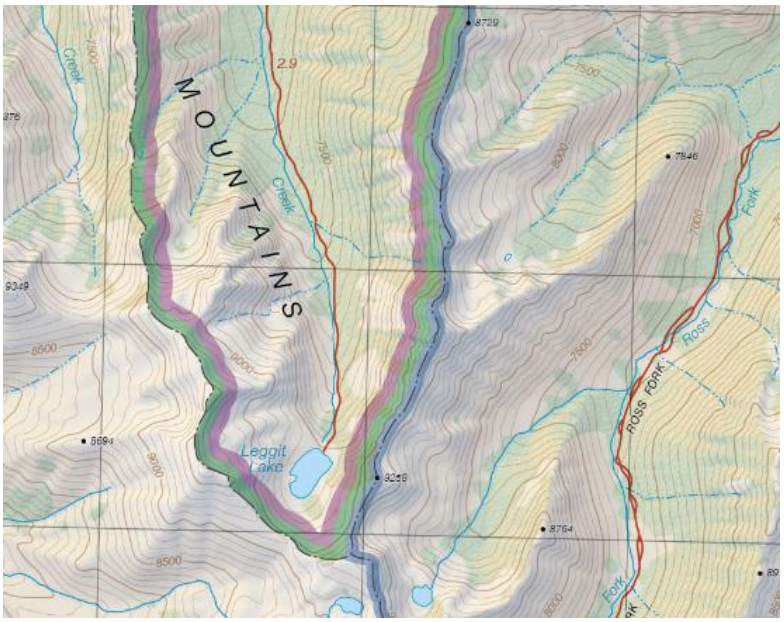



**Figure 11: Sawtooth Wilderness (Tavernas 2013)**

- What is the map name, map theme, scale, and source of the map?
  - Sawtooth Wilderness - Aaron Taveras
  - Recreation Map
  - 1:50000
  - http://nacis.org/awards/2013-winner-sawtooth-wilderness/
- What is the intended audience and purpose of this map?
  - Outdoor recreationalists looking to explore the Sawtooth wilderness in Idaho. Map could be used for hiking, camping, boating, and fishing.
- What type of data is represented well on this map?
  - Small lakes, forests in orthoimagery, land use boundaries, elevation
- Are there any additional notes that should be taken in regards to style, additional text, or graphics?
  - The map does a particularly good job at balancing elevation representation through contour lines/hillshading and land cover simultaneously. Color and linetype choices for adjacent polygons is excellent. This map was the winner of the 2013 NACIS Student Map Competition.

# Chapter 6

# The Cartographic Process

## 6.1 Defining the Extent

The extent of a map in paper form will always be limited by the size of the paper, the features to be mapped, and the density of those features. For this map there are specific areas which contain the features necessary to be considered a historical and recreational map. As mentioned earlier in the text, the main features to be mapped will be historical elements of the built environment and recreational elements of the natural environment. The goal is to define an extent that will include and balance all of the features within the two broader categories. There are certain areas where the density or shape of features will not fit on the main map. This section will explain the justification for the main map extent, scale of the main map, location of inset maps, and scale of inset maps. This section will also explain the need of a locator map.

Before extent can be defined physical limitations of paper size need to be taken into consideration. The size of the paper is based primarily on what is available for large-scale printing, what is practical to carry and view, and the size of other maps with a similar theme. This paper and size of this map will be based largely on the work of The National Park Service, National Geographic Trails Illustrated, Michael Hermann's Purple Lizard Maps, and Parque Nacional Patagonia.

### 6.11 Main Map

When deciding on the scale of the main map there are a few issues that need to be taken into consideration. First, be sure that the spaces between the features being mapped are not too dense or too sparse. If features are too dense there will be no room for labeling and navigation will be difficult. If features are too sparse, it may be difficult to relate the location of certain features to one another. The proper balance must be found between scale and density of features.

Also, all of the most important features of the map must be within the extent. Ensuring all important features are within the map can be done by using aerial imagery as a placeholder (in the event that one does not have all map data). It is highly unlikely that the desired map will conveniently fit within the given extent. The orientation, or direction North within the map, can changed along with the scale in order to fit everything.

**Table 3: Details of Main map**

| | |
|---|---|
| **Map Size** | 32 x 24 (inches) |
| **Data Frame Size** | 31.5 x 23.5 (inches) |
| **Margin** | .25 (inches) |
| **Orientation** | Landscape |
| **Scale** | 1:37000 |
| **Boundaries** | N: 41.1761<br>S: 40.74348<br>E: -76.0089<br>W: -75.4774 |

### 6.12 Lehigh Gorge

The Lehigh Gorge map will be on the reverse side of the main map. It takes up the entire canvas space, but will include many inset elements within it. The Jim Thorpe walking map will be inset within this map with locator lines showing its place within the larger map.

**Table 4: Details of Lehigh Gorge map**

| | |
|---|---|
| **Map Size** | 24 x 36 (inches) |
| **Data Frame Size** | 23.5 x 35.5 (inches) |
| **Margin** | .25 (inches) |
| **Orientation** | Portrait |
| **Scale** | 1:37000 |
| **Boundaries** | N: 41.0980<br>S: 40.7722<br>E: -76.0089<br>W: -75.4774 |

### 6.13 Jim Thorpe Walking Map

The Jim Thorpe Walking Map must be included as an inset because it requires a much larger scale in order to view its features. The buildings, parks, and historic points of interest would be too clustered to show on the main map. Fortunately, downtown Jim Thorpe is laid out linearly in an East to West fashion. This works well with the other elements on the backside of

the layout. The Lehigh Gorge inset will take the majority of space on this side, but the space it will take will be vertical.

**Table 5: Details of Jim Thorpe Walking map**

| | |
|---|---|
| **Map Size** | 24 x 36 (inches) |
| **Data Frame Size** | 23.5 x 35.5 (inches) |
| **Margin** | .25 (inches) |
| **Orientation** | Portrait |
| **Scale** | 1:37000 |
| **Boundaries** | N: 41.0980<br>S: 40.7722<br>E: -76.0089<br>W: -75.4774 |

### 6.14 Locator Map

The locator map in this project will serve two purposes. The first is to show Jim Thorpe within the greater context of Eastern Pennsylvania, New York City, and New Jersey. The second

is to show the main routes from population hubs to the area. The two main population hubs are related to the audience and are the cities of New York and Philadelphia.

**Table 6: Details of Locator map**

| | |
|---|---|
| **Map Size** | 24 x 36 (inches) |
| **Data Frame Size** | 23.5 x 35.5 (inches) |
| **Margin** | .25 (inches) |
| **Orientation** | Portrait |
| **Scale** | 1:37000 |
| **Boundaries** | N: 41.0980<br>S: 40.7722<br>E: -76.0089<br>W: -75.4774 |

## 6.2 Data Collection, Processing, and Representation

Data collection over such a large extent can be a daunting task. In fact, this can be the most time consuming task for a mapping project. For this project in particular, there is a large breadth in the type of data required. The idea of data collection is something familiar to those in the field of cartography and geography, but may not be to those outside the discipline.

It can be helpful to think of the data on a map as all the elements there are listed in the legend. Roads, terrain, cities, forest types, state parks, populations, trails, are all types of data that may or may not be *recorded* or *publicly available*. Within these general types of data there are also degrees of specificity that are used for more detailed representation. For example, for

one data type, roads, there are different types of roads: expressways, paid toll roads, municipal roads, county roads, dirt roads, hiking trails etc.

One can imagine that the collection of this data can take a hundreds of hours depending on the detail or resolution in which the data is collected. Luckily, for cartographers both amateur and professional, there exist many publicly available data sources. In fact, for the case study, nearly all the data is publicly available via the internet. This data, as is everything available openly on the internet, contains differing degrees of accuracy.

Currently there does not exist a thematic map representing the outdoors and heritage in the case study of Jim Thorpe. This means that data within the new map must be "mined," recorded, or taken from various maps that have previously been printed. It will be a useful exercise to review the process of data collection by data type for the case study. Below, the data type and method of collection will be described in detail.

OpenStreetMap will act as the main repository and source of data. It is important to note that OSM is rarely a primary source. The majority of OSM data is uploaded from other sources. These uploads can be as direct as adding TIGER/Line shapefiles from the census or as indirect as a student tracing lakes from aerial imagery in a high school geography class. The key to the data that is uploaded to OSM is that it is free and open data in the public domain. Proprietary data is not allowed to be uploaded to OSM. Examples of public domain data are the National Hydrography Dataset, US Census TIGER/Lines, etc. Examples of proprietary data are buildings traced while viewing Google Earth, using building names listed on Nokia Maps, etc.

In order to more efficiently download data from OSM, it is best to automatically have the coordinates of the map extent bounding box saved. For a map of this size, it is necessary to

use the Overpass API, which is simply a mirror site that will access the same data. The coordinates for the bounding box are:

*N:* *41.0980*
*S:* *40.7722*
*E:* *-76.0089*
*W:* *-75.4774*

All of the data within this bounding box will be downloaded from OSM, but not all of it will be used. The data will be filtered through an external OSM data management software called OSMIQ. This external software allows users to select data based on attributes and geometry, then export that data in a variety of file formats such as kml, shapefile, geojson, etc.

Once all the data is within the map it must be processed and represented. Data never comes from sources, especially open sources, free of error or in the form the user desires. Once the source of the data has been listed and described, a brief description of processing and representation will be given. The order in which the data is listed is the same order in which the layers will be drawn on the map. In other words, the data are being described "from the bottom up."

### 6.21 Raster Data

#### *Land Classifications: National Land Cover 2011 USFS Tree Canopy*

**Data Source: http://www.mrlc.gov/nlcd11_data.php**

The original data comes from the National Land Cover 2011 USFS Tree Canopy (cartographic) dataset. This data is 3.2 GB uncompressed and requires a java application to download. Luckily, PASDA hosts a subsection of the data that can be downloaded via an FTP

Download. The original data comes in raster format of pixels ranging from values of 0 to 100, 0 being unforested area and 100 being fully forested area (Figure 13). The original data was created using a combination of LIDAR, satellite imagery, and ground sampling.

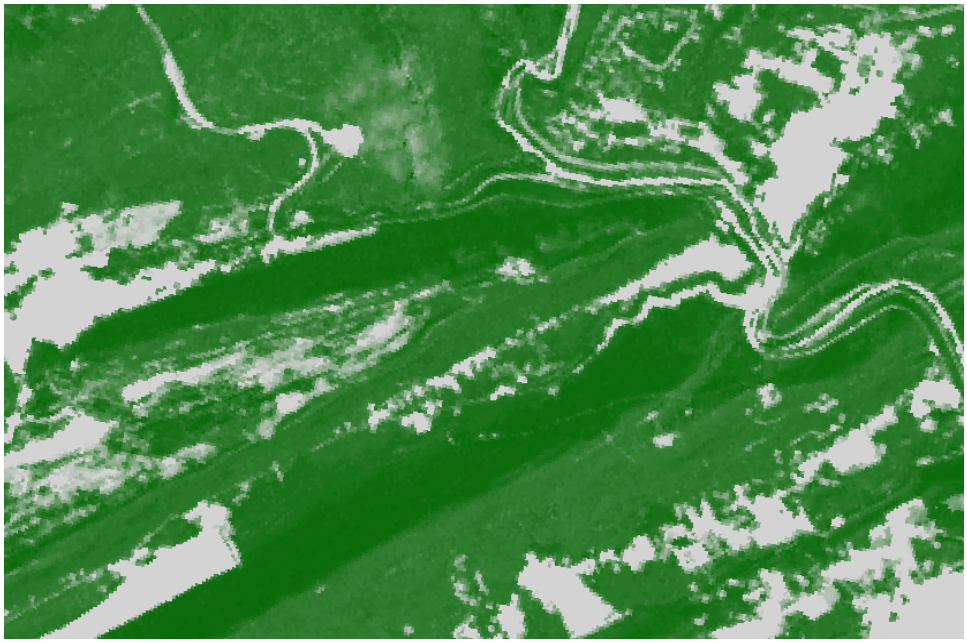


**Figure 12: The raster data in its original format. Pixel colors range from gray to dark green according to forest cover**

This level of detail in describing forest cover is not required for the Jim Thorpe Map. For the Jim Thorpe Map, the data has been simplified into two general classes rather than 100 different pixel values. Using the complementary data documentation provided by the USGS, the 100 pixel values were translated to only two different classes: 1 (unforested) and 2 (forested). Pixel values 1-20 were designated unforested and pixel values 20-100 were designated forested. The values of these raster pixels were changed using a Python script. Figure 14 depicts in the result of this new classification.

**Figure 13: The raster data reclassified into only 2 classes: forested and unforested**

The data still needed further refinement before design could take place. Due to the resolution and raster nature of the data, the boundaries between unforested and forested lands were pixelated. The raster layer was vectorized so that each continuous area of unforested or forested land was turned into a polygon. Once these areas were vectorized into polygons, the polygons could be smoothed to a certain tolerance. In this map, a tolerance of 100 feet was used. The smoothing algorithm was used twice. Figure 15 is the result of this process.

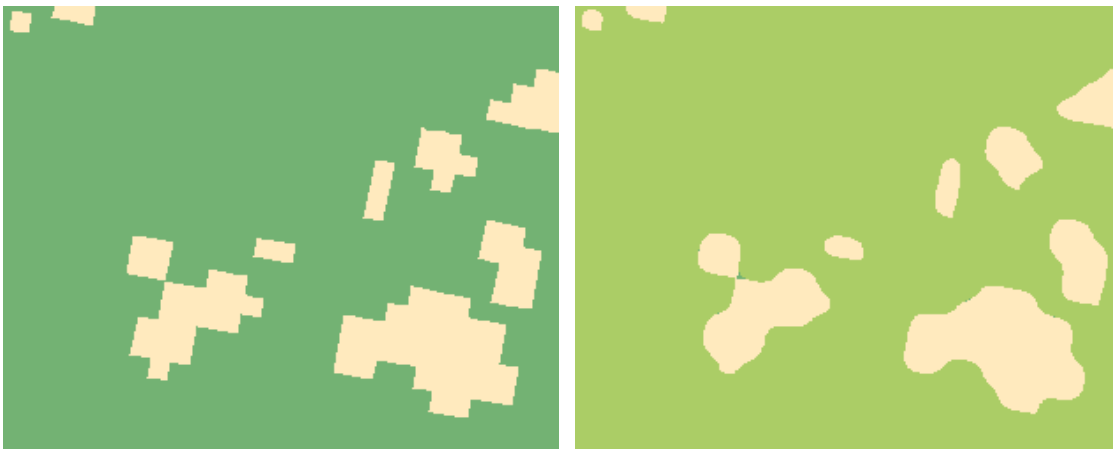


**Figure 14: The vectorized canopy data (left), The vectorized data after being smoothed twice (right)**

***Digital Elevation Model: USGS 30(m) National DEM***

**Data Source:**

**http://www.pasda.psu.edu/uci/MetadataDisplay.aspx?entry=PASDA&file=dem30meter.xml&dataset=100**

The original data comes from the USGS 30m national DEM. The data was downloaded tile by tile from the Pennsylvania Imagery Navigator. The DEM mosaic was created using 15 different merged tiles. Mosaicking the tiles is required in order to have a seamless DEM that can be used to derive hill shading and contour lines.

There are some difficulties that can result from mosaicking different raster files. During the process for this map, there were gaps in data between some of the rasters. These no data points were given values using a nearest neighbor function. The function takes the mean of the nearest five cells surrounding the no data cell. The tool that can run this function is in ArcMap and labeled Focal Statistics.

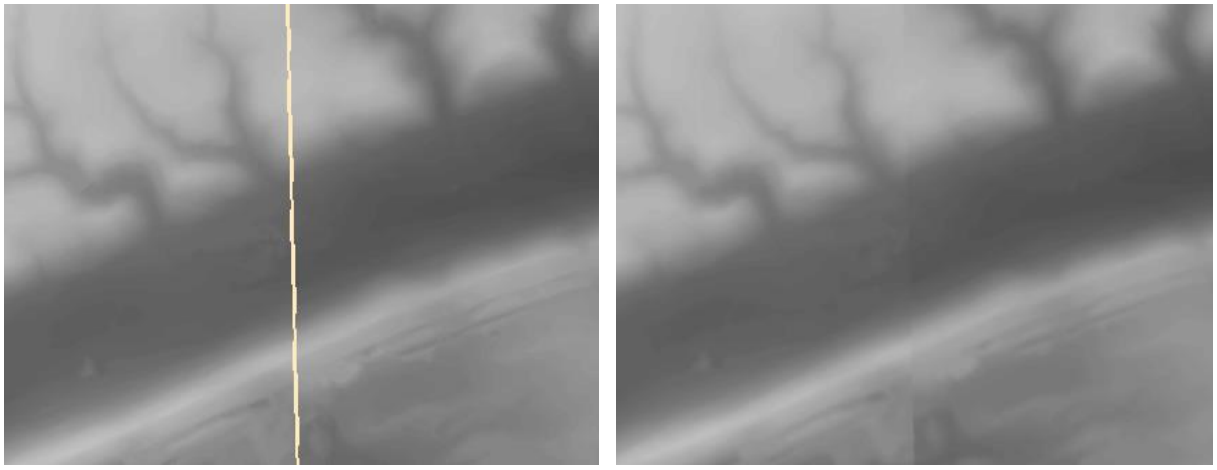


**Figure 15: The mosaicked raster data with gap between two tiles (left), the seamless mosaicked raster data post-nearest neighbor function (right)**

### 6.22 Vector Data

***Roads: OpenStreetMap***

**Data Source: http://wiki.openstreetmap.org/wiki/Highways**

The roads will be based on data from OSM. Using the road data from OpenStreetMap will add to the open-source nature of this map and is likely to be the most accurate freely available data. OSM road data is based primarily on the US TIGER/Line. The OSM data was chosen over the basic TIGER/Lines because it is more likely to be kept up to date and accurate by locals. Also, the TIGER/Lines can be made even more accurate through the use of the Strava Slide Tool, which is described in further detail under the *Trails* section.

Only slight variations were made to the road data after being downloaded from OSM. The roads were designed to contrast little with the rest of the map and appear closer to background information. This subtlety in design was done so that the recreational and historical

features could be more in focus. Also, much of the design of the roads is based on the design of web reference maps such as Google Maps and OSM.

### *Whitewater Features: The Lehigh River Gorge Map, Pocono Whitewater Rafting*

The Lehigh River is one of the most popular rivers in Pennsylvania for whitewater activities. Adding features like river rapids, river rapid classes, put-ins, and take-outs add great value to the map. Currently, there is only one map that includes this information and it is featured above (Figure 11). The rapids and the classes associated with them will be taken directly from this map, and later fact checked with local whitewater outfitter Pocono Whitewater Rafting.

The put-ins and take-outs for boaters are more complicated. There are multiple put-ins and take-outs that are available on the river, but each has its own set of regulations. These regulations restrict certain areas for commercial use, private use, public use, or a combination of all three. For all put-ins and take-outs, the DCNR and their map can be used to acquire data. For any outside of the Lehigh Gorge State Park, local outfitter Pocono Whitewater rafting will be consulted.

### *Trails: Strava Global Heat Map, Strava Slide Tool, OpenStreetMap*

**Data Source:** http://labs.Strava.com/heatmap/#6/-120.90000/38.36000/blue/bike
**Data Source:** http://labs.Strava.com/slide/
**Data Source:** http://wiki.openstreetmap.org/wiki/Tag:highway%3Dpath

Originally, the trails were to be the most difficult data to acquire for the case study. As the map is to be recreational and Jim Thorpe is a rural area, the trails are to be the main emphasis. The old method of acquiring this trail data in the form of polylines would require a

GPS unit, an able body, and hundreds of hours of data collection and refinement. The following is the original method that was to be used to collect trail data: *1. Consult all related previous maps published of the area, 2. Acquire GPS unit and manually take tracks of each trail, 3. Take detailed notes of trail intersections, 4. Combine GPS tracks with detailed notes to represent, segment, and name trails, 5. Ground truth the accuracy of the trails with printed map.* Luckily, recent technological improvements and social mobile applications have made this process faster, more efficient, and more accurate.

The new method will allow much of the trail data collection to be done digitally and from a remote location. The possibility of this method is owed to external software companies and websites. **OpenStreetMap, Strava,** and **OSMIQ** used properly can provide a global database for trails. The new method follows a very similar format to the old, but with the most time-consuming step removed. The following is the method used to collect trail data in the case study: *1. Consult all related previous maps published of the area including the **OSM database** and the **Strava Global Heat Map,** 2. Use the **Strava Slide** tool to create new trails to be added to the **OSM database,** 3. Consult previously published maps and **Strava Segment Explorer** to section trails and provide names, 4. Ground truth the accuracy of trails using **OpenStreetMap.*** Currently, this is the fastest way to create a trail database from scratch.

This is a method which was developed primarily for this case study, as there does not currently exist a comprehensive trail database covering the chosen extent. There will be some definite inaccuracies using this model, but they should not be any more drastic than if the original method were employed. Overall, a higher degree of accuracy in a faster time is expected. Below, the trail data collection process, in detail, is described.

1. *Consult all related previous maps published of the area including the **OSM database** and the **Strava Global Heat Map***

Consulting previous maps is an essential step for the entire cartographic process of the case study. Existing maps provide the groundwork for which the new trail database will be built. The majority of the maps that currently exist and could be consulted are often inaccurate and only in print form. Therefore, they can only be used as an occasional visual reference. Their greatest use will be employed when the trails must be named and segmented.

The OSM database contains a moderately large database of trails contributed by volunteers. The accuracy of Volunteered Geographic Information is currently being assessed by many geographers. For the case study at hand, trails submitted via VGI can be used, so long as the data eventually undergoes a ground truth.

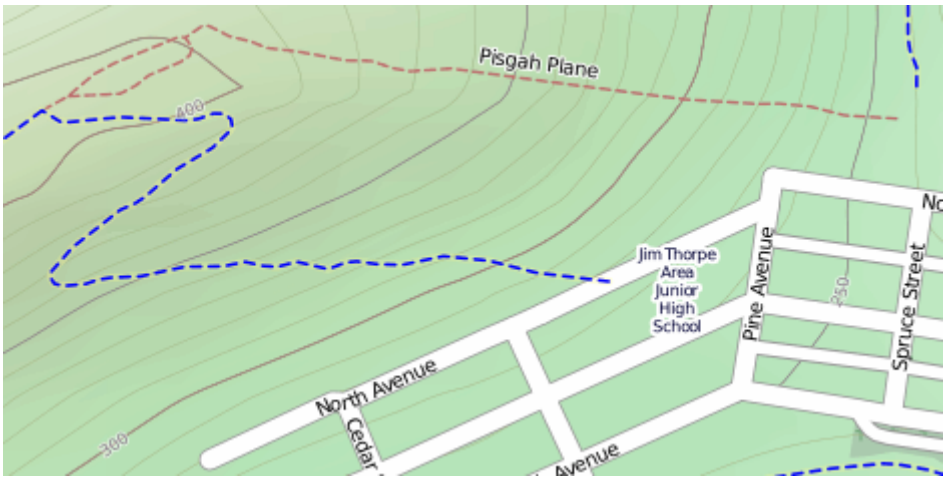



**Figure 16: Trails added through VGI shown on OSM's interface (openstreetmap.org 2015)**

The OSM database can serve as a reference, an area to store data, and an area to download data from external sources. Methods to download and store data will be mentioned later in this section. For this section, it should be understood that OSM is a valuable reference to be used for multiple types of information. Depending on the location, it is frequently updated by contributors.

The Strava Global Heat Map will be the most useful reference map to be employed for the case study. Strava is a website and smartphone application that allows users to track, rank, and store exercise routes. The most frequent users of this application are trail runners, hikers, mountain bikers, and road bikers. This is the ideal group of contributors for the case study.

When users turn on the Strava Application their smartphone or other compatible GPS device will automatically add their GPS track to the Strava database. The Strava database holds all user's GPS tracks and times. From this database, Strava has created a global heat map containing the trail data from their users across the world.

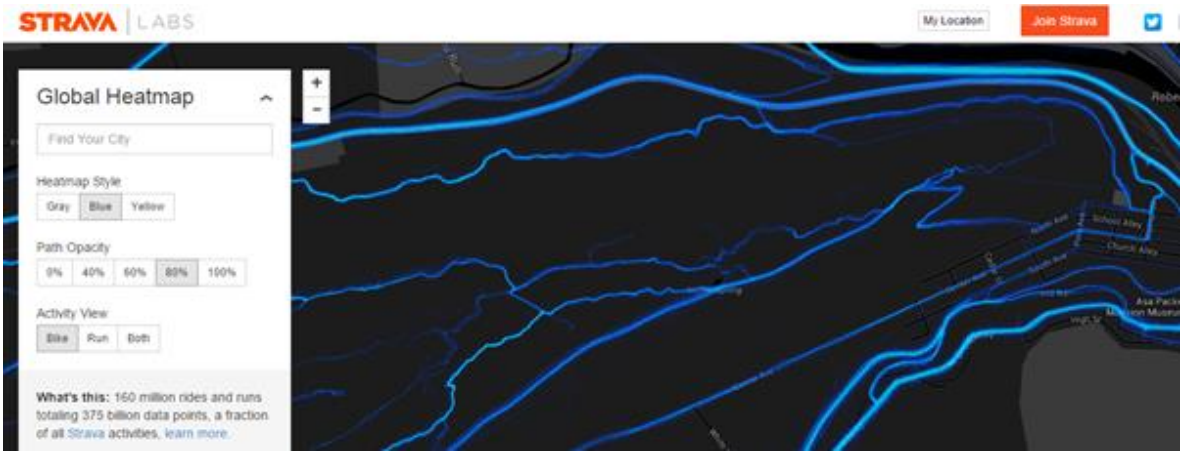



**Figure 17: Strava Global Heatmap (Strava 2015)**

The heatmap shows the trail data contributed by Strava users in various degrees of blue (Figure 18). The trails themselves are actually not lines, but are individual GPX points linked so closely together that they resemble trail lines. This allows users to see the frequency with which trails are used. Although this map does not include the names or segments of trails, it is an excellent way to view where trails exist and their popularity.

2. *Use the **Strava Slide** tool to create new trails to be added to the **OSM database***

Above it is noted that the Strava Global Heatmap does not contain lines, segments, or names for any of the trails. The global heatmap only shows GPX points which cannot be downloaded. This does not mean that they cannot be used for a further purpose than a reference map.

Developers at Strava have created a unique tool that can be used as an add-on in OpenStreetMap. This add-on allows users to create trail segments from the global heatmap using a clever algorithm. This add-on is called the Strava Slide tool.


**Figure 18: The Strava Global Heatmap shown overlaid in OSM's interface (openstreetmap.org 2015)**

Figure 19 above represents both unrefined GPX points from the heat map along with data that has already been contributed to OpenStreetMap. By referencing the OSM data, the heatmap, and existing paper maps, an understanding of what trails exist in the OSM database and what

trails need to be added can be gained. It is clear that a new trail segment should be created as is indicated by the blue line in the center of the screenshot. Using the OSM ID Editor users can manually add a line by creating vertices over the heat map GPX points.


**Figure 19: The same figure as shown above with a trail segment added (openstreetmap.org 2015)**

Figure 20 shows the same area with a rough line digitized over the heatmap. This line has roughly 17 vertices and depicts a coarsely accurate representation of the trail shown on the heatmap. The Strava Slide tool will add more vertices and "slide" the rough line to the heatmap GPX points.

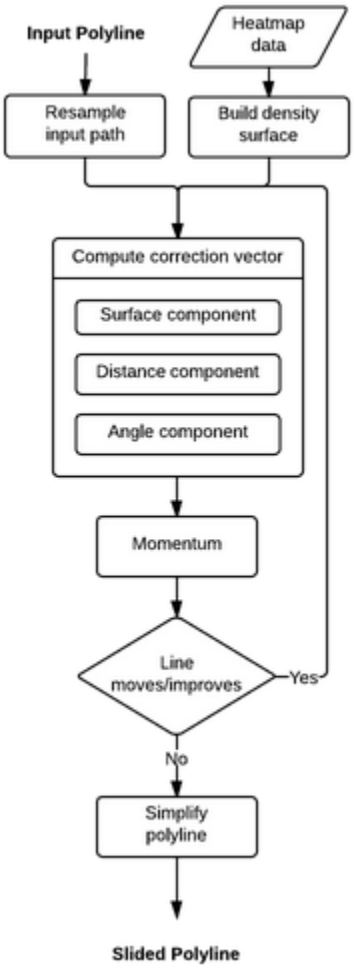



**Figure 20: A model of the process Strava uses for the Slide tool (Strava 2015)**

Figure 21 shows the process created by Strava in order to "slide" the rough polyline to the GPX points from the heatmap. Figure 22 shows the refined polyline with name and trail type attributes added. Note the smoothness of the line and its resemblance to an actual trail. Due to the nature of the Strava Global Heatmap taking the average of the GPX points of many users, this is an extremely accurate representation of the actual trail.

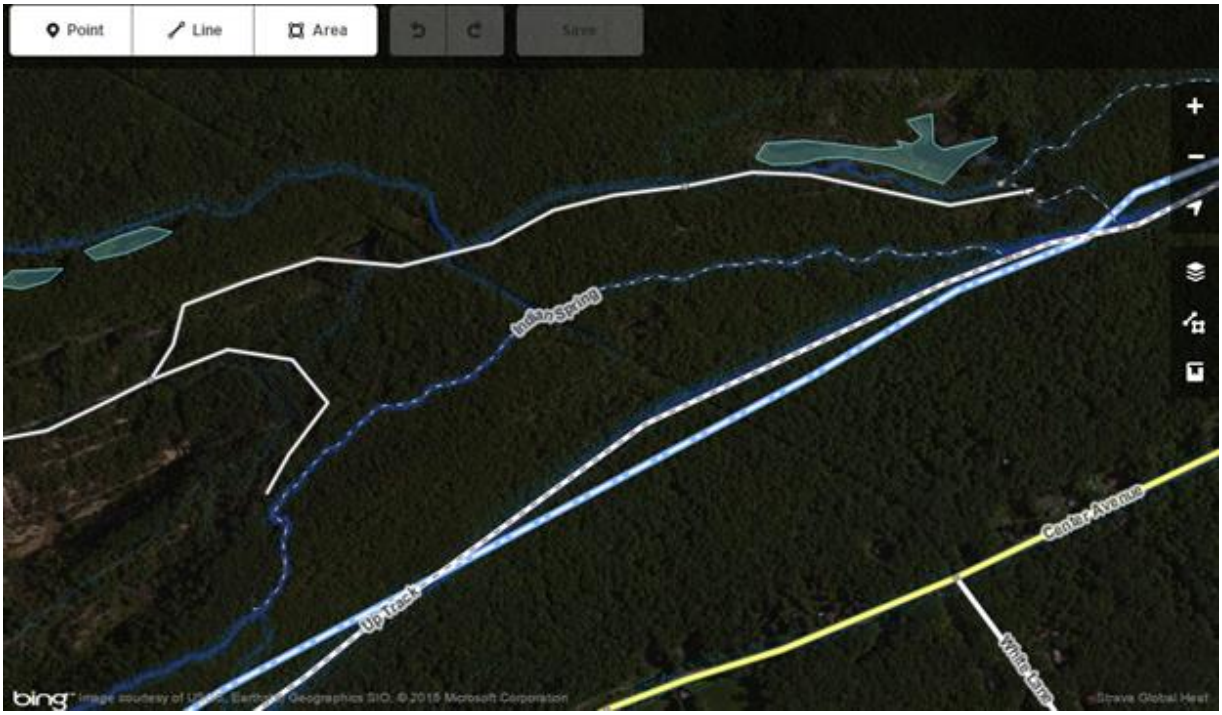



**Figure 21: The refined trail based on the Strava Global Heatmap with trail type and name attributes added (openstreetmap.org 2015)**

The Strava slide tool can also be used on any other lines existing in the OSM database. The tool can be used to clean up other line features such as dirt roads, gravel paths, hiking paths, etc. Even national data like TIGER/Lines can be smoothed using the Slide tool.

3. *Consult previously published maps and the **Strava Segment Explorer** to segment trails and add names and source attributes to the **OSM Database***

Using the above steps, an accurate representation of trails and their geometry can be added to the OSM Database. Still, other attributes such as trail type and name must be added in order to make an accurate map. An example of different trail types could read as follows: *singletrack, doubletrack, fire road, hiking only, horseback accessible, etc.* In order to find these attributes, previously published maps and Strava Segment Explorer can be used.

Names are often the easiest attribute to add to a trail. They can be somewhat arbitrary and may change entirely depending on the user. For a mostly unmapped area, such as the one in the case study, many of the trail names may be created by the cartographer. A moderate degree of

cartographic license can be used when making trail names, but the cartographer should still aim to represent existing trail names, names used by locals, or names that reference features on the trail.

The Strava Heatmap above gives an excellent portrayal of the entire trail system of the case study, but it does not easily depict where one trail ends and another begins. These segments are important because they, not an entire trail system, will indicate the trail type and name attributes to be attached to the trail geometry. Previously published maps help greatly to understand the segmentation and naming of trails, but there will still be many trails for which these attributes do not exist.


**Figure 22: Strava Segment Explorer indicating different segment lengths and names (Strava 2015)**

The Strava application allows users to name trail segments with start and end points based on GPX trails they or other users have created. Figure 22 shows how the high use of Strava works to a certain degree against the cartographer. On the left side of the figure, there are four different segment names for the same trail segment: *Full Wagon Road, Wagon Road Down, Down to the raccoon shoot, and Wagon Road Up.* There is not an empirical formula that can be used to choose a correct name for this segment. Also, the start and end points of each segment vary. The segment length can be narrowed down by viewing surrounding terrain and other trail

or road intersections. The name should be chosen by taking name elements from all segments listed. For this example, *Wagon Road,* will be the name given.

Above is shown the method for creating trail geometry using Strava Slide tool, creating trail names through Strava Segment Explorer, and using other references for trail type. Still, it is essential for all of this information to be stored. For the case study, the OSM Database will store the majority of this data.

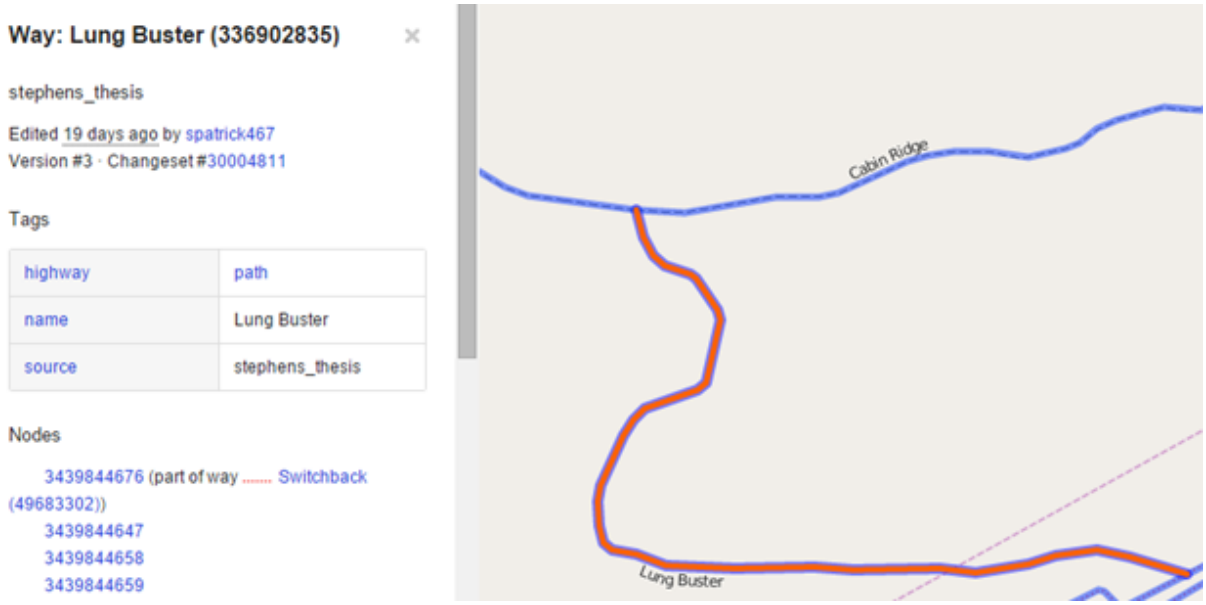



**Figure 23: Attributes that are associated with an OSM feature (Strava 2015)**

Figure 23 represents a simple view of an OSM trail created through the Strava Slide tool with associated attributes like trail type and name. OSM stores attributes associated with geometries through a series of tags. The three tags are associated with the trail (highlighted in red) shown on the right side of Figure 24. The tag, *highway: path* refers to the trail type, the tag *name: Lung Buster* refers to the trail name, and the tag *source: stephens_thesis* is a created field used for data organization and the case study.

The first tag, *highway: path* is used by OSM to decide the symbology to be used to represent the trail on their API. This tag can have a number of different options with many different subsets of those options. Other attributes such as *Surface, Width, Structure, Access, Incline, Hiking Difficulty, Mountain Biking Difficulty, Reference, and many more* can be added. For the purpose of the case study, the three tags above are sufficient.

The second tag, *name: Lung Buster,* was derived through Strava Segment Explorer using the method mentioned above.

The third tag, *source: stephens_thesis,* will be used to target specific features within the OSM Database that will be downloaded and used in other geospatial software such as OSMIQ and ArcGIS.

*4. Ground truth the accuracy of trails*

Considering the nature of this data, it is essential that it is ground-truthed before being published on a map. Although the data is typically reliable, there are a number of problems that can create a "false trail." There can simply be a GPS error in accuracy or precision. Strava users may be using the application while hiking through the woods not on a trail. And most importantly, there is no way of knowing what type of trail the data is related to.

In order to address these issues, the data must go through a two-step screening process. First, any previously published map should be consulted. These maps will provide trail type, trail name, and ensure that it actually exists. Different symbology should be used for trails before and after they have been screened in order to avoid confusion. The second step requires the map to be taken into the field where they will be ground truthed. The trail type (singletrack, 4x4, service road, etc…) and whether or not it actually exists will be recorded.

***Waterbodies: USGS National Hydrography Dataset, OpenStreetMap***

**Data Source:** **http://nhd.usgs.gov/**
**Data Source:** **http://wiki.openstreetmap.org/wiki/Tag:natural%3Dwater**

Data for water bodies, which refers to lakes, ponds, estuaries, reservoirs, etc. are sourced from the National Hydrography Dataset and OSM. Initially, the NHD appeared to be sufficient data, but after further investigation there were gaps in the data. Some very small water features were not included in this dataset. OSM data filled in these gaps. Both layers will have the same graphic display.

***Towns: OpenStreetMap***

**Data Source:** **http://wiki.openstreetmap.org/wiki/Key:place**

Data for towns will be sourced from OSM. The data is in point form and fall under the tag gnis:Class | Populated Place. For this map only *villages* and *cities* will be labeled. Other place names, like hamlets, are too small to be significant enough to represent in this map.

***Point Features: National Register of Historic Places***

**Data Source:** http://www.nps.gov/nr/research/data_downloads.htm

The point features of this map will require much manual entry. The types of point features that will be represented are parking areas, ranger stations, historic points of interest, trailheads, vistas, waterfalls, etc. There is not a standard source from which this type of data can be derived. Many of these features will be sourced from primary and secondary sources. There

are, however, a few different sources that will aid in adding these point features. State Park maps will provide information like parking areas, trailheads, vistas, etc. Types of data that are unavailable via these secondary sources will be waterfalls, vistas, etc. The only primary source for which there is data is the National Register of Historic Places.

The points on this map, for the most part, will be represented through the same point symbols used by the National Park Service. In the United States, the National Park Service is the standard for both recreation and historic map production. They have an extensive list of symbols that can be used. Also, considering the popularity of the National Park Service Maps, users will be more likely to recognize what the symbols represent.

***Boundary Areas: Pennsylvania Game Commission, DCNR Interactive Map Resources***

**Data Source: http://pgcmaps.pa.gov/pgcpublicviewer/**
**Data Source: http://www.gis.dcnr.state.pa.us/maps/index.html**

The boundary areas for a number of parcels of State Game Lands and the Lehigh Gorge State Park required the most attention to detail and alteration. There are many different features that run along the Lehigh Gorge, including: the Lehigh River, tributaries of the Lehigh River, the Lehigh Gorge Rail Trail, trails branching from the rail trail, an active railway, boundaries for the Lehigh Gorge State Park, and boundaries for a few different state game lands. This messy geometry is exampled below (Figure 25).

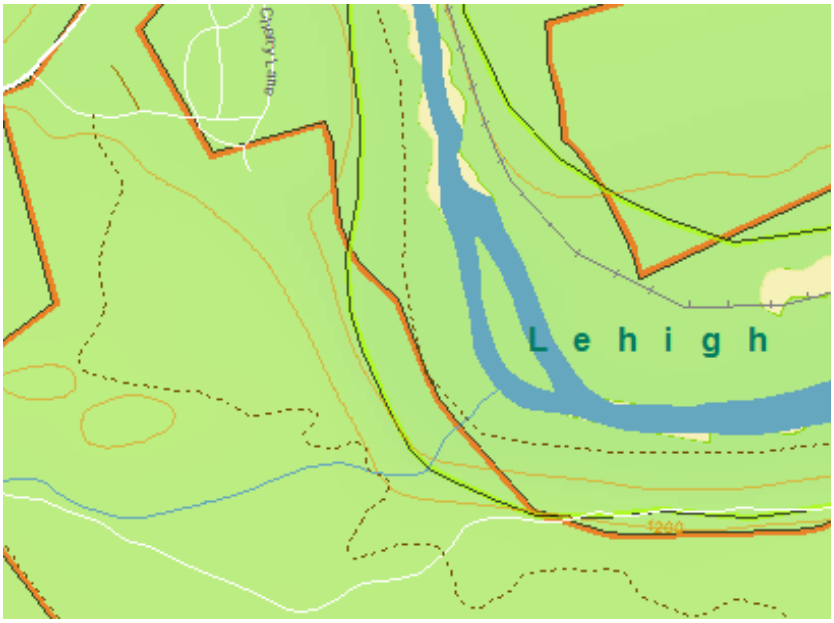



**Figure 24: Complexity of features along the Lehigh Gorge**

In order for the map to be more legible, the geometry of these features needed editing and required a small degree of "cartographic license." Cartographic license in this case is moving geometry of features away from their true location in order to make the map more legible. A number of buffer functions was done on the centerline for the Lehigh River in order to streamline this process. The buffer essentially created a space around the Lehigh River where features can be placed without overlapping or if features do overlap, their vertices can be connected.

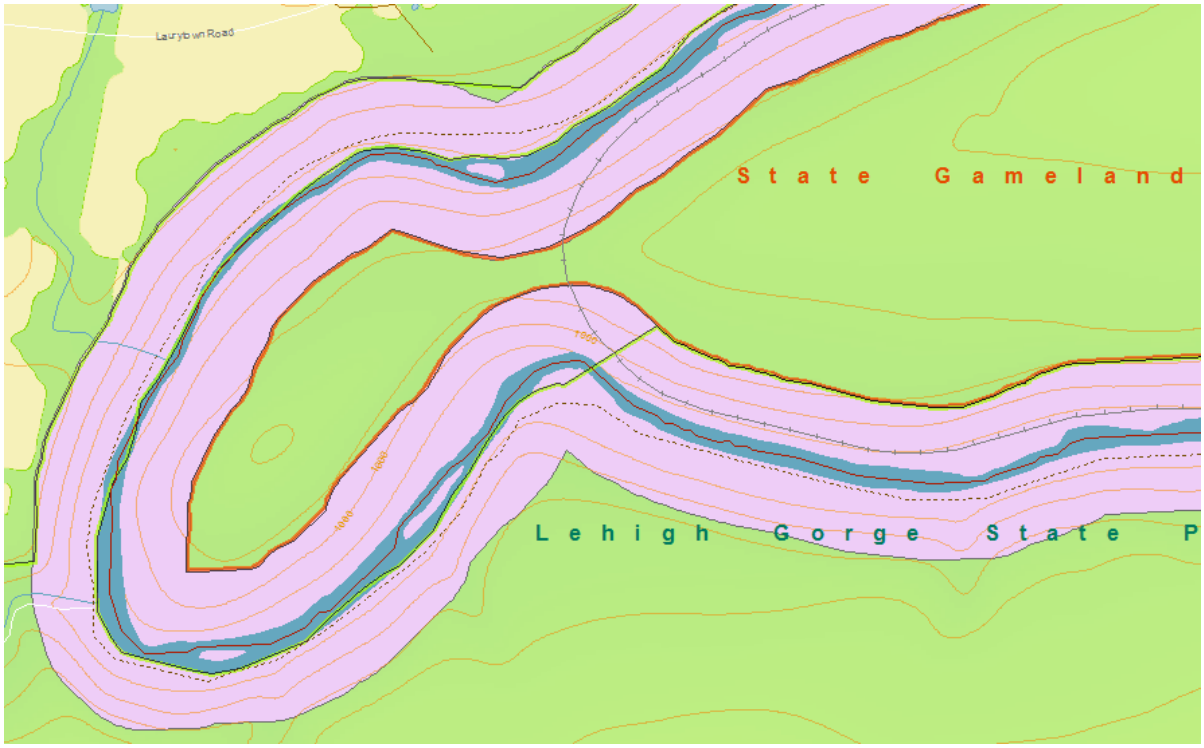



**Figure 25: A 500-foot buffer (purple) around the Lehigh River used to simplify geometry**

The largest buffer will be a 500-foot buffer. This buffer will be used to align the boundaries of the state parks and the state game lands. Two other features will typically be shown within this larger buffer, the rail trail and the active railway. Using buffers of 500 feet, 350 feet, and 200 feet, these three features will always be kept separate (except when intersecting) by 150 feet.

## 6.3 Additional Text and Graphics

Additional text and graphics are necessary for a map of this theme. These additional elements go well beyond a legend and title. These elements serve as a translator between the spatial elements of the map to the map user. Additions can do this in many different ways.

Photos and diagrams can aid in the current sense of place or help the user to understand an area that looked different in the past.

Text will often be needed to describe certain things that cannot be done through geometry and symbols alone. For example, rapids on the Lehigh River should be noted for both safety and navigational reference. The rapids are single geometric points with many attributes: name, class, and distance from put-in. All of these attributes cannot be represented within the map space. To counter this problem, a table can be added somewhere within the canvas to organize this information. Spatial information can then be linked through rapid name to the table.

Although the map is to be printed on the entirety of the canvas, there are still many spatial components within the map that will not need be displayed. Additional text and graphics can be overlain in these areas. Canvas space is valuable and all areas should be used to make the most usable map, even if that means covering spatial elements.

Space must also be set aside for disclaimers, warnings, and sources. Information like this, due to its importance, is often kept off the map and located somewhere near the legend or title. Disclaimers must let users know that the spatial information represented in the map may change between the time of printing and the time they are using the map. An example of a warning may be definitions of river rapid classes and a notification that these rapid classes may change due to dam releases, weather, and erosion.

All sources for information on the map must be acknowledged. For a map of this caliber and complexity, this can include many sources. Above, in the *Data Collection, Processing, and Representation* section, all data sources for this map are explicitly listed. This degree of detail cannot be listed on the map, and so sources will simply be listed by name. This is standard for most maps of this nature.

There is, however, a difference when using open sourced data from OpenStreetMap. Users can personally add or change the data of the map if they have an account. Immediately after OpenStreetMap is listed as a source, a small piece of text is dedicated explicitly telling map users that they can manipulate the data on this map. When they make edits or contributions to the map, they can tag the map, notifying the cartographer that the changes were made specifically for the Jim Thorpe Map. An example tag could be: *source:offhemapzedit.* This will make updates and revisions easier in the future and keep the map true to its VGI roots. This will allow the mapmaker to have a specific hashtag which can be searched for on OSM.

# Chapter 7

## Revising and Updating Data

This will not be the only version of the map published. In fact, this will only be considered the first edition. The types of features that are represented within this map are dynamic, and need to be updated periodically. Even if features do not change, their status or geometry may need to be revised.

The types of changes will most likely be made to roads and trails. Already, there is one major bridge under construction that will have implications on the map. Additionally, there is a major pedestrian bridge in planning that will connect the Lehigh Gorge Trail to the Lehigh Canal Trail. Although these features are not currently built, they will be essential to add in the future.

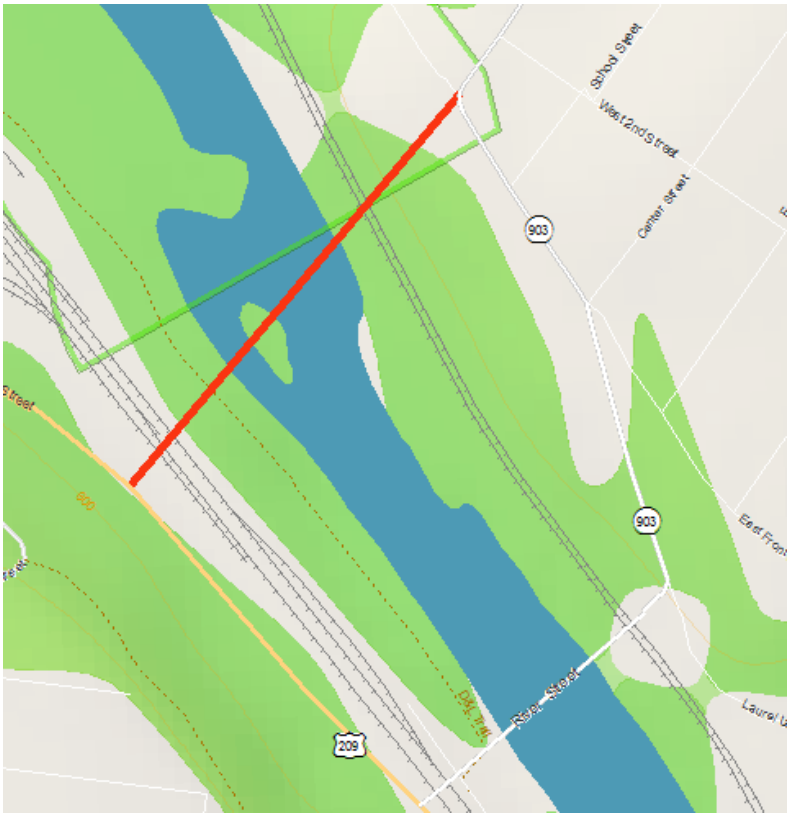



**Figure 26: Bridge under construction (shown in red) and current bridge (shown in white)**

There will also be revisions that must be made according to user feedback. It is possible that some recreation users may find certain trails difficult to navigate. Slight geometric adjustments can be made to make these features more legible. The Pennsylvania Fish and Game Commission may find that listing some trails located within State Game Lands is detrimental to the wildlife there. These trails may need to be removed or changed to "hiking only."

The goal is to avoid as many of these revisions as possible through ground-truthing and communication, but it is not possible to address all of them before printing the map. Much of the feedback will not be attainable until the map has been published, placed into circulation, and used. Also, certain revisions may only be needed if many users make the suggestion. For example, the suggestion of one tourist who found the walking map confusing may not warrant a redesign. But, if multiple tourists, some store owners, and local residents find the walking map confusing, this will likely warrant a redesign.

No matter the case, revisions will eventually be necessary and so it is important to prepare the data for a redesign and make updated version available. The simplest way to make these updates available is through a second edition of the map. Once a sufficient amount of suggestions and changes have been made, the redesign will have to take place. There are two main difficulties when using this method. The map will always be slightly inaccurate between printings and there is an unfair expectation of buyers having to purchase a second edition after they already have the first.

Both of these issues could be handled quite well through an accompanying web-map. If Mapbox supported exporting to Adobe Illustrator, this would not be an issue. The majority of data is already hosted on OSM, and so many of the updates could be made automatically by

users. This data could automatically be fed into a map hosted online. This updated web-map could also be offered through ArcMap using ArcGIS online, but this would likely not be cost-effective. Also, using ArcGIS online, the data would not be sourced from OSM, and would not carry as smooth of an updating process. For future work, a web map could be provided to users who have purchased the map.

For the case study, updates will simply be a list of revisions available between printings available online. These updates will be in text form with an accompanying screenshot and be available to anyone who visits the website. This page on the website could also function as a forum where users can comment on the current status of the map. This way, if a user has a suggestion for the map, they can browse forums to see whether or not that suggestion has already been made or will be available in the next printed edition.

# Chapter 8

## Conclusions and Future Work

The purpose of this study was to develop a folded paper map with a historic and recreational theme using the most up to date technology. An audience and the intended map use of that audience was acknowledged and described. A review of the advantages and disadvantages of the modern common map mediums was given, and paper was selected as the most functional for the type of map being produced.

A review of modern software available to create this type of map was given. It was found that there is a variety of both proprietary and free and open source software available. This study also used hardware that is available or already owned by many - the iPhone. The open source data focus of this study proves that high funds are not necessary for map creation of this type.

For future work on using software for purposes for which the software was not designed, it is recommended that the proposed method is tested with sample data. An example of all data types should be imported, manipulated, and exported to test the functionality of the software. If this was done first, the labeling problem when exporting from TileMill to SVG would have been found sooner, saving time.

This same type of testing, using all data types, should be performed on all software to be used before starting the cartographic process. There was, for example, also a slight problem with OSMIQ. OSMIQ does not support exporting polygonal shapefiles. Any polygons (areas) created in OpenStreetMap will import into OSMIQ correctly, but upon exporting them from OSMIQ there is an error. OSMIQ will export the polygonal shapefiles, but they will be in polyline, not polygon form. When in polyline form, ArcMap will treat these shapefiles as lines rather than polygons. This has adverse effects on design and functionality.

In order to export polygons (areas) from OpenStreetMap, two online tools had to be used. The first, *overpass turbo (http://overpass-turbo.eu/),* must be used to isolate and export the polygons. Features can be isolated through a tagging system that is similar to the way features are isolated in OSMIQ. Overpass turbo, however, does not support exporting features as shapefiles. This is only a small processing step and not a problem, because the features can be exported as GeoJSONS and then converted to shapefiles using another online tool.

The second online tool is Mapshaper *(http://www.mapshaper.org/).* Mapshaper is an online conversion tool that can be used to convert the GeoJSONS exported from overpass turbo into shapefiles that can be read by ArcMap. Once exported from Mapshaper, the original OpenStreetMap exported polygons can be correctly read by ArcMap. This process was needed for all polygons exported from OpenStreetMap. All lines and points from OpenStreetMap could be exported through OSMIQ (see *Data Collection, Processing, and Representation* for full list of data sources).

The justification for creating a map of this type in the area surrounding Jim Thorpe is given. The types of features to map and how to represent them is given. A review of current maps of the area is given as well as a review of benchmark maps of the selected theme. A brief description of how to extract the data from existing maps is also given.

The entire cartographic process is explained, with detailed descriptions ranging from data sources and defining the initial extent to data processing and land classification representation. This study provides a contribution to anyone attempting to create any map that is recreationally or historically themed.

Overall, the process took about 400 hours. This number includes research, data collection, data organization, data transformation, writing, field work, and map design.

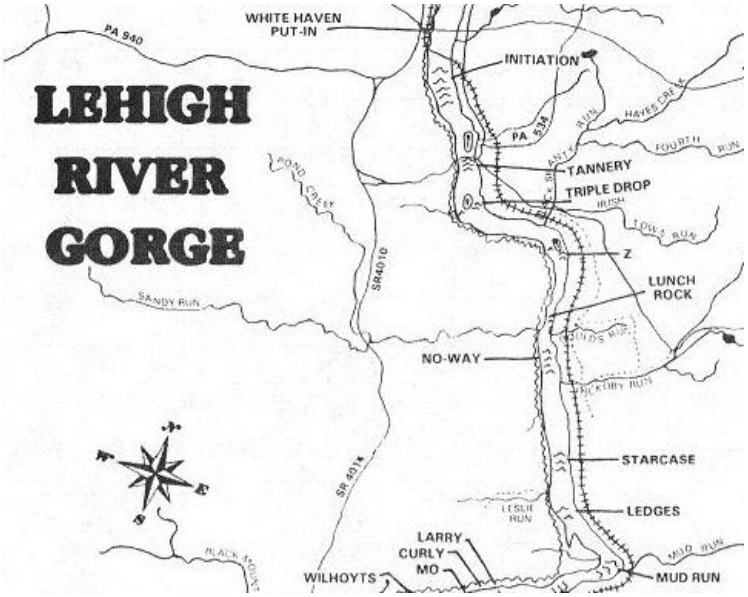
Obviously, a second map of the same style produced using the same method would take less time. Although, this could be said of many cartographic products. Once the process is figured out, the second, third, fourth, and so on become easier. This is a logical conclusion that results from the cartographer gaining more experience with each project. However, this workflow in particular is valuable and different in the way that it collects data. Using Strava data as the first pass to find the data saves an incredible amount of time. It is a new and interesting method for getting the "insider's perspective" or "local area knowledge."

The effort and research itself in this case have been very general. This only interprets a workflow and does not dive into the obscure details present in the world of cartography. There are entirely new projects ahead that can be studied and used for the benefit of this kind of map. Typeface, terrain symbolization, design elements of the brochure itself, etc. are just some of the many design points that could be investigated.

# Appendix A

## Current Maps of Area

### Lehigh River Gorge




**Map 1: Lehigh River Gorge**

- Who designed the map? What is the map theme? What is the extent that the map covers? Where can the map be found?
  - Unknown Cartographer
  - Recreation map
  - Extent covers the Lehigh River Gorge from White Haven to Jim Thorpe
  - *http://www.jtraft.com/river-description-and-map/*
- What is the intended audience and purpose of this map?
  - Recreationalists wanting to navigate the Lehigh River Gorge via the Lehigh River or the Lehigh Gorge Rail Trail. Recreationalists could be rafters, kayakers, canoers, bikers, or hikers.
- What are the types of data that can be extracted from this map (that cannot be more easily extracted from other sources), what is the data type, and under what label would it be in the Jim Thorpe Map?
  - Boating put-ins and take outs **point**
  - Rapids **point**
  - Access roads **line**
  - Hiking trails **line**

- Are there any additional notes that should be taken in regards to style, additional text, or graphics?
    - The map has a specific method for balancing three linear elements that are parallel and close to one another: The Lehigh River, the railway that parallels the river, and the trail that parallels the river. This could give insights on how to deal with this densely area.
- Has the map gone under the complete review and has all the data been extracted and added to the database?
    - The map review is: complete October 29, 2015
    - The data extraction is: complete December 5, 2015

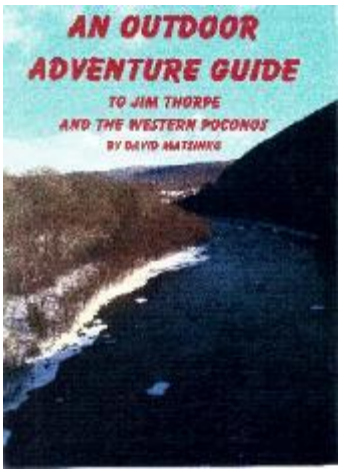
**Lehigh River Water Trail**


**Map 2: Lehigh River Water Trail**

- Who designed the map? What is the map theme? What is the extent that the map covers? Where can the map be found?
    - The Lehigh River Water Trail - The Wildlands Conservancy
    - Recreation, some historical text included
    - The Lehigh River from Whitehaven to Bowmanstown
    - *http://wildlandspa.org/lrwt/*
- What is the intended audience and purpose of this map?
    - To educate river users about river rapids, put-ins, take outs, canals, and river regulations

  - What are the types of data that can be extracted from this map (that cannot be more easily extracted from other sources), what is the data type, and under what label would it be in the Jim Thorpe Map?
  - Rapids Points
  - Boat Launches Points
- Are there any additional notes that should be taken in regards to style, additional text, or graphics?
  - This map contains rapid class information for nearly every rapid within the extent of the map. Labels for every rapid are not included, but these can be obtained from other maps.
- Has the map gone under the complete review and has all the data been extracted and added to the database?
  - The map review is: complete December 5, 2015
  - The data extraction is: complete December 5, 2015

**An Outdoor Adventure Guide to Jim Thorpe & the Western Poconos**

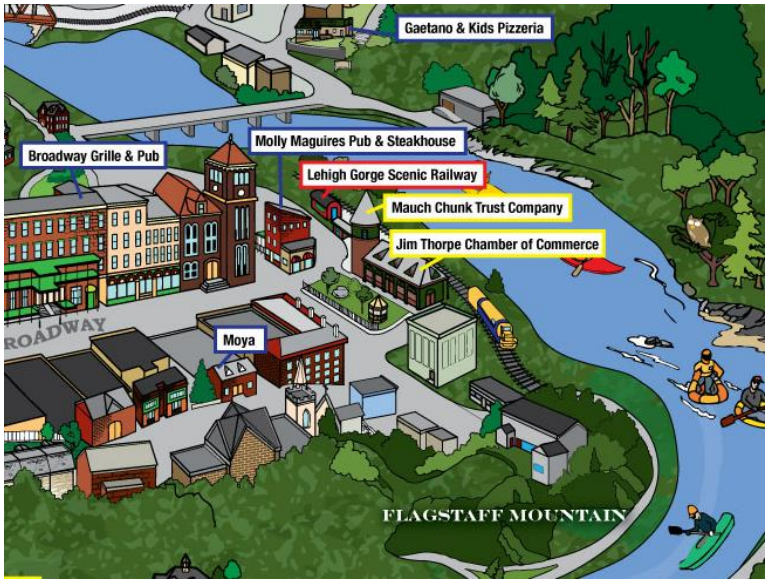



**Map 3: An Outdoor Adventure Guide to Jim Thorpe & The Western Poconos**

- Who designed the map? What is the map theme? What is the extent that the map covers? Where can the map be found?
  - An Outdoor Adventure Guide to Jim Thorpe and The Western Poconos - David Matsinko
  - Recreation, some historical text included
  - Western Poconos, Broad Mountain, and Jim Thorpe
  - *http://www.dmatsinko.com/adventureguide.html*
- What is the intended audience and purpose of this map?
  - Recreationalists looking to hike, bike, and cross country ski.

- What are the types of data that can be extracted from this map (that cannot be more easily extracted from other sources), what is the data type, and under what label would it be in the Jim Thorpe Map?
    - Points of interest Points
    - Trails Lines
- Are there any additional notes that should be taken in regards to style, additional text, or graphics?
    - Although this piece of work includes many maps, it is mainly a guide. As a guide, it includes much information that would normally supplement a map. Names of trails, names of trail loops, difficulty of trails, trail uses, trail types, and more qualitative information is provided with the actual trail geometry. This kind of information is helpful for representing and classifying trails. Also, this guide may provide additional text that can be integrated into the map.
- Has the map gone under the complete review and has all the data been extracted and added to the database?
    - The map review is: complete December 5, 2015
    - The data extraction is: in process October 29, 2015

**Carbon County Map**

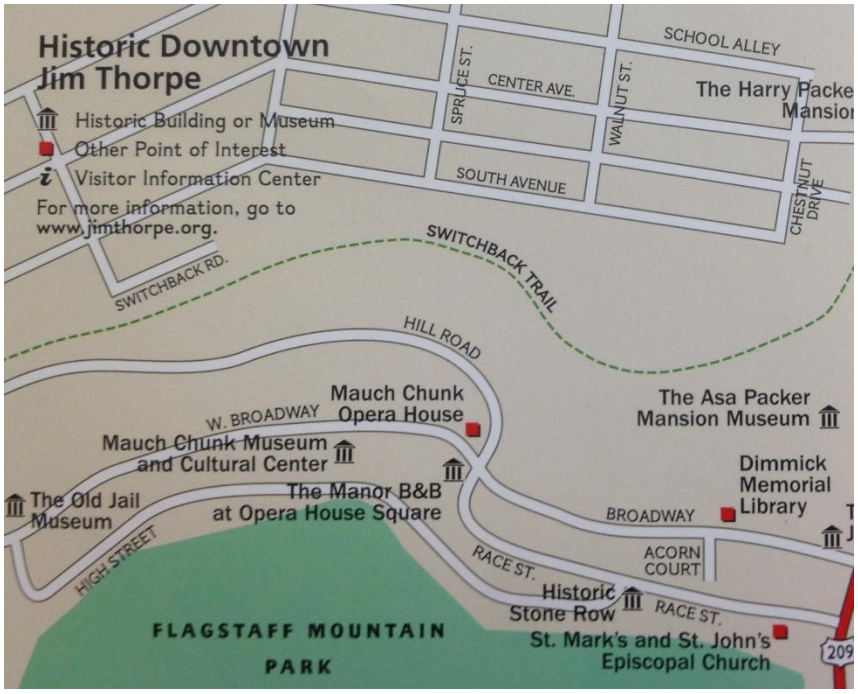



**Map 4: Carbon County Map**

- Who designed the map? What is the map theme? What is the extent that the map covers? Where can the map be found?
    - Carbon County Map - True North Advertising
    - History, Recreation, Advertising
    - The majority of Carbon County
    - *http://carboncountymap.com/map.html*

- What is the intended audience and purpose of this map?
    - Carbon County tourists in search of business that can outfit the adventures illustrated on the map. The map serves mainly to advertise selected businesses on the cartoonish map illustration.
- What are the types of data that can be extracted from this map (that cannot be more easily extracted from other sources), what is the data type, and under what label would it be in the Jim Thorpe Map?
    - Points of interest Points
- Are there any additional notes that should be taken in regards to style, additional text, or graphics?
    - Potential advertisers can be drawn from this map. If businesses are willing to advertise on a map of this nature, it is likely that they will be willing to advertise on the Jim Thorpe Map.
- Has the map gone under the complete review and has all the data been extracted and added to the database?
    - The map review is: complete December 5, 2015
    - The data extraction is: complete October 7, 2015

**Poconos Mountain Destination Map**

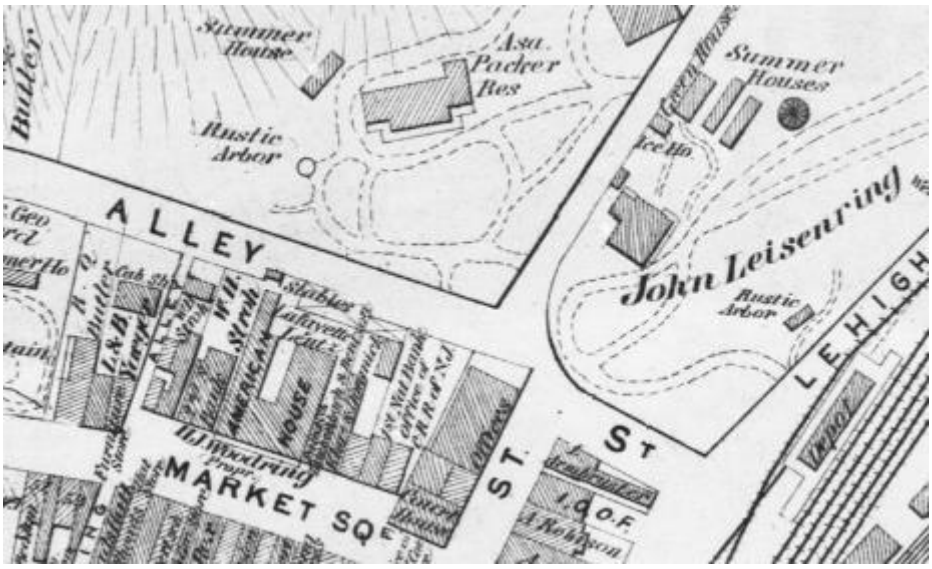



**Map 5: Pocono Mountain Destination Map**

- Who designed the map? What is the map theme? What is the extent that the map covers? Where can the map be found?
    - Poconos Mountain Destination Map - National Geographic

  - Recreation
  - The greater Poconos region, Lehigh Gorge Trail, Downtown Jim Thorpe
  - *http://shop.nationalgeographic.com/ngs/product/maps/travel-and-hiking-maps/destination-city-maps/pocono-mountains-destination-map*
- What is the intended audience and purpose of this map?
  - Tourists or locals wishing to recreate within the extent.
- What are the types of data that can be extracted from this map (that cannot be more easily extracted from other sources), what is the data type, and under what label would it be in the Jim Thorpe Map?
  - Points of Interest Points
- Are there any additional notes that should be taken in regards to style, additional text, or graphics?
  - This map is at such a small scale that it is not useful for much data extraction. It serves better as a confirmation of point features that were already to be featured.
- Has the map gone under the complete review and has all the data been extracted and added to the database?
  - The map review is: Complete December 5, 2015
  - The data extraction is: Complete December 5, 2015

**County Atlas of Carbon Pennsylvania, 1875**

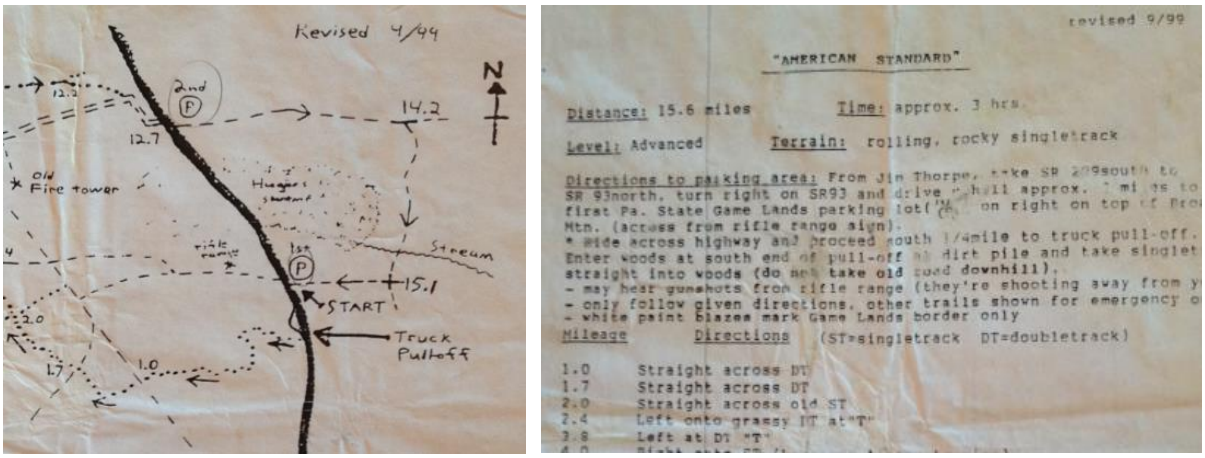



**Map 6: County Atlas of Carbon Pennsylvania, 1875**

- Who designed the map? What is the map theme? What is the extent that the map covers? Where can the map be found?
  - F.W. Beers, Jack Sterling, and Friends
  - Parcel Map, Survey, History
  - Carbon County

- http://freepages.genealogy.rootsweb.ancestry.com/~carbdat/beers/mc/idx.html
- What is the intended audience and purpose of this map?
  - This map was intended to represent ownership of property. Users could find parcels of land and contact those who own the land.
- What are the types of data that can be extracted from this map (that cannot be more easily extracted from other sources), what is the data type, and under what label would it be in the Jim Thorpe Map?
  - Points of Interest point
  - Historic Houses polygon
- Are there any additional notes that should be taken in regards to style, additional text, or graphics?
  - This map is excellent for finding historic features found throughout the area. the information within this atlas will be especially helpful in designing the Jim Thorpe Walking map.
- Has the map gone under the complete review and has all the data been extracted and added to the database?
  - The map review is: complete December 5, 2015
  - The data extraction is: in process October 29, 2015

**Various Hand Drawn Maps**

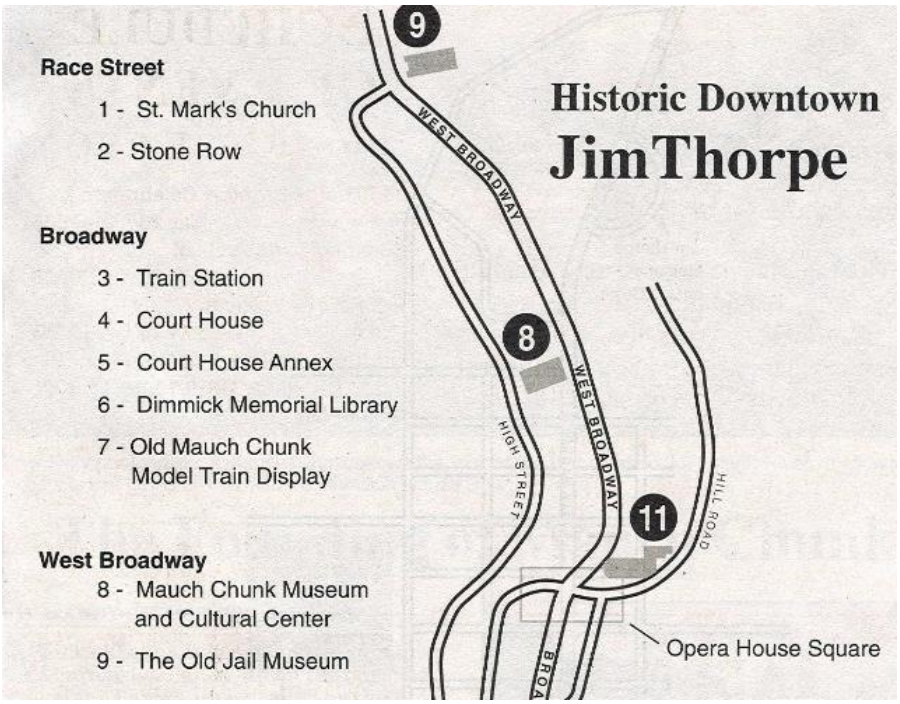



**Map 7: Various Hand Drawn Maps**

- Who designed the map? What is the map theme? What is the extent that the map covers? Where can the map be found?
  - Names listed as trail loop names
  - Recreation themed
  - Jim Thorpe, Broad Mountain, Southern Poconos
  - Local Bicycle Shops
- What is the intended audience and purpose of this map?
  - Hikers and Mountain bikers to navigate trails

- What are the types of data that can be extracted from this map (that cannot be more easily extracted from other sources), what is the data type, and under what label would it be in the Jim Thorpe Map?
    - Points of interest Points
    - Trails Lines
- Are there any additional notes that should be taken in regards to style, additional text, or graphics?
    - These maps function as trail guides as much as they function as maps. They provide subtle information that may not be available from simply viewing the geometry of trails.
- Has the map gone under the complete review and has all the data been extracted and added to the database?
    - The map review is: complete December 5, 2015
    - The data extraction is: complete December 5, 2015

**Historic Downtown Jim Thorpe Map**

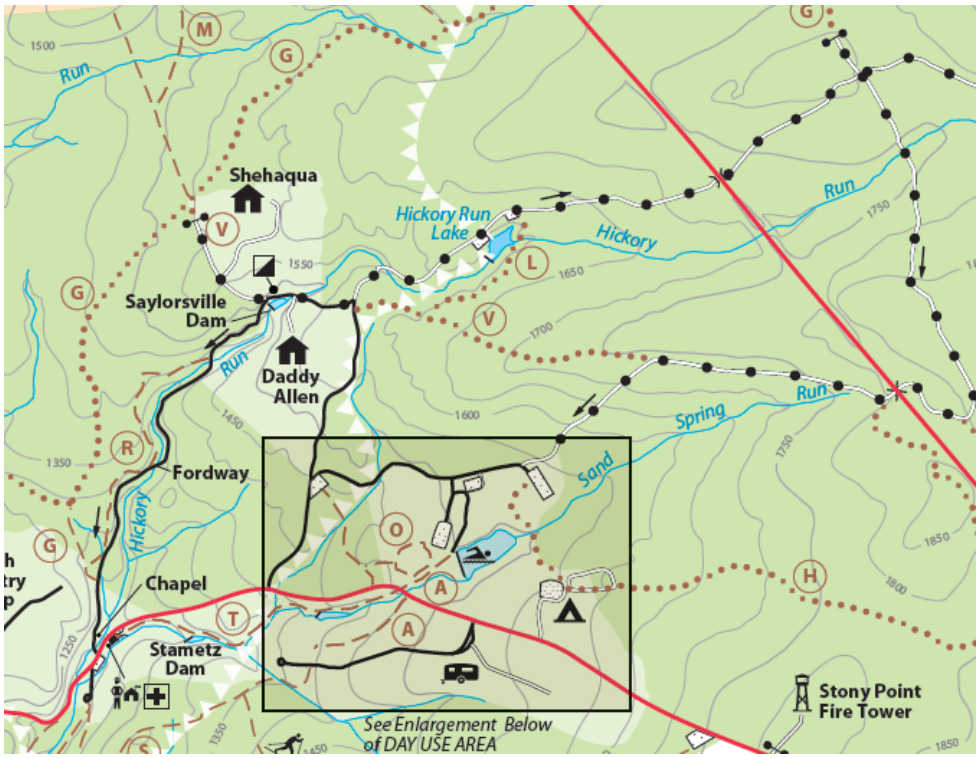



**Map 8: Historic Downtown Jim Thorpe**

- Who designed the map? What is the map theme? What is the extent that the map covers? Where can the map be found?
    - Historic Downtown Jim Thorpe Map
    - Unknown Cartographer

  - Downtown and historic Jim Thorpe
  - The Jim Thorpe Visitor Center
- What is the intended audience and purpose of this map?
  - Tourists visiting the downtown area to visit historic points of interest.
- What are the types of data that can be extracted from this map (that cannot be more easily extracted from other sources), what is the data type, and under what label would it be in the Jim Thorpe Map?
  - Points of Interest point
  - Historic Houses polygon
- Are there any additional notes that should be taken in regards to style, additional text, or graphics?
  - They way that the points of interest are represented using numbers can be very useful because the downtown area is very dense with interesting features. Also, these features are then subcategorized by their location (West Broadway, Packer Hill, Race Street, etc.) The polygonal house features will be added and attributed to OpenStreetMap and later extracted with OSMIQ.
- Has the map gone under the complete review and has all the data been extracted and added to the database?
  - The map review is: complete December 5, 2015
  - The data extraction is: complete December 7, 2015

**Various Pennsylvania DCNR Maps**




**Map 9: Various Pennsylvania DCNR Maps**

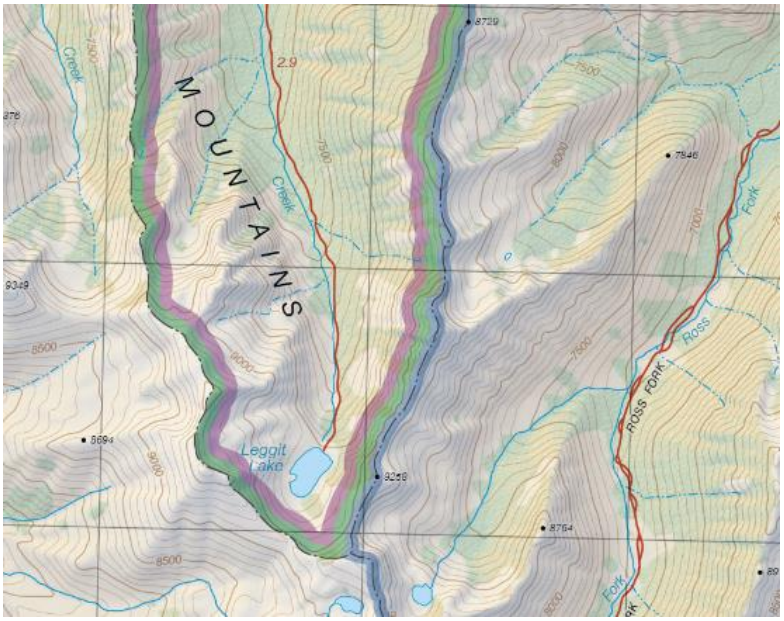
- Who designed the map? What is the map theme? What is the extent that the map covers? Where can the map be found?
  - Hickory Run State Park, Lehigh Gorge State Park, Beltzville Lake State Park
  - Recreation
  - The parks mentioned above with some information on nearby state game lands
  - Ranger stations for the various parks
- What is the intended audience and purpose of this map?
  - Visitors to these state parks who will use them to navigate while hiking, biking, camping, cross country skiing, etc...
- What are the types of data that can be extracted from this map (that cannot be more easily extracted from other sources), what is the data type, and under what label would it be in the Jim Thorpe Map?
  - Trails point
  - Gates point
  - Service Roads line
  - Points of Interest point
- Are there any additional notes that should be taken in regards to style, additional text, or graphics?

    - These maps are of the most similar style top the map being produced. Attention should be paid to all elements of style like contours spacing, labeling, coloring, boundary representation, point of interest representation, etc...
- Has the map gone under the complete review and has all the data been extracted and added to the database?
    - The map review is: in process December 5, 2015
    - The data extraction is: in process October 29, 2015

# Appendix B

## Thematic Benchmark Standards

### Sawtooth Wilderness




**Map 10: Sawtooth Wilderness**

- What is the map name, map theme, scale, and source of the map?
  - Sawtooth Wilderness - Aaron Taveras
  - Recreation Map
  - 1:50000
  - http://nacis.org/awards/2013-winner-sawtooth-wilderness/
- What is the intended audience and purpose of this map?
  - Outdoor recreationalists looking to explore the Sawtooth wilderness in Idaho. Map could be used for hiking, camping, boating, and fishing.
- What type of data is represented well on this map?
  - Small lakes, forests in orthoimagery, land use boundaries, elevation
- Are there any additional notes that should be taken in regards to style, additional text, or graphics?
  - The map does a particularly good job at balancing elevation representation through contour lines/hill shading and land cover simultaneously. Color and line-type choices for adjacent polygons is excellent. This map was the winner of the 2013 NACIS Student Map Competition.

**Parque Nacional Patagonia**


**Map 11: Parque Nacional Patagonia**

- What is the map name, map theme, scale, and source of the map?
  - Ross Donihue and Marty Schnure (Maps for Good)
  - Recreation, Conservation
  - ?
  - http://mapsforgood.org/presentation/MapsforGood_NACIS_2015.pdf
- What is the intended audience and purpose of this map?
  - Tourists looking to visit the reservation
- What type of data is represented well on this map?
  - The marginalia is particularly well balanced in this specific map. There are many different maps contained within the layout of this map.
- Are there any additional notes that should be taken in regards to style, additional text, or graphics?
  - This map includes a timeline and walking map. These could serve to influence the balance between the Jim Thorpe Timeline and walking map

**Bike There! (Portland and Vancouver)**


**Map 12: Bike There! (Portland and Vancouver)**

- What is the map name, map theme, scale, and source of the map?
  - Bike There!: Your map for cycling in and around Portland and Vancouver (Oregon Metro)
  - Recreation, Navigation, Reference
  - Not listed
  - http://www.cartographicperspectives.org/index.php/journal/article/view/cp74-sterling-grube/1241.
- What is the intended audience and purpose of this map?
  - Residents and tourists of the city of Portland and Vancouver. The map is focused on cycling infrastructure in and around the cities.
- What type of data is represented well on this map?
  - Different cycling trail and lane types are balanced well. Also, the map represents many shades of green that will be similar to the Jim Thorpe Map. The representation of hillshade is done both effectively and subtly.
- Are there any additional notes that should be taken in regards to style, additional text, or graphics?
  - N/A

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# Patrick Stephens

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## Education

**Schreyers Honors College**
The Pennsylvania State University**,** University Park, Pennsylvania
Bachelor of Science in Geography (Geographic Information Science)
Intended Graduation: August, 2016

## Experience

**The Hamer Center** *GIS Research Assistant*
August 2015 – December 2015 (15 hours per week)
University Park, PA 16802

- Land cover modeling in Mexico, LIDAR processing and analyzing for archeologic relics and land cover change

**TerraSim, Inc.** *GIS Analyst Intern*
May 2015 – August 2015 (40 hours per week)
Pittsburgh, PA 15222

- Three-Dimensional terrain simulation, airfield modeling research, software testing

**The Pennsylvania State University** *Geography & Literacy Tutor*
January 2015 – May 2015 (20 hours per week)
University Park, PA 16802

- Tutoring student-athletes in geography, tutoring adults in literacy for professional development

## International

**Quito, Ecuador** *Study Abroad at Universidad San Francisco de Quito*
January 2016 – May 2016 (4 months)

- Written Spanish (fluent), Spoken Spanish (proficient)
- Community mapping for *Engineers Without Borders*

**Iznájar, Spain** *Workaway Program*
August 2010 – November 2010 (3 months)

- Construction for local contractor

## Technical

Proficient in using *TerraTools, Virtual Battle Space, L3DT, ArcGIS Desktop, Adobe Illustrator, Microsoft Office*

- Three-Dimensional terrain simulation, cartographic design, geospatial analysis, geospatial compilation, geovisualization, remote sensing

Experience in using *RStudio, MapBox, LIDAR Analyst, HTML, Javascript, CSS*

- Spatial analysis, remote sensing, LIDAR Processing
- Web-map and webpage design

## Other

Member Phi Beta Kappa, North American Cartographic Information Society, Pennsylvania Geographical Society, Sociedad Honoraria Hispánica, contributor FixWikiMaps, active in competitive cycling

*-- For a complete portfolio, please visit www.offthemapz.com --*