RECREATIONAL OFF-ROAD ADVENTURE MOTORCYCLE MAPPING SYSTEM (ROAMS):

A WEB APPLICATION FACILITATING ADVENTURE MOTORCYCLING IN IDAHO PUBLIC LANDS

by

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To Philip, my parents and Pepper

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Abbreviations

AGOL	ArcGIS Online
AMA	American Motorcyclist Association
ATGAT	All the Gear All the Time
BDR	Backcountry Discovery Route
BLM	Bureau of Land Management
BMW	Bavarian Motor Works
CC	Cubic Centimeters (displacement)
DT	Drive Tourism
EV	Electric Vehicle
GIS	Geographic information system
GIST	Geographic information science and technology
GPS	Global Positioning System
HP	Horsepower
POI	Point of interest
PPE	Personal protective equipment
ROAMS	Recreational Off-road Adventure Motorcycle Mapping System
RTW	(a)Round the World (travel)
SSI	Spatial Sciences Institute
TGIS	Tourism Geographic Information System
USFS	United States Forest Service
WCAG	Web Content Accessibility Guidelines
VGI	Volunteered geographic information

Abstract

Recreational Off-road Adventure Motorcycle Mapping System (ROAMS) is a novel application created to facilitate motorcyclists' enjoyment of nature, friends, and adventure. Currently there are limited route planning tools developed specifically for adventure motorcyclists. The developer of this application strives to apply relevant criteria and the needs of the emergent market of adventure motorcycling to this application. ROAMS is a web-based application which provides the ability to explore and locate user submitted routes that contain paved and unpaved roads and motorcycle permitted trails. Dynamic environmental events layers keep motorcyclists safe by identifying risks related to inclement weather, fire, and air quality. Points of interest such as camp sites, parks, and emergency services assist the rider in planning their experience. The application was designed to streamline the planning process and keep people safe by displaying which trails may be closed, what types of terrain may be encountered, and where weather events are occurring. In addition to enhancing the motorcyclist's experience, the byproduct of this application protects the environment by keeping riders on designated trails, away from fragile ecosystems. All routes were developed in ArcGIS Pro to allow the user the ability to filter by difficulty or seasonal closures in the web-application. This application was created using ArcGIS Online's Experience Builder and hosted in a GitHub page. ROAMS considers the motivations for motorcycle travel and incorporates these needs into a functional application; however, there is significant room for improvement in automation, data management, and interpolation. Future developments include the expansion of the pilot area, formalized user group testing, quality control, and network development.

Chapter 1 Introduction

Motorcyclists who travel off-road have a limited toolset to assist with route planning. The objective of this thesis was to provide off-road motorcyclists with a planning tool to enhance safety, support on-trail decision making, define, and modify the viability of identified routes, and improve situational awareness.

Adventure (ADV) motorcycling is a style of riding characterized by on and off-road travel. The subculture places a high priority on self-reliant, multiday travel that highlights the experience more than the destination. The emergence of the ADV segment was gradual, evolving based on available tools and technology. The ADV segment, characterized by motorcyclists who ride on and off-road, has grown in popularity in recent years. Presently, the ADV market is a complete industry in which motorcycles, gear and accessories are specifically developed and marketed for the ADV rider. Navigation tools specifically targeting ADV riders are lagging compared to the rest of the industry.

There is a market need for the development of a map-based application which will increase as the adventure motorcycling segment continues to grow. This segment is the fastest growing market in the motorsports industry (Bertram 2022). As the industry grows there will be additional need for these tools and additional financial resources for products that support the industry. This segment influx also means there will be an increase in the number of individuals who are new to route planning and route finding in off-road areas. Newer ADV riders possess a more limited skillset in planning knowledge and technical riding skill. These individuals will most greatly benefit from the direction and support that an ADV oriented mapping application can provide. Experienced riders can benefit from finding exciting new places to ride. The need

for a mapping application is present and growing as technology progresses a map with variable features can support both new riders and experienced riders.

This project created of a novel product – the Recreational Off-road Adventure Motorcycle Mapping System (ROAMS) – that supports riders with a variety of skill levels with route planning and safety. Application users can sort, and filter user submitted routes by criteria such as length, seasonal availability, and terrain difficulty. This allows a user to quickly find routes in their area of interest which correspond to their comfort level, skill level or vehicle capability. The application serves a target audience for whom the criteria that create a good ride are highly variable, meaning that each rider has a different idea of that a good ride looks like.

1.1 A Background on Adventure Motorcycling

The ROAMS application serves the ADV motorcycling niche of the powersports industry. This section establishes the framework for understanding adventure motorcycling in historical and current contexts. It explains how ADV motorcycling is defined and provides a history of the subject, then cruises through to the present day.

1.1.1 What is Adventure Motorcycling?

Adventure travel can be characterized as a trip that includes physical activity, interaction with the natural environment and cultural immersion (Wang et al. 2019). This type of travel can encompass nearly any mode of transportation; this thesis will specifically observe adventure motorcycling. Adventure motorcycling can describe a style of riding, the motorcycle itself, and the market. While the style of riding has few strict parameters, it places a strong focus on experience and exploration. The rider often favors experiences which entail less traveled dirt or poorly paved “goaty” roads as can be seen in Figure 1 which depicts a scenic adventure route.

Figure 1. Example of an adventure route (Rupert 2022)

Poorly paved and dirt roads connect to both physical activity and interaction with nature, which defines adventure tourism. Adventure motorcycles are known for a high level of comfort, for traveling long distances as well as suspension capable of maneuvering over obstacles. An adventure motorcycle is the tool that provides access to these areas. The capabilities of the tool, in this case a motorcycle, must be practical for the riders' needs and for their intended terrain. The next section offers further context into the history and trajectory of the adventure motorcycling market.

1.1.2 A Brief History of Adventure Motorcycling

The first motorcycle was invented in 1867, created by Pierre Michaux, and was a modified bicycle propelled by steam (Timeline of Motorcycles n.d.). In 1885, two German inventors developed the first diesel engine and shortly thereafter the first mass produced motorcycles began being developed worldwide. The early 1900s saw the emergence of current

manufacturers such as Royal Enfield, Triumph, Harley Davidson, and Indian. Subcultures of motorcycling began to evolve both in formalized groups such as motorcycle clubs (MCs) or informally such as groups like the mods and rockers, where membership was based on personal style. As motorcycles became more specialized, subcultures evolved in parallel.

The adventure motorcycling segment evolved with pioneers like Carl Stearns Clancy who was the first to officially circumnavigate the globe by motorcycle in (Mannion 2020). Since then, there have been many notable figures who have participated in long distance travel by motorcycle. These individuals did so prior to the advent of modern conveniences such as cell phones, community forums or ubiquity of GPS. Notable riders such as Bessie Stringfield (1930s), Ted Simon (1930s), Ernesto “Che” Guevara (1940s), Elspeth Beard (1970s), Ewan McGregor (2000s), and many others paved the way for what is the modern adventure motorcycling subculture.

1.1.3 Adventure Motorcycling in the Present Day

Adventure motorcycling in the present day is one of the fastest growing segments in the motorsports industry (Bertram 2022). The adventure specific items on the market include specialized protective gear, accessories (known as farkles), and motorcycles themselves. While true ADV style motorcycles have been on the market since the 1980s, the segment is seeing a new increase in ridership and is responding with a wider range of motorcycles within the class. This range allows yet more access to the segment, with models that are more specialized for each rider. Recently, smaller adventure bikes have become more common such as the Honda CB500x (Figure 2) or the BMW 310GS. These small displacement, lower seat height motorcycles are allowing people who are smaller in stature to comfortably enjoy adventure riding.

Within the motorcycle industry adventure riders are often viewed as having a high level of acceptance of new technology integrated tools such as improved safety equipment like airbag vests and auxiliary lighting. There is an opportunity in this market to push improvements in navigation and mapping related tools.

Figure 2. Honda CB500X with rider in full gear (Greaser 2019)

1.2 Application Objectives and Overview

This section provides an outline of the aim of the ROAMS application, describes the target users, defines the pilot area as well as software requirements. Motivating factors for the development of this application can be summarized as supporting new tools for the adventure motorcycling industry through understanding the needs and limitations of GIS based applications. There are few GIS based applications that directly serve the needs of adventure motorcyclists. In addition to supporting new technologies, the development of the ROAMS seeks to support conservation efforts through awareness and safe utilization of public lands.

1.2.1 Motivation

This research is inspired by a desire to make adventure riding more accessible by assisting newer riders with route planning and helping all riders have a safe and enjoyable experience on our public lands. While the adventure motorcycling segment is growing, it still makes up a relatively small portion of overall motorcycling groups. ROAMS and similar applications help lower the barrier to entry and this allows for a more diverse range of individuals to enjoy the great outdoors. Developing the necessary skills to navigate safely through different types of environments can take many years. An application like ROAMS helps bridge the gap between new riders and more seasoned riders. There are several critical skills that an adventure rider needs, including how to ride a motorcycle across different surfaces, how to navigate in the wilderness, as well as basic first aid, and survival skills. While simple web mapping applications may not be able to provide the user with all these necessary skills, the ROAMS application is seeking to utilize new technology to support individuals who are performing preliminary research before their expeditions off of the beaten path. The application can inspire confidence and increase safety measures by informing riders of current conditions in the area as well as general difficulty levels of routes.

Approximately 63% of the state of Idaho are public lands (Idaho Conservation League n.d.). These include United States Forest Service (USFS), Designated Wilderness areas, Bureau of Land Management (BLM), county and city managed areas. Unlocking the ability to explore these areas can help individuals gain access to a wide swath of lands which would otherwise be inaccessible. When individuals are permitted to recreate in public areas it creates the opportunity to instill a desire to safeguard and preserve those resources. Main concerns for off-road accessibility regard emissions and the disturbance of vegetation. This application helps to

minimize both concerns by helping riders stay on trails during appropriate time periods, and supporting safe, respectful travel.

For a number of trails in the system, travel is permissible only during specific time periods or motorized travel is completely prohibited. This application allows the user to input their intended travel dates to find routes that are legal and accessible during that time. This supports safe and legal travel through public lands by helping to keep users on appropriate roads with less risk of going off-trail or into zones that are not permitted, such as environmental rehabilitation zones. Allowing users to search for nearby routes minimizes highway travel which contributes to far more emissions in comparison than off-roading. Traveling on improved surfaces increases the mileage that riders may comfortably traverse per day. Riding off-road increases cost values like obstacles or challenging road surfaces which decrease the expected mileage of the rider. As the milage decreases so do the emissions.

The application lowers the barrier to enjoying the natural, rugged beauty of Idaho by simplifying the planning process. Suitable off-road motorcycling routes are often shared through word of mouth or tracing lines across paper or online maps. These forms of route planning are limited, and typically cross-referencing of regulations, elevation, and conditions is done prior to departure. This allows for an increase in tourism to rural places that would not otherwise be visited.

Motorcycle specific tourism has not been studied as thoroughly as other forms of tourism. As the ROAMS application gains usership the platform can provide additional data to support future studies on ridership so that science can better understand motivations, impacts, and infrastructure needs. This information in turn supports a better experience for the rider by allowing businesses to better serve this demographic specifically.

1.2.2 Target Users

Terms like “biker” or “motorcyclist” evoke mental representations of leather clad riders, chrome, and risky behavior. This characterization embodied by television and films such as Sons of Anarchy and Wild Hogs. In contrast to this stereotype, Adventure riders may be more appropriately defined by a shared interest in novelty and exploration on two wheels, rather than a one size fits all image (Gerai n.d.). The ROAMS application caters to individuals from a wide background, and with a wide array of interests and skills, united by a common interest in adventure motorcycling. To achieve this, ROAMS combines a streamlined user interface with a clear description of each route and filtering abilities.

The term ADV can refer to not only the type of rider, but also the style of motorcycle common to adventure riders. The industry definition of an adventure motorcycle is a medium to large motorcycle, capable of both on and off-road, and known for a high level of comfort for riding long distances. Top manufacturers for this segment are BMW, KTM, Yamaha, and Honda.

Despite the availability of these specially designed motorcycles, adventure can unfold on almost any type of motorcycle. A rider might choose a unique style for many reasons including that they are more comfortable with the performance, they seek the challenge of a less appropriate machine, or they are using what they already have in the garage (sometimes referred to as “run what you brung”). From scooters to superbikes, examples of popular adventure icons who travel via unconventional methods are Juvena Huang (The Wandering Wasp (Figure 3), Ed March (C90 Adventures), and Sjaak Lucassen.

Figure 3. Juvena Huang traveling the world by scooter (Huang n.d.)

For many styles, a benefit in one area creates a shortcoming in another. For instance, in general, super-sport motorcycles were designed for an extremely high-level of performance on fast, paved courses. This creates limitations when using this machine in other applications. High horsepower and aggressive throttling leads to wheelspin on surfaces where traction is limited. This means this type of vehicle can be more challenging to ride on unpaved or poorly paved surfaces or during times of inclement weather.

These types of performance differences across vehicle types reinforce a need for a highly customizable route recommender system. Developing a practical, appropriate route for both rider and machine depends on many variables. ROAMS includes information about the quality of unpaved sections of road to allow users to select routes based on what is appropriate or manageable for their machine.

1.2.3 Pilot Area

The pilot area for ROAMS is the state of Idaho with the intention of developing a national application. Idaho is known for agriculture, specifically potatoes, and an abundance of natural beauty, and open space. In Idaho, federal land makes up more than half of its land area; the majority of which belongs to the United States Forest Service (USFS) (Table 1).

Table 1. Federal Lands in Idaho

Agency	Acreage
U.S. Forest Service	20,465,014
U.S. National Park Service	507,585
U.S. Fish and Wildlife Service	48,947
U.S. Bureau of Land Management	11,610,111
U.S. Department of Defense	4,178
Total Federal Land	32,635,835

Idaho has twelve wilderness areas, nine national monuments, six National Parks, and one national conservation area (Congressional Research Service 2020). Figure 4 identifies the ten largest National Forest areas in Idaho.

Figure 4. Idaho State Map

The U.S. National Park Service published a study in 2013 that determined Idaho's national parks and monuments generated 614,410 visitors and $29.4 million (Ballotpedia n.d.). State recreation lands include 32 state parks generating $6.3 billion in visitor spending and $461 million in state and local tax revenue.

1.2.4 Software Requirements

The ROAMS application primarily leverages Esri ArcGIS suite which includes ArcGIS Pro, ArcGIS Online and ArcGIS Experience Builder to create a browser-based, interactive application that assists motorcyclists with route planning. ArcGIS Pro is a desktop geographic

information system (GIS) software which assists with mapping, geoprocessing, data management and integration with ArcGIS Online.

ArcGIS Online is a cloud-based platform which is accessed via web browser. ArcGIS Online supports data hosting, sharing, and application development. ArcGIS Online also visualizes hosted layers through an online web map. Web maps can be developed to utilize personally hosted layers or connect to publicly available layers such as those in the Living Atlas. ArcGIS Online also provides the ability to link to streaming data layers to visualize real-time data in a web map. Experience builder provides a streamlined interface for efficient and effective development of web-based applications. This product uses a drag and drop interface, a range of out-of-the-box widgets and extensive customization with connections to layers, maps and applications hosted in ArcGIS Online.

GitHub is a web-based platform which supports software development though the ability to host and manage code repositories. Web pages can be hosted using GitHub Pages. Pages are created by publishing a repository in a pages branch. The web page is customized using HTML, CSS, and JavaScript. These pages can be published and edited as needed.

1.2.5 Development

The ROAMS application was developed using ArcGIS Pro's geoprocessing tools for all data development. This data was then published to ArcGIS Online where it was incorporated into a web map. The web map was configured, and all additional datasets were added from authoritative sources. A web mapping application was created using experience builder and linked to the aforementioned web map. The application was configured, styled, and then embedded in a Git Hub web page.

Chapter 2 Related Work

The ROAMS application is designed to facilitate the creation of personalized routes by leveraging near real-time conditions and user selected preferences such as travel distance, road surface, and proximity to scenic areas. Research in related fields include tourism, recreation, and travel planning applications. Understanding and identifying tourists and their motivations allows the application to meet the needs of users. Identifying related travel applications helps develop a framework to build a novel application specific to adventure motorcycling. The related work chapter provides a review of studies and literature related to moto-tourism, current applications and seeks to scientifically answer the question – what makes a good ride?

2.1 Tourism and Community

Understanding patterns in tourism and community-informed decision making for the ROAMS application by illuminating economic, social, and cultural impacts of tourism, tourism sustainability, changes in tourism since the onset of Covid-19 and the perception of tourism by members of the community.

2.1.1 Community and Perception

The International Journal of Culture, Tourism and Hospitality Research found that while some negative perceptions toward motorcyclists appear to continue among some tourism operators, the economic value is improving the overall appeal of the market segment (Quadri-Felitti, Sykes and Chen n.d.). Sentiments toward motorcyclists are slowly changing and the more that people continue to tap into this market the more changes will occur.

2.1.2 Drive/Motorcycle Tourism

Drive Tourism is a market that consists of individuals who utilize a vehicle to travel for leisure. This may include single or multiday trips to one or more destinations (Queensland Government 2020). Factors that motivate drive tourism include marketing, destinations, highway networks, infrastructure, attractions, and the vehicle itself. This information supports aspects of the ROAMS application functionality, such as road networks, infrastructure, and specifying travel needs based on the vehicle's capabilities. Drive tourism relies heavily on local infrastructure including road networks, fuel availability, lodging, and local businesses.

A recent study sought to clarify the relationship between transportation infrastructure and the income of rural residents and concluded that transportation infrastructure, specifically roads, correlated with a reduction in poverty levels and income inequality (Lu et al. 2023). This study used self-reporting measures in a rural corridor with limited road network access. Research also found that resident groups were not impacted at equal rates, residents with lower socioeconomic status and less formal education did not receive as many benefits. It highlights that there is a correlation between road infrastructure and income in rural areas.

Motorcycle tourism is a subset of drive tourism; however, there has been limited academic research within social sciences despite industry growth (Cater 2017). The ROAMS application was created with this in mind, as usership grows the collected data provides scientific level data that can be leveraged to increase our knowledge base in the motorcycle tourism sphere.

The motorcycle tourism segment is representative of a market that spends upwards of $100 each day on amenities, fuel, and food (Sykes and Kelly 2016). While this number is near to the amount that other drive tourists may spend, adventure motorcycle tourists have an increased ability to disperse wealth to locations that are more remote. A significant increase in motorcycle

tourism can positively affect local economies in areas where riders commonly congregate. The article also presented a self-reported study that showed “Exploring new tourist destinations” was the top factor in choosing a destination for motorcycle tourism (Sykes and Kelly 2016).

2.1.3 Tourism and Social Media

A positive image can trigger tourists’ visit behavior (Rodrigues et al. 2023). The Idaho Backcountry Discovery Route Documentary Film as of June 2023 has over 342,460 views and 187 comments on YouTube (RideBDR 2015). The film documents the accounts of several riders across 1,300 miles of scenic motorways, highlighting beautifully remote and rugged locations. This film was successful in 2015 and is still relevant today by triggering visit behavior from riders across the globe.

Not only is social media driving tourism, but it is also informing what we know about tourism. Social media is increasingly leveraged to amend our knowledge of trends. In the past, travel related studies most often had access to observation, trail and road counters, ticket sales, survey data, and focus groups (Teles da Mota and Pickering 2020). These methods have major flaws, such as being resource intensive and/or having a high potential for bias. Utilizing public data from social media such as Flickr, Instagram, Twitter, Open Street Map (OSM), Geocaching, and other task specific applications can inform modern tourism and recreation studies. Geographic studies are accessible through the act of geotagging posts and photos, where coordinates are associated with user submissions. This information can help us understand more detailed information at a low cost. Topics of knowledge include understanding visitor needs and sentiments, economic values, spatial, and temporal analysis, and ecosystem services (Teles da Mota and Pickering 2020). Potential sources of errors center around representation as those more likely to utilize social media tend to only represent specific populations. As the number of park

visitors grow, the need for improvements and infrastructure also grows. The information sourced from social media assists in supporting and prioritizing infrastructure and continued support of tourism in the face of changing demographics.

2.1.4 Tourism Sustainability

Tourism sustainability is concerned with the balance of economic advantages with preserving local identity, environmental resources, and infrastructure (Cruz et al. 2022). Drive tourism specifically is reliant on rapidly changing factors such as vehicle technology, marketing, political environments, and climate change. The speed in which these influences change can have profound implications for social and economic ecosystems. Achieving economic and social balance in the tourism market may be unattainable; however, there are avenues that can help to mitigate undue stress on communities.

The increase in population and tourism to the state of Idaho means being attentive of the development of the application is a particularly critical component. Ensuring incorporation of any applicable laws for road segments, including approved uses and seasonal availability results in safety and more sustainable travel measures. The simplification of off-road travel in approved areas support the protection of nature by limiting riders becoming lost and damaging ecosystems in closed areas or off trail. The application supports local businesses and entrepreneurial ventures by including local businesses, rather than prioritizing map results for global companies.

To accomplish social sustainability, facilitation of cross-cultural commitment such as ecological or spiritual development should be highlighted as opposed to the focus on more superficial goals (Cruz et al. 2022).

2.1.5 Tourism Post Covid-19

The Covid-19 pandemic impacted the world in a near limitless number of ways, and as much, fundamentally affected the tourism and hospitality market. During the height of the pandemic travel limitations were imposed in every state, causing closures, and irrevocable financial harm to local economies reliant on tourism opportunities.

Understanding the Covid-19 Tourist Psyche: The Evolutionary Tourism Paradigm looks at how Covid-19 amplified fundamental human anxieties regarding social isolation and personal safety (Kock et al. 2020). A massive increase in disease avoidance behavior meant that people increasingly developed negative perceptions toward crowding and public places. How individuals understood and felt risk meant that motorcycles were not the number one threat to life and limb.

As travel restrictions began to lift, individuals increasingly prioritized outdoor leisure activities. Activities like motorcycle riding afforded more personal space while maintaining a sense of camaraderie if riding in a group (Wada, Bizen and Inaba 2023).

2.2 Current Applications

The ROAMS application contains aspects of systems such as recommender systems and navigation tools. Recommender systems seek to recommend content or services to the user based on user input. Navigation systems assist the user in navigating through the environment; this might include navigation through road or trail infrastructure or understanding the user's geographic position relative to points of interest. These applications may be available in multiple forms, most notably web versus mobile applications. Mobile applications are only available via a smart phone or device, while web applications may be accessed with a computer and internet connection.

2.2.1 Recommender Systems

Recommender Systems (RS) are systems deployed to share recommendations for services to users. Recommender systems heavily utilize algorithms, filtering, and databases. Processes that define recommender services are based on key factors that include available data, filtering mechanism, result enhancement, database scalability, system performance, objectives, and quality (Ravi and Vairavasundaram 2016). The goal of an effective recommender system is to help the user visualize only relevant information. ROAMs application meets these criteria by allowing the user to self-select criteria such as road surface and travel dates to filter the data, showing only what the user needs.

Yelp is a commonly used example of a recommender system. Yelp employs a simple interface. The list takes precedence in the center of the screen, with the map shown on the right (Figure 5). Filters to specify results can be found on the right side of the screen. Their filters include price point, category, features, neighborhood, and distance. Users can also interact with the map directly and can select the option to refresh the search as the map moves. This tool is particularly powerful as applied because the map can be set up to react to the user's location (if the user allows location access from their browser). When the map moves to the user's location items that are geographically relevant will populate in the list. Yelp's recommender system shows a powerful integration between the list and mapping tool.

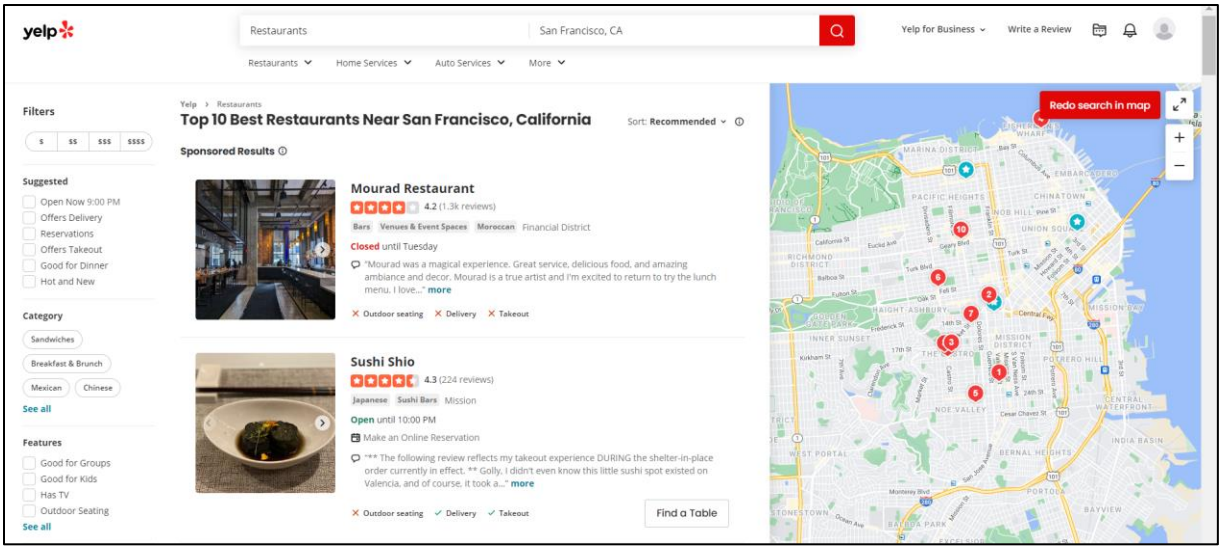

Figure 5. Yelp Recommender System (Yelp n.d.)

2.2.2 Navigation Tools

Google Maps has become the standard of mapping user interfaces. The straightforward design punctuated by clear symbols is easy to understand by a broad range of users. The aim of the ROAMS application is a similarly simple interface while maintaining the ability to feature critical information on request. There are two main reasons to use a navigation application: for necessity or for curiosity. Those who are interested in a more exploratory search spend a good amount of time panning and zooming. The ROAMs application utilizes ArcGIS Online functionality which supports standard map navigation such as click and drag for movement and scroll wheel zoom. Those who are interested in exploration also frequently utilize the point of interest tools to find local restaurants. Furthermore, they tended to utilize this feature to look up menus or home pages (Savino et al. 2021). This shows that navigation apps are extensively used as a tool for exploration, rather than specifically to get from one place to another.

MyRoute-app (Figure 6) is a web and mobile application that allows users to plot routes by searching for POIs or tapping the screen to add waypoints. My Route has features such as color, the ability to code waypoints and reverse directions (MyRoute n.d.). The application can

export the planned route to GPS devices such as Garmin or TomTom. My route does include a motorcycle feature; however, it does not consider road prioritization specific to the needs of motorcyclists. The ROAMS application is developed with a motorcyclist in mind, the search results are specific to the user in more terms than geography.

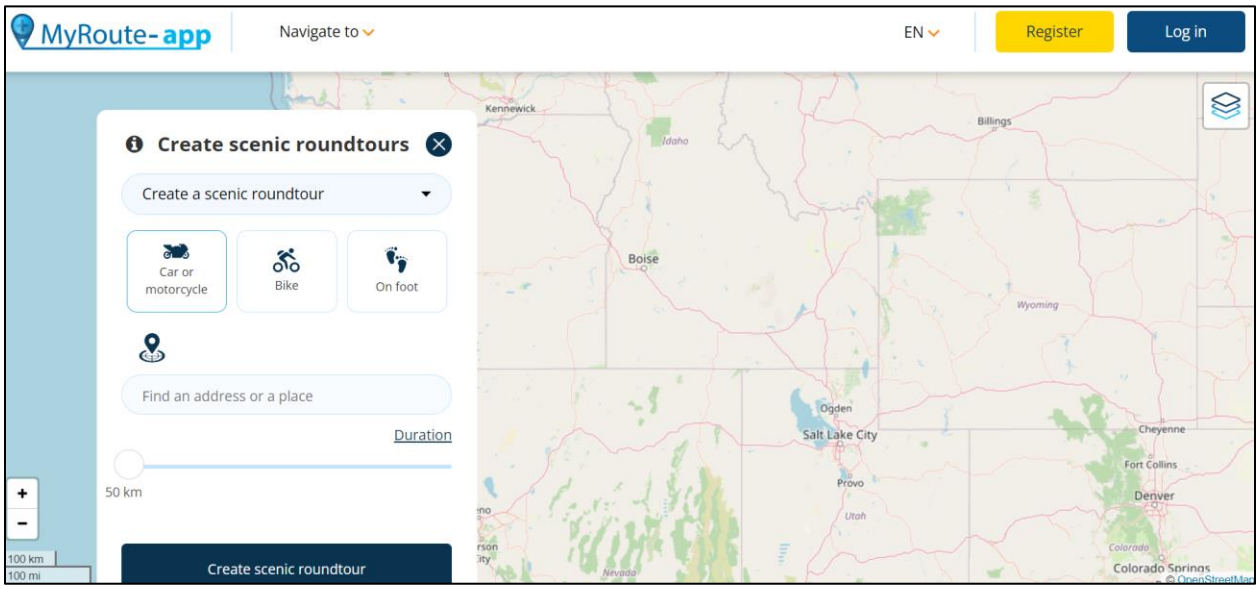

Figure 6. MyRoute App (MyRoute n.d.)

OnX Offroad is a blend of both a recommender system and a navigation tool. OnX Offroad launched in Google Play and iOS app store in late 2019. The application delivers a smooth mobile application where users can access over 550 miles of trails (Offroad onX n.d.). The routes are submitted by users and contain difficulty ratings, photos the application also contains trail closure dates and recreation point details. Custom waypoints can be included, and the routes can be downloaded for offline use. The application is available for a $30-100 per year fee depending on the subscription features. In late April 2023, OnX Offroad released a route builder feature that allows users to string together segments to create custom routes (Stoecklein 2023). The function automatically traces the closest road or trail to build a route. Once created, users can use a GPS enabled device to follow the route.

According to OnX, the trails network was created from the ground up by a geospatial team evaluating content to create a navigable network of trails. Over 1.6 million edits were made to the network as of April 2023. Figure 7 shows the OnX web application which allows users to discover new off-road routes. The available routes are submitted by users including the difficulty levels and other information. The main way to navigate the web application is via the map. When the user selects a route the details window pops up on the left showing the information about that route. This mapping application was built using Mapbox tools, which allows for custom mapping applications for both web and mobile. Mapbox also supports applications such as Strava and All Trails.

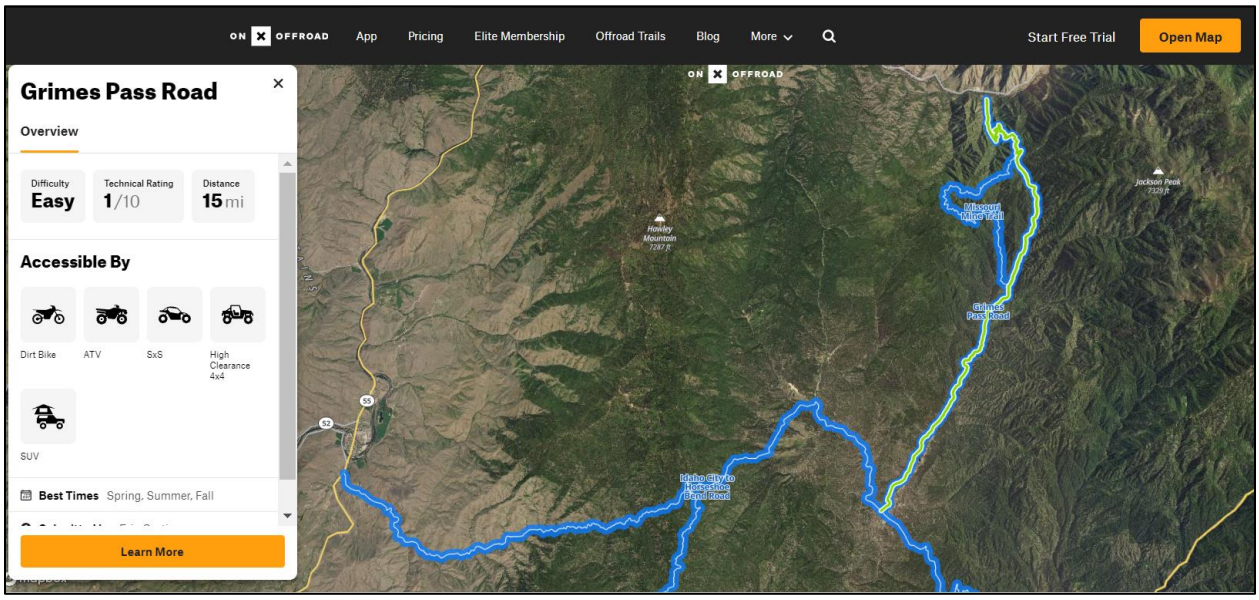

Figure 7. OnX Route Builder (Offroad OnX n.d.)

2.2.3 Web Versus Mobile Applications

Seventy-seven percent of travelers search for travel information via mobile devices (Lu et al. 2015). Reliance on smartphones for transportation is also commonplace. Attributes of successful mobile applications include perception of relative advantage over competition, consistency with user values, and marketing strategies. They include the ability to utilize unique

services through tapping into a phone's hardware such as the camera, sensors, and projectors. Studies have shown that despite this potential for innovation a negative user perception is common due to perceived inability to use the product (Lu et al. 2015). This can be minimized through prior user experience with similar technologies. This shows that the interface is of the utmost importance, particularly for mobile applications.

In many areas of rural Idaho service tends to be intermittent which could cause the application to not function properly. Adoption of the ROAMS application requires the ability to download maps for offline use; many adventure riders use GPS devices to navigate in areas with little or no cell signal. Specific to development, mobile applications also have a higher developer cost, phones and tablets vary in size and are continually changing. This means that frequent updates to manage both the functionality and user interface will be necessary.

2.3 What Makes a Good Ride?

What makes a good ride? A phenomenon described as the flow state is when an individual is completely immersed in an activity until action and awareness merge and total concentration on the task is present (Boudreau, Mackenzie and Hodge 2020). This flow state is an enjoyable, strong motivational factor for adventurists of all kinds. The flow state is a sought-after sensation experienced during a ride which can be identified as good. The flow state is measured using nine variables the first of which is described as an appropriate balance between skill and challenge of the activity (Boudreau, Mackenzie and Hodge 2020). Motorcyclists with varying levels of skill and perception of challenge can be observed in this state at different levels of difficulty. To achieve the flow state the rider must seek out and pinpoint the balance between their personal comfort zone and a challenging level of terrain. While specific criteria can be

highlighted as having a strong importance to unfolding a good ride, the weight and range of those criteria is dependent on the rider.

2.3.1 Criteria

The top reasons adventure motorcyclists embark on a ride are to experience adventure, interact with nature and enjoy friendship (Figure 8) (Ramoa, Pires and Añaña 2021). Interacting with nature can look like camping, hiking, having a picnic or simply riding motorcycles through green spaces.

Table 1. Motivations for adventure activities.

INTERNAL MOTIVATIONS – PERFORMANCE OF ACTIVITY		
1	Thrill	Adrenalin, excitement
2	Fear	Overcoming fear
3	Control	Maintain physical and mental control of one's body
4	Skills	Using expertise to perform very difficult tasks
5	Achieve	Overcoming challenges to reach difficult goals
6	Fitness	Activity simply as a way to keep physically fit
7	[Risk]	[Danger as a direct motivation]
INTERNAL/EXTERNAL MOTIVATIONS – PLACE IN NATURE		
8	Nature	Appreciation of beauty
9	Art	Perception of activity as artistic
10	Spirit	Activity as spiritual experience
EXTERNAL MOTIVATIONS – SOCIAL POSITION		
11	Friends	Enjoyment in sharing an activity with others
12	Image	Enhancing how one is perceived by others
13	Escape	A change from routine of home or work
14	[Compete]	[Competition against others]

for those items shown in square brackets [], some studies did identify these factors as motivations, but others specifically excluded them

Source: Buckley (2012)

Figure 8. Motivations for Adventure Activities (Ramoa, Pires and Añaña 2021)

Enjoying friendship seems like an unexpected motivation for ADV motorcycling because during motorcycling there is limited verbal communication between riders. Riders use many communication strategies including body language to communicate on the trail, some may even employ rider to rider communications in the form of a headset installed inside the helmet. In addition to communication on trail riders also stop for frequent breaks for food, water, rest, and

exploration. Participating in these activities with friends can be very rewarding and shared experience of the adventure itself can help to solidify that bond.

Experiencing adventure is a vague term. Adventure can be different scenarios for different individuals. Many adventures are in search of the flow state. Achieving the flow state as well as adventure itself centers the idea of skill and challenge. This can look like a variety of things to different individuals. Individuals' need for adventure can be based on skill level and comfort zone.

2.3.2 Risk

Challenge can be strongly correlated with risk. While a high level of risk taking is not intrinsic to adventure tourism, challenge and risk play a critical role in individual motivations for engaging or avoiding specific activities. Adventure travelers have higher rates of engagement with risky recreational activities (Wang et al. 2019). This correlation shows that a foundation of understanding of risk and risky behaviors should be developed to provide a framework which appeals to adventure travelers, specifically adventure motorcyclists. Adventure travel is divided into categorical risk variability; a soft adventure is relatively low risk, while a hard adventure involves higher levels of risk (Wang et al. 2019). The source article splits these items based on activity (i.e., skiing vs. rock climbing); however, it is important to note that within these activities there is significant variability in risk tolerance among individuals. While motorcycling can be considered a high-risk recreational activity, there is still a wide range of risk tolerance amongst participating individuals. While travel literature suggests that risky behavior can be related to environmental triggers, psychological research suggests that engaging in risky behaviors is correlated with sensation-seeking personality types (Wang et al. 2019). Sensation seeking is associated with a need for varied and complex sensations and often characterized by

an increased level of risk tolerance. Some risks can be mitigated through implementation of safety measures as related to adventure tourism; there is a distinct population of individuals that seek higher levels of engagement through adventure recreation. While risk is accepted by the individual, ultimately the success of the activity is directly tied to the ability to arrive home safely (Wang et al. 2019). This shows that understanding the level of risk and the variables related to adventure riding that compose risk will serve to help riders arrive back home safely, and therefore have a more positive experience.

2.3.3 Safety

While it may take a combination of many factors to make a good ride, a safety incident can negate any positive experience. Riding a two wheeled vehicle inherently comes with a heightened vulnerability that includes instability and lack of crash protection (Elliot et al. 2023). These factors must be considered for the development of ROAMS to achieve the optimal outcome. Factors that are most likely to contribute to the death or injury of the rider are speeding, overtaking and instability.

Riding off-road or in inclement weather increases the probability of encountering a situation with insufficient traction. When a rider has limited traction rider input such as braking or turning must be performed with extreme care or the motorcycle can overturn. In a motorcycle overturn situation, there is significantly less engineered protection than in a four wheeled vehicle. Motorcyclists are strongly encouraged to wear personal protective equipment (PPE) to assist with impact resistance and slide resistance. Particularly helmet use is of large concern in this, however, use of a helmet is not required in all states and may by rider preference.

Safety courses are also thought to lower the level of risk for motorcyclists. Safety courses for motorcycling both on and off-road have become more accessible for new riders and seasoned riders.

Chapter 3 Methodology

The methodology chapter explains the steps taken and elaborates on the decisions made during the development of the ROAMS application. Understanding the methodology to create ROAMS begins with establishing the needs and objectives of the web mapping application. ROAMS's primary objective is to support the adventure rider route planning experience by creating a searchable database of routes tailored to the needs of motorcyclists. Secondary objectives bring in other aspects of a "good ride" such as providing environmental context, points of interest, safety and social aspects. Once the objectives are identified, selecting the software can begin. There are many tools that can be used to create a web mapping application, ROAMS leveraged the Esri products ArcGIS Pro, ArcGIS Online, and Experience Builder. These tools were selected because of their high level of interoperability and accessibility.

Data was then prepared for integration into the web mapping application. Data was sourced and processed to assist in integration into the web mapping application tool, Experience Builder. The application was built out with considerations for accessibility, ease of use and finally deployed in a GitHub page. This section outlines the methodology used to develop the ROAMS application including requirements and objective, data description and development and software leveraged to create the product.

3.1 Requirements and Objectives

The primary functionality of ROAMS is to display an interactive database of routes created by the developer and via user survey entries. The database contains fields related to the identified criteria in the related literature that can be identified as playing a major role in a good ride. Identified criteria that make a good ride include social and community aspects, finding flow

and interaction with nature. It is well documented that social pull is a strong reason for tourism and travel.

To find flow, a balance of challenge and comfort must be achieved. To support overcoming challenges to reach difficult goals the application allows users to filter based on level of route difficulty, where comfort level can vary from rider to rider. This can be facilitated through searchable routes database by providing route difficulty ratings as accurately as possible. The mark of a successful database is searchable and filterable data via the deployed web application.

Dynamic environmental events layers need to provide real-time or near real time environmental context to be relevant to the user. The most straightforward way to accomplish this is to stream layers from ArcGIS's Living Atlas which provides a wide range of data to users to include in maps.

ROAMS also contains geographic information identifying campsites and public lands. These points of interest do not have to be updated regularly; however, they do need to be updated on a semi-regular basis. This means that these items should also be streamed from authoritative datasets or using the ArcGIS Living Atlas layers.

3.2 Software

The tools used were primarily components of the Esri Suite including ArcGIS Pro, ArcGIS Online and Experience Builder. In addition to Esri Products, GitHub was used to host the application on a webpage.

3.2.1 ArcGIS Pro

Initial data processing was performed in ArcGIS Pro 3.1. Initial processing consisted of field calculations, merging layers and development of initial routes. ArcGIS Pro is a desktop

mapping software which allows a user to create maps, edit data and publish layers to the web. This program was chosen because it provides all the necessary tools to edit the data. Tools leveraged are merge, calculate field, add features and publish to the web. While there are many other GIS software and tools available, ArcGIS Pro is currently the industry leader. The platform provides direct access to online portals, tools and public data. This means even after the data is processed in ArcGIS Pro, the transition to a web application will be straightforward and any additional layers can be sourced through the ArcGIS Living Atlas. The Living Atlas is a collection of geographic information that can be directly linked into web maps and even includes real time and near real time content. As part of the University of Southern California's Master of Geographic Information Systems and Technology program, the university provides a license to use ArcGIS Pro.

3.2.2 ArcGIS Online

In addition to providing access to ArcGIS Pro, the University of Southern California provides access to both ArcGIS Online and ArcGIS Enterprise. While ArcGIS Online and ArcGIS Enterprise functions much of the same way, ArcGIS Enterprise offers additional customization and integration (ArcNews 2023). ArcGIS enterprise supports widget customization which allows for greater functionality of the application. Utilizing this USC's enterprise would allow for greater functionality of the ROAMS application by developing widgets that negotiate limitations of the out-of-the-box widgets provided by ArcGIS Online services. The two services can be used in conjunction; however, in previous theses work issues have arisen with configuration of developer support within the USC web server (Khatry 2023). While the researcher found a temporary solution, the application could not be successfully launched as intended. It was for this reason that the ArcGIS Online environment was decided to

be the optimal placement despite limitations in configuration and networking processes. While leveraging ArcGIS enterprise would provide additional flexibility and functionality, the goal to successfully launch the piloted application was prioritized with the option of moving the application later.

Within the ArcGIS Online environment, the ROAMS application utilizes Experience Builder, an Esri tool capable compatible by use with both web and mobile applications. The developer can select to design the application based on different screen sizes and ways to navigate the tools (mouse, touch screen). Experience Builder has a high level of interoperability, particularly with other Esri tools. Esri tools were leveraged to achieve an integrated workflow.

The web experience includes a web map which serves as the container to the layers both hosted and accessed through ArcGIS Online. ArcGIS Online, a software as a service (SaaS) tool provides a database of public and authoritative hosted layers, images, and web maps. These authoritative hosted layers are maintained outside parties, this reduces maintenance costs and allow users to receive the most updated information possible.

3.2.3 GitHub

GitHub was used as the hosting service for a webpage in which to publish the application. This serves as a holding space to share the project. ROAMS was developed to be marketed as an application that will be integrated into the client's pre-existing webpage. To show this functionality, the application has been embedded into a temporary holding space which Git Hub provides free of charge.

GitHub is a cloud-based system, which is primarily used as a storage space in which a repository can be created for a project's code. GitHub Pages can host static web pages using a

HTML, CSS and JavaScript which are stored in a repository. These services are free to use provided they comply with GitHub's terms of service.

3.3 Data

Data leveraged in this application includes roads by authority, forests and points of interest (POIs). Current conditions include wildfires, weather, and snowpack information (Table 2). The data was either downloaded from authoritative online sources or added directly to the web map by linking to a published web service via URL. Initially sourced data, layers now also include VGI sourced information that allows users to submit information regarding trail conditions and safety.

Table 2. All Data

Name	Category
Satellite (VIIRS) Thermal Hotspots and Fire Activity	Dynamic Environmental Events
AirNow Air Quality Monitoring Site Data	Dynamic Environmental Events
Live Stream Gauges	Dynamic Environmental Events
USA Weather Watches and Warnings	Dynamic Environmental Events
Mask	Map Support
Mask Countries	Map Support
Roads	Network
Routes	Network
User Routes	Network
Police Stations	Point of Interest
Ranger Stations	Point of Interest
Medical Emergency Response Structures	Point of Interest
Campgrounds (BLM and USFS)	Point of Interest
Alternative Fuel Stations	Point of Interest
USA Census Populated Place Areas	Point of Interest
USA Parks	Point of Interest
Recreation Structures (Campgrounds, Trailheads, Cabins, Shelters, Picnic Areas, Headquarters, Visitor Information, Ranger Stations)	Point of Interest
USA Airports	Point of Interest

3.3.1 Roads ITD

The Idaho Department of Transportation publishes a GIS dataset representing the centerlines of all roads in Idaho. The original layer's coordinate system is NAD 1983 Idaho transverse Mercator using Meters. This layer contains 115,938 features as of October 29, 2023,

and is routinely maintained by Idaho Department of Transportation. This line layer has five fields, Object ID, Shape, SegCode, BMP (Begin Mile Post) and EMP (End Mile Post). This layer was used to show standard roadways managed by Idaho's Department of Transportation in the state of Idaho.

3.3.2 Roads USFS

The USFS publishes a comprehensive data set of managed roads within areas designated as forest services. The original coordinate system is WGS 1984 Web Mercator (auxiliary sphere). There are 169,597 segments located across the states. Each line segment contains fields including route number, name, segment length, jurisdiction, status, operable maintenance level (passenger vehicles, high clearance, etc..), surface type (gravel, native material, improved, etc.), permitted use (truck, car, motorcycle) and dates open for each permitted use. This information supports user query widgets by isolating the motorcycle use column and motorcycle dates open. It is important to note that this USFS Roads layer contains some overlap between the Idaho Department of Transportation Roads Layer.

3.3.3 Trails

The USFS publishes a data set that represents trail locations and characteristics on ArcGIS Online. The line layer shows trail location and quality in USFS Areas across the United States. The original coordinate system is NAD 1983. This dataset is updated at irregular intervals. There are currently 24,887 segments in this dataset. Attributes include trail name and number, surface, where and when users may be prohibited from using the segment.

3.3.4 Dynamic Environmental Events

Dynamic environmental events layers show the user fire information, stream depths, air quality and emergent weather information. Dynamic environmental events assist in supporting rider planning by providing insights into current conditions in the area. These layers are streamed hosted via their authoritative sources that are updated frequently to allow the user to see the most updated data possible. The service layers can be linked into a web map while reflecting updates to the original source layer. The dynamic events are included to assist the rider in understanding potential conditions they might encounter on the trail.

The Satellite (VIIRS) Thermal Hotspots and Fire Activity shows points where the VIIRS sensor on the NOAA/NASA Suomi NPP and NOAA-20 satellites have detected areas of thermal activity in the previous seven days (see, e.g., Figure 9). This layer is hosted by Esri as a part of the Living Atlas program and is managed by Esri live feeds. This layer was created on April 1, 2020, is updated every fifteen minutes using aggregated live feed methodology and points are available in the service approximately three hours after initial detection.

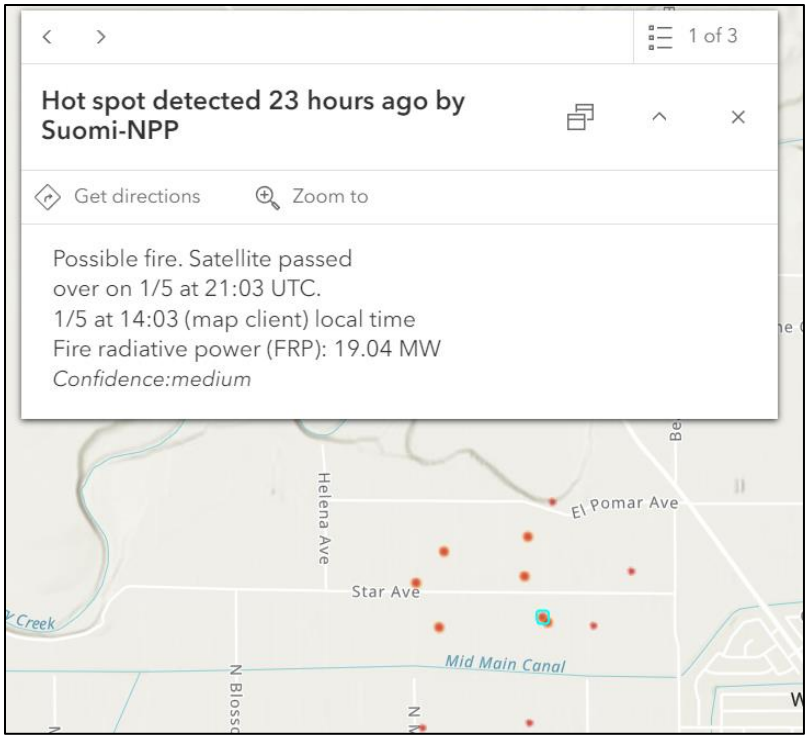

Figure 9. VIIRS Thermal Hotspots

VIIRS is a radiometer device which travels on the Suomi NPP and NOAA-20 satellite. The device measures land, atmosphere, cryosphere, and oceans in both visible and infrared bands (Esri 2024). The thermal hotspots representing potential fire activity is a product of the VIIRS imagery derived from NASA's VNP14IMG_NRT active fire detection product. The layer contains attributes including hours old, confidence and FRP which describes the radiative power of the fire in megawatts. Due to the sensor sensitivity, false positive points may occur as the sensor will produce a point for anything which has a thermal signature including volcanoes and oil wells.

The AirNow Air Quality Monitoring Site Data (Current) is a point feature layer that reflects the latest hour of air quality as monitored by stations which report to AirNow (EPA 2023) (Figure 10). This data was originally published on April 2, 2019, and is hosted by EPA's Office of Air Quality Planning and Standards. Data is updated at the end of every hour. The Air

Quality Index is focused on protecting human health and as such calculates the air quality based on ground level ozone, particle pollution, carbon monoxide, sulfur dioxide, and nitrogen dioxide. AQI us scored based on levels of health concern and ranges from Good to Hazardous with colors representing this range.

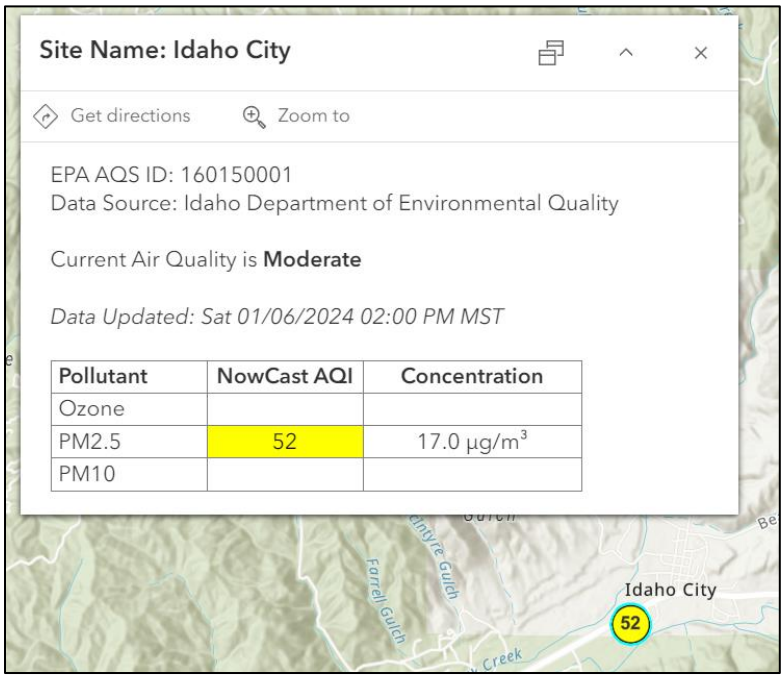

Figure 10. Air Quality Monitoring

The Live Stream Gauges layer shows current and past water depth trends at measurement points. Forecasted water depths are provided when they are available (Esri 2021). This layer was originally created January 22, 2021, and is a part of the Esri Living Atlas. This layer is managed by Esri and is updated every hour. Current data contributors to the Live Stream Gauges layer include United States Geological Survey, National Weather Service, several individual states, and country datasets are also included. It should be noted that no Idaho state specific datasets are included in the Live Stream Gauges layer; however, there are still many stream monitoring locations located in Idaho (Figure 11). The stream standard symbology is a blue point; the point adjusts to orange or red to highlight any streams which are currently flooding.

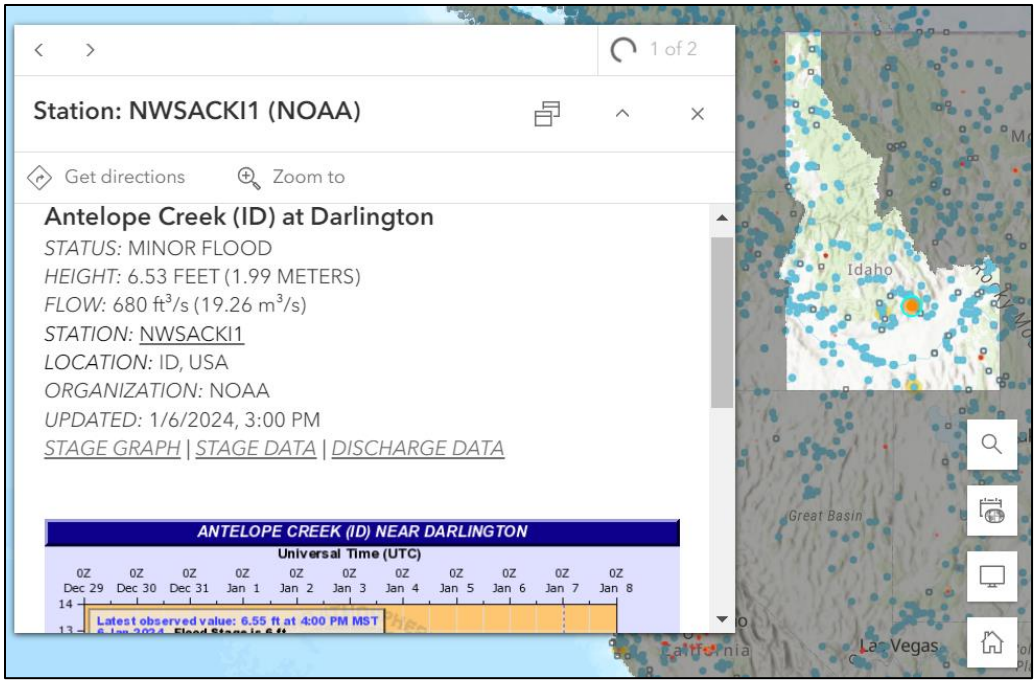

Figure 11. Stream Gauges Layer

The USA Weather Watches and Warnings is an Esri Living Atlas group layer. This data is sourced from the National Weather Service and displays polygons showing official weather, warnings, watches, and advisory information (Esri 2023). The layer is updated every five minutes. This layer is composed of over 100 categories established by the National Weather Service and include these categories include warnings for extreme wind, flash flood, fire forecasts, shelter in place, law enforcement emergency and other warnings, advisories and watches. Each of these categories is symbolized using assorted colors (Figure 12). An advisory indicates a less serious event than a watch, while a warning is more serious than a watch.

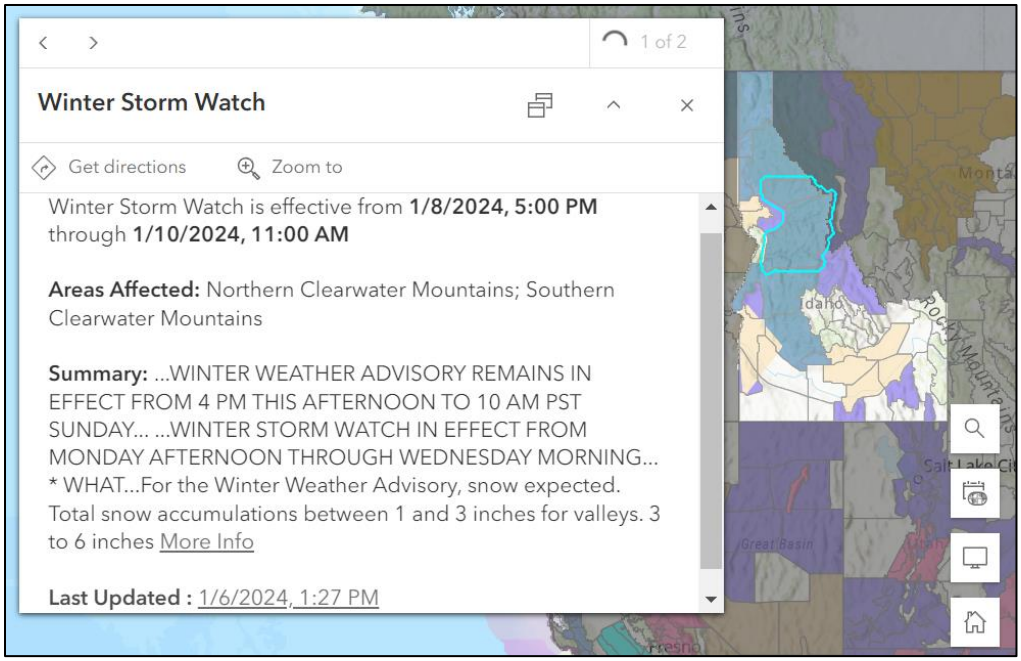

Figure 12. USA Weather Watches and Warnings

3.3.5 Points of Interest

Points of interest are layers with less frequent update intervals. While these layers are still streamed, they are less focused on delivering live feed information due to less frequently changing data. These layers reflect contextual points such as such as police stations, ranger stations, medical structures, recreation locations, airports and fuel stations.

The Police Stations is part of a group called Law Enforcement Structures which leverages National Geospatial Data Assets to show points representing police stations as well as prisons (Esri US Federal Data 2021). Published on June 29, 2021, by Esri US Federal Data, this layer is checked weekly for updates. Only the police stations layer which was chosen to be included as emergency services can be relevant to application users. In addition to the aforementioned layer, the Medical Emergency Response Structures group layer was also created by Esri US Federal Data using Nation Geospatial Data Asset data. This layer contains point locations for hospitals,

ambulance services and fire stations. This layer was also originally published on June 29, 2021, (Esri US Federal Data 2021).

The Recreation Structures layer group contains multiple layers that were used in the ROAMS web map. This group contains point layers showing campgrounds, trailheads, cabins, shelters, picnic areas, headquarters, visitor information centers and ranger stations in the United States (Esri US Federal Data 2021). This is published as a part of the Living Atlas by Esri US Federal Data.

The USA Parks layer shows both national parks, state parks, forests, country, regional and local parks (USA Parks 2014). The layer was created by Esri March 13, 2014. Parks in this layer are represented by polygons. Airports were also included as a part of the application context.

3.4 Data Processing

All initial data was processed in the ArcGIS Pro environment. ITD Roads, USFS Roads and Trails layers were downloaded from online sources. Once downloaded they were clipped to the Idaho State Boundary. To produce one layer which contains all sources, the layers were merged. During this process, attributes were knitted to together to tailor the needs of Experience Builder's filtering criteria. Any attributes that were not used in future steps were removed to streamline the product and minimize processing time. Once these steps were completed, seasonality was calculated using the calculate field tool. Seasonality refers to months during which the trails are open as per USFS fields. These attributes are calculated to allow searchability in the Experience Builder application. The next calculation performed is the difficulty field. The calculate difficulty field is performed to provide the user with context and searchability related to the level of challenge they can expect for each segment.

Initial routes were developed by selecting individual segments, calculating a new field to identify routes, copying those identified segments and merging those features based on the routes field. Once the features are merged the maximum difficulty level and the minimum seasonality are selected from each segment which composes the route. These steps are shown in the data diagram in **Error! Reference source not found.**.

Figure 13. Data Diagram

3.4.1 Clip and Merge

All data was clipped to the extent of the Idaho State Boundaries before any data processing occurred. Clipping the data prior to any other processes limited the processing time and storage associated with the storage of larger files. The USFS layers initially contained data for the entire United States

ITD Roads, USFS Roads and USFS Trails were merged into one layer, maintaining source information and fields. The merged layer was set to the Web Mercator projected coordinate system for use with ArcGIS Online.

3.4.2 Calculate Seasonality

The USFS Trails layer contains information on seasonal trail open status by specific vehicle type. For this application, the field *Motorcycle (Open Date)* needed to be used to create a

month open date in the application. *Motorcycle (Open Date)* is a text field with the open season shown by the date open, a dash and date closed. As is, this format is incompatible with Experience Builder's query functionality. To circumvent this widget limitation, the season open duration was re-coded into text string containing each month the season is open (Table 3). When added to the merged layer fields this data allows the user to specify their month of travel using a "Contains" the text filter on the Seasonal Code field.

Table 3. Calculate Seasonality Example

Road ID	Motorcycle (Open Date)	Month Open
Example 12345	01/01-12/31	January February March April May June July August September October November December
Example 12346	6/01-8/31	June July August

3.4.3 Calculate Difficulty

Difficulty was calculated for each road segment. The maximum difficulty for each route based on road segments was then calculated and used in the final product. Difficulty levels range from 1 to 4 (Table 4). These difficulty levels were developed with background information in mind; however, it should be noted that as client discussions commence difficulty levels will be refined based on the specific audience of the client.

Table 4. Calculated Difficulty

ROAMS Difficulty Level	Description
1	Novice
2	Beginner
3	Intermediate
4	Advanced

Difficulty was based on three fields from the datasets: TRAILCLASS, OPER_MAINT_LEVEL and Source. USFS Trails Trail Class fields describe the level of trail development for each segment (United States Department of Agriculture n.d.). Trail Class 4 well developed, wide trail that is smooth with a few irregularities. Trail Class 3 is single lane with areas for passing, obstacles are not substantial. Trail Class 2 is a single lane which is narrow and rough, developed with native materials and obstacles can be challenging. Trail Class 1 may require route finding, and can include narrow passages, brush, steep grades, rocks, and logs.

The USFS Roads OPER_MAINT_LEVEL describes the level of maintenance that is required for each segment (United States Department of Agriculture 2012). Maintenance level 5 is a double lane road with centerlines and edge markings, paved with stabilized shoulders (Figure 14). Maintenance level 4 must prove a moderate degree of comfort during normal season of use for a standard passenger car. These roads are double lanes and may be paved or stabilized aggregate surface. Maintenance level 3 roads are low speed, gravel surface, passable in a passenger car and may have potholes or wash boarding. Maintenance level 2 roads are maintained for use by high clearance vehicles. They have low traffic volume and often used for dispersed recreation. Maintenance level 1 are roads that are prohibited for use. This marker is often used for planned road deterioration. Standard roads sourced from Idaho Transportation

Department did not contain any conditions indication and were given a blanket value of 1-Novice with the understanding that many of these roads are paved, maintained throughways.

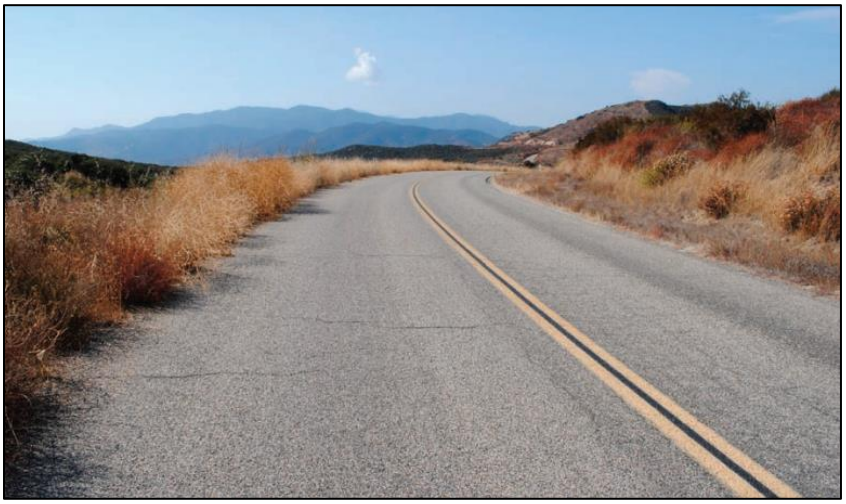

Figure 14. Maintenance Level 5 USFS Road

To simplify the process of creating a merged route difficulty and create a foundation of automation required for future application development the following script was developed for use with the calculate field tool.

```
if ($feature.TRAILCLASS=='TC1 - MINIMALLY DEVELOPED'){
    return 4;}
    else if ($feature.TRAILCLASS=='TC2 - MODERATELY DEVELOPED'){
    return 4;}
    else if ($feature.TRAILCLASS=='TC3 - DEVELOPED'){
    return 3;}
    else if ($feature.TRAILCLASS=='TC4 - HIGHLY DEVELOPED'){
    return 3;}
    else if ($feature.OPER_MAINT_LEVEL=='2 - HIGH CLEARANCE VEHICLES'){
    return 2;}
    else if ($feature.OPER_MAINT_LEVEL=='3 - SUITABLE FOR PASSENGER CARS'){
    return 1;}
    else if ($feature.OPER_MAINT_LEVEL=='4 - MODERATE DEGREE OF USER COMFORT'){
    return 1;}
    else if ($feature.OPER_MAINT_LEVEL=='5 - HIGH DEGREE OF USER COMFORT'){
    return 1;}
    else if ($feature.MERGE_SRC=='ITD_Roads'){
    return 1;}
```

3.4.4 Initial Route Development

While future routes are intended to be developed by users, initial route development was performed to provide a basis on which to develop the application. Routes were chosen based on significant research on local adventure motorcycling forms and established rides. The route segments were selected and the segments of which a part was noted in the route field. Some of the segments contained more than one route indicator. The summarize tool was used to summarize each route's maximum difficulty, seasonality and sum of segment miles. Segments indicating that they are part of routes were merged and the summarized information was joined into the merged segments.

3.5 Application Development

This section provides a detailed account of the stages to application completion specific to processes using ArcGIS Online's Experience Builder tool. Once the initial process was complete, the Routes layer was published to ArcGIS Online. In ArcGIS Online a web map was developed. A web application built on the web map. When the application was complete, it was deployed in a webpage hosted by GitHub. Considerations for accessibility and user experience are detailed in the following sections.

3.5.1 Web Map

The ArcGIS Online environment seamlessly integrates with ArcGIS Pro; all data was processed in ArcGIS Pro and published to ArcGIS Online (AGOL). Once published, the routes, roads and editable routes layers were added to a web map in AGOL. The web map serves as the foundation for the web mapping application. Esri's topographic basemap, that shows cities, water features, highways and administrative boundaries was used in the ROAMS web map. The basemap prioritizes mountains and natural areas using shaded relief imagery and "green" space.

The basemap can provide coverage to 1:4 scale for much of the world. The basemap was chosen for its visual simplicity that allows the roads and dynamic environmental events layers to take visual precedent.

Dynamic environmental events layers help the rider visualize the kinds of conditions they might be encountering. These dynamic events layers are streamed by linking to the originally published items. This results in limited work needed immediately or as updates occur. Points of interest layers were also linked into the web map. These layers help riders locate important safety, lodging and infrastructure. Labels and symbols were changed to be consistent with styling of the web map and to be more intuitive in the context of the ROAMS application.

3.5.2 User Submitted Route Form

To allow this application to grow with the user base, ROAMS is designed to accept and share route submissions from riders. These submissions will go through a formalized quality control process before they are integrated into the database.

A distinct layer was created to contain any user submissions. Attributes added were route name, route difficulty, route length, notes, and source. ROAMS uses the Edit widget to allow users to add routes (Figure 15). The user can create features by clicking and following the trail and the tool will automatically snap to the trails layer to help assist the user with accuracy. Once the user adds the route, they complete the information on the form, which was created to streamline the process of route addition. The form requests the name, difficulty, notes, and source of the route. The route length is automatically calculated and populated using an arcade expression. Once the user has entered all the required information, they can select the Create button which will create the new layer.

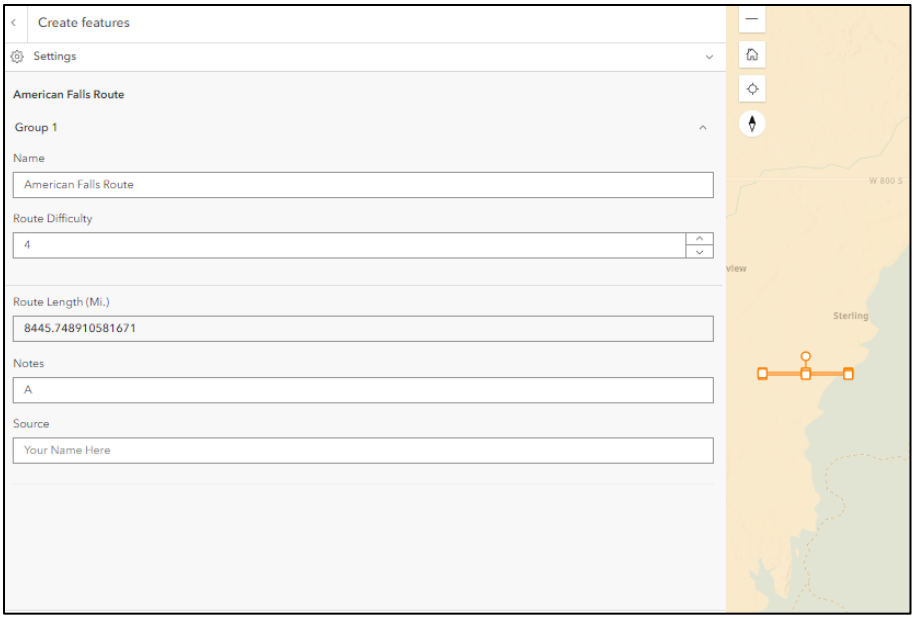

Figure 15. Create Features

3.5.3 Experience Builder

The ROAMS experience was built on the platform of the web map described in section 3.5.1 Web Map. Experience Builder is an Esri product which is accessed via ArcGIS Online (Figure 16). The tool can be configured in countless ways to create objective specific applications. The ROAMS application opens with a window disclaimer. This is particularly critical as ROAMS is in the initial stages of development. Windows can be set to pop up any time that the application is loaded or refreshed. The colors and styling used for the disclaimer are consistent with the main page of the application. The title of the page contains the application title, subtitle and three widgets to allow users to share, print maps or get directions. The directions widget can only give directions to existing roadways, not trails.

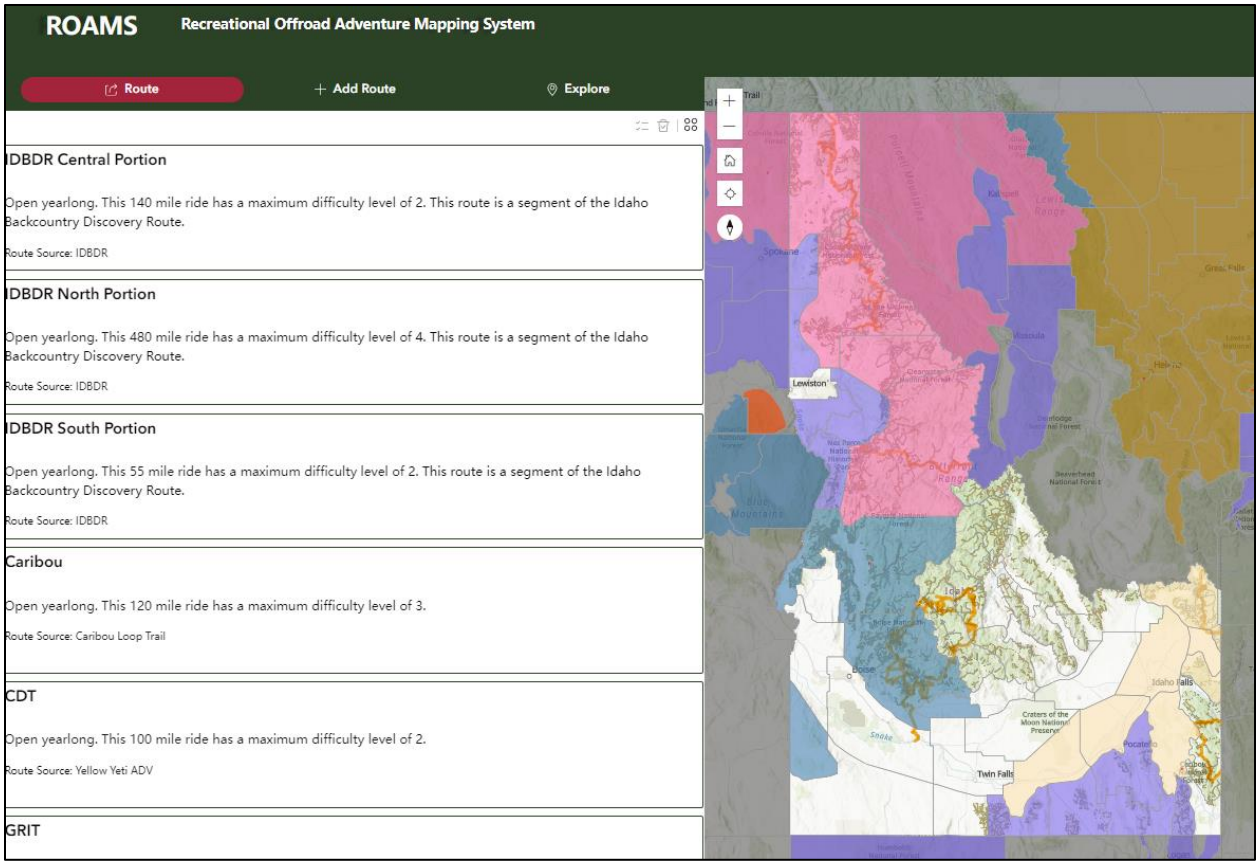

Figure 16. ROAMS Web Application

The main page contains two primary parts: the map on the right and the list and navigation on the left. The navigation utilizes three sections, which are Route, Add Route and Explore. The route section is how the application opens. This shows a list of all the available routes and a short description. The description shows the seasonal availability, route length, difficult level, notes, and the source of the original route. When the user clicks on a list item the map will zoom and highlight the selected route. The actions pop out shown as four circles can allow the user to filter routes or export routes to CSV, JSON or GeoJSON.

The add route section allows the user to create new routes by using an edit tool. The edit tool uses an editable layer called User Routes and allows the user to type in information necessary to proceed to the quality control stage.

The explore section summarizes nearby points of interest. When the user zooms to a route via the route or add route section, the results of the nearby widget show nearby VIIRS hotspots (if any) and summarizes air quality (Figure 17). The user also has the option to explore addition layers from this screen by turning them off or on.

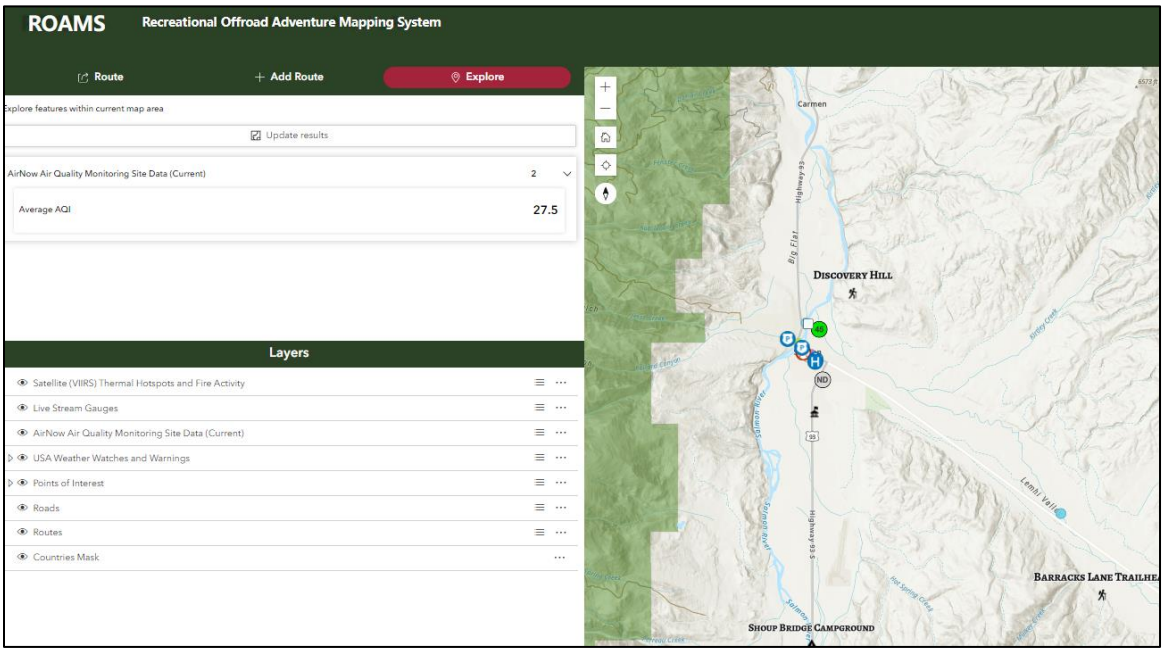

Figure 17. Explore Section

3.5.4 Deployment

The ROAMS application was deployed in a GitHub web page. To embed the experience in the page an iframe code was used. HTML iframes can be used to display a webpage in another webpage, in this context we are displaying the ROAMS web application within the GitHub page by including the web address in the source code. The image frame was set to 1025px width and 600px height, this is because the application was developed for this size. This limited the need to reformat the application. The rest of the page was formatted based on HTML as a continuation of an existing portfolio. This page was created to show the potential to include this web application in other websites once a client relationship is established.

3.5.5 Accessibility and Interface

Development of the ROAMS application included considerations for ease of application navigation, screen sizing, color palette, and other Web Content Accessibility Guidelines (WCAG) Requirements. WCAG provides detailed guidelines to improve equality and inclusion when it comes to web content (Henry 2023).

While some of these guidelines can be challenging to apply to web mapping applications, these guidelines must be followed as closely as possible to allow for a higher diversity of users, as well as to meet current regulations set forth by the business which adopts the application and prepare for future regulations. Users must be able to navigate the application intuitively, quickly, and receive the information they want. Navigation through the application pages were made possible by using the Experience Builder section and navigation widgets. There are three buttons, Route, Add Route, and Explore, which correspond to three different pages within the application. Route is the main page; this page displays all the available routes and includes a filter option. Add Route allows users to submit their own routes to the application. Explore shows the user's area of interest with layers that provide environmental and infrastructure related layers. Users are required to access the application via a web browser from a phone, tablet or computer with an active internet connection. This means the user will interact with the application in one of two ways; by using a mouse and pointer or a touchscreen. The buttons were developed to be large format to help the user accurately select the button that are aiming for.

Additional considerations were made for accessibility while wearing motorcycle riding gloves. Many gloves now have touch screen capabilities; however, these gloves add bulk to the finger which may result in some difficulty selecting the proper button. To accomplish this objective ROAMS selected a large area in a prominent location on the top left of the application, below the title to include the page navigation. The ROAMS application also considered not

placing additional buttons directly adjacent to the navigation buttons to avoid accidental selections. WCAG also highlights the importance of clear and consistent navigation (Henry 2023). This means that websites should have consistent styling and position for navigation buttons across the application. After building the Route page, subsequent pages were developed using the Route page as the framework. This kept all buttons, styling, and placement as consistent as possible.

Users are required to access the application via a web browser from a phone, tablet or computer with an active internet connection. Experience Builder can be set up for three different screen sizes. ROAMS is configured to be viewed on a computer screen (1280 x 800 pixels), a tablet (834 x 1112 pixels), and a phone (360 x 720 pixels). For screen sizes that fall in between these sizes, the application will automatically adjust to best fit the screen. Adjusting for alternative screen sizes adds multiple layers of complexity. Esri's auto-resize did an adequate job showing the most valuable information; however, much of the stylized items including the navigation pane was cut off and required readjustments. This means the application needs to be recreated for each screen size setting.

The ROAMS color palette was developed for a high level of contrast while exuding a sense of adventure and excitement. The ROAMS color palette contains primary color (Green – 2C4227), a secondary color (Red – A4243B), a secondary variant (Orange-D8973C), black, and white. The primary, secondary, and tertiary variant colors all contain a higher grey value than traditional reds or greens. This is intended to create a sense of cohesiveness and nostalgia. The green represents forest and nature, the red and orange represent excitement. These colors were assessed for accessibility considerations including color blindness using the Coolors web application (Bianchi n.d.). This shows that there is sufficient contrast between the primary and

secondary colors to differentiate between them. Areas with more text, such as the list of routes, are shown as black text with a white background to assist in distinguishing the information. The color palette is the first thing a user will observe, and a poorly chosen palette can render the application unusable. For the aforementioned reason, the color palette was designed carefully with considerations to make the application accessible to as many people as possible. To increase usership, the application needs to appeal to a diverse range of individuals so considerations for accessibility are paramount. In addition, to appeal to users, the application also needs to consider the potential future client who may be required to adhere to specific standards. Therefore, the application needs to be built in a way that can support both current and future guidelines.

Chapter 4 Results

ROAMS aimed to assist adventure riders by uniting data that had previously been disjointed and by highlighting information that is specific to a “good ride”. The application achieved these results by showing and summarizing routes submitted by users (Figure 18). The application can be accessed through GitHub at: https://advkat.github.io/Portfolio/Portfolio_ROAMS.html.

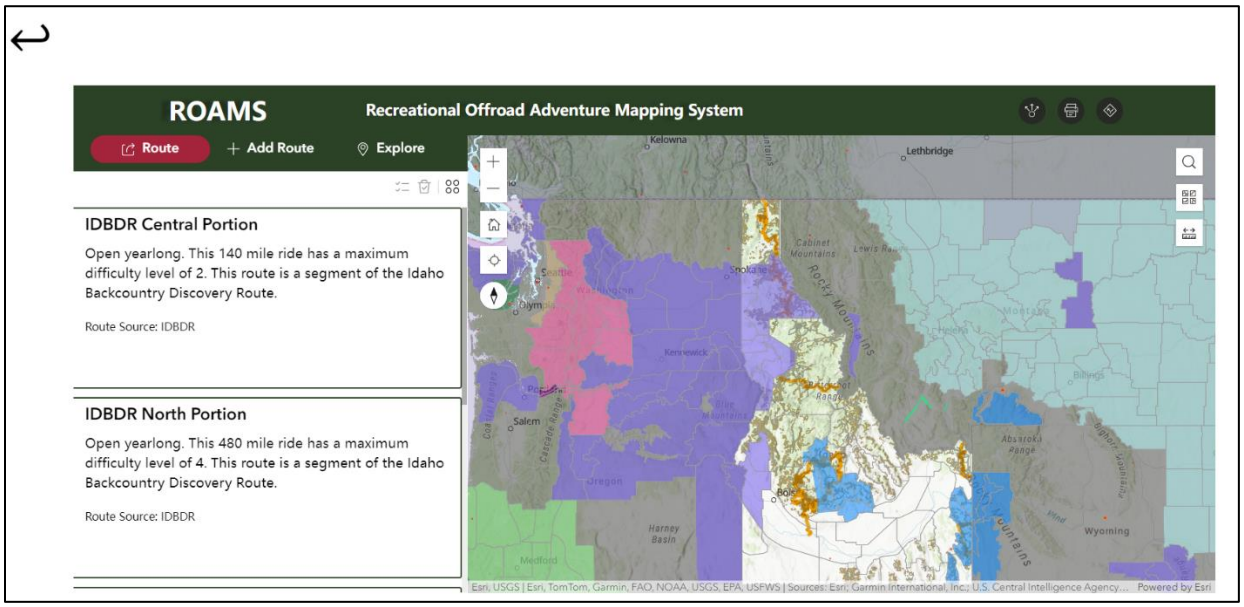

Figure 18. ROAMS Application

The ROAMS experience was built on the platform of the web map described above (see section 3.5.1). Experience builder is an Esri product which is accessed via ArcGIS Online. The tool can be configured in numerous ways to create specific applications to fulfill various objectives. The ROAMS application opens with a window disclaimer. This is particularly critical as ROAMS is in the initial stages of development. Windows can be set to pop up any time that the application is loaded or refreshed. The colors and styling used for the disclaimer are consistent with the main page of the application. The title of the page contains the application title, subtitle, and three widgets to allow users to share, print maps or get directions. The directions widget can only give directions to existing roadways, not trails.

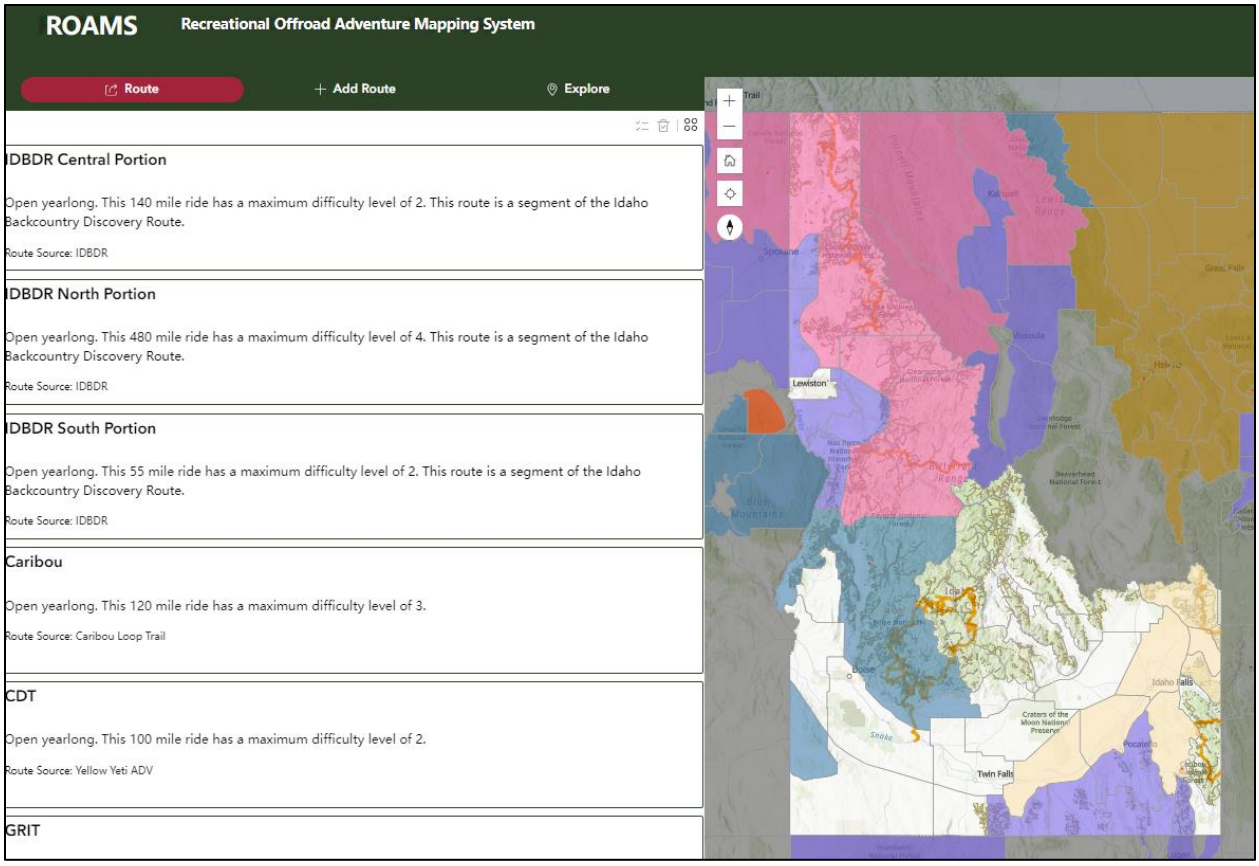

Figure 18. ROAMS Web Application

The main page contains two primary parts: the map on the right and the list with navigation on the left (Figure 18). The navigation utilizes three sections, which are Route, Add Route, and Explore. The route section is how the application opens. This shows a list of all the available routes and a short description. The description shows the seasonal availability, route length, difficulty level, notes, and the source of the original route. When the user clicks on a list item the map will zoom and highlight the selected route. The actions pop out shown as four circles can allow the user to filter routes or export routes to CSV, JSON or GeoJSON.

The add route section allows the user to create new routes by using an edit tool. The edit tool uses an editable layer called User Routes and allows the user to type in information necessary to proceed to the quality control stage.

The explore section summarizes nearby points of interest. When the user zooms to a route via the route or add route section, the results of the nearby widget show nearby VIIRS hotspots (if any) and summarizes air quality (Figure 20). The user also has the option to explore additional layers from this screen by turning them off or on.

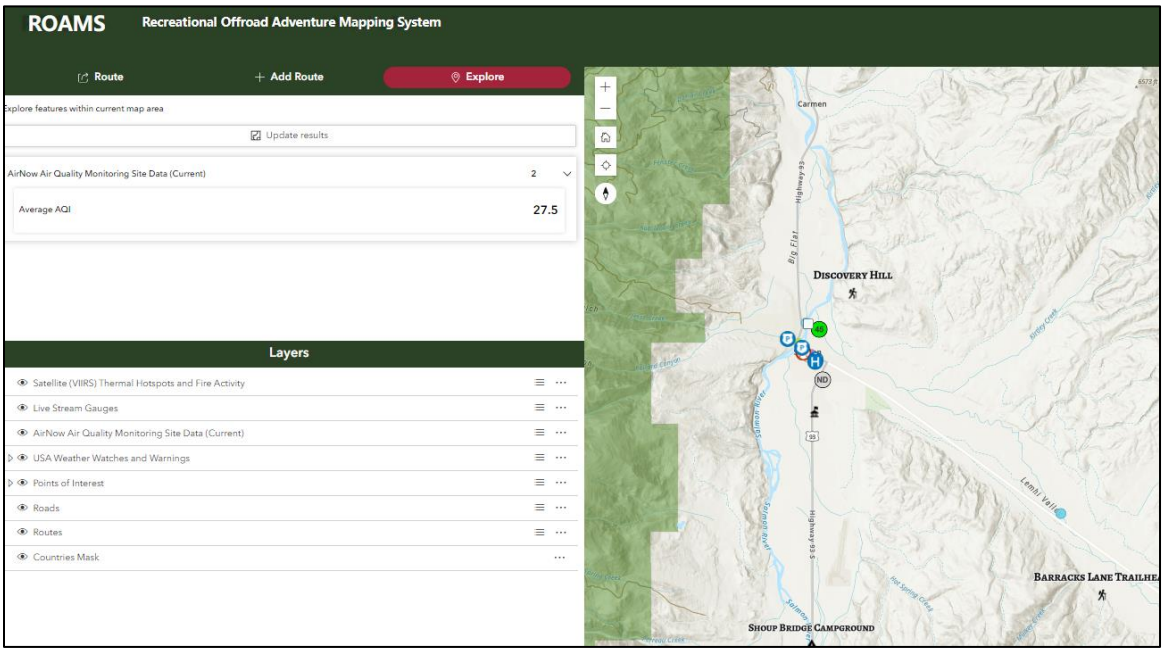

Figure 19. Explore Section

4.1 User Requirements

While this document represents ROAMS's initial stages of development, future work is intended to expand and refine the product. ROAMS requirements to use the product are computer or cellphone and an active connection to the internet. The need for internet connection presents limitations for use in areas with little to no internet access, such as while out riding. This product is intended to be marketed and published as an add on to a website with considerations for future work to bring the application out of the browser and into an app store.

4.2 Routes and Criteria

Five initial routes were created to test the initial work of the application. These routes are shown on the left of the application as a list widget (Figure 21).

Criteria identified in section 2.3.1 found the top reasons for motorcycle travel are interaction with nature, achieving the flow state, community, and social drivers. Interaction with nature was made possible in two ways; in allowing the ability to cross reference routes with the parks layer and by lowering the barrier to entry to get off the beaten path by assisting with route planning. Social drivers are supported by allowing users to share routes, publish their own routes, and easily share all routes stored in the database. To achieve the flow state the rider must experience a balance of skill and challenge. ROAMS allows the user to filter routes based on difficulty level.

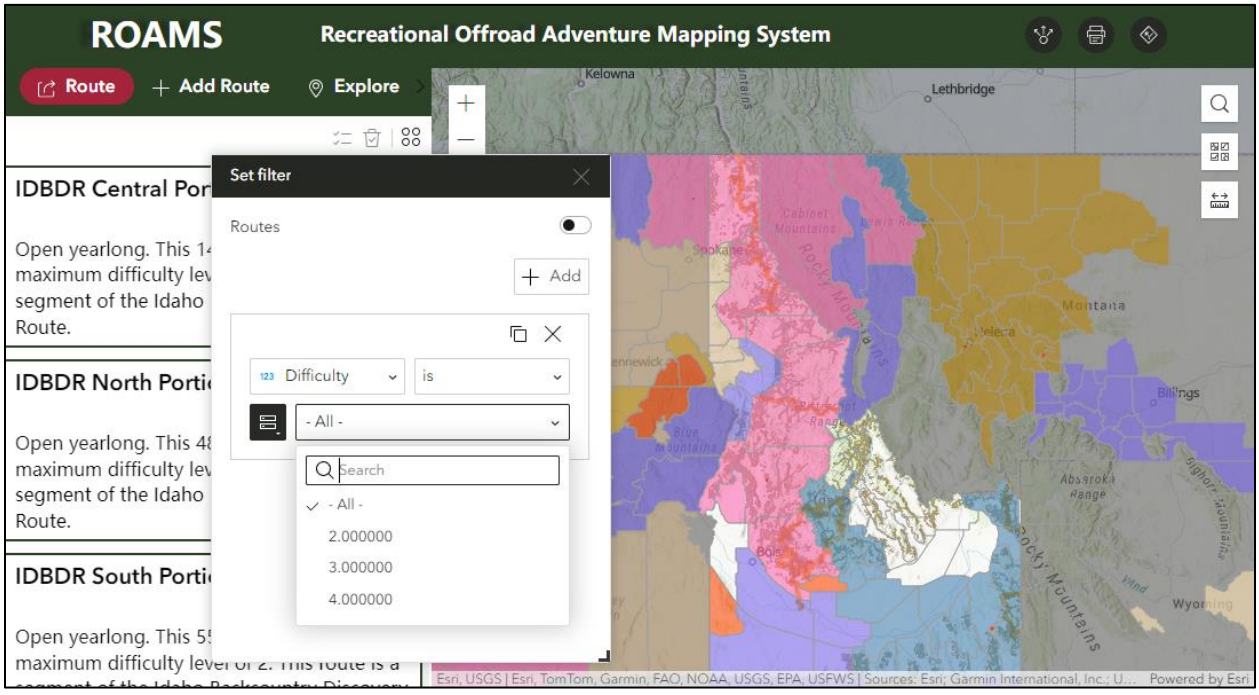

Figure 20. Filtering Routes

4.3 User Submissions

The user can develop new rides by selecting the "+ Add Route" section button from the main menu. The user traces their route, adds additional information, and can submit that route for processing and inclusion into the application. Once complete the user selects the create route.

Quality assurance and quality control will be required for any user submitted feature, but particularly routes. This is because these routes contain information which is critical to be accurate. Information provided by users can contain their perception of the level of difficulty which has the potential to be very subjective. For this reason, the difficulty will be cross referenced based on methodology defined above (see section 3.4.3). In addition to difficulty level, it is also critical to have the lines match to original trail lines. Current tools may not be practical to expect a high level of accuracy in the route geometry when users are drawing routes manually. When the route is included, the application maintenance technician will be responsible for integrating accurate geometry, subsequently merging the quality-controlled user route into the routes layer.

4.4 Filtering Routes

In ArcGIS Pro, the "Motorcycles (Dates Open)" text field from USGS contains a range of dates. With the end goal of allowing the user to select their travel date, another text field was added called *MonthsOpen*. The field was populated using the calculate tool and a selection of items with the same date range. The names of each month contained within the open period were added to the new column. It should be noted that some dates did not fall on the 1st or last day of the month, so these months were not included. The Query widget utilizes the *MonthsOpen* field using a contains statement and predefined values for each month of the year (Figure 19).

The Operational Maintenance Level allows the user to specify the type of terrain. USFS provides this field based on the options “High Clearance Vehicles,” “Passenger Vehicles,” and “Moderate Degree of User Comfort.” As this application advances more specific options will be available based on additional fields such as Road Surface and Elevation. The application has been developed to only show options that are allowable based on user input for the first clause.

Once the user has made these elections, they are able to either zoom to the extent or select the extent using a point or polygon drawing tool and select their buffer distance. Once these are applied the user can see, select, and export the results.

4.5 Dynamic Environmental Events

The Explore Section shows the user fire, stream depths, air quality, and emergent weather information. As this section opens, a Near Me widget is embedded in this page to allow the user to find items within the map view. The user can then navigate back to the list of routes by selecting the Route section. The dynamic environmental events layers support riders to make safer decisions about their route by providing real time context for their ride.

Fires are an ever-growing concern in many areas; this is of particular concern for heavily forested, dry areas, like many locations in Idaho State. The VIIRS thermal hotspots fire activity produces data approximately three hours after satellites detect the thermal area. While this information may not assist an individual who is in an imminently dangerous situation, it can help see where small fires may spread and become larger fires. This layer is also supported by the USA Weather Watches and Warnings that contains a fire forecast warning which seeks to provide red-flag information on areas which have high potential for fire activity. While a physical fire can be an immediate, acute hazard to travelers, most often the hazard is the air quality.

AirNow Air Quality Monitoring Site Data can be helpful to understand what the current air quality is before leaving for a trip. Air quality can change quickly but can also be hazardous even after the fire danger has passed. In addition to fire caused hazardous air quality, poor air quality can also arise during cool seasons where wood stoves are common and during certain wind conditions.

There are also specific conditions which can cause stream and river waters to rise; one of these conditions is a high level of snowmelt. Some routes may contain water crossings. If a water crossing is unmanageably deep this results in a dangerous situation for the rider. Getting an idea of nearby streams that are flooded can help riders make decisions that prioritize their safety based on understanding of current conditions.

As previously stated, while these conditions may change more quickly on the ground than can be updated in real time, they can still help the user get an idea of what they might expect to encounter on the trail. As the technology becomes more sophisticated the temporal accuracy will increase. It is also likely that there will be additional data points for better spatial accuracy as time goes on. The benefit of streaming these layers is that as updates occur, they will be automatically updated in the application which saves resources for future development of the application in other avenues.

4.6 Points of Interest

The points of interest layers show context that is updated less frequently than the dynamic environmental events layers. The points of interest can be understood as emergency services (Police Stations, Ranger Stations, and Medical Emergency Response Structures) and recreation (Recreation Structures, USA Parks).

4.7 Accessibility and Interface

Mobile view provides a way for users to interact with the application from a small device such as a cell phone or tablet. The Application was formatted for three size screens Mobile (360 x 720), tablet (843 x 1112), and desktop (1280 x 800). To access the application outside of the web browser format, the website provides a link below the embedded application which directs users to the application which can sense and resize the application appropriately.

4.8 Software and platform

Software leveraged was ArcGIS Pro, ArcGIS Online, and GitHub. ArcGIS Pro and ArcGIS Online were created to work in synchrony. Layers published online can be accessed both in the online format or through the ArcGIS Pro software. The ROAMS application was embedded in the GitHub page using HTML tags which allows a web page to be shown within another page. This allows users to access the application when it is published in another page. This is to allow a client to adopt the application and add ROAMS to their existing website.

Chapter 5 Discussion

The application successfully achieved the goals outlined in section 3.1. There were frequent challenges that presented themselves during the development of this project. This chapter enumerates those challenges and reviews areas where opportunities for future developments remain. Challenges include inconsistent data updates, lack of resources for network development, limitations on customization, and connectivity limitations. This section also includes a comparison to OnX Offroad, which was developed during the same period in which ROAMS was developed and shares similar goals as ROAMS.

At this point in the application there are no user submitted routes. All routes have been pre-created as examples to show what routes will look like once users begin to make submissions. As the user submits a route it will be manually added to the official routes layer. This process has only been completed a few times so there may still be additional refining done to the process. Additionally, there may be a point in the application where user submission volumes increase, and the quality control process has financial or time limitations on keeping up with the demand. In this case, future refinements will need to be completed in the form of python scripting or ArcGIS Model Builder to automate the task.

Essential factors which make a good ride are identified as interaction with nature, friendship, and adventure. These criteria were confirmed to be supported in the application. These criteria can be seen in dynamic environmental events and points of interest layers. Emergency services and dynamic environmental events assist the rider in planning a safe ride. While most often these are not forecasting tools, these layers can still provide information for rides which are planned soon. Point of interest layers show the user where emergency medical services may be located which serves the safety criteria. The recreation layers show locations

where the user can camp, hike, or visit a park, this assists users to interact with nature, another criteria identified as making a good ride. Social criteria can be fulfilled through sharing the rides with others they plan to take a journey with or publishing their own ride.

User submissions allow for the user to include their own routes in the application. The user submits these routes using ArcGIS Online Forms integrated into the Web Experience. While this ultimately was successful, there is some potential for the quality control measure to become too labor intensive to continue to process new route suggestions. This will need to be automated in the future which poses a large challenge because of the human factor of entry.

Many of the route filtering functionality changed throughout the development of this process. The final filtering method used the list widget to allow users to query their results. The integrated tool is excellent for streamlining the look of the user interface, users may find the filtering feature challenging to find or difficult to use (Figure 22).

ArcGIS Pro and ArcGIS Online Experience Builder worked seamlessly together. In the future development of this application there should be consideration for moving this to ArcGIS Enterprise to allow for a higher level of widget customization. The ability to customize widgets would allow ROAMS to carry a more distinctive style and polished user interface/user experience.

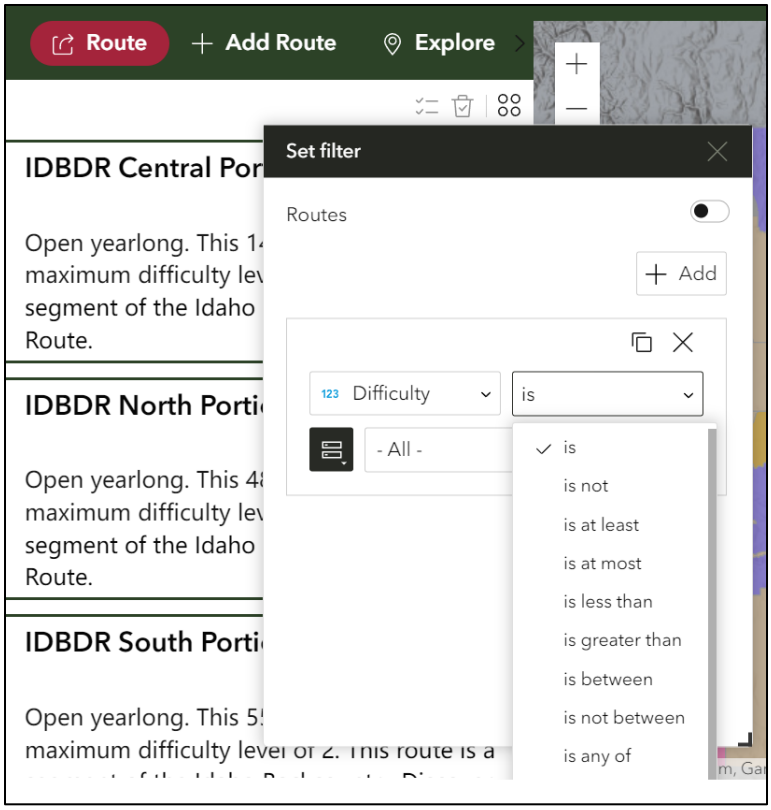

Figure 21. Filtering Clause Set

5.1 Challenges and Opportunities

There were a significant number of challenges to the development of the ROAMS application, including infrastructure limitations, and unplanned data inconsistencies. Initially the work offered to build a network that could allow users to develop their own route, this proposition was abandoned due to time and resource limitations. The work also proposed development of custom widget which also was not possible under the current system. Additionally, the datasets were changed during the development of the application which required an overhaul of the systems originally in place. These types of issues should be expected when building an application and can be accounted for with expertise with the systems along with ample communication.

5.1.1 Data Updates

Data challenges to the development of ROAMS center on the idea of building consistency in a frequently changing world. A critical trial to this data is that the three datasets that represent roads (ITD Roads, USFS Roads, and USFS Trails) are updated irregularly. Changes to these roads could be addition or removal of roads or adjustment of fields, such as the dates the route is open or closed. The merged layer used as the basis of this application is a standalone layer that does not have the capability update as the foundational layers change. Adding functionality for regular updates would bring a new level of value to the product. Development of this tool is currently in progress via the model builder application. Efforts were made to develop a scripted model to perform the data update process; however, during testing a field name was changed in the published USFS GIS, the model broke, required troubleshooting, and needed repair. This led to delays in the republication of the dataset, as well as reconsideration for the viability of the model. To create a product that is effective, we will need to communicate with USFS GIS team to alert them to changes in the data structure to avoid future issues. Additionally, the publication of new field names caused the need for a full update of the application due to the field name dependent widgets. Inconsistencies in regularly updated data is common. The solution to this is communication of these updates and planning flexibility into the application.

5.1.2 Network Development

The ROAMS application was initially proposed to be a customizable network dataset; however, with limited time this proved to be a concept that will need to be addressed in future deployments. The application idea was originally conceived of with the intention of allowing users to select distance, season, and develop a route based on a customized network. A network

dataset is a transportation model which can serve as a platform to solve connectivity scenarios. These datasets can be used for many different types of transportation modeling such as bus, rail, and road networks. Esri currently allows users to utilize their pre-made network dataset. This service is not free to use and only contains drivable roads, not trails. To include trails a new network dataset needed to be developed based on the data sourced for roads, forest service roads, and forest service trails. The road segments proved to require significant human processing to create a viable product. Manually linking all the connections and processing each roadway was not possible in the limited time to develop this product. Future work should be completed to begin reformatting the lines to achieve this need in the future. This concept is discussed in greater detail in section 5.2 Comparison to OnX Offroad.

5.1.3 Widget Customization

By their nature, every service has limitations; offerings of the service have natural borders which mean that which services are used must be carefully considered. Previously published work determined that due to structural system limitations in USC web server creating custom widget to show routes would not be possible at this time. Initially it was intended to develop customized applications that appealed more to the target audience. Because the custom widgets could only be created in ArcGIS Enterprise this option was no longer available. This created a limitation by having to only rely on out-of-the-box widgets, using existing settings to provide the best possible result for the user. While out-of-the-box widgets were able to satisfy the ultimate goals of the project, the user interface could continue to be refined in the future using custom widgets that allow for additional flexibility and improved user experience. Specifically, the list widget which displays each route could have been improved upon by allowing a filtering system that was more streamlined. A filtering system would add value to the

product by improving the ease of use and efficiency of the application, as well as upgrade the overall look of the product. This step would be optimal after a client relationship was established to fully incorporate the client style guidance.

5.1.4 Connectivity Limitations

There is a strong need here to improve the application to allow for additional functionality while offline such as downloading the data for offline use or downloading the route for use with a GPS device. In its current state, the application requires an internet connection. Accessing the application with limited connectivity is not possible. If the user has already navigated to the application layers showing current conditions will be unavailable or out of date. The current events features were developed for riders to observe changes in their environment in real time. This suggests riders will use this application while riding. In many areas with a surplus of off-road opportunities there is limited cell service which interferes with the usability of the application. This issue can be resolved by making an offline compatible version of the application which would allow the user to save their map by printing or saving the image locally. This solution poses several technical challenges which include consideration for any updates to real-time environment information layers that are hosted by other organizations and streamed into ROAMS which would not be updated. This solution also suggests that a static map is adequate for users and does not provide an interactive system. A second solution would be to improve interoperability between a GPS or other device and ROAMS. This would allow users to send routes directly to their preferred offline device before they begin their journey. This solution would be particularly beneficial if the application supported turn by turn directions in the future.

5.2 Comparison to OnX Offroad

The OnX Offroad application identified a need in the market in parallel to the ROAMS application. The newest feature, allowing for route planning, is being unveiled during the development of the ROAMS application. OnX exemplifies the goals of the ROAMS application; however, these features come at a cost to users. The OnX data development shows that a network is possible given an extended timeline, additional financial, and personnel resources.

Potential criticisms of OnX Offroad include that difficulty ratings lack consistency. This can be attributed to the ability of users to submit their own difficulty ratings. Difficulty ratings can change based on skill level, vehicle type, capability, and environmental changes. Trail difficulty ratings can be a challenge to pinpoint due to changing conditions, machine performance, and personal preferences. While it doesn't directly solve the issue, ROAMS includes supplemental information such as river and creek level indicators and weather conditions to help account for the challenge here. ROAMS also uses a standardized system of rating based on trail maintenance levels, so the system is consistent in the level of maintenance provided the data delivered by USFS is accurate and current.

In addition, ROAMS is specific to motorcycle travel, and while difficulty can still vary significantly, there are specific factors that are related to traveling on two wheels rather than four. While OnX offers several different vehicle types, they only show one rating. An easy route for a jeep may be extremely difficult for a motorcycle. For instance, rocky surfaces may be much more difficult on two wheels due to the balance which is needed to manage surfaces which are moving as the vehicle travels over it. Likewise, some routes may be easier for a motorcycle because a narrower footprint may mean that they can select a more optimal "line" or path of travel through the obstacle.

5.3 Future Work

Future work for the ROAMS application can bring significant value to the application. Two such examples of future work are formalized user group testing and the expansion of the pilot area.

5.3.1 Formalized User Group Testing and Quality Control

ROAMS will benefit from both user interface testing and field data confirmation. User interface testing would serve to find additional opportunities in the resulting application. The focus groups will help determine if the user interface is effective and the application meets the needs of the rider through a survey. Testing will consist of focus groups where participants will be selected from a pool of adventure motorcyclists with consideration for a sample size which includes a range of levels of experience. The participant will be asked to use the application and then complete a survey that will be deployed using Google Forms. Published data will be field verified on a ride-by-ride basis by local adventure riders after the commencement of this document. The rider intent would be to confirm difficulty rating, include any additional information on the route, and verify all locations are open and maintained.

5.3.2 Expansion of Pilot Area

As this idea is adopted by an interested party the area shall be expanded to the client's area of interest. The success of the pilot area showed it will be possible to expand the scale of the application. Idaho proved to be an excellent opportunity to explore the scope of the application. The main objectives have proved to be possible to meet with an application such as this. One of the goals of the ROAMS application is to unite multiple agencies and jurisdictions which have been disjoined by formalized boundaries. Allowing the ROAMS application, a wider geographic range reinforces this notion. Additionally, a more expansive geography would allow for a greater

number of users to use the application. As the number of users grows the number of routes that have been volunteered will also grow. This in turn will increase the impact of the application. It should be noted that when expanding the application some areas may have very limited off-road. States like California have far less routes available to off-road riders. Areas with more off-road availability will be more influential on the application and these should be a higher priority when planning expansion.

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Appendix A: Data Diagram