

ANGELES HIKE FINDER:
CREATING A SPATIAL DATABASE AND WEB APPLICATION TO DISCOVER HIKES BASED
ON ATTRIBUTES AND DIFFICULTY

by

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To a new chapter

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List of Abbreviations

AHF	Angeles Hike Finder
ANF	Angeles National Forest
CWA	Cucamonga Wilderness Area
GIS	Geographic information system
SBNF	San Bernardino National Forest
SSI	Spatial Sciences Institute
UI	User Interface
USC	University of Southern California
USDA	United States Department of Agriculture
UX	User Experience
VGI	Volunteered Geographic Information
WYSIWYG	What you see is what you get

Abstract

The Angeles National Forest (ANF) contains miles of backcountry hiking trails easily accessible to residents of Los Angeles. Those who are planning to go on a hike have several options to aid in their planning process from guidebooks, to online resources, to mobile applications. These resources often include trail descriptions, directions to the trailhead, and statistics regarding each hike, which sometimes includes a vaguely defined difficulty rating. However, not every hiker experiences trail difficulty the same way. New hikers are unlikely to agree with experienced hikers as to the difficulty rating for the same hike. Similarly, different hikers may disagree on what exactly makes one trail harder than another.

To address this, this project developed the Angeles Hike Finder (AHF). The AHF allows users to identify which factors they consider to be most difficult, and receive a customized output of trails in the ANF that meet the search criteria. This application was developed from a manually generated trail database of hiking trails in the ANF, containing trail data regarding trail distance, elevation gain, maximum elevation, and trail type. Once the database was developed, the AHF was created using Esri Web AppBuilder. The AHF allows users to determine what range of attributes or difficulty ratings they are interested in before the application generates the customized trail listing. The goal of this application development project was to address the lack of defined difficulty ratings for trail planning present in other hiking applications. Through the creation of the AHF, hikers in the ANF can see what is perceived as most difficult for their unique needs. The AHF can serve as a template for how other hiking applications address the concept of the difficulty for hiking trails.

Chapter 1 Introduction

The Angeles National Forest (ANF) lies primarily within Los Angeles County and contains miles of trails accessible to anyone with a vehicle. Even in hot weather, higher elevations offer conditions that are cool based on summer months in Southern California. In winter, these same high elevation trails can be covered in snow, offering opportunities for activities like snowshoeing and mountaineering.

Information regarding these trails is available in print and online sources, but before the completion of this project, there was a lack of a unified database of backcountry trails that could be easily input into a geographic information system (GIS). These sources also lack the ability for users to decide what characteristics of the trail they find to be difficult. Instead, they usually rely on a relative rating stemming from the author's opinion or a crowd rating. The goal of this project was to create a database of backcountry hiking trails in the ANF, as well as a web mapping application that allows users to find hikes within the ANF and rank these hikes based on their own definition of difficulty.

1.1. Study Area

Despite the reputation of Los Angeles as a flat city covered in asphalt, the ANF is a drastic topographical change from the city, with a maximum elevation of 10,000 feet, and a diverse array of plant life (United States Department of Agriculture 2020). The vegetation varies from chaparral environments to pine and fir forests at higher elevations (USDA 2020). At higher elevations, snow is common in winter months, leading to the existence of ski lifts near Mount Baldy and Mount Waterman. Trails are accessible from several road access points, including the Angeles Crest Highway and Highway 39. The ANF contains 557 miles of trails (USDA 2020). This includes 73 miles of National Recreation Trails and 176 miles of the Pacific Crest Trail.

The ANF consists of two main areas, one just north of the LA basin, encompassing the San Gabriel Range, and another section just north of Santa Clarita (Figure 1). The project focused on trails in the section just north of the LA Basin due to its closer proximity to the large population of Los Angeles.



Figure 1. Study area, including CWA, in context to the Los Angeles region

The easternmost portion of the ANF is comprised of the Cucamonga Wilderness Area (CWA), which is jointly managed by the ANF and the San Bernardino National Forest (SBNF). Roughly 1/3rd of the CWA lies within the ANF, with the other portion in the SBNF (USDA

2020). A small number of the trails employed in this study cross the boundary of the ANF into the SBNF. These trails are included for a couple of reasons. All of the trails are at least partially within the ANF, and the ones that do cross over are still within the CWA.

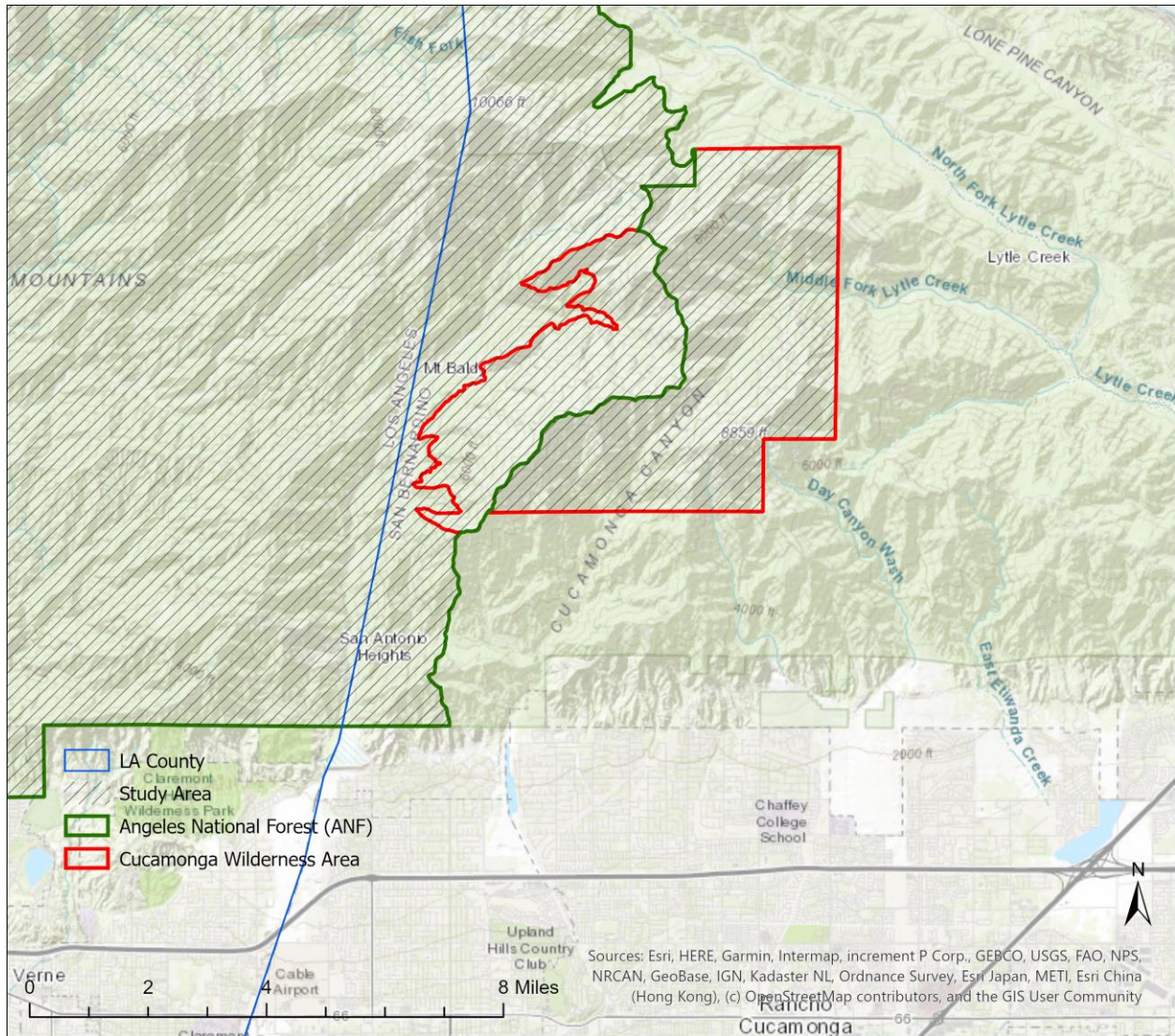


Figure 2. Location of the CWA in relation to the rest of the ANF

1.2. Hazards in the Angeles National Forest

Hiking in the ANF carries inherent risk, due to trail conditions, vegetation, and weather. The presence of Poodle Dog Bush, a plant causing painful skin irritation is frequently found in areas of forest that have been burned recently. Hikers who are experienced on trails in summer

conditions may suffer harm during winter recreation on the same trails, as was the case when a hiker went missing and a search and rescue worker was killed in the resulting search (Andone 2019). From May 2019 to April 10, 2020, incident reports from the ANF WildCad page show 66 search and rescue operations. WildCad is a service that allows wildfire and other emergency communication centers to track incidents in their jurisdiction and dispatch aid as needed.

Inexperienced hikers may find themselves overly ambitious despite their skill level, such as the Eaton Canyon hike. A quick search for “Rescues in Eaton Canyon” returns results from early 2020 and date back over 10 years, despite an official closure of a deeper and more difficult section of the trail back in 2014 (Trinh 2014). Improved preparation on the part of hikers can mitigate the chance of emergencies, injuries, death, and search and rescue operations.

1.3. Existing Trail Data

While information on hiking trails is widely available, existing GIS databases of trail data focus on trails within city boundaries. Smaller nature paths and green spaces make up the majority of the data, and are available from the Los Angeles County GIS Data Portal (Figure 3). Larger trail datasets available from the United States Forest Service focus on National Scenic Trails. Currently, there is no database consisting of backcountry trails in the ANF that can be downloaded into ArcGIS. This limitation prevents other GIS analysis of trails within the ANF, and makes the development of hiking applications focusing on the region more difficult. With this project’s focus on hiking trails in backcountry regions, a lack of a GIS ready dataset serves as a major obstacle to application development. Since the backcountry trail data that is available from applications like Modern Hiker and AllTrails allows users to download a line feature of individual trails, and does not include additional information, the metadata must be added in separately to a trail database. The first stage of this project focused on creating such a database,

containing the necessary information regarding trails that serves as the foundation for the web application.



Figure 3. Department of Parks and Recreation Trail Data. Only one trail falls completely within the boundaries of the study area.

1.4. Project Goal

Applications like AllTrails and Modern Hiker exist that already focus on mobile use and will provide in depth information on a trail once it is selected. This project instead focused on the initial planning for a hike and developed the AHF, an application. During the planning stage, users are looking to see what hikes are available to them, and can search for them based on two

approaches, searching by trail attributes, and searching by trail difficulty ratings for the associated attributes. Users can see this information within the attribute table of the trails layer, allowing them to explore the data before choosing their inputs. Therefore, the goals of this project were as follows:

1. Create a database of hiking trails that can be easily incorporated into a GIS
2. Create a web application that includes a database of hiking trails that users can explore
3. Allow users to search for trails based on both their attributes and associated difficulty rankings based on their desired criteria

Once they can see what hikes are available, other resources can provide more detailed information for the next phase of planning. From a user perspective, the goals of the web application were as follows:

1. Navigate around trails in the ANF
2. Interact with the map through movement and being able to turn layers on and off
3. Find their location with location services enabled on their device
4. Search for trails either by their attributes or difficulty ratings
5. View more detailed information about individual trails
6. Export the trails resulting from their search results as a table

With these user requirements in mind, the AHF was developed to accomplish them.

The application was developed with Esri Web AppBuilder Developer Edition. In order to facilitate a positive user experience, the application emphasizes a simple user interface, taking cues from other web applications, such as Google Maps, to allow users to use the application with minimal teaching. Finally, users can export the list of trails they generate based on their search parameters input into the application for later use.

At the start of this project, the initial goal was similar but slightly different. Instead of searching for trails based on their attributes or difficulty ratings, users were going to be able to rank trails by whichever difficulty factor they found to be most difficult. This would have allowed for users to define difficulty for themselves, instead of using predetermined difficulty ratings. Accomplishing this unfortunately became impossible within the project's timeframe, due to numerous technical difficulties and troubleshooting steps. This initial goal informed some of the decisions made to create the application, and while the goal had to shift, these choices still allowed for the goals listed above to be accomplished. A deeper exploration and discussion of this initial goal, and the choices made to accomplish them can be found in Chapters 3 and 5.

1.5. Thesis Layout

The remainder of the thesis will examine the academic literature relating to the AHF, the methods used to complete the development of the database and application, the results of the project, and finally the conclusions drawn from the completion of the project. Each subsection of the Related Work chapter addresses individual components of the project. This includes the database development, difficulty factor for ranking the hikes, application development, and similar applications already being used by hikers in the Los Angeles region.

Chapter 2 Related Work

This chapter explores the different components of the AHF, from developing the trail database to developing the web application to rank the hikes. These sections will also examine sources exploring factors relating to trail difficulty, as well as existing applications and how they differ from the proposed project.

2.1. Database Construction

While existing web applications have their own databases, they are not available for download other than as individual components. Doing so only yields trail geometry without its associated information. AHF therefore has two components in the database, a geometry component, and an attribute component. Ensuring the proper information was included in both components, as well as guaranteeing the two can be implemented together seamlessly was of utmost importance before creating the application. The following section explores how different studies developed databases from multiple information sources to support a geodatabase for spatial analysis. These resources informed an effective workflow in developing the AHF.

A study focusing on the creation of a database to help determine the locations of new public facilities in Minna, Nigeria, involved creating a database of existing public facilities, and defining how to select the locations for recommended new facilities (Umar et al. 2015). Since the study involved creating a database that linked both spatial and non-spatial data, it served as an excellent framework for creating a similar database for this project. The authors integrated data from both spatial and non-spatial sources together, which helped with the conceptualization of the database used in the AHF.

Establishing guidelines for the database design was an important step before the actual database was constructed. Using pre-established professional guidelines from other organizations

can serve as a baseline for the design (Newman 2019). Newman focused on creating a geologic database to assess the risk of landslides in Washington State based on standards and guidelines established by the United States Geological Survey and the National Geologic Map Database. This database consisted of several different geologic features, including geologic units, faults and folds, and map points. Each dataset was added after the creation of geologic maps and provided additional attribute information to corresponding points on the map. Eventually, the database served to develop geologic maps to provide information regarding risk. While creating the geodatabase, organizing individual components with proper associated information allows for an easier separation of features that may otherwise be hard to distinguish. Ensuring the use of proper symbology leads to a better end result that more clearly communicates the desired information. Since Newman's project focused on the spatial component of the data, but still needed the underlying attribute information, a geodatabase served as the answer. This solution was applied to developing the AHF, where visible trail data needs its attribute data to function properly.

Since the raw information for creating a database may need to be taken from multiple sources, data needs to be properly integrated together into a unified dataset within a geodatabase. Data integration is the process where the different sources are combined in a way to allow for comparative analysis. In a paper meant to provide a general overview of data integration, the authors discuss the challenges faced when attempting to use multiple sources of data that do not match up (Haas, Lin, and Roth 2002). The authors discuss the concept of database federation, which serves as a middle step to access the multiple sources of data. In database federation, a relational database management system is used to link multiple sources of data together through relationships. As a result, a user will experience the data as a single entity. This article was useful

in conceptualizing the approach of integrating multiple data sources together. The Angeles Hiker Finder integrated several data sources together, and allow the application to reference the data as a single unit.

The nature of the project was such that the database needed to be constructed to serve as the base information for the web application. Babcock developed a similar project where the author constructed a web application based upon volunteered geographic information (VGI) that was input into a database (Babcock 2019). This project focused on creating a database for biochar, a substance with ties to climate change and environmental management. The application in turn allowed for visualization of the database, as well as the ability to interact with the spatial data to serve a user's own research interests. Babcock developed a database which in turn supported the project goal of creating a web application for the data. Finally, Babcock distributed a survey among the targeted user base to evaluate the success of the web application. This project has a similar structure to the AHF. Consequently, it serves as an excellent framework from which to build off of.

The creation of a database reveals what components are necessary for simplified database management. In order to query the data, different datasets need to be in similar vector formats or combined into a single raster dataset to prevent difficulties in queries (Vaitas et al. 2019). This study created a database of climate information, mapping out how the different components related to each other with UML mapping and Entity-Relationship diagrams. Due to the large amount of data implemented, a separate application was created in order to input the data into the database. Although this project does not deal with as large of a dataset, the study highlights the importance of a well-designed database to ensure a subsequent application will run smoothly.

2.2. Trail Attributes

Since the project goal was to allow users to define their own difficulty on trails using the AHF, this section will explore trail attributes commonly associated with difficulty. While different hikers may experience these factors in unique ways, examining the literature can narrow down which attributes are most important. Additionally, if classes need to be created for the factors, divisions amongst each class can be better determined from the information in the following section.

For many hikers, altitude has a major impact on trail difficulty. Most hikers who begin to feel the effects of acute mountain sickness do so at above 2,500 meters, or 8,200 feet, and the effects increase in probability and intensity beyond that elevation (Paul et al. 2018). This study focuses on illness that results from being at high elevations without proper time to acclimate to the lack of oxygen. The paper aims to educate people on how to adjust to higher elevations, and provides an overview of the effects that elevation can have on the human body when it is not used to it. While this research has a medical approach, it contextualizes the effect of high elevation on those unprepared for elevation, and explains the risks and side effects associated with these conditions. Symptoms are even more powerful above 3,480 meters, or 11,400 feet (Burtscher et al. 2019). The authors also evaluate how elevation is linked to potential adverse health effects. Additionally, the study looks at more extreme health conditions, and how there is a potential for predicting risk based on initial exposure to high altitudes. The paper breaks down health effects at different elevations, and provides some guidelines for potential categories of elevation difficulties for the proposed application.

Slope, or steepness, also makes a hike more or less difficult. Hikers consume 2.5 times as much oxygen at a 15% gradient (Burtscher 2004), and gait is heavily affected even at a 9%

slope, regardless of uphill or downhill direction (Sun et al. 1996). Sun et al. sought to better understand how human effort and gait are influenced by differing slopes in an urban environment. The study examined thousands of participants over a three-month period to fully study walking speed, cadence, and step length variation over the different slopes. The authors found that on descents, step length decreased to make steps easier, meaning down slope can still be difficult like going up slope. Burtscher sought to understand the demands hiking places on the bodies of older hikers by evaluating different factors that influence difficulty, and provides recommendations regarding how to address them. Burtscher (2004) evaluated how slope and elevation change affects aerobic activity, and shows how high elevations and steep trails increase the amount of effort in hiking. Based on this information, elevation change, overall elevation, and length can all be considered as attributes within the trail database.

2.3. Existing Applications

There are currently several hiking applications that provide information on trails in the ANF. This section will explore some of these existing applications, highlighting the niche they serve in informing hikers about hikes, and what they lack that sets this application apart from them. These existing applications exist as both web resources and mobile resources, and some as both. Some exist as resources for planning a hike, and others can be used on a mobile device on the hike itself.

The website Modern Hiker provides reports on specific hiking trails. Each trail has its own page that describes the trail, including overall statistics like total distance, elevation gain, an estimated time to complete, and difficulty rating (Figure 4). The difficulty rating contains six classes: beginner, easy, moderate, challenging, strenuous, and expert. The main report describes the trail, and includes pictures that provide an overview as to what can be expected on a trail.

The reports do a good job pointing out interesting information, and covering any possible confusing trail junctions. Each page also has a download for a kml or gpx file, an elevation profile, links to driving directions for the trailhead through Google Maps, and a map through Natural Atlas to show where the trail is located.

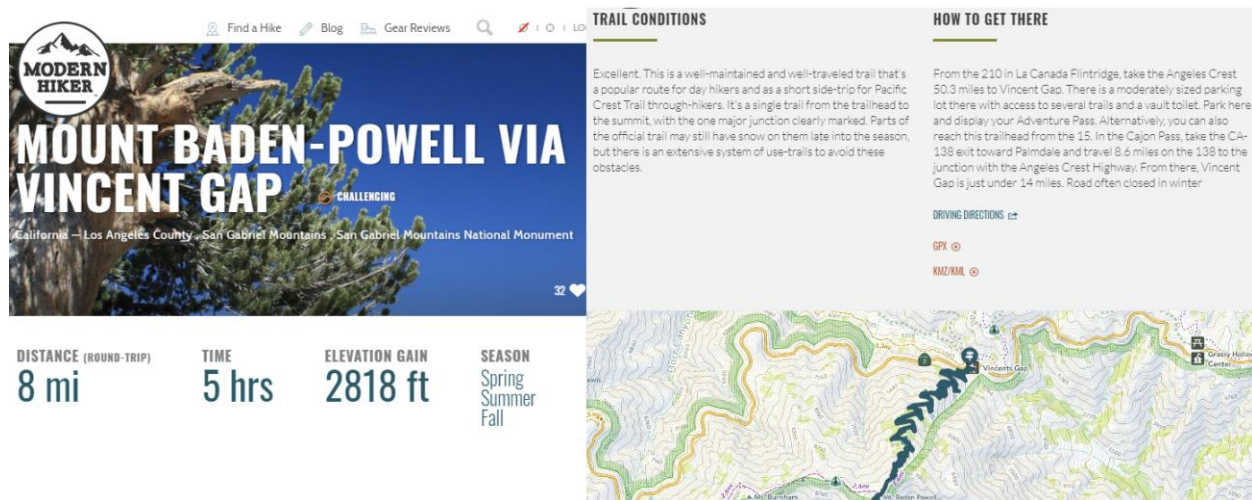


Figure 4. Sample from Modern Hiker of a hike. The hike name and basic information (left), and directions and downloadable data (right).

To find hikes, users can search in a search bar for hikes they know of, or they can use a feature called Find a Hike. On this page, a map is visible with flags for each hike. Using filters, users can select what state, region, distance category, time category, season, difficulty category, and elevation gain category they desire. After filters are applied, the page refreshes, showing the hikes that fall under the criteria selected, and a list with the basic information for each hike (Figure 5). While this feature can help narrow down what hikes users see based on the provided criteria, it does not allow users to choose which difficulty factor they find most challenging, and what determines the difficulty rating is not clearly defined. Additionally, the categories are in classes that do not have justifications. With elevation gain, the categories do not have a uniform range between categories, and all hikes with gain above 3,000 feet are grouped into a singular category. Very different hikes into a single category, where a hike with 3,000 feet of gain would

show up with ones having 8,000 feet of gain. Without allowing users to choose what they find most difficult, a user may find themselves with a list of hikes that does not accurately reflect what they want.

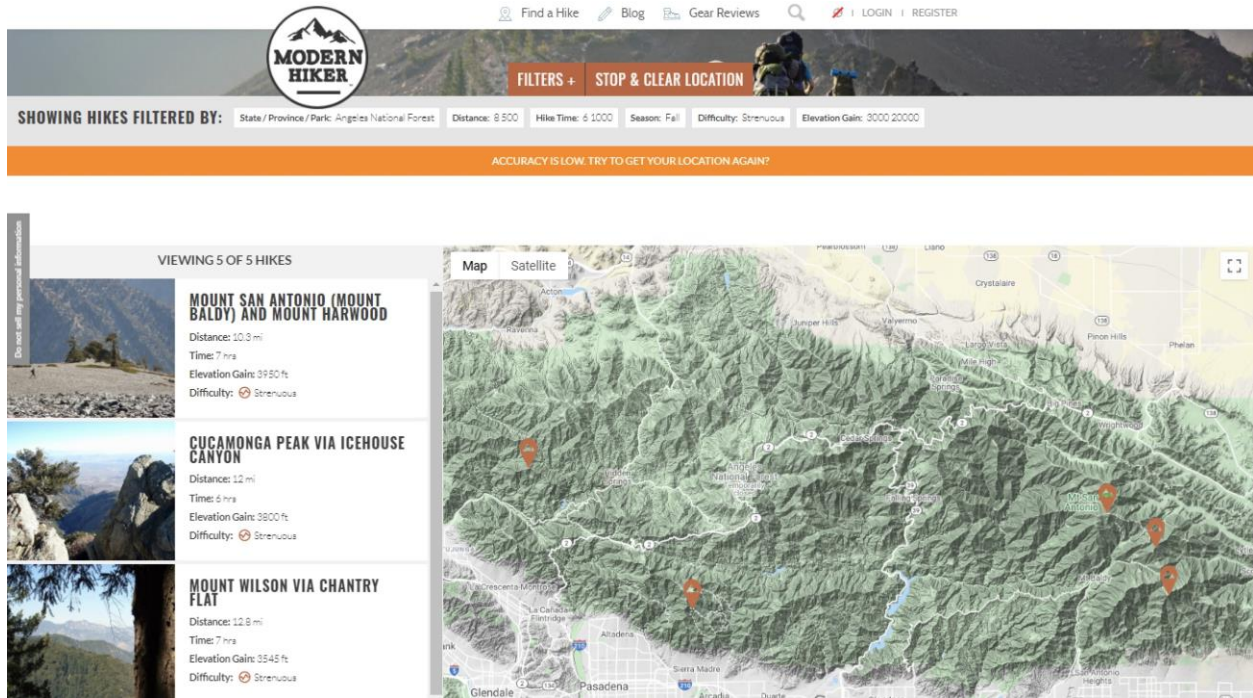


Figure 5. Modern Hiker Find a Hike page with filters applied for area, distance, hike time, season, difficulty, and elevation gain.

AllTrails is available both as a web and mobile application. Like Modern Hiker, each trail has a write up with information regarding the hike, as well as providing basic statistics. This information includes distance, elevation gain, and route type, which can be loop, or out and back (Figure 6). The difficulty rating stems from VGI, allowing users to rate the trail and leave comments regarding their experience on the trail. To find a trail, users can either search manually, or view a map which has flags for each hike similar to Modern Hiker. The mobile application functions in a similar way, with the same features, but with a different interface.

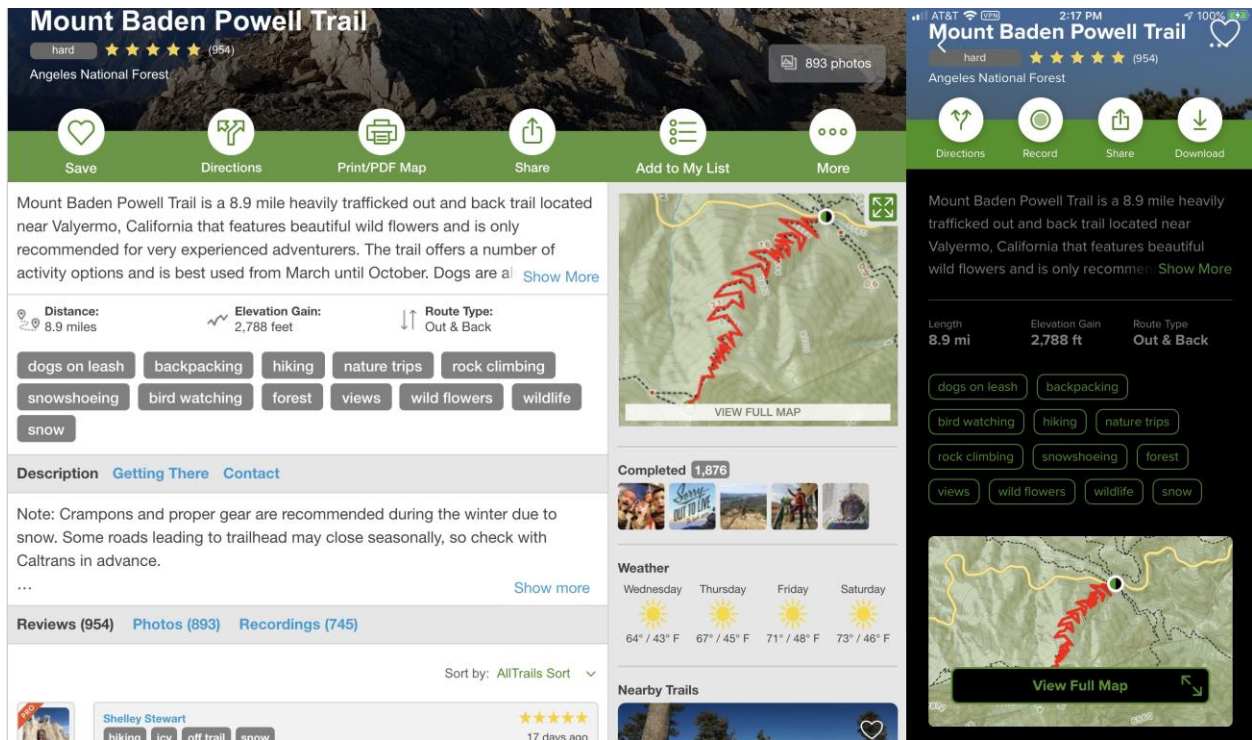


Figure 6. AllTrails page on Mount Baden Powell on the desktop site (left) and on iOS (right)

To sort the hikes on the AllTrails explore page, users can use a slide bar to define their own category, allowing them to choose their desired length, or distance range. The other factors, like rating and difficulty allow selection of each difficulty, rating, and route type (Figure 7). However, AllTrails uses only three difficulty ratings—easy, moderate, and hard. Unlike Modern Hiker, AllTrails does allow users to select multiple difficulty ratings at the same time. Trails can also be tagged with features, like dog friendly, which can be incorporated into the search filters. Like Modern Hiker, AllTrails does not define how their difficulty ratings are determined. It does allow users to choose the distance and elevation gain interval they are interested in, but does not allow users to determine which factor is considered most difficult.

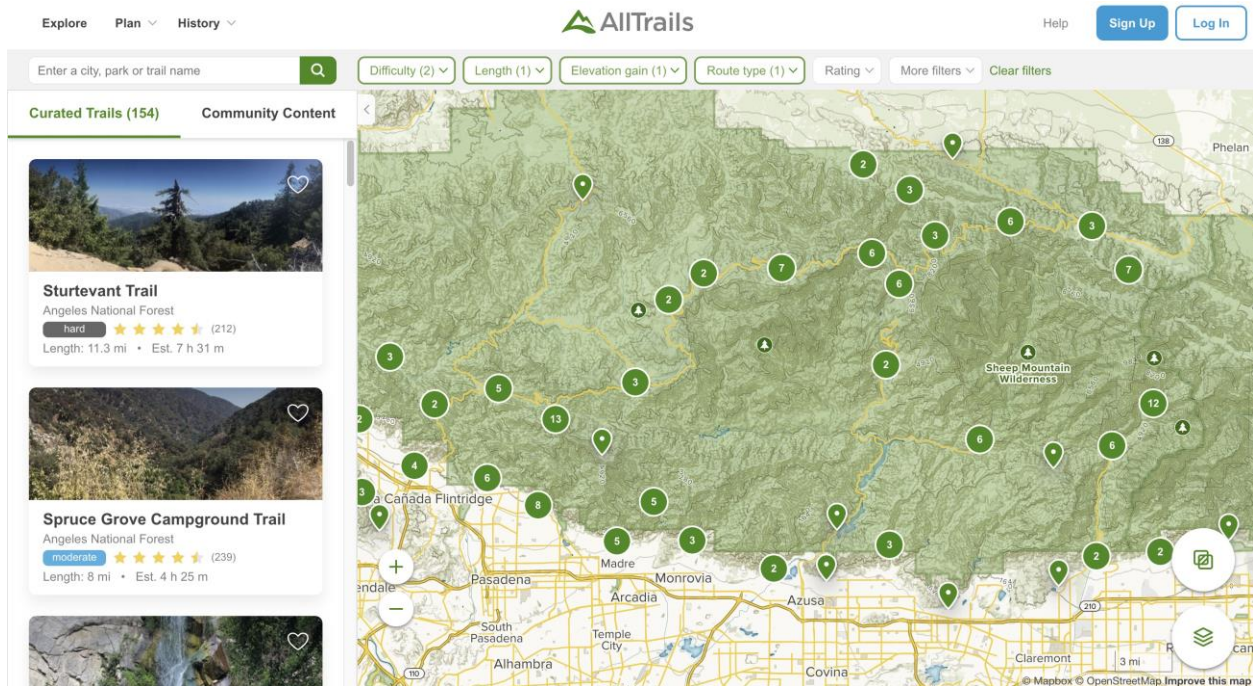


Figure 7. AllTrails Explore page to find a hike. Several filters have been applied to narrow down the selection

2.4. User Interface and User Experience

User Interface (UI) and User Experience (UX) refer to how a user interacts with technology, and how they feel about that interaction, respectively. The UI focuses on what a user interacts with, in this case the web application, while UX is how the user feels about the experience of working with the actual application. Focusing web application development on UI/UX can ensure that a website or application is consistently used, and that similar competing sites and applications are not used instead (Hardianto 2019). A large part of ensuring a good UI/UX is to conduct user testing, which is further expanded upon in section 2.6.

To ensure good UI/UX design, emphasis should be placed on simplicity and centering the design around the end goals for the application (Wong 2020). By focusing on the goals laid out in section 1.4, the design of the AHF can improve the overall UI/UX by emphasizing the search capabilities of the application to find desired trails. Wong (2020) also suggests minimizing effort

needed by users to interact with the application. If there are too many extra steps to complete a task, there is more possibility for user to get confused or make a mistake, which in turn negatively impacts the UX. Limiting the number of components within an application leads to a more streamline UX, as a user is less likely to be overwhelmed with a smaller number of capabilities. Finally, explicitly outlining the capabilities of the application for the user will improve the UI/UX as a user will know what the application is capable of, and what they can do with it (Wong 2020). Their expectations are immediately set and managed, and they know what to expect from their interaction. By framing the project goals through the lens of these suggestions, the AHF can be developed to be as effective as possible from a UI/UX standpoint.

Any application is only as good as its ability to be easily operated and understood by its users. Almarashdeh and Alsmadi provide insight into developing an application that is user friendly and intuitive (Almarashdeh and Alsmadi 2016). The paper evaluated government mobile applications, and made recommendations as to how problems with their usability could be addressed. The authors had several experts evaluate a mobile government application's overall usability, and provide feedback for improvements. This study provides some examples of common mistakes and suggestions for overall improvements that can be applied to the proposed study application in development. Some of these mistakes include using conventions that vary from other applications users may already be familiar with, and not being concise enough with any instructions. From this study, the authors suggest ensuring that applications are reviewed by the targeted end user base, and overall emphasis is placed on easy usability for the user base. If an application is too difficult for someone to use, they simply will not use it.

Creating an effective application that any novice user can immediately navigate with ease is no small task. To accomplish this task, a paper by Roth provides a survey of opinions from

professionals in the geospatial industry (Roth 2015). It seeks to find what experts think in regards to human interaction with spatial applications and data, and how these interactions can be improved. In essence, the author is asking other GIS professionals the who, what, when, where, and why of GIS. This article explained concepts that can be applied to the construction of the proposed application, and how it can be better developed so users can interact with it more efficiently. Roth provides the example of how users are frequently expecting applications to function across multiple platforms with an emphasis on mobile devices. This consideration informed the decision to use Esri WebAppBuilder, which simultaneously allows for application construction across multiple platforms. Considering the questions raised in the study can help guide the application design process, and allow for a better identification and fulfillment of needs for the final product.

2.5. Application Platforms

For developers with limited coding experience, a WYSIWYG application can increase their ability to develop an application they may not otherwise be able to develop (Lennartz 2008). WYSIWYG applications allow for interaction with the application components directly as opposed to code, making the development process simpler. The other benefit of a WYSIWYG application is the development process requires interaction with the components of the final application, meaning the developer will have a similar UX to the end user while in the process of configuring the UI. This means that better choices regarding UI/UX can be made sooner in the development process.

Esri Web AppBuilder is a what-you-see-is-what-you-get (WYSIWYG) application, allowing for the creation of other web applications without the need for writing custom code (Esri 2020). It provides a platform where a developer can see individual components of the

application, including the map and widgets, and use or edit them immediately. This allows developers to adjust the UI of the application without needing custom code, and can improve the overall UX as a result. Esri Web AppBuilder allows users to develop mapping applications available online for easy viewing (Esri 2019). It allows customization of themes and widgets, and has built in tools to minimize the need for coding. Widgets in Web AppBuilder are modular software components that can be individually added or removed from an application in order to provide additional functionality. Using Esri Web AppBuilder can simplify the development process.

There are other competing products to Esri Web AppBuilder that serve as WYSIWYG platforms for application development. Some of these products could be used to develop an application like the AHF. However, for various reasons, Esri Web AppBuilder became the better choice. Some of the other alternative WYSIWYG platforms include Froala Editor, TinyMCE, Vev, Summernote, and Setka Editor. All of these platforms offer varying degrees of customization, set up, administration, and usability, but despite all of their strengths, none of them focus specifically on developing spatial applications focused on a map. Esri Web AppBuilder does, and has the added benefit of being streamlined for use with ArcGIS Pro.

A similar project on hiking trails used Esri Web AppBulder to construct their application (Yeung 2017). Yeung used Esri Web AppBulder to construct an application for hiking trails in Santa Barbara supported by VGI. While Yeung's project focused on the VGI component, the AHF focused more on user customization. Yeung faced limitations in using Esri Web AppBuilder to host his project, which mainly centered around the inability to create a many-to-one relationship between the VGI and a single trail feature. Since this project focuses on how a user interacts with preexisting data, the platform is beneficial.

2.6. Application Testing

Creating an application is simply the first step in a development project. Without feedback from outside users, an objective evaluation of the application will be severely limited. Feedback from users familiar with the subject matter can provide insight as to who else may benefit from the application, and detail what works well and what does not (Gao et al. 2014). Gao et al. outline how to implement application testing. The authors provide an overview of the different kinds of testing that are available, and why each one may be appropriate and useful. This is done through a literature review of other application testing studies that focus on particular methods. They also outline different approaches to testing, and how different issues can develop throughout the testing process. This study is excellent in providing both an overview of different testing methods, as well as including other literature to review in the event that this application will need a more specific testing method. The paper helped determine which questions should be included in the user survey, and stressed the importance of inquiring about how the users interact with the application.

In a study that created a geospatial database of Mexican migration, users who tested it were able to provide insight to the author regarding the overall success of the project (Rodriguez 2019). This feedback allowed the author to determine the overall success of the project, and validate that the goals of the project had been met. The study also discusses the creation of a database, and was done for the SSI program, which makes it useful on multiple levels.

Considering the diverse array of technological platforms, testing a web application from multiple technological sources can also aid in assessing an applications functionality (Macauley 2018). Testing an application from platforms like desktops, tablets, and mobile phones and through multiple web browsers can serve as an initial step in the testing process before users

provide feedback. Identifying potential issues from this testing can lead to more responses if a certain platform does not properly run the application. This in turn would lead to more useful responses from the user base.

The Gao et al. study serves as an excellent overview of application testing as a subject. It examines common strategies for evaluation, as well as how different methods excel in certain ways while suffering from some shortcomings in others. It also highlights other projects with application development as the focus that can be reviewed for a better understanding of the subject as the time comes for testing of the proposed project. The Rodriguez and Macauley sources are SSI application development thesis papers. Both projects developed applications and contained a component of user testing. The fact that the two papers were written for the same project provides an excellent context for what the proposed project can be tested for. Ideally, testing can be done early enough in the project to accommodate for adjustments in the application based on feedback from testing.

Chapter 3 Methods

This project developed a web application supported by a database of hiking trails wherein users have the ability to search for hikes based on their attributes or difficulty ratings. After the application was developed, it was tested and evaluated through a survey of volunteers. The following section highlights the necessary steps for completing the project. These steps include the initial development of a trail database based on existing hiking information, the creation of the application itself, and finally, user testing of the application and the completion of a survey to evaluate the success of the web application. These are all highlighted in Figure 8.

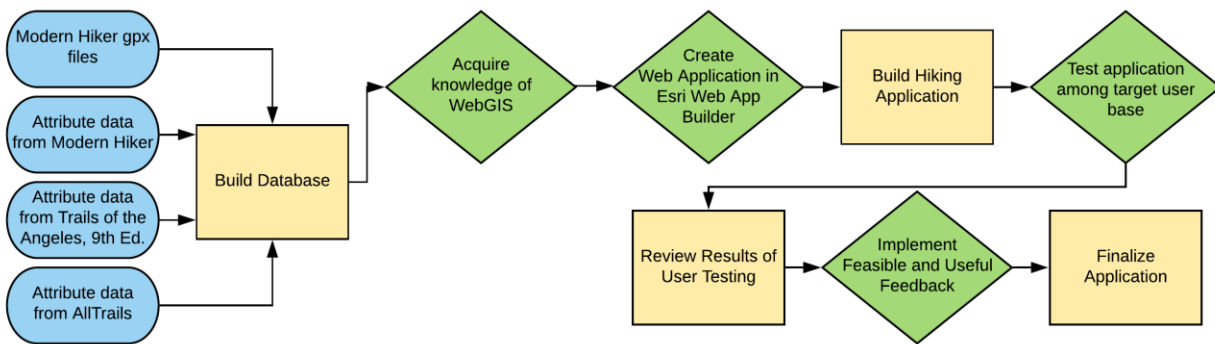


Figure 8. Simplified development of hiking trail application

While the following section details the work conducted to complete the project, there was a great deal of work conducted in the pursuit of a slightly different objective. Because the initial goal influenced some of the early choices made for the project's overall methodology, the initial goal is briefly described here. As mentioned in section 1.4, the original goal of this project was to allow users to define what attributes of hiking trails they found most difficult, rank these factors as most and least difficult, and then receive an output of all trails in the database with a customized difficulty rating. This approach would have ranked each trail relative to each other within the database, and provided a more customized approach to hiking trail difficulty. Numerous technical glitches in Esri products made this goal impossible to achieve in the

project's time frame, even with three separate Esri support staff involved with troubleshooting. The goal was therefore shifted to a fully developed application allowing users to search for their hikes by either their attributes, or by difficulty ratings, and the methodology for the final application is reflected throughout the document.

3.1. Platform Choices

Several different software applications were needed in order to accomplish the goals laid out in section 1.4. ArcGIS Pro, Microsoft Excel, and Esri Web AppBuilder Developer Edition were selected to accomplish them. Other programs, like Google Sheets, could have been used to record attribute information, but Excel was chosen for its ability to save data in multiple file formats, including csv files, which can be used in ArcGIS Pro. ArcGIS Pro contains all of the functionality needed to manage data, construct a database, and export a web map for use in a web application. Like ArcGIS Pro, Esri Web AppBuilder Developer Edition is a product managed by Esri, and the two programs are specifically built to support each other. As a WYSIWYG application, Esri Web AppBuilder allowed for extra focus on UI/UX throughout the development process. With the added benefit of compatibility with ArcGIS Pro, it was the natural choice.

Esri Web AppBuilder provides a platform for application development that simplifies the design process of application constructions. The program provides several themes, allowing users to choose how the different components of the application will be organized, and how end users will interact with the interface. As an Esri product, data from ArcGIS Pro can be shared and serve as the base data for an application. The greatest benefit of the standard version of Web AppBuilder is the ability to do all application development online, hosting the application on ArcGIS Online. Esri Web AppBuilder also provides an environment that does not require

expertise in coding, making the development simpler, as well as numerous themes allowing for a customizable and user friendly interface.

Initially, the goal of the project was for the user to receive a ranking of trails based on their chosen difficulty attribute. This could have been achieved with the app running a field calculation in the background using a geoprocessing widget in Web AppBuilder, but could only be developed using the Web AppBuilder Developer Edition. The Developer Edition was therefore initially selected to build the app. After the goals shifted, this version became unnecessary. However, with all of the data already imported into the Developer Edition, and with all of the same functionality of the standard version, the Developer Edition continued to be used. Microsoft Excel was also used to help with data management during the database construction. More rationale for its use can be found in the following section.

3.2. Database Construction

As mentioned earlier in section 1.3, GIS trail data is only available from the County of Los Angeles for trails closer to urban spaces and not in National Forest land. The trails in the National Forest Service Trails file only includes the trails directly managed by the USDA, and does not include the trails involved in this project. Trail data for the trails in this project are widely available from online resources like Modern Hiker and AllTrails, as well as printed guidebooks, yet it is not a simple matter to import this data into ArcGIS Pro. The online sources have elevation profiles and gpx files available for download to a mobile GPS device to aid in navigation along the trail. The database for the AHF is constructed from the gpx files to provide geometry within ArcGIS Pro before the trail data was added in. The database of hiking trails contains attributes for trail distance, elevation gain, maximum elevation, as well as the difficulty

ratings for those three factors. The other attribute information added was trail type, which was provided as context for the user but otherwise does not affect the application.

The database of trails for this project was developed from a preliminary experimental database consisting of ten trails and their associated attribute data. The goal of the preliminary database development was to ensure that generating a larger database later on would not be too time consuming, necessitating a separate project altogether. It was important to discover the necessary steps to add in each individual trail, and what data to include in the shapefile versus what to join later on from an attribute table.

The dataset needed to be manually generated, which took time because it was not easily automated. Trail geometry first was downloaded as a gpx file from either AllTrails or Modern Hiker. AllTrails gpx tracks for in and out trails are only for one direction of travel, requiring less data editing, and are preferred to tracks from Modern Hiker, which required deleting the duplicate track recorded when a hiker turned around. After acquiring the gpx file, the Gpx to Features tool in ArcGIS Pro converts the file into an Esri shapefile of a series of points. Next, the Points to Line tool was used to convert the features to line geometry. A new field was added with the name of the trail. Finally, the newly created trail line feature was added to the overall trail database using the Append tool. The workflow for the trail database creation is summarized in Figure 9.

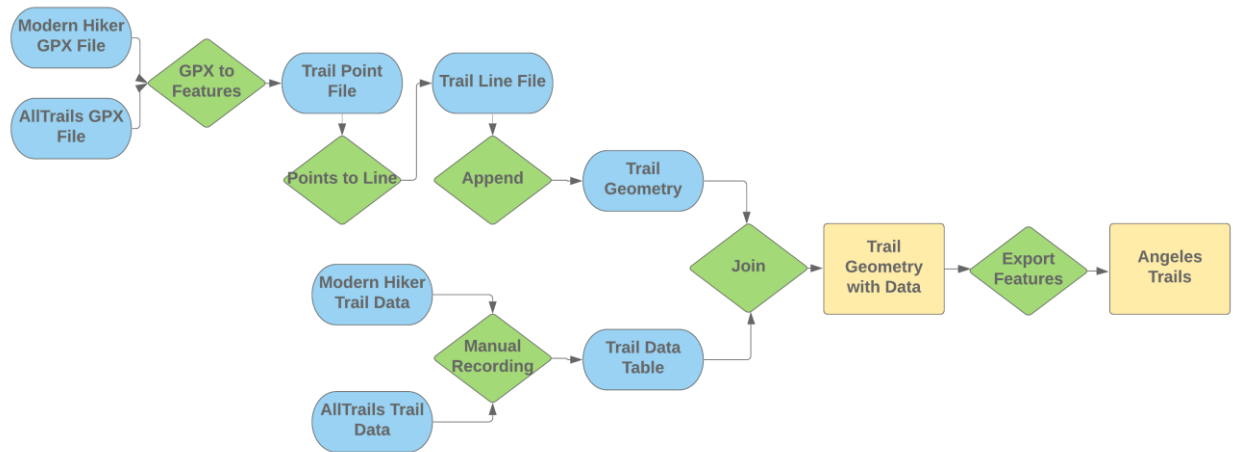


Figure 9. Workflow for trail geometry and trail data generation before final creation of trail database.

In a separate Excel file, the trail attribute was recorded using the ObjectID field to join the information to the main dataset after all of the trails were added to the spatial database. Attribute information was recorded in Excel to avoid potential error in appending the trail geometry to the spatial dataset. Excel also allowed for easy recording of attribute data and to export the table as a csv file, which ArcGIS Pro can read as a standalone table for eventual joining to the trail geometry. The Append tool in ArcGIS Pro requires the same fields between the new data being added and the target dataset. If every trail attribute field needed to be added to a new trail before the append step, it would have added several extra steps. Instead, using Excel allowed for a faster recording of trail attributes, and only the name field needed to be added to each trail geometry feature before it was appended to the main dataset. The ObjectID field was automatically added by Esri, and corresponds to the order that each trail was added into the geodatabase. The Excel file contains fields for trail distance, elevation gain, maximum elevation, and trail type. The difficulty categories were calculated based on the attribute information. The difficulty categories correspond to a range of values seen in Table 1. These categories are defined by the range of values research in Section 2.2, and personal experience

with the hiking trails included. Each category has separate levels of difficulty divided into scales from 1 to 5, representing difficulty levels for each category of length, elevation gain, and maximum elevation.

Table 1. Difficulty Values with Corresponding Attribute Ranges

Difficulty Values	Length	Gain	Max
1	0-3	0-800	0-3000
2	3.1-6	801-2000	3001-5000
3	6.1-9	2001-3500	5001-7000
4	9.1-12	3501-5200	7001-8500
5	12.1-16	5201-7300	8501-10100

Once the database was completed, the data was exported as a csv file and added into ArcGIS Pro where it was joined to the shapefile containing the trail line data. A join was added using the ObjectID fields, and finally the data was exported into a complete trail database in a single feature. The two components of the database share a one to one relationship as summarized in the Entity Relationship Diagram in Figure 10.

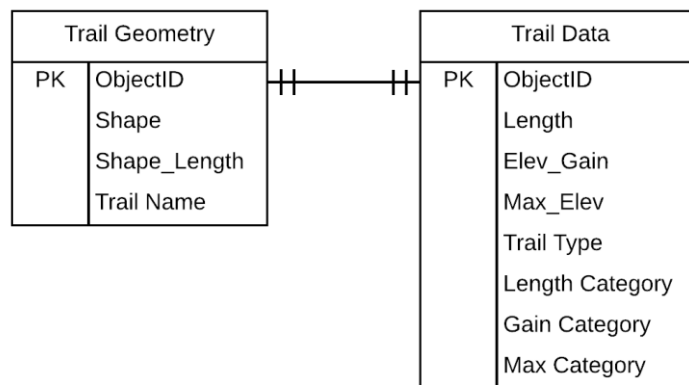


Figure 10. Entity Relationship Diagram of trail database

A summary of the fields and their data types is available in Table 2. Database Field Design Table 2.

Table 2. Database Field Design

Field Name	Field Description	Data Type
ObjectID	Unique ID for each trail	ObjectID
Shape	Polyline Z. Generated from conversion from gpx file	Geometry
Shape_Length	Esri calculated distance in Degrees	Double
Trail Name	Unique name for each trail	Text
Length	Trail length (miles) from Modern Hiker, or AllTrails if unavailable from Modern Hiker	Double
Elev_Gain	Elevation gain (feet) from Modern Hiker, or AllTrails if unavailable from Modern Hiker	Long
Max_Elev	Maximum elevation (feet) from Modern Hiker, or AllTrails if unavailable from Modern Hiker	Long
Trail Type	In and out, loop, or point to point. Indicates to hikers what to expect, and if special consideration for a trail is needed	Text
Length Category	Trail difficulty on a scale of 1-5, with 1 being least difficult and 5 being most difficult	Long
Gain Category	Elevation Gain difficulty on a scale of 1-5, with 1 being least difficult and 5 being most difficult	Long
Max Category	Maximum Elevation difficulty on a scale of 1-5, with 1 being least difficult and 5 being most difficult	Long

3.3. Application Development

The main focus of the project was the development of an application based upon the trail database. The following section describes the steps taken to develop the ANF, including the design process, the creation of the foundational basemap, and finally the application and its components. Also included is a description of the initial attempt to incorporate the geoprocessing widget to accomplish the original goal of the project. While attempting to develop the geoprocessing widget to allow for trail ranking, technical issues between publishing ArcGIS Pro tasks to Web AppBuilder proved insurmountable. Three separate Esri representatives were

unable to sort out the issue within the project timeframe, and in order to progress, the goals for the project shifted to those highlighted in section 1.4.

The workflow for the application development process and the application components can be viewed in Figure 11.

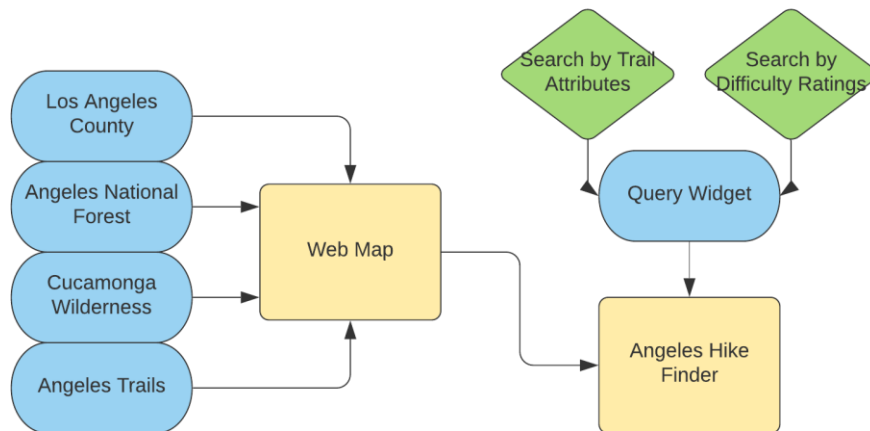


Figure 11. Project workflow from the database published as a web map integrated into the final application, AHF

3.3.1. Application Design

The application design was centered around the project goals outlined in section 1.4. The application UI was designed so that users can select a range of values for either the factors or difficulty ratings they desire, and generate a custom list of trails as a result. The list provided for the user allows them to explore the options available to them and view where they fall on the map. Finally, this report can be exported if the user desires.

Widgets, which are tools that add functionality to the application can be added as desired. Widgets can also be moved throughout the application to make them more or less prominent depending on their importance to the project. The Developer Edition allows for even greater customization within the application, and users can create custom widgets and designs within the

Web AppBuilder platform. An overview of the developer view of Esri WebApp Builder can be viewed in Figure 12.

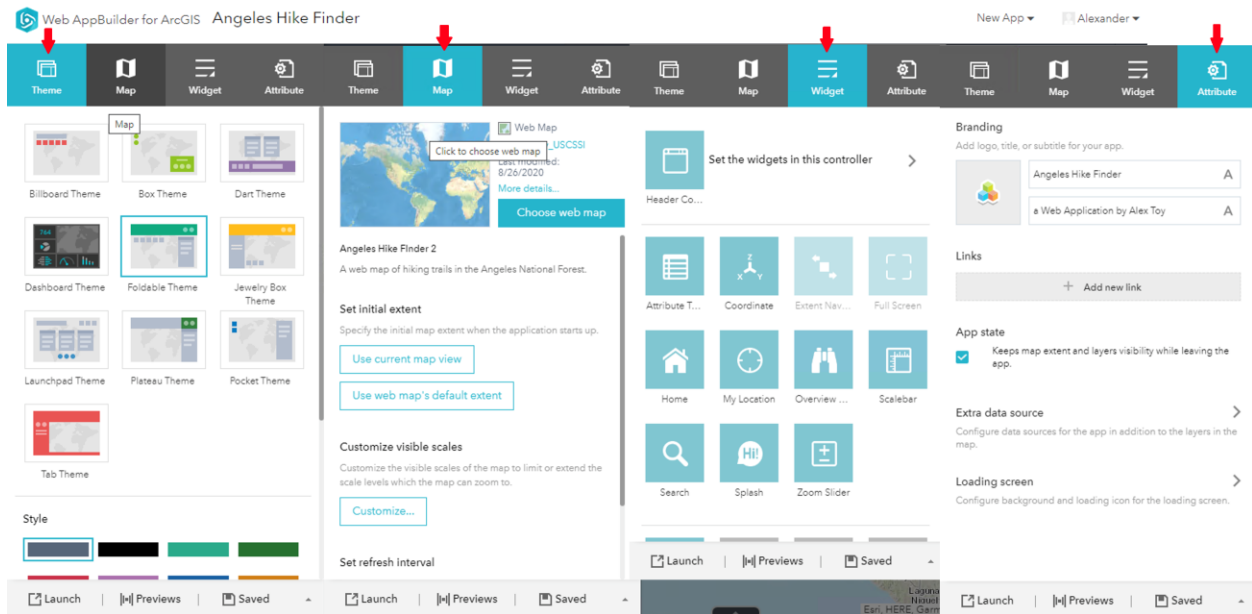


Figure 12. View from the developer perspective of the 4 main tabs to configure the application. The tabs include allow the user to set the theme, the base map, configure the widgets, and change the credits within the application. All of these functions do not require additional coding.

3.3.2. Creating the Web Map

Creating the application stemmed from the work accomplished at the conclusion of the database development outlined in Section 0. The web map includes several other components besides the trail database, including an outline of Los Angeles County, the ANF, and the CWA. The county boundary helps provide context for the study area, and as a unique shape, it can help provide context for a user of what geographical area they are looking at. The boundaries for the ANF and CWA also provide context for the study area, and serve to contain the trails that are included in the study. The symbology for the county boundary is the least obtrusive to the eye, with a thinner line weight and softer blue color. It is noticeable, but the other two polygons are

more prominent with their symbology. The ANF and CWA both use a thicker line weight, and more visible color than the county boundary to highlight their importance. The ANF boundary uses a green color to match with the fill of the ANF on the base map. The CWA is a vivid red to attract attention and compensate for its smaller size compared to the other two boundaries. The trails use a dark green color that is visible against the base map, but also fits in with the theme of being in the ANF. A thinner line is used to prevent distortion from overlaps between trails. The base map used contains plenty of location data that allows users to help orient themselves, including city names, highways, and the ANF itself. It uses a different color for the ANF, and combined with the polygon boundary, the study area is prominently highlighted.

Once all of the necessary data was assembled and mapped in ArcGIS Pro, the data needed to be moved to ArcGIS Online in order to be used in Esri Web AppBuilder. This step involved publishing the data created in ArcGIS Pro to a web map in the University of Southern California (USC) Spatial Sciences Institute (SSI) online account. The web map was set to a public profile, allowing anyone to view it. The extra benefit of the web map is the ability for a third party to view the published trail database, and save a copy of it if they so desire. The dialogue screen to publish the map and the fully published web map in ArcGIS Online can be viewed in Figure 13.

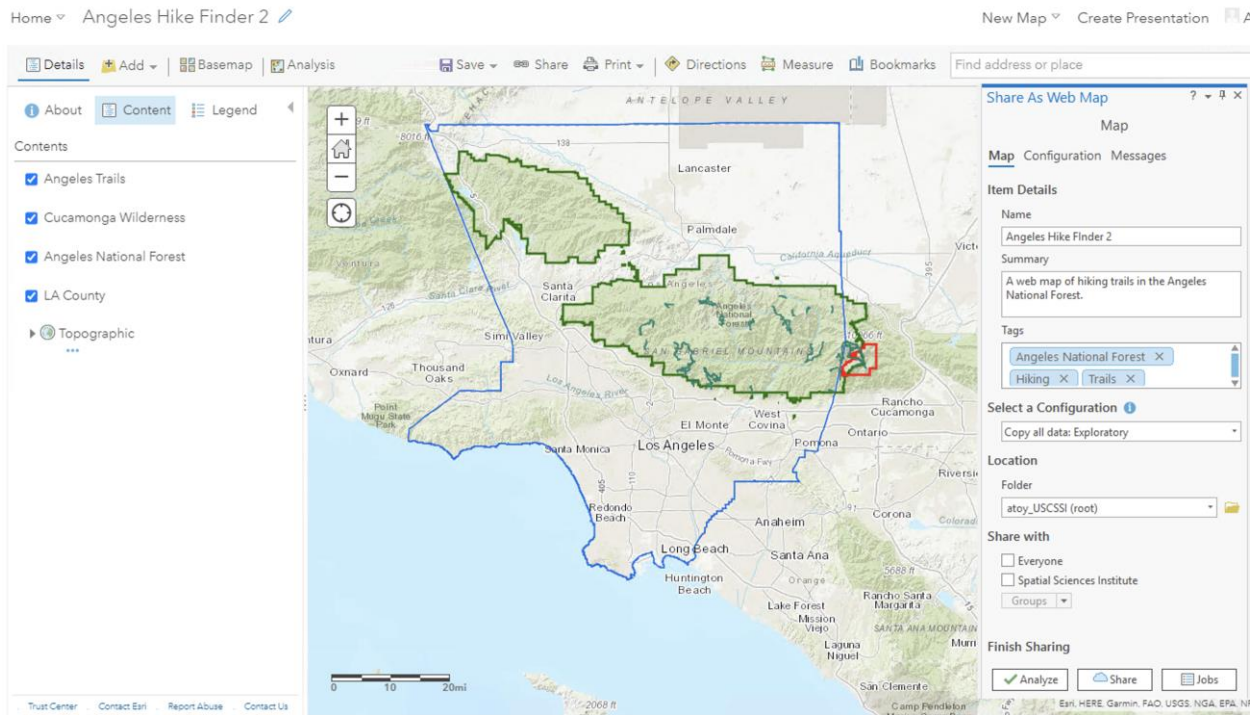


Figure 13. Dialogue box to publish web map (right) and published web map in ArcGIS Online

3.3.3. Creating the Web Application

Esri Web AppBuilder is optimized for the Windows operating system. A private remote desktop needed to be set up in order to use Web AppBuilder. Once installed, the application was created with the remote machine as the server. Upon the creation of a new application, it will display a default world base map. In order to bring the relevant data into the application, the base map was instead set to the web map published in Section 3.3.2. With the Angeles Trails layer that was described in section 0 added in, functionality and customization could be added in before publishing the application.

3.3.3.1. Splash Screen

A splash screen serves as both a welcome to users of the application as well as an instruction on how to interact with it. Without it, users have no guidance on how to interact with the application unless they have some preexisting knowledge of what the application is meant to

do. However, too much text on the splash screen would dominate the initial view, and would be more likely to cause a first time user to click away from an overly long explanation of features. In order to be as useful as possible, brevity and clarity within the splash screen ensured that a user would take away the key information needed for using the AHF. The size of the splash screen was made to be large enough to immediately attract attention, yet small enough to be obvious it was a splash screen. Esri Web AppBuilder allows for the simple construction of a splash screen, which was employed to provide a very brief description of the application and instructions on the key query functions within it. The configuration for the splash screen can be viewed in Figure 14. The configuration screen allows the user to change the text included on the splash screen, the appearance of the splash screen box, and the option to allow users to disable future appearances of the splash screen or a requirement of acknowledgment.

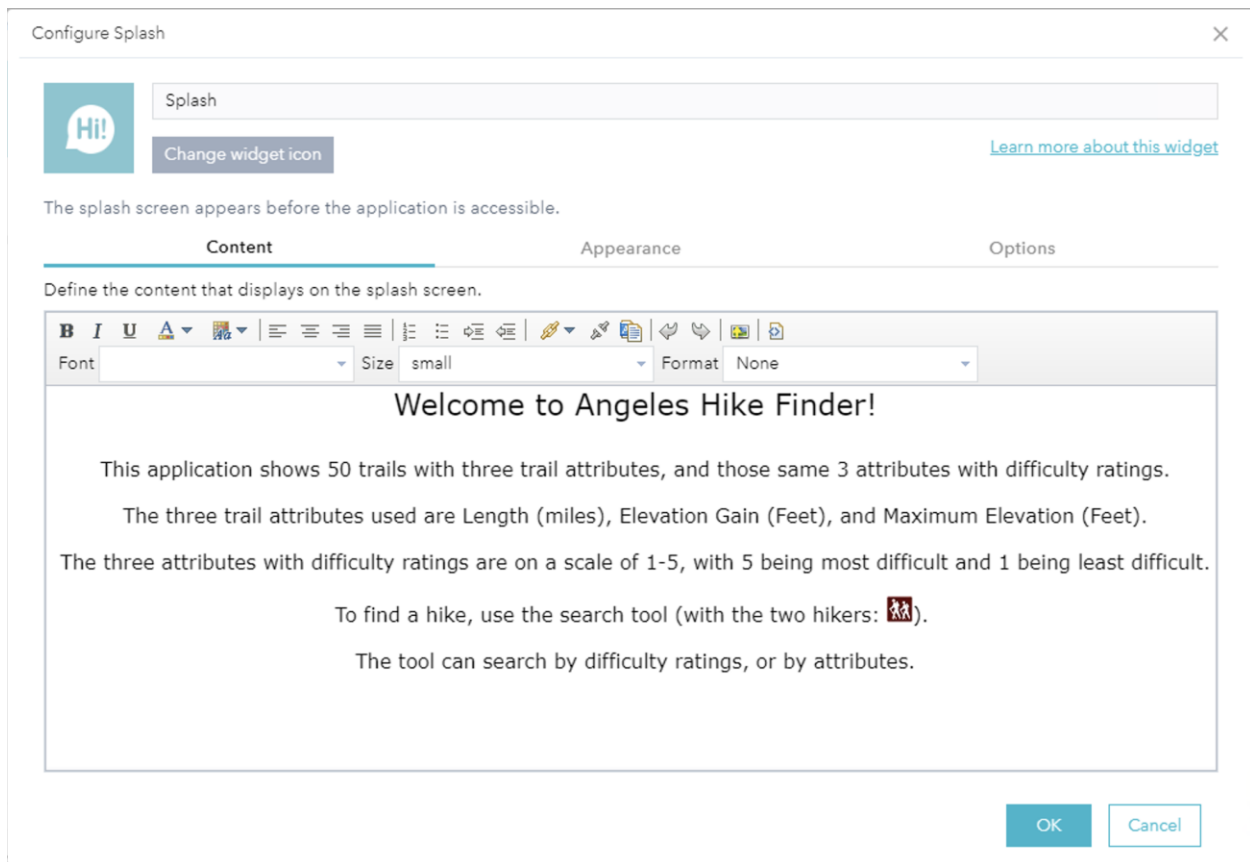


Figure 14. Configuration for the Splash screen on the content tab, allowing text edits

3.3.3.2. Initial Goal: Geoprocessing Widget.

The initial goal mentioned earlier required using the geoprocessing widget. This widget requires either a service URL or a geoprocessing service from ArcGIS Online in order to function. The Calculate Field tool in ArcGIS Pro allows users to populate an empty field based on a selected mathematical expression, and would have provided the customized ranking. However, errors kept preventing an export of this geoprocessing task from ArcGIS Pro to ArcGIS Online. This meant that the geoprocessing widget in Web AppBuilder could not be set from ArcGIS Online. An attempted workaround showed some promise when the geoprocessing task was able to be shared to ArcGIS Enterprise instead. However, when the geoprocessing

widget referenced the service URL from the task now in ArcGIS Enterprise, a new error occurred saying it was an invalid task.

At this point, help was sought out from Esri, but despite several weeks of attempted solutions with three separate representatives from Esri, the geoprocessing widget was still not functional. With the time constraints for the project, the geoprocessing widget was abandoned, and the goals outlined in section 1.4 were adapted to complete the project. This in turn led to the selection of the query widget to provide the necessary tasks to complete the application and address the project goals.

3.3.3.3. Adding Widgets and Customization

The core functionality of the application allows users to search for trails based on their attributes or difficulty ratings. To facilitate this, the query widget was added. As a way to highlight the importance of this tool, the default icon for the query widget was changed to a hiking trail icon of two figures with walking sticks that is commonly associated with hiking trailheads. Once added to the application, the widget was edited to provide the search functions. Adding widgets is accomplished on the widget tab as seen in Figure 12, before launching the widget's configuration screen, available on every visible and added widget.

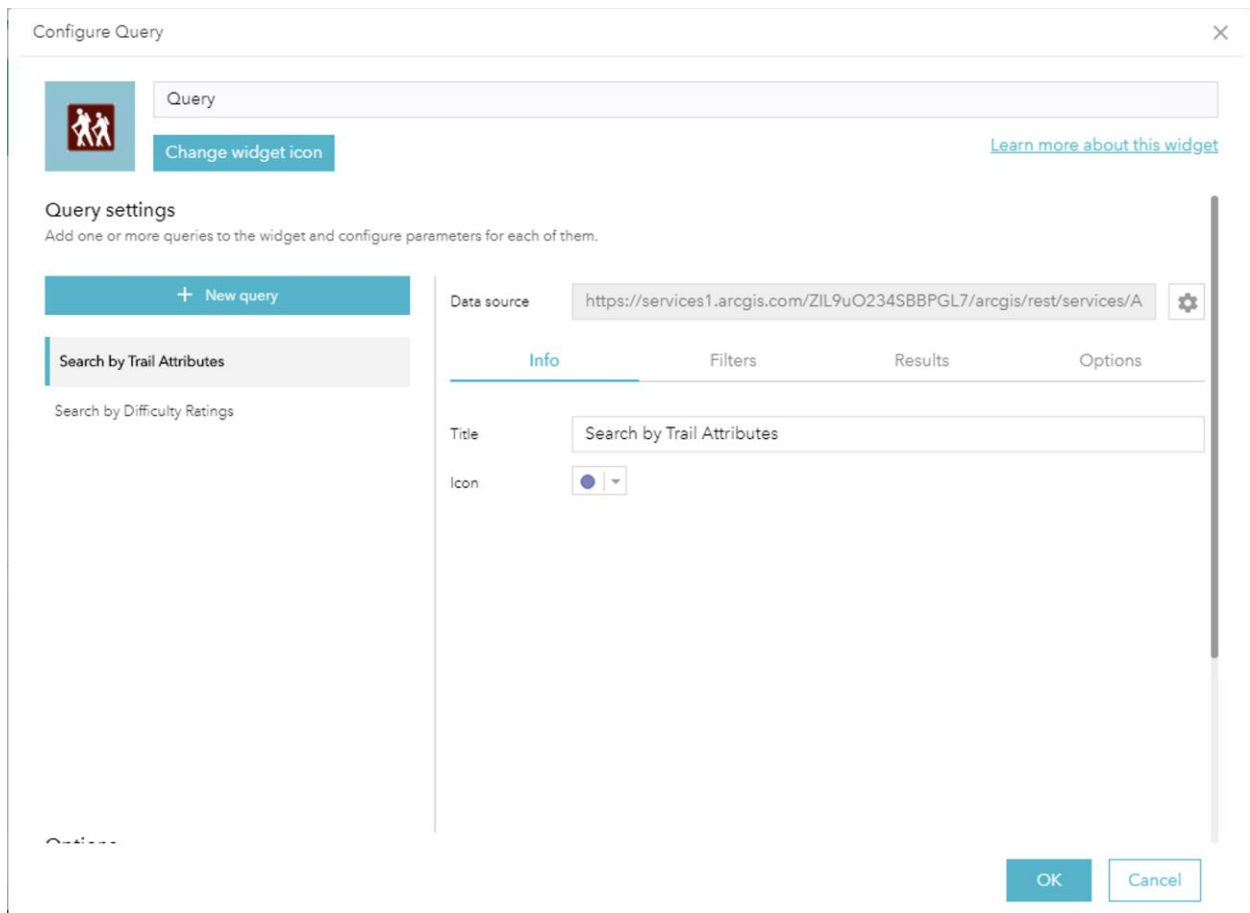


Figure 15. Configuration screen for the query widget, with the information tab open

The widget has two possible query options, search by attributes and search by difficulty.

In order to allow users to search for trails in two different ways, separate icons were used to distinguish one from the other, with one visible in Figure 15. Setting up the queries required the same basic steps for both:

1. Select the trail layer as the data source to be queried
2. Launch the query builder
3. Add multiple expressions
4. Set each expression to appropriate field in the trails layer
5. Select the “Ask for values box”
6. Provide a hint to guide the user to appropriate selections

main widget area of the widget configuration tab seen in Figure 12, and simply need to either be turned on or off, or configured if necessary by the developer.

3.4. Application Testing

Once the web application was developed and functioning, it needed to be tested by hikers in the Los Angeles region, the target user base. In order to conduct the survey on potential users, approval was needed from the USC Institutional Review Board (IRB). To complete this process, a preliminary application was submitted and the IRB determined that a survey issued online meets the criteria for Human Subject Research, necessitating a full application for approval. This application (UP-20-00388) was completed and submitted, and the IRB approved the survey for use with the condition that all surveyed hikers will be adults over the age of 18. For the survey, hikers in the Los Angeles region were asked to evaluate the application in order to see if it met the development goal. Additionally, these testers evaluated the overall success of the application in regards to its interface. Emphasis was placed on questions regarding how easy it was to navigate around the map and interact with the trail database.

A group of 16 individuals known to the author were asked if they would be interested in testing out the AHF application and filling out a survey to evaluate their experiences with it. These individuals were chosen due to their either experience with hiking in the study area, or interest in hiking in the study area. These individuals were chosen due to convenience, and are nonrandom and nonrepresentative of Los Angeles hikers as a whole. Once consent was given through text, a formal invitation was sent out via email providing a brief overview of the project, as well as links to both the application and the survey. The survey was distributed via Google Forms, allowing for an easy evaluation of survey results for individual questions as well as respondents.

Users were asked a series of questions using a Likert scale including a 1-5 to rate the ease of use concerning map navigation, the query system and how it is used, and the output of trails generated. They were also asked for their overall impressions, what improvements or limitations they see, and what other hiking applications they may already consult. This survey allowed for the collection of concrete data to evaluate the outcome of the application. It also addressed any shortcoming or improvements that may need to be made in order to better fulfill the goal of the application that the testing group experienced or suggested. The full survey and responses are included in Appendix A.

Chapter 4 Results

The completion of this project resulted in a publicly available web map containing a database of 50 hiking trails in the ANF, the completed AHF application, and 13 survey responses resulting from application testing. The trail database, while not representative of every trail in the ANF, serves as a template for any future work to expand it, or for others wishing to use it. The application allows users to explore trails in the ANF, search for them based on their attributes or difficulty ratings, and export the results of the searches. The survey evaluated user experiences with the AHF, and provided insights into the successes and limitations of the project.

4.1. Trail Database and Web Map

The trail database, as described in section 0 was successfully published to the USC SSI Organization on ArcGIS Online as a part of a publicly accessible web map. As a part of a web map, anyone can access and download the trail layer for their own use in a GIS. Consisting of 50 trails, this database can serve as the basis or template for future analysis of hiking trails in the ANF. At the beginning of this project, data for these trails was not available in an Esri ready format. Developing the AHF has resulted in a dataset that is publicly available and ready for immediate use in a GIS.

4.2. Angeles Hike Finder Application

The following section outlines the components of the AHF, serving as a description of the application and its individual parts. It encompasses the user experience when the application is first opened and the splash screen is launched, as well as the included widgets and the core query function that allows users to make their trail selections and view their results.

4.2.1. Splash Screen

When the application is launched, a user is greeted by a splash screen seen in Figure 17. This splash screen welcomes the user to the application, and provides an overview of the application and its functionality. This description includes the number of hikes displayed in the application, the ways a user can apply filters, the trail attributes and difficulty ratings, and how to launch the widget that actually filters the hikes for the user. There is also the option to prevent the application from displaying the splash screen again if the user were to refresh the web page.

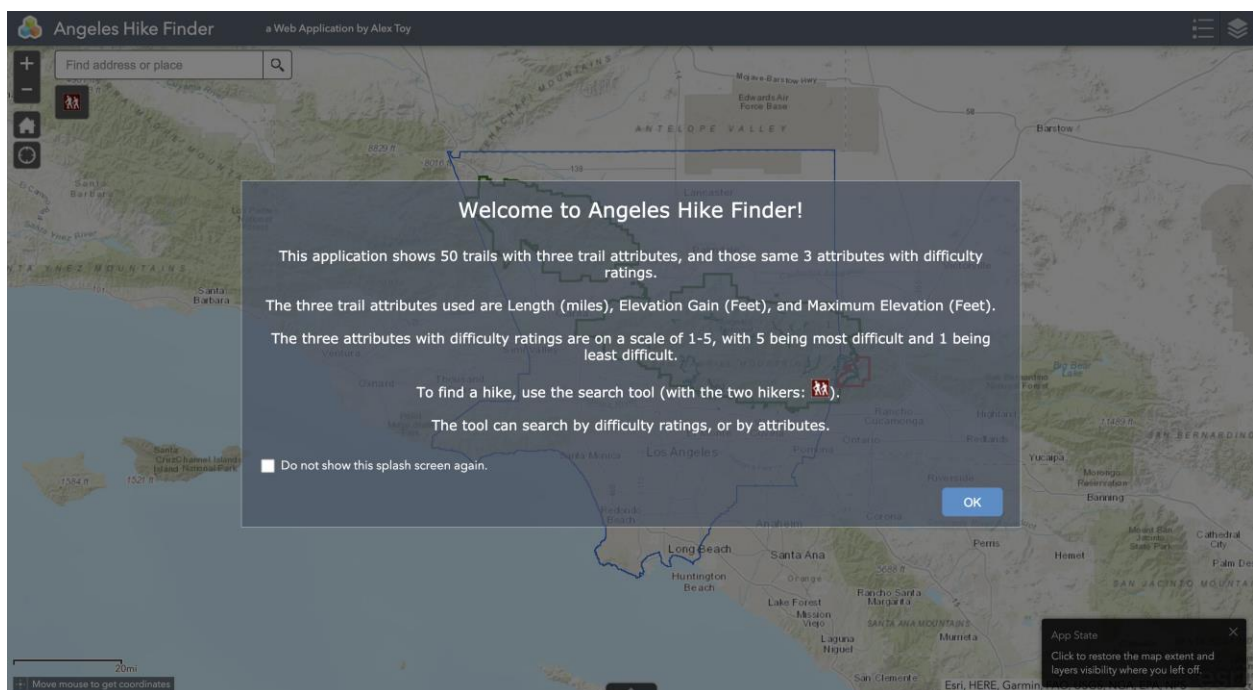


Figure 17. The splash page greeting a visitor when the application is first launched

4.2.2. Query Widget

The Query Widget provides the core functionality of the application. When launched, users have the option to search by trail attributes or by difficulty ratings. If a user selects the option to search by trail attributes, the widget then prompts the user for inputs for each trail attribute. The application includes textual prompts for each attribute input, explaining the range of values that a user can select for the respective feature. For example, the trail distance input

prompts the user to choose a range between 0 and 16 miles, and will return trails that satisfy the selection that the user inputs. Figure 18 illustrates the query widget with the Select by Attributes option selected and inputs provided.

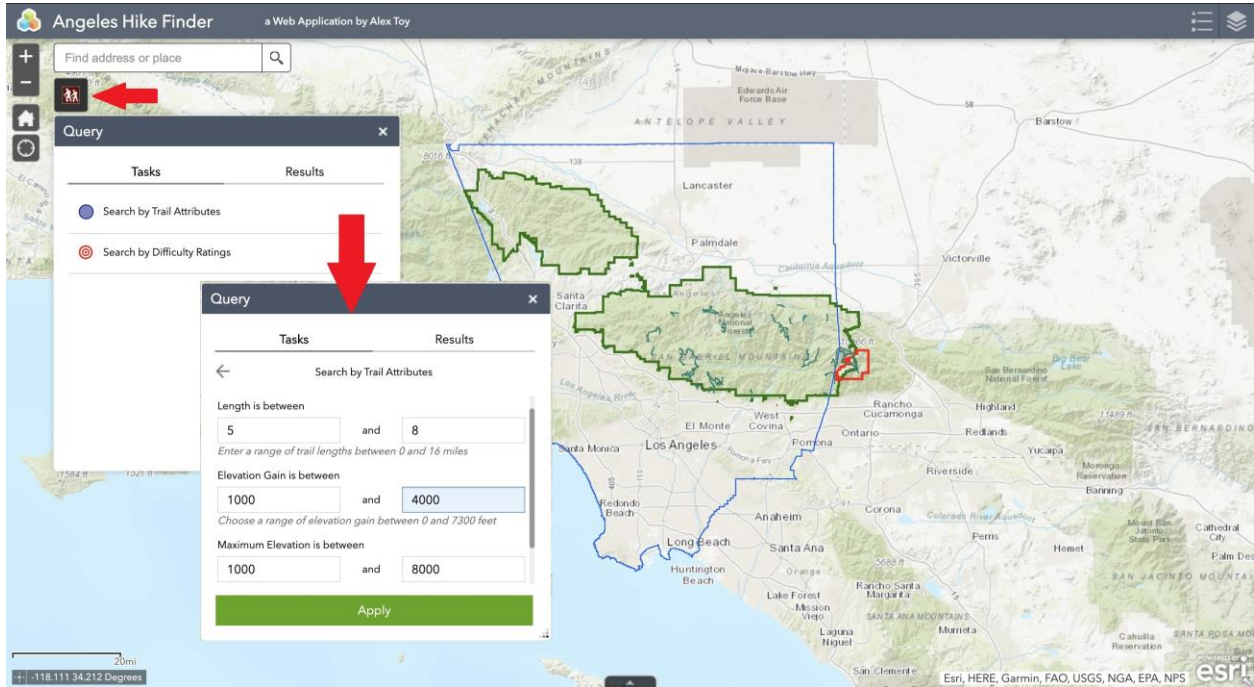


Figure 18. AHF when a user selects query widget, then select by attributes, and provides inputs

After the user inputs values or leaves a selection blank for Distance, Elevation Gain, and Maximum elevation, they hit the apply button and the AHF returns all trails that satisfy the user requirements. This process can be viewed in Figure 19, where the trails that satisfy the query are displayed, and the resulting trails are added to the map as a new layer that can be toggled on and

off for visibility.

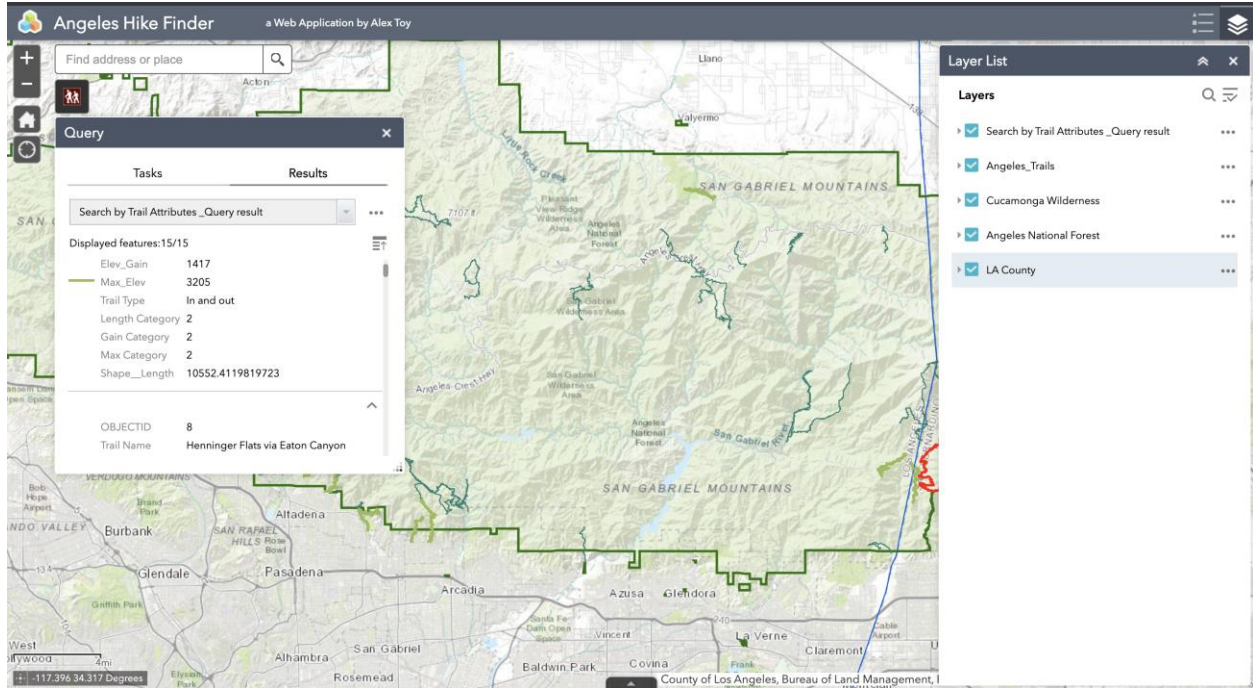


Figure 19. Results of Select by Attributes with query layer added

The process is similar for a search using difficulty ratings. To distinguish the difficulty fields from the attribute fields, each factor has the name Category after it (e.g. Length Category, Elevation Gain Category, and Max Elevation Category). The difficulty ratings for each field range from 1 to 5, with 5 being most difficult, and 1 being least difficult. Users are still able to input a range of values, allowing them to see a range of difficulty amongst their selected trails. The output can also be renamed, or the default can be used, Search by Difficulty Ratings _Query

result, as seen in Figure 20.

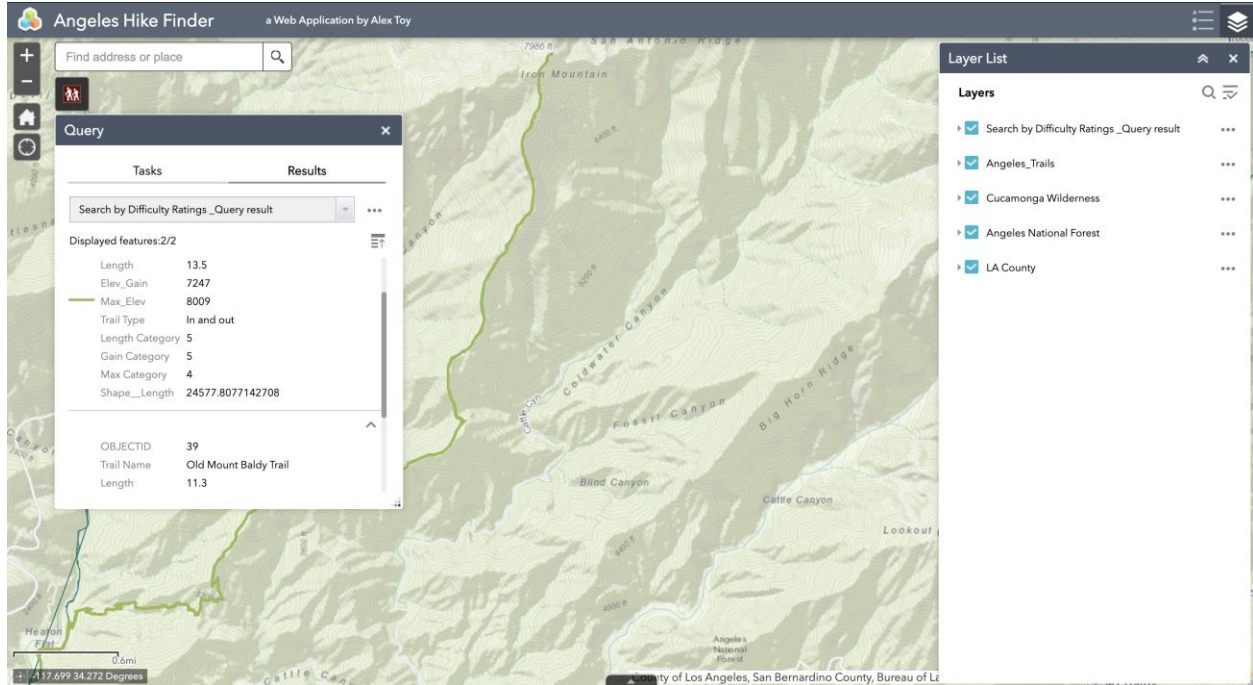


Figure 20. Results of Search by Difficulty query with result layer added

Regardless of the search method used, the AHF returns a list of trails that satisfy the search parameters specified by the user. These trails are listed in order of their ObjectID, and display the rest of their attribute data. Selecting one of these trails in the results area will cause the application to zoom in on the selected trail, and a secondary window displaying the individual trails attributes appears as well. If multiple searches are conducted, users are able to switch between previously run queries using a drop down menu at the top of the query tool dialog box. Users are also able to export the results of their search by clicking on the feature actions menu, represented by 3 dots next to the drop down menu, and selecting one of the export options, including csv file, feature collection, and GeoJSON. The feature actions menu also allows users to delete the query, view the results in an attribute table, or view a statistical

summary of the returned hikes as seen in Figure 21.

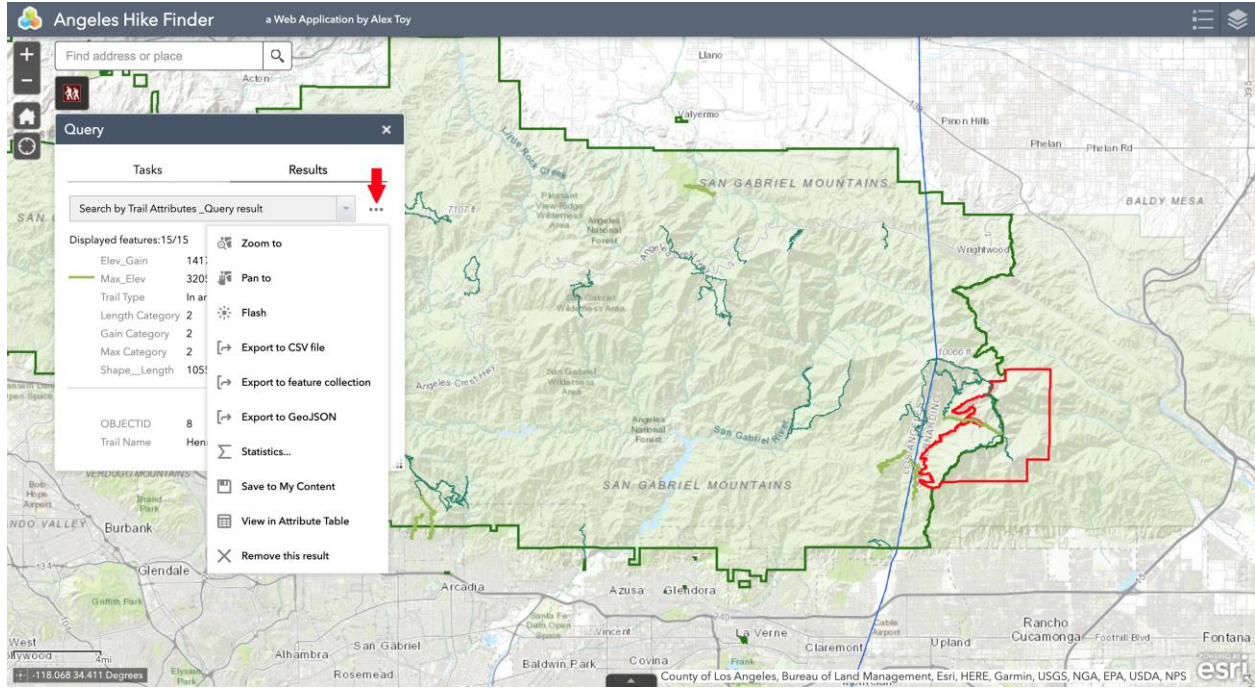


Figure 21. Drop down menu in results allowing for exporting trails

4.2.3. Additional Widgets

Other than the main query widget, the AHF also has a few secondary widgets for easier interaction with the application. On the left side of the screen, there are a cluster of widgets for navigation. The Home Button will take users back to the default extent of the map, which overlooks Los Angeles County and the ANF. The My Location widget is best for users already in the Los Angeles area, and allows the user to see where they are relative to the trails. There are

zoom in and out buttons as well. These widgets are all identifiable in Figure 22.

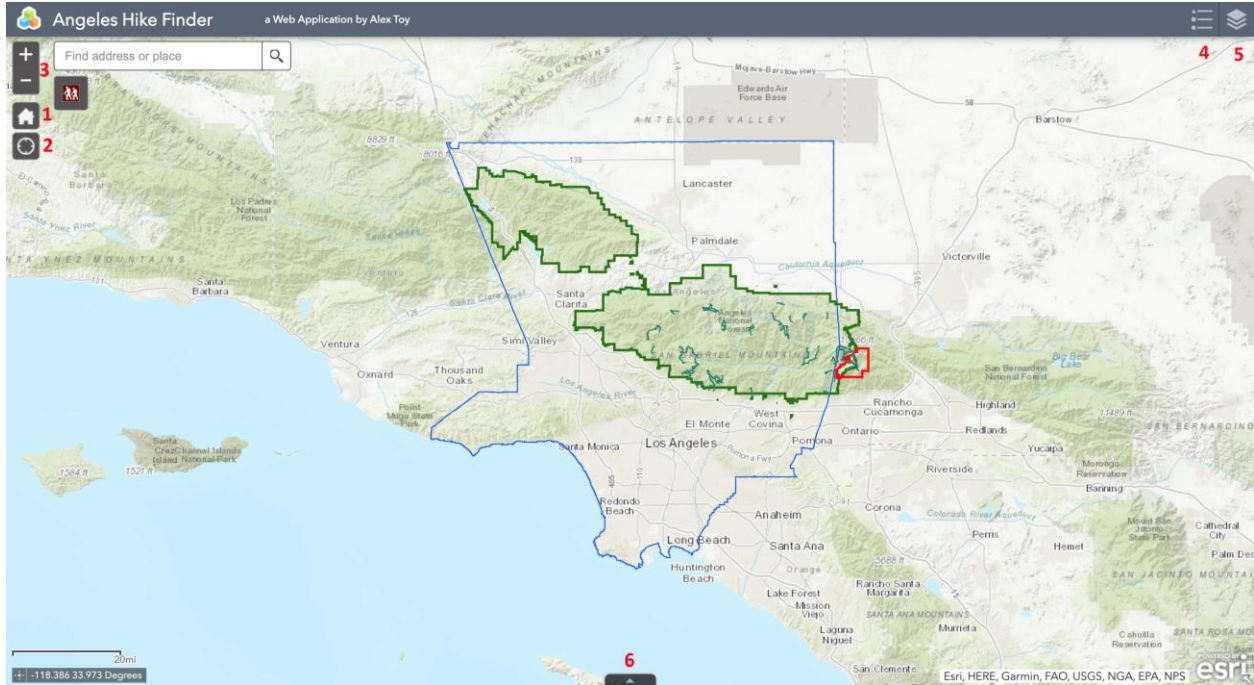


Figure 22. Additional widgets: 1 Home Button, 2 Find My Location, 3 Zoom, 4 Legend, 5 Layers, 6 Attribute Table

In the top right, there are the Legend and Layers widgets, allowing a user to see what each map feature is and turn them on or off to let them control feature visibility. At the base of the screen, there is an arrow allowing the attribute table of every layer to be seen. The default attribute table that becomes visible upon launch is for the trail database, letting a user explore which trails are available to search for at any point while using the application. The application

with the opened attribute table is visible in Figure 23.

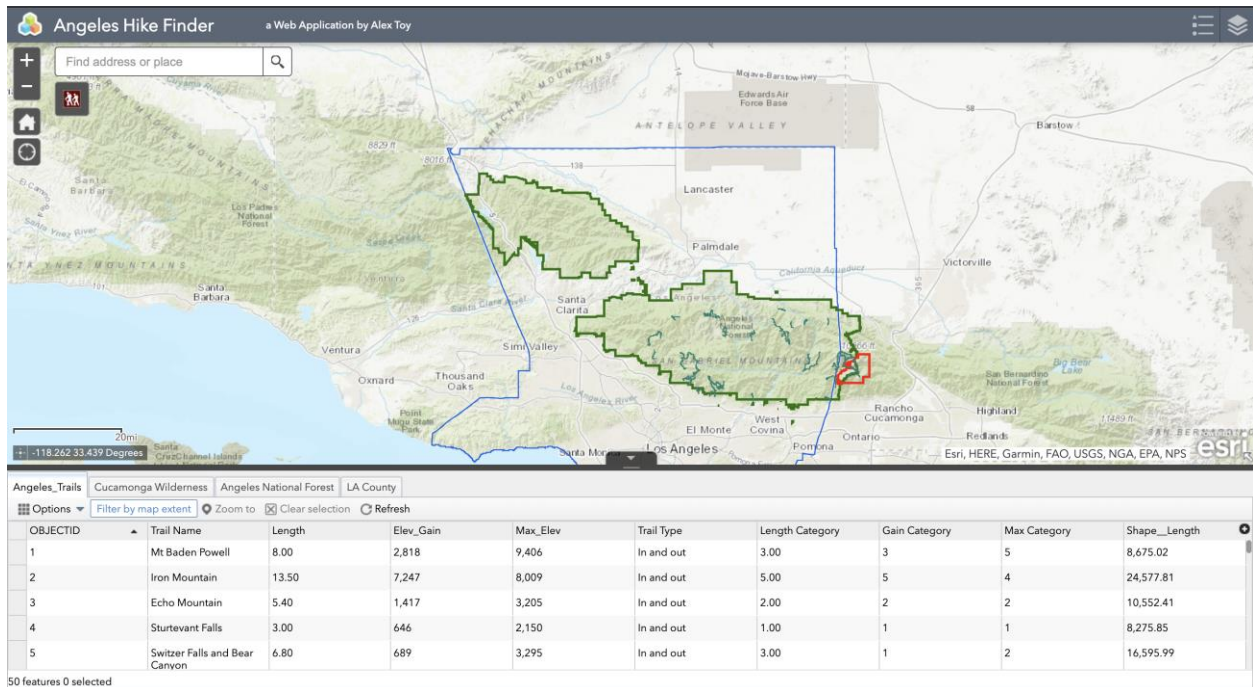


Figure 23. AHF with open attribute table displaying trail layer data

4.3. User Testing and Survey

Once the application reached a functional level, a group of 16 hikers were sent an emailed invitation to test the application, along with a link to a survey in Google Forms, as discussed in Section 3.4. Of the 16 people contacted, 13 completed the survey to provide feedback on the application. Since an identifying email address was not required, it was not possible to determine exactly which 3 participants had not responded, and no further communication attempts were made. A detailed view of the survey and the responses can be viewed in Appendix A. As a whole, the responses to the survey indicate that users found the AHF to be fairly simple to use, and found the ability to find trails based on their attributes as well as their difficulty to be helpful. Of the respondents, 9 stated that they found it overall simple to use, and 10 rated it either a 4 or 5 out of 5, with respect to usefulness, with 5 being very useful with respect to being able to search by both attributes and difficulty.

Other questions regarding the ease of use for the application yielded similar results.

When asked about how easy to use different features were on a scale of 1-5, with 5 being very easy, 11 rated the ease of navigation around the map as a 4 or 5, while 2 rated the ease of navigation as a 3. 10 respondents rated their comprehension of the search function as a 4 or 5, while 3 rated it as a 2. 9 respondents rated the ease of applying parameters to their search as a 4 or 5, with 1 rating it as a 3, 2 as a 2, and 1 as a 1. These results are summarized in **Error!**

Reference source not found..

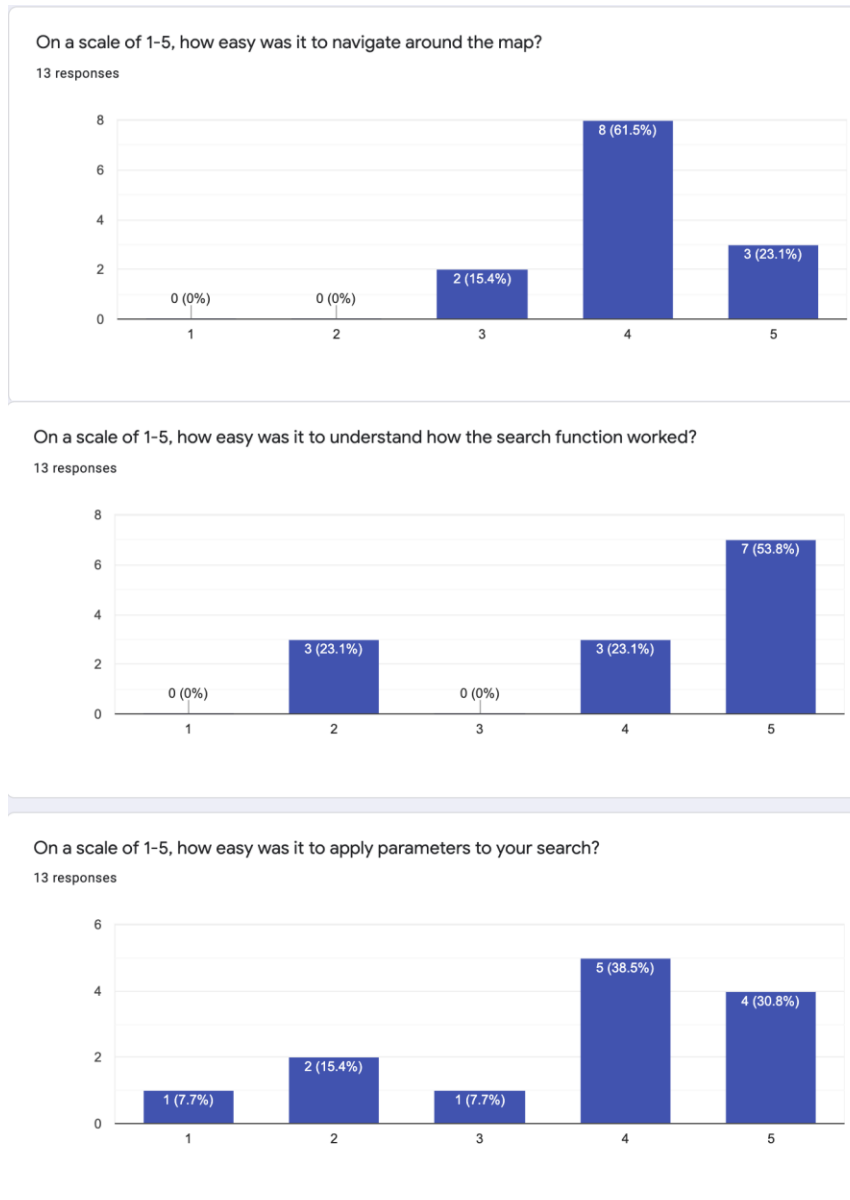


Figure 24. Charts of survey responses for interacting with the AHF

The one question that revealed a different trend regarding ease of use for the application concerned the ability to export the output result of a trail search, where only 6 respondents gave the application a score of 4 or 5, while 5 gave it a score of 3, and scores of 1 and 2 each received one vote. This question can be viewed in more detail in Figure 25.

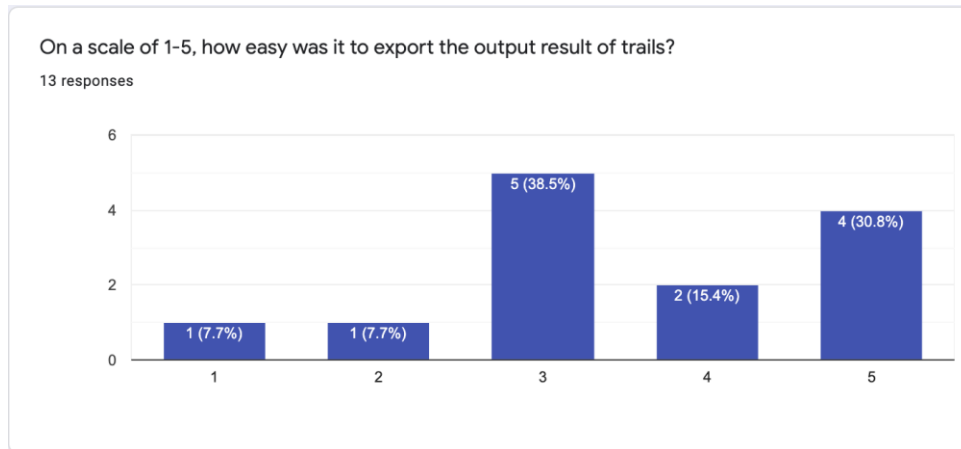


Figure 25. Survey results for the ease of exporting trails

Survey respondents were also able to explain some of their answers further and leave comments. This feedback led to more informed information outlining how the application could be improved. One participant suggested using sliding bars instead of directly inputting the desired range of values into the search parameters. Another pointed out that the search bar should be refined to only query the trail layer. A recurring theme in the written feedback was the benefit of being able to search for hikes by both the attributes and the difficulty, and the ability to compare the two together. Considering this feature was the defining characteristic of the AHF, this survey result reveals the success of the application in meeting the development goal.

Chapter 5 Conclusions

This section examines the achievements of the application, the challenges and limitations, and the areas of opportunity for future improvements. The applications successes are examined through what sets the AHF apart from several already existing applications, as well as its overall ease of use to the testing group. The challenges and limitations will address the setbacks faced throughout the development process of the application before its completion, and the subsequent challenges experienced as a result in testing. Finally, the future improvements section will address the areas that could be improved upon with additional work or by other studies.

5.1. Application Achievements

The results of the survey as discussed in Section 4.3 reveal that the AHF at its core level allowed users to search for hikes based on either their attributes or difficulty factors. 10 out of 13 respondents rated the application a 4 or 5 out of 5 concerning the usefulness of being able to search for hiking trails based on their trail attributes, or trail difficulty ratings. Additionally, 9 stated that they found the application easy to use. Based on the feedback from the survey results, the AHF can be considered to be an overall success. Some of the additional comments highlighted its uniqueness from other applications, in that the AHF has difficulty ratings that are defined and attributable to their actual statistics instead of a poorly defined label provided by the application. Additionally, the fact that each attribute had its own associated difficulty rating allowed users to see what in particular made a hike difficult, whether it is only one factor, such as trail length, or multiple.

The survey results also reveal that the application can be run on both a desktop as well as a mobile platform. With so many applications already available on a mobile device, it is important that the AHF is not only usable on a desktop. Luckily, the Esri Web AppBuilder

platform builds mobile functionality directly into the application, making development for both a desktop and mobile user essentially the same. Including a question in a follow up survey regarding how respondents viewed the application may reveal trends and differences in usability between the two users, and reveal clear approaches to improving the application.

5.2. Challenges and Limitations

This project faced significant challenges throughout the development process that ultimately put more constraints on the application versus the original version that was planned. The sheer number of technical difficulties, and the time taken to troubleshoot them consumed more time than originally anticipated. As a result, improvements to the application that were identified as a result of the survey were not able to be implemented, as well as a more robust version of determining a difficulty rating.

5.2.1. Technical Difficulties

Esri Web AppBuilder Developer Edition is optimized for the Windows operating system. With this restriction, a private remote workstation needed to be set. Regular correspondence became necessary to get Web AppBuilder to function remotely, delaying the development process. Other technical difficulties included an inability for anyone else to view the application, an insecure connection to the site, resulting in a security warning for those attempting to view the site, and registering the IP address causing the site URL to change several times. While delays were worked into the original timeline for completion, future work should account for even more time for troubleshooting technical issues.

5.2.2. Adapting the Project

While the AHF used the query widget to provide its core function, the geoprocessing tool was originally considered instead. Using this tool would have used a field calculator to calculate a distinct ranking for each hike so users could compare hikes to each other. However, the desired field calculation necessary for this function would not function in ArcGIS Pro during the initial development. Trying to move this calculation into Web AppBuilder was not any more successful either. Three separate Esri representatives were unable to troubleshoot the issue within the necessary timeframe, leading to the necessity of switching focus to the query tool and a different direction for the AHF. This solution sidestepped the problem, addressing the goal of the AHF to allow users to choose what difficulty factors they are interested in, just without the same level of precision that was originally wanted.

5.2.3. Esri Web AppBuilder: Developer Edition versus Online Edition

Given the attempts to develop the geoprocessing widget as explained in the beginning of Chapter 3, it was originally decided to use the Developer Edition of Esri Web AppBuilder. Once the decision was made to switch to the query widget to provide the application's core functionality as discussed in Section 5.2.2, the level of customization needed to complete the development decreased. As a result, the AHF could have been developed using the standard online edition of Esri Web AppBuilder, and not the Developer Edition. The AHF was configured within the online setting. The only customization that was attempted could have been done in the online setting as well.

Using the Developer Edition led to several technical problems addressed in Section 5.2.1. The Developer Edition requirements led to the necessity of the remote desktop, and the issues with registering the URL. While the Developer Edition is optimized for use on the Windows

Operating System, the Online Edition is browser based, meaning the computer operating system does not matter as much as it does for the Developer Edition. Unless the added customization features of the Developer Edition are needed, switching to the Online Edition can simplify the Application Development process and would have eliminated several problems faced during the creation of the AHF.

5.2.4. Shortcomings Revealed by Users

While the survey results for the AHF were overall positive, there were a few users who did not find the application easy to use, and listed several problems. The lowest rated feature was the ability to export a search result. For this feature, 7 of 13 respondents rated the ease of use for this feature to be a 3 or less, with 5 being very easy. Based on this feedback, future improvements should make exporting trails less difficult for users. Additionally, with the development of the AHF conducted on a desktop platform, mobile consideration was secondary. Because of this, three survey respondents mentioned issues with the application on a mobile device. Some of these critiques include the zoom rate when using fingers, and locating the parameter filters on a mobile screen.

5.3. Future Improvements

While overall the project achieved its goal, there are definite improvements that could be made. The trail database, currently with 50 trails, could be expanded, and more attributes included. The application could be optimized to be used more easily on a mobile device, and the application overall could add in more precision in trail difficulty selection. Finally, additional testing and surveys would reveal if improvements improved the application for the user identified issues, and determine if it has been optimized for mobile use as well.

5.3.1. Database Improvements

While 50 trails serve as a core that demonstrates the utility of the application, the ANF contains numerous more. Several hiking trails overlap with each other, allowing for numerous variations on routes that are already included. The database could be expanded upon to include more trails, and perhaps a way to identify trails that overlap with each other, perhaps as another field listing its connections to others. Other difficulty factors could include aspect, relating to sun exposure, or vegetation coverage for ease of traverse.

5.3.2. Mobile Optimization

The AHF was developed with the intention of desktop use. However, users are already used to using hiking applications on their mobile devices and several respondents in the survey stated that they tested the AHF on their mobile device. Thus in the future more steps should be taken to ensure a positive user experience on these devices. Based on the results discussed in Section 5.2.4, more testing should be done to improve the ease of zooming on a mobile device, and identifying the parameters. Further user surveys should also include a question regarding how the application is tested, on a desktop or mobile device. This added question could help further isolate issues experienced on one device over another.

5.3.3. Difficulty Ratings Improvements

Users reported in their responses overall satisfaction with being able to rank hikes on attributes as well as difficulty ratings. In the short answer responses, the AHF was complimented for the fact that users can see which attributes are difficult, because the ratings are associated with each category, and not for the trail overall. However, the original vision for this application involved a greater level of precision in choosing what factors an individual user finds to be most difficult. Integrating this into the application ended up causing a considerable amount of

problems, particularly with the geoprocessing widget necessary to implement this function. Given more time and assistance from Esri representatives, this issue is likely solvable in a future generation of the AHF. The query function could still be available, and the geoprocessing tool would be a second way for hikers to more precisely determine which difficulty factors they find most important, and how that affects which trails are recommended for their needs. Regardless, the AHF functions as desired, and can serve as a foundation for future improvements.

5.3.4. Further User Testing

After the improvements outlined in the previous sections have been addressed, the application could undergo another round of user testing and surveying. Ideally, the same participants as the first round would be surveyed again, and the survey could then ask the participants how they feel the application has been improved. A question would be added asking users if they tested the application on a desktop or a mobile device setting, as well as a section for comments addressing issues unique to the testing platform. This round of questioning would also emphasize if the ease of exporting the search results has improved. These two issues came to light during the first survey, so questions directly addressing them can provide information on whether or not they have been adequately addressed.

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Appendix A Survey Questions and Responses

A.1 Questions

Section 1 of 2

Angeles Hike Finder Survey

My name is Alexander Toy, and I am a student in the Geographic Information Science & Technology Program at the University of Southern California's Dornsife Spatial Sciences Institute in Los Angeles, California.

This project intends to develop a hiking application that lets users search for trails based on their attributes, as well as difficulty ratings for those attributes. The survey is a convenience sample, not intending to represent the views of the public more generally. However, this project seeks to understand how hikers would feel about an application that ranks hikes.

Your participation will help the researcher better understand attitudes towards hiking applications in the Angeles National Forest. Your response would be fully anonymized.

Your participation in this project would involve a short survey, which would take 5-10 minutes to complete. You would also be asked whether you would be willing to participate in a potential follow up email if there are any questions regarding your survey answers.

Benefits and Risks: The benefit of your participation in this research project is that you will help me better understand if the application functions as intended, and is easy to use for hikers. There is no cost to you for taking part in this research project. I believe there is little risk to you participating in this research project. However, if you are ever uncomfortable answering the questions, you can stop and withdraw at any time.

Confidentiality and Privacy: During the research project, all data will be kept in a secure location. Study staff will have access to the data, although legally authorized agencies, including the University of Southern California Office for the Protection of Research Subjects, have the right to review research records. In the data set, your response will be anonymized.

Voluntary Participation: Participation in this research project is voluntary. At any point during this project, you can withdraw your permission.

Questions: If you have any questions about this project, please contact me via e-mail at atoy@usc.edu. If you have any questions about your rights as a research participant in this project you can contact the University of Southern California Office for the Protection of Research Subjects by phone at (213) 821-1154 or by e-mail at oprs@usc.edu.

I acknowledge the terms and conditions above *

Yes

What is your email address? (optional)

Short answer text

.....

Survey Questions



Description (optional)

Which hiking applications have you used? *

- AllTrails
- Modern Hiker
- Gaia GPS
- Other...

On a scale of 1-5, how easy was it to navigate around the map? *

	1	2	3	4	5	
Extremely Difficult	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Extremely Easy

On a scale of 1-5, how easy was it to understand how the search function worked? *

	1	2	3	4	5	
Extremely Difficult	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Extremely Easy

On a scale of 1-5, how easy was it to apply parameters to your search? *

	1	2	3	4	5	
Extremely Difficult	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Extremely Easy

On a scale of 1-5, how easy was it to export the output result of trails? *

	1	2	3	4	5	
Extremely Difficult	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Extremely Easy

Overall, did you find this application easy to use? *

- Yes
- No
- Maybe

Please explain your previous answer *

Long answer text

⋮
On a scale of 1-5, how useful did you find the ability to search by both trail attributes as well as trail difficulty? *

- Not at all useful 1 2 3 4 5 Very useful
-

Please explain your previous answer *

Long answer text

⋮
Do you have any further comments or feedback? *

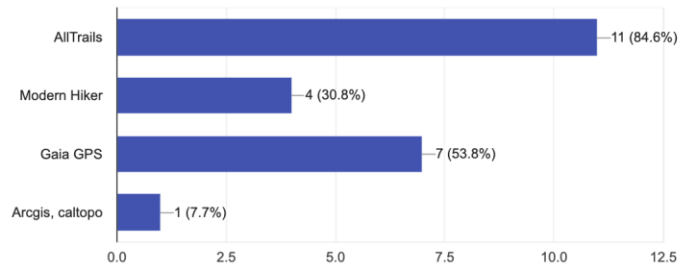
Long answer text

A.2 Responses

Survey Questions

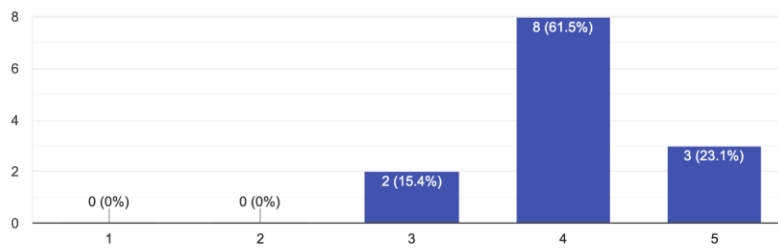
Which hiking applications have you used?

13 responses



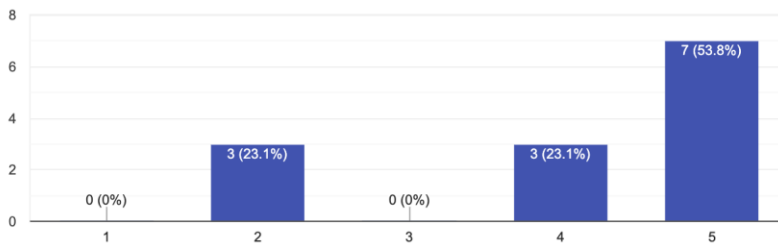
On a scale of 1-5, how easy was it to navigate around the map?

13 responses



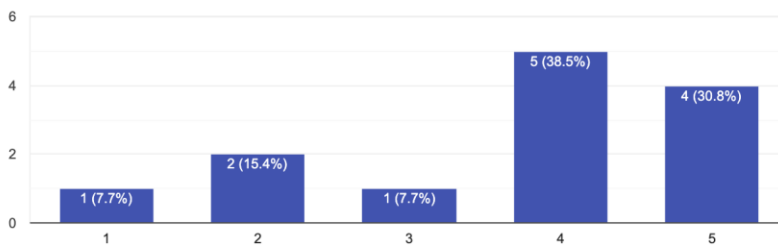
On a scale of 1-5, how easy was it to understand how the search function worked?

13 responses



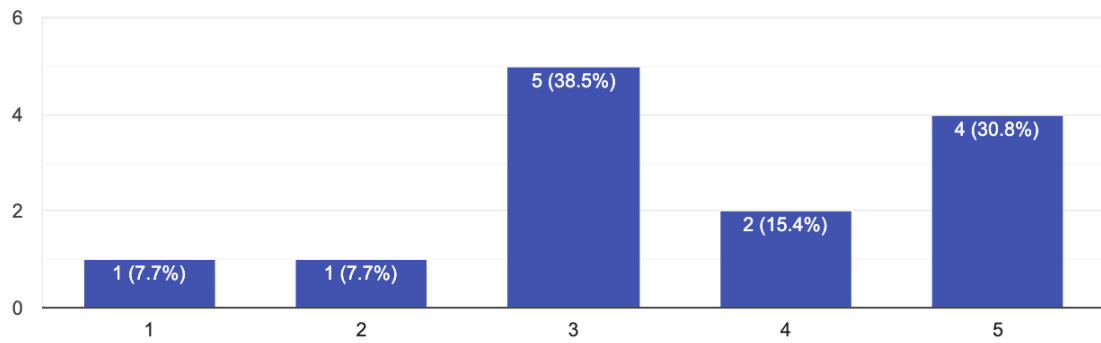
On a scale of 1-5, how easy was it to apply parameters to your search?

13 responses



On a scale of 1-5, how easy was it to export the output result of trails?

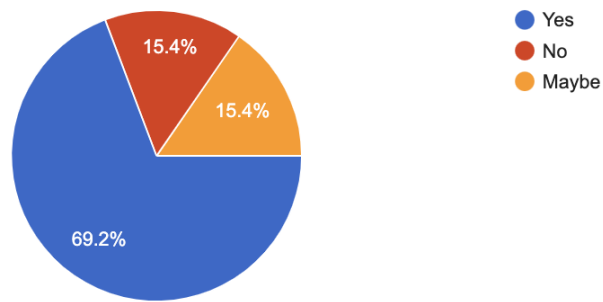
13 responses



Overall, did you find this application easy to use?



13 responses



Please explain your previous answer

13 responses

Application interface was intuitive. However, tapping specific trails often resulted in multiple selections far from the original selection. Additionally, when selecting a trail, the LA County boundary was always selected, so the user had to scroll to the specified selection. The query tool was very straightforward and returned the desired results.

it's relatively straightforward and accurate

It's super streamlined. So it makes it quick and easy

It would serve my purposes. I was able to locate a hike with my specified interests.

Search function was not intuitive; not really sure what to expect for results

For my purposes, the app provided enough information needed to make trail selection easy without having to look too much into detail about how technical a particular trail may be.

Easy, and simple. Didn't take long to figure out how it worked. I suppose one thing would be a larger font or more of table format to make it easier to read.

It's quite intuitive. Took a minute to locate the search parameter/filter at the bottom of the screen on my iPhone

For popular trails, the search function and maps are relatively easy to understand. However, I do sometimes find the written instructions a bit confusing when trying to find certain trailheads without the gps feature.

Finding hikes was quite easy, but i had a really hard time applying filters.

Zoom speed rate is too high. Consider a way for users to scroll across the map with more ease ie. using 3 fingers to swipe. The wording of the parameters also threw me off and I thought it to sound a bit clunky. Please include an option for sliding "tabs" instead of having to physically input the exact numbers into the parameters. This would make it more user friendly. Color palette can also be a bit more inviting or mimic those of actual physical trail maps / topo maps.

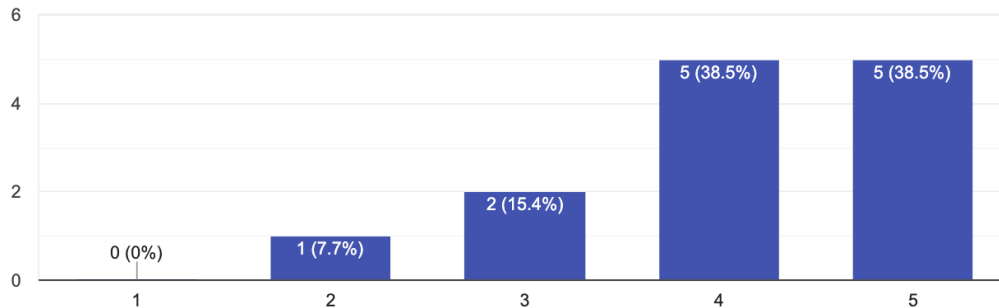
One thing would that would make it easier for people to use is by using symbol for the attributes in the introduction. Took me a few minutes to find it but once I found it. It was easy to use on both computer and cell phone.

Great tool! Definitely something I would use in Alaska.

On a scale of 1-5, how useful did you find the ability to search by both trail attributes as well as trail difficulty?



13 responses



Please explain your previous answer

13 responses

It is much easier to have the trails already rated for difficulty. Often, it is difficult to assess what metrics other applications uses to rank trial difficulty.

there really isn't a search function. I have to manually search for trails or areas

Most apps will give a 1-5 rating on difficult, or rate a trail by it's difficulty overall. This is better because the trail attributes let's me know what is the most difficult part. I can check if it's the elevation gain, or length.

Depending on one's mood, either search preference could be helpful.

Not enough results

Knowing how the scale is measured ahead of time helps in selecting trail difficulty.

Helps for planning or trying out a new trail

Categorizing hikes by length/elevation/max gain/overall difficulty was very useful. Other apps contain this information but don't really give you the option to filter by these parameters. Helpful in finding hikes nearby that suit your current mood/fitness level/etc

I find it pretty simple to filter by mileage and difficulty. I have not used it to specify any particular attributes besides those parameters.

The search bar worked great and the map was very responsive. I just had a hard time applying filters.

Hmmm...can't explain

One attribute I would like to see is a elevation chart for each hike. Also having a place to download a file / gps coordinates.

The tool was easy to use and descriptive as to the purpose of each entry space.

Do you have any further comments or feedback?

13 responses

The application worked as intended!

it would be nice if it could find an area or trail and find it on the map

I assume it's still in development, some pictures would be helpful. Especially for trail heads.

Great work!

Not enough results for what I was looking for (understandable if this changes as the app evolves a/o expands)

None at this time.

When I used the search engine the details of the hike wouldn't show up but it would bring you to that trail. Once I clicked the trail the details appear but sometimes people don't like an extra step. I didn't mind but suppose someone else might.

I would totally use this to find hikes that interest me

The only feature I wish AllTrails app had was a way to filter by hikes whose trailheads are very closely accessible by car or near a parking lot. Sometimes when searching for a trail for a social group hike, I end up spending a long time digging through search results and finding what seems to be the perfect trail, only to find it is a trail about 1+ miles into the mountain from the car, which is not ideal when with a large group.

No, great app though! The mapping software is pretty cool

No! Goodluck

Maybe don't use blue (Los Angeles) as an outline due to the fact that it reposes water on a map. Maybe trying a dark gray / black outline with gray in it.
The red outline for (Cucamonga) pops out to much, people think it might be dangerous/ off limits.(I know what you trying to go for) Trying a different color that makes it more natural for a hiking map/app. Maybe another green like seaweed / dark green. So that doesn't take away the person's interest of another area on the map.

Only suggestion would be updating pop-ups for the attribute field names and values. I.e. OBJECTID, remove underscores etc.