Planning a Bike Trail: The Northwest Segment of the Sun Corridor Trail

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Abstract: The Sun Corridor Trail is a proposed 1,500-mile trail that will connect communities in the Southwest United States and stretch from Las Vegas, NV to Douglas, AZ. It will cater to a myriad of users including cyclists, hikers, and horseback riders, and it will consist of on- and off-road sections. The goals of the Sun Corridor Trail Alliance (SCTA), who are overseeing development of the trail, include connecting existing roads and trails, providing cultural and nature-based experiences to users, linking communities that provide amenities to users, and building a route that accommodates experienced and novice users on single day and multi-day outings. The purpose of this study was to research and test routes for the northwestern segment of the trail between Williams, AZ and Bullhead City, AZ. Additionally, this study aimed to test the feasibility of gravel bike users and credit card touring along this segment of the trail. Test routes were selected with the help of Google Maps and Gaia GPS to identify potential obstacles and points of interest. Once a route was determined, it was traversed using an appropriate bike to emulate the target user. Criteria was created based on previous research to assess and score each tested route. In addition, ArcGIS Pro was used to conduct a cost corridor and least-cost path analysis in respect to existing roads and trails, land ownership, and slope between destinations within the study area. These analyses were then compared to GPS tracking data that was collected while traversing selected routes. I conclude with providing recommendations for each route tested and the practicality of the GIS analyses.

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Introduction

In the last few decades, the outdoor recreation industry has experienced unprecedented growth (Weaver, 2021). Mountain biking and rock climbing made their Olympic debut and the long-distance hiking, backpacking, and trail running industries have boomed. Long-distance cycling activities have also recently seen a resurgence, including the emerging gravel cycling industry (Singleton, 2022). Whereas cross-country road cycling routes, such as the TransAmerica Bicycle Trail and long-distance backpacking trails such as the Appalachian Trail have maintained national recognition, long-distance gravel cycling events have grown in popularity. Singleton (2022) notes that gravel races have popped up in many states and, unlike competitive road races, gravel events cater to more casual participants. In addition, the COVID-19 pandemic and growing remote jobs market has accentuated a demand for outdoor experiences and more people have gravitated toward outdoor recreation to compensate for growing and more frequent at-home lifestyles. Matt Eby, CEO of Seawall Capital which owns outdoor brands including Kona bicycles, states “the work-from-home environment enabled [people] to pick up new activities that became hobbies” (Bruton, 2023).

The Southwest United States is home to many outdoor experiences including long-distance trails. The Arizona Trail promotes a backcountry experience to hikers, backpackers, and equestrians as well as mountain bikers through its non-Wilderness sections. The Arizona Peace Trail stretches north to south in western Arizona and provides OHV users the ultimate off-road experience (Arizona Peace Trail, Inc., 2022). Yet, there are no long-distance trails that directly connect rural and metropolitan communities and provide non-motorized, frontcountry recreational experiences. One such trail that seeks to fulfill this need is called the Sun Corridor Trail (SCT) and is in its initial planning stages. The SCT is a proposed regional trail that will stretch diagonally from Las Vegas, NV to Douglas, AZ and cater to cyclists, hikers, runners, and horseback riders (Sun Corridor Trail, 2023). It will link towns and cities across the region,

ranging from small rural towns to major metropolitan areas. One of the goals of the trail is to promote 'credit card' tourism to invigorate the region's recreational economy while also promoting conservation and cultural immersion into the environments and communities it routes through.

The proposed route of the SCT's northwest segment between Williams, AZ and Las Vegas, NV is relatively unknown and research on the possibilities for a route was needed. The Sun Corridor Trail Alliance (SCTA), the organization overseeing the development of the SCT, has been particularly interested in investigating the possibilities for the trail through this segment due to this region's ruralness, lack of existing trails, lack of public lands, and mountainous boundaries. While previous work on other sections of the trail have produced methods and a framework to determine the best possible route of the SCT (Smath, 2020), little attention has been given to this northwest segment. Updating and applying previous research methods to determine possible routes through the northwest segment will provide necessary input for the development of the SCT. The research conducted for this project is an investigation of possible routes in the northwest segment of the SCT between Williams, AZ and Bullhead City, AZ. Mapping web applications and satellite imagery was used to select routes and each route was tested targeting a specific user type. In addition, 7 criteria were scored for each route tested. Finally, least-cost path and least-cost corridor GIS analyses were conducted and compared to the results of the test route to determine if these tools could be used to suggest potential routes in future research.

Literature Review:
Reasons for and what to include in the development of a trail.

Certain themes were present when examining literature about the reasons for and what to consider when planning a trail. The economic impact of a regional trail–such as the SCT–should be considered, including the overall benefits and drawbacks for individual towns and sections. When assessing the possible route configurations, it is also important to keep in mind the eventual users and their preferences. Another potential benefit of regional trails is linking ecologically diverse environments that provide for recreational demand while also providing a mode for conservation efforts. Finally, the SCTA is partnered with multiple organizations and their involvement and cooperation in the development of the trail is necessary to its success. While the literature reviewed for this research offers insight into the reasoning for conducting research on the northwest section of the SCT, the gravel cycling and credit card touring industries are relatively novel and research literature is lacking. Therefore, additional review may be warranted as more information comes to light.

Economic Impact and Financial Means

One of the goals of the Sun Corridor Trail Alliance is to stimulate economic gains in the communities that the trail routes through (Smath, 2020). Users of the trail would enjoy amenities along the way; such as restaurants, grocery stores, lodging, and gear supply and maintenance as well as other tourist attractions that provide economic benefit to business owners and community members. Other regional cycling trails, such as in the case of the Vennbaun cross-border regional trail, have shown an increase in total overnight stays and economic gains related to recreational use as a benefit to regional trails (Stoffelen, 2018). In addition, proximity to trails, greenspaces, and recreation can positively impact the intrinsic and economic value for trail communities. For instance, property values have been shown to

increase with relative proximity to greenspaces and public open spaces (Munroe, Parker, and Campbell, 2004). This is consistent with residents' and property owners' beliefs about salability of properties adjacent to trails (Corning, Mowatt, and Chancellor, 2012).

Economic gains may also influence the maintenance and further development of the Sun Corridor Trail. Tourism stimulates economies, potentially more so in rural areas, which may be realized in government tax revenues. Munroe et al. (2004) noted the increase in tax revenue to local governments that could be used to maintain trails, such as the SCT, and develop other recreation opportunities. Furthermore, recreational development and ecological conservation can be merged in the development of regional trail systems which can reduce maintenance costs. With limited financial means, the design of regional trails can incorporate conservation and recreation costs (Courtenay, Carrol, and Lookingbill, 2014). For instance, trails can promote awareness of conservation issues and educate users on the environmental, cultural, and historical significance of the lands it travels through. By providing access to lands, trail users gain ownership in maintaining trails and conserving resources thereby reducing these costs to land managers and recreation organizations. Similarly, promoting good trail ethics amongst users reduces maintenance costs for land managers, and Williams et al. (1992) found that desirable trail conditions can support proper trail ethics.

Recreation and Conservation

As mentioned above, pairing recreational and conservation goals may help alleviate financial limitations of either. The kinds of users of the SCT will be diverse, and include not only long-distance tourists traveling the entire length or significant section(s) of the trail, but also local community members utilizing the trail for other purposes. Therefore, it is important to understand the desires of diverse users. People living close to multi-use trails mentioned access, physical fitness, and the natural environment as benefits to the trail (Corning, Mowatt, and Chancellor, 2012). Corning, Mowatt, and Chancellor (2012) found that access was the most

important benefit to users as other benefits wouldn't be realized without trail access. They also found that being able to exercise through various forms of recreation and connect with nature enhanced users' quality of life. Some of the Southwest's most populous communities will have access to the SCT, and recreationists can choose from various means to exercise and experience the trail's diverse natural landscapes. Community members realizing these recreational benefits have a vested reason to promote and maintain the trail.

Proper maintenance also has been linked to the highest overall trail experience by Appalachian Trail thru-hikers. Peterson et al. (2018) noted that the section of the Appalachian Trail that scored highest for overall user experience was at Baxter State Park in northern Maine where management objectives prioritized conservation. This section also scored the highest for tread aesthetics which influenced its high overall experience score. While it's important that the SCT connects users with beautiful environments, it's also important that the trail itself is pleasing and enjoyable to traverse. This should influence the selection of existing routes where conservation of the trail can be developed and maintained. In addition, SCT conservation and maintenance efforts will be employed by multiple partnering organizations, and caution must be taken in considering the environmental degradation often associated with trails.

User Perception

Positive economic impacts to trail communities along the SCT are one of the goals of the trail, but without providing a route and trail conditions that meet user preferences, these economic benefits may suffer. The SCTA wants to attract gravel cyclists and a more leisurely, accessible touring experience as opposed to other long-distance, rugged 'backpacking' trails such as the Arizona National Scenic Trail. Terrain that is difficult to traverse may deter users and impact communities and stakeholders invested in the trail's development. Gravel cycling, as opposed to mountain biking, makes use of road-touring style bikes with larger tires and gearing

to traverse nontechnical on- and off-road terrain. Therefore, designing the SCT in such a way as to be traversable by a 'gravel bike' maintains accessibility to a wide array of users.

Both the perception of the trail itself and the scenic beauty it provides relate to users' experience and satisfaction. In their research, Peterson et al. (2018) looked at the influence of trail conditions on four experiential elements related to the trail itself: user's ability to maintain an ideal pace, level of challenge, impact to musculoskeletal system, and valuation of tread aesthetics. Valuation of trail tread aesthetics was ranked as the most important experiential element, and the trail conditions that participants said influenced tread aesthetics most was muddiness, ruggedness due to impediments like rocks and roots, and incision depth in relation to the trail's sides (Peterson et al., 2018). Therefore, it is important to consider these trail characteristics when selecting a route for the SCT. In addition, scenic beauty must also be considered in the design of trails as the chance to experience natural beauty is a primary reason why people visit (Lee et al., 2019). The SCTA hopes to develop the SCT using existing trails and roads, and these findings highlight the importance of addressing tread and scenery in recommending options for the trail's route.

Trail Planning Using GIS

One method for planning a new trail is by implementing a least-cost path analysis using GIS. This type of analysis considers user-defined factors to determine the best possible path over a defined landscape. However, little research has been published showing the efficacy of this type of analysis for planning trails (Snyder et al., 2008). Snyder et al. (2008) concluded that conducting a least-cost path helps automate the process of identifying possible routes for trail planning. This suggests that this tool may be extremely helpful, especially in unknown landscapes. In their research, Snyder et al. (2008) considered factors such as land ownership, slope, and viewshed and showed that weighting the importance of these factors changed the results. For instance, if the analysis considered slope the most important factor, the results may

be different than if land ownership was considered the most important factor. This means that an individual or organization should define what factors are most important when designing a trail. One limiting factor to this method of trail planning is the availability of high quality and detailed spatial data (Tomczyk, A., & Ewertowski, M., 2013). High quality and detailed spatial data may dilute the quality of least cost path results especially for a large study area such as the northwest segment of the SCT. However, it can provide structure to the trail planning process for consideration by agencies, riders, and the public (Snyder et al., 2008).

Stakeholder Cooperation

The success of the trail and accomplishment of objectives outlined by the SCTA will depend on investment and cooperation from various land management, conservation, and government organizations as well as other stakeholders. Stoffelen (2018) notes, in the case of the Vennbaun Trail, that the establishment of the trail itself promotes cooperation between stakeholders, but conveners may be required to bring unrepresented organizations and stakeholders together. Furthermore, in regards to interregional cooperation, Monroe et al. (2004) note that "it is important to understand how the effects of the trail will vary over space", and some jurisdictions, organizations, and other stakeholders may benefit much more in terms of economic gains and tax revenue. For instance, it may be easier to maintain sections of the SCT that are closer to population centers. Developing and Maintaining large sections of the trail in Arizona's Maricopa county or Nevada's Clark county which each have well over a million residents may be more feasible than even maintaining trail sections in counties with small populations such as Arizona's Mohave county. The same is true for regions that have more public lands such as USFS or BLM lands. In addition, communities, business owners, and other stakeholders in rural areas may have the most to gain in the establishment of a regional trail. Connecting large populations to small populations can increase economic opportunity, but it also may require greater investment from rural communities often represented by fewer

individuals. Corning et al. (2012) suggests incorporating input from landowners and community members is a determining factor in acceptance and satisfaction of a trail as well as its success. The SCT will reach rural communities such as Ash Fork, Seligman, and the Hualapai Peoples in Peach Springs, and large communities such as Las Vegas and Phoenix, and it is important that stakeholders within these communities are represented and collaborate with each other.

Conclusion

The Sun Corridor Trail is a 1,500-mile regional trail in its early stages of development. It will reach communities in multiple states–though mostly in Arizona–providing recreational opportunities and stimulating local economies in the Southwest. It will cater to cyclists, hikers, and equestrian users, but it will also provide other recreational opportunities within the communities it passes. The SCTA, along with previous researchers have established criteria to meet those goals (Smath, 2020). Review of the literature has given insight into the implications of these goals as well as highlighted other aspects, such as economic gains for trail communities, desirable trail characteristics, and recreational users' needs, to help determine the trail's route and its success. In addition, using GIS to determine possible routes may help in identifying areas to investigate in the northwest segment of the SCT.

Users of the SCT will spend money in the communities the trail reaches, paying for lodging, purchasing and repairing gear, eating at restaurants, purchasing groceries, and participating in other community attractions. The trail may also positively influence property values in these communities. The SCT will also offer recreational opportunities to local users who may invest in bicycles, hiking and running shoes, and other recreational equipment. Recreational and economic investment into the trail may also influence conservation of the trail and the environments it routes through. For these benefits to be realized, the trail itself must be perceived as desirable by users while also meeting the goals set by the SCTA. These factors justify and guide further research into the SCT's northwest section.

As the SCT project gains speed, there must be continued (and possibly increasing) investment from all organizations and stakeholders involved. Smath (2020) reports that a continuous evaluation of the SCTA's goals and criteria for trail development is necessary as the project evolves and potential hurdles are encountered. Consulting the SCTA and the organizations involved in the northwest section of the trail is paramount to continuing research along undefined sections of the trail. With this literature in mind and further examination of other relevant literature, a context of the goals of the SCTA takes form and directs this research.

Background

Previous Research

In 2020, Adam Smath completed preliminary research on the Sun Corridor Trail to assess route development from Sedona, AZ, through Flagstaff, and ending in Williams, AZ. The research conducted for my project was an extension of his research and findings, but focused on the Arizona section of the 2 segments in the northwest part of the trail; continuing from Williams to Kingman, AZ (defined by the SCTA as segment 2) and from Kingman, AZ to Las Vegas, NV (segment 1).

Smath's research methods consisted of consulting the SCTA to define inclusion and exclusion criteria (Appendix A) for the trail, and, after consulting knowledgeable persons and relevant land management agencies on potential routes that fit the criteria in the study area, going into the field to assess those possibilities. His research was unique in that he was not only the researcher, but also the recreational user. He rode a gravel bike to evaluate a total of 363.76 miles and kept a journal during his field work to assess the possible routes. As per the criteria developed with the SCTA, routes were determined by linking existing roads and trails, and part of his research was to see if those routes did indeed link together and were accessible and passable.

The routes were also assessed by the ability to ride a bike that fit the SCT's intended trail user. Smath kept a journal log that included a description of the route, the presence of other users, route maintenance level, ease of navigation, and path obstructions. To be transparent about potential biases in his reporting, he also logged his emotional and physical feelings on the days he rode . Furthermore, these field notes were accompanied by photos and videos to develop a narrative using ArcGIS StoryMaps and provide educational and promotional material to the SCTA.

Smath noted that the SCTA should revisit the selection criteria to ensure that it meets the goals of the trail, especially as it pertains to different sections. As mentioned, much of the northwest sections go through state, private, BLM, and tribal lands (Figure 1). This also means that the possibility of connecting existing public roads and trails may be limited.

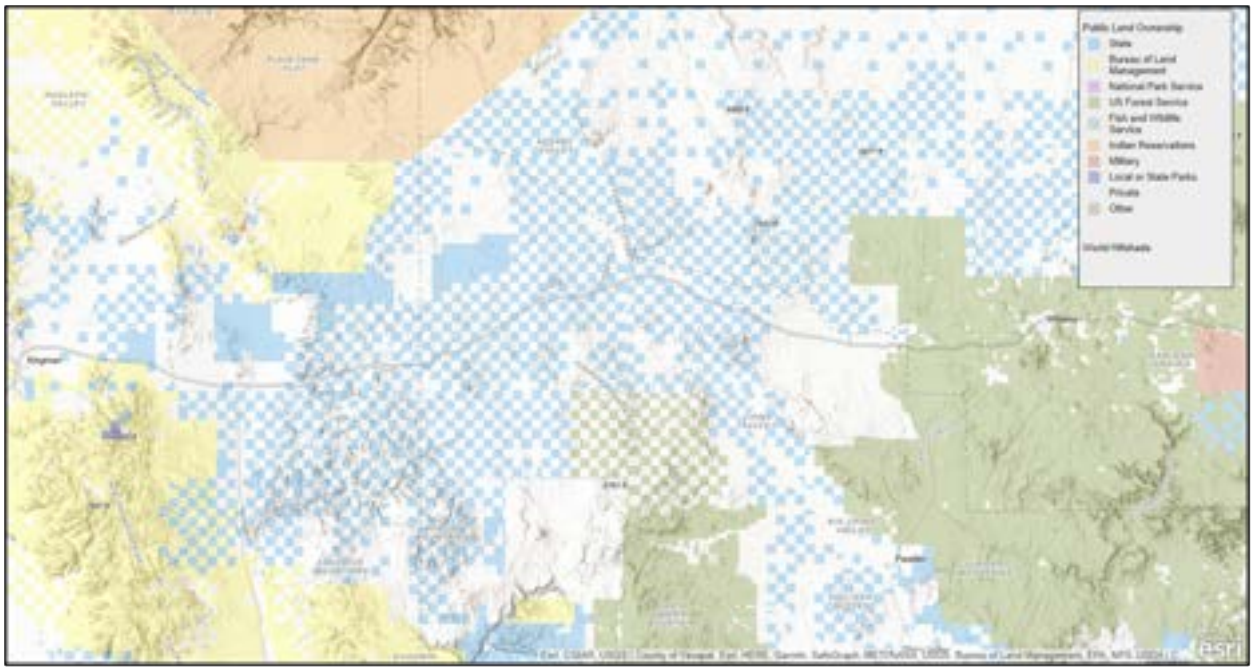


Figure 1. Blue areas represent State land and white areas represent private land; two land ownership types that the SCTA wishes to avoid. Obtained from Arizona State Land Department on 10/30/2021 (https://land.az.gov/maps-gis-0)

Modes of Biking

Various trails cater to specific types of biking. For instance, downhill mountain biking focuses on the technical aspect of descending a technical trail quickly. Road biking, on the other hand, typically covers long distances and focuses on speed and efficiency. A form of biking growing in popularity–called gravel biking– requires riding capabilities over long distances on a blend of surfaces, still focusing on road-bike efficiency but not confining the user to smooth, often paved, surfaces.

The idea of riding bikes on multiple types of non-technical surfaces-such as paved, gravel, and dirt roads-has been around since the advent of the bicycle. However, as technology progressed, bikes became more specialized to specific disciplines such as mountain biking, touring, and road biking. The hybrid bike has been around for many decades and has been somewhat of a bridge to road and mountain biking but lacked the performance and long-distance aspect and is designed for short jaunts on paved and unpaved non-technical surfaces. Though not modeled after the hybrid bike, the design of the gravel bike allowed riders to leave the paved road but also venture longer distances while maintaining comfort. A gravel bike features drop handlebars on a lightweight rigid frame (without the suspension of a mountain bike) and keeps it relatively compact to offer speed to users. It also incorporates wider tires with knobby tread and gearing that allows riders to tackle non-paved hills (Singleton, 2022). Singleton reports that gravel bike sales have risen over 100% between 2019 and 2021, and there are over 2.2 million miles of unpaved roads in the United States.

Like the gravel bike sector, electric bicycles, or e-bikes, are also on the rise and are in fact the fastest growing sector of bikes (Sorenson, D., 2021). The styles and capabilities of e-bikes have expanded as well, and numerous brands now make gravel e-bikes. This is an important factor as it increases accessibility to long-distance trails by lowering the physical demand needed to participate. This may attract people looking for a more leisure experience as well as novice riders or the aging population. However, the recreational industry has seen challenges with regulating e-bikes, and several issues have risen. E-bikes are technically motorized, which means they are not allowed on trails designated as non-motorized, and there is also concern that e-bike use could lead to greater degradation of trails and conflict with other users, such as hikers and equestrian users (Miller, 2022). Still, gravel e-bikes could offer an alternative to users looking to experience the cultural and environmental value of the southwest and bring more users to the communities visited on the Sun Corridor Trail.

Credit card touring is often associated with multi-day bike trips, but this style of cyclotourism can also apply to day trips. Simply put, credit card touring is a form of cyclotourism that allows the tourist to carry minimal equipment and provisions because services–such as food and lodging–are available in accessible increments. In addition, credit card touring promotes supplementary tourism activities such as visiting museums, parks, theaters, and other amusements. This form of touring can promote greater comfort to the user while also promoting the tourism economy within communities.

Methods and Procedures

Overview

The methods of this research involved collecting secondary data from the SCT website (Sun Corridor Trail, 2023), a promotional website for the trail, to determine preferred destinations within the segments that correlated to this project's study area. Additional destinations were added where preconceived destinations were geographically farther apart, and midpoints were needed to stay within the distance bounds determined by Smath and the SCTA. These destinations had to offer amenities in the form of lodging, food, and/or supplies. For the purpose of this research, sections were defined as the area between two nearest destinations.

Gaia GPS web application and Google Maps Satellite and Street View were used to determine a test route for each section. These map tools helped identify potential obstacles, such as private property, gates, non-existent roads/trails, level of road maintenance, and disconnected paths. In addition, these alternative mapping tools were used to look for potentially desirable conditions such as attractions, hotels and camping locations, food and supply locations, etc. Sections consisted of many route possibilities, and these tactics were used to determine one, or in some cases multiple, test routes. In some cases, once a possible route(s) was determined for each section, an offroad vehicle was used to carry out an initial investigation of any potential obstacles before further testing. Where obstacles were confirmed, test routes were modified, and possible routes were narrowed further. This was especially true for sections that lacked public lands. Based on the results of the initial investigation, Gaia GPS was used to create a route to guide the researcher in the field.

With test routes determined, the researcher rode a specific bike, explained in the following sections, to emulate the target user to investigate each test route. Field notes and photos were collected, and Gaia GPS application was used to collect data about the ride

including length of ride, time to completion, and elevation gain/loss. The data collected with the web applications also provided spatial data which was transferred to the project GIS database. Finally, each test route was given a score based on certain criteria, outlined below.

ArcGIS Pro was used to create a least-cost path (LCP) and least-cost corridor (LCC) for each section, and results were compared to field tested routes. In addition to destination point data, land management, slope, and existing roads and trails, a section study area was created for each section. The LCC denoted areas within each section study area that more closely met the analytic factors, and the LCP denoted a single best possible route in each section. The results of the analyses and field work provided feedback for each method of selecting a route.

Scope

This project's study area encompassed Arizona's northwest segments of the SCT which has been partitioned into 2 segments on the SCT website. Segment 1 heads southwest from Las Vegas, NV to Kingman, AZ, and segment 2 continues west from Kingman, AZ to Flagstaff, AZ. Smath's (2020) research mostly took place in segment 3, Prescott, AZ to Flagstaff, AZ, but also extended to Williams, AZ of segment 2. Smath's research headed in a south to north and then east to west trend. Therefore, this project continued west from Williams, AZ to Kingman, AZ and then to Bullhead City on the Arizona and Nevada border.

This project takes place in 3 counties in Arizona and 1 county in Nevada: Mohave, Yavapai, and Coconino County in Arizona and Clark County in Nevada. The study area was further divided into sections based on destinations mentioned on the SCT website and/or places where lodging options existed. Smath, in conjunction with the SCTA, determined that a daily riding distance of 25 to 55 miles was ideal, and this factor was also considered in determining sections. The focus of this project was to determine possible connections between destinations, so specific routes through cities such as Kingman and Bullhead City were not considered.

The approval for this project was May 4, 2022, and the project began thereafter. Field work persisted from July of 2022 through April of 2023. The goals for the test routes of the project were to 1) determine a route that could accommodate credit card tourism and 2) determine if it was possible (and to what extent) to ride a gravel/hybrid bike type between destinations in the study area. This type of user was adopted from Smath's (2020) research and defined in this paper as a gravel bike credit card user (GBCC). To accommodate credit card tourism, destinations needed to provide amenities such as lodging, food, and supplies that could be purchased with a credit card, thereby reducing the amount of equipment needed while traveling. Furthermore, the gravel/hybrid bike type would restrict travel to mild off road terrain. Technical terrain such as large rocks, sand, and drop-offs were to be avoided.

Destinations and Sections

The first part of this research was to determine what destinations in the study area were to be considered. A destination had to be a specific and distinct location, such as a town or point of interest. To support the concept of credit card tourism, the destinations should offer lodging, food, and other supplies. Successive destinations should also be between 25 and 55 miles apart, or within the target effort for one day's ride. Other trail destinations, including communities that don't offer these amenities, cultural destinations, and attractions could later be considered if they fell within the least cost corridor analysis of each section. The SCT website was used to gather information and determine destinations.

The SCT website's "Explore the Trail" webpage has short descriptions of each segment including possible destinations. The destinations mentioned in the description of segment 2 include Kingman, Hackberry, Valentine, Peach Springs, Seligman, Ash Fork, Williams, and Flagstaff. The description also mentions Historic Route 66, which is hard to avoid as this road passes through all the destinations mentioned. Using Google Maps to search for lodging in each

of these destinations, it was determined that Hackberry and Valentine offered no lodging, nor camping options. Furthermore, Valentine had no other amenities such as food or supplies.

Destinations mentioned in section 1 include Las Vegas, Searchlight, Laughlin, and Bullhead City. The description of segment 1 also mentions the Mojave Desert, Colorado River, and Hualapai Mountains, which are substantial and comparatively indistinct locations. However, the Mojave Desert spans the entirety of segment 1, and there is no way to avoid crossing the Colorado River when traveling between Las Vegas and Kingman. To include the Hualapai Mountains, the small community of Pine Lake was considered as a possible destination. Pine Lake has lodging, camping, and food and is located near other points of interest including Hualapai Peak. Laughlin and Bullhead City are only separated by the Colorado River, so it was only necessary to select one as a destination. Bullhead City, AZ was selected as this research only considered routes in Arizona.

In addition to the segment descriptions, the SCT website also has a trail map designating the parts of the trail which are in the open, planned, or concept stage. Segment 1 is entirely in the concept stage, and segment 2 is nearly all in the planned stage (figure 1).

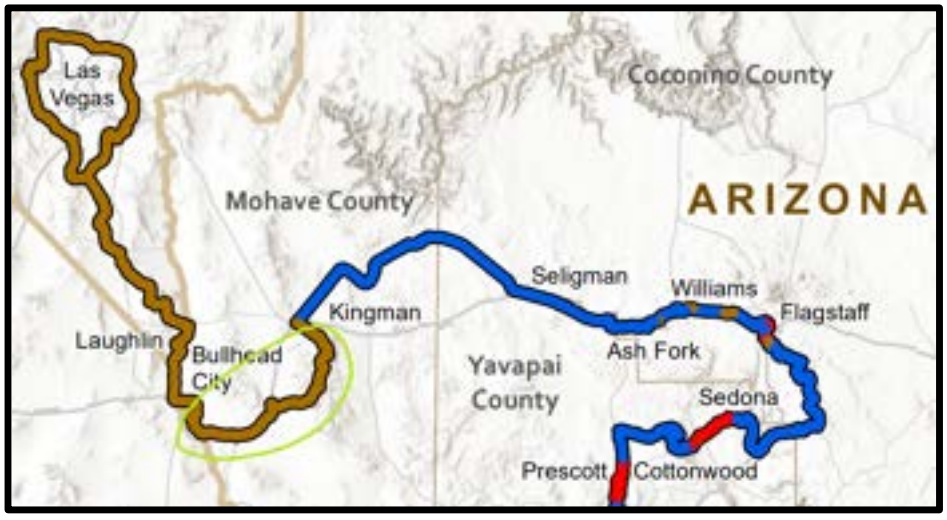


Figure 1. Northwestern segments of the Sun Corridor Trail. The green oval was added to show an area where lodging within a reasonable distance was a concern. Obtained from suncorridortrail.org (06/15/22).

This map was used in conjunction with Google Maps to determine if there were any other destinations. No other destinations that included lodging options were found. I found that the concept area diverted south through the Hualapai Mountains to Yucca, AZ, then east toward California before heading north to Bullhead City. Using Google Maps, I found that routing through Yucca from Kingman to the nearest lodging via I-40 would be over 60 miles, and that doesn't include routing through the Hualapai Mountains as the map suggests. Therefore, this area was excluded from the analysis.

The following Arizona destinations were chosen:

- Segment 1 (Arizona only):
    - Bullhead City, Kingman
- Segment 2:
    - Kingman, Pine Lake, Blake Ranch Road (exit 66), Peach Springs (lands of the Hualapai people), Seligman, Ash Fork, Williams

With the destinations determined, it was possible to establish sections between consecutive destinations. Then, a square study area was created in ArcGIS Pro for each section.

Route Selection

Once the destinations were determined, Gaia GPS and Google Maps were used to look for possible routes between each destination. Gaia GPS uses ESRI, Mapbox, and OpenStreetMap for its basemap to provide accurate and up-to-date existing roads and trails. This basemap works in conjunction with Gaia GPS's create route tool to trace existing roads and trails and generate an elevation line chart and route distance as routes are created. This allowed for relatively quick analysis of sharp elevation changes and distances between destinations for various route options.

Google Maps satellite layer and Street View tool were also used to check for obstacles such as gates, non-existing roads and trails, disconnected roads and trails, etc. The Street View tool is limited to where the Waymo car (formerly Google self-driving car project) has been. However, many of the potential routes funnel onto roads where the Street View tool is available. This allowed the researcher to view intersections of possible routes to look for signs that announced private property or gates that restricted access.

Satellite image layers in Google Maps and GaiaGPS provided a further overview of possible routes. Obstacles such as private property and non-existent or unmaintained roads and trails were noted to help determine viable routes. These satellite images are often not up to date, and can be months to years old, so it is possible that some obstacles observed or not observed were inaccurate. However, this was a relatively quick way to assess routes before going into the field. Before selecting a test route, a vehicle was used to further investigate areas with potential obstacles such as gates identified with Google Street View and get an initial look at the terrain and surface condition of some of the possible routes.

Ground Truthing and Data Collection

The researcher has significant backcountry navigation experience and modest offroad biking experience. Some training and fitness preparation was conducted prior to field testing. The Sun Corridor Trail website does not specify exclusivity to any specific user experience level, and while the researcher's goal was to assess the ability to bike between destinations within a day's ride, it was allowable to dismount due to fitness level.

A Polygon Heist 5 hybrid bike was chosen for field research. While it's not designated as a gravel bike, it comes stock with 45 mm gravel tires and has similar geometry as a typical gravel bike. However, it also has front suspension with 60 mm of travel and a wide, flat handlebar that allows for more forgiveness and stability while riding on unknown terrain than a typical gravel

bike with narrow drop bars and rigid suspension. It is a 10-speed bike with the smallest cog having 11 teeth and the largest cog having 42 teeth. It was also outfitted with an 11-liter handlebar pack, a small seat pack, and rear safety light. An iPhone SE 3rd generation (released March 2022) was used to collect field data including photos, notes, and GPS tracking data.

Gaia GPS was used to collect GPS points of photos to document impasses and obstacles, views and attractions, and amenities (food, lodging, etc.) along the route. This application was also used to determine time and speed between destinations, elevation gain/loss, and distance. Written documentation of the route including the names of roads and trails ridden, obstacles encountered, and overall thoughts about the route were digitally documented within 24 hours of each field test.

To provide a measurable assessment of each route tested, Smath's inclusion and exclusion criteria was modified to provide a rating system. Unless the route was deemed unsafe or impossible for the researcher to traverse, the routes were considered. Instead of logging specific inclusion or exclusion criteria, criteria were given a score and then each route was given a total score. The following data were recorded but not given a score for each route:

- Aesthetics and POI
- Length: routes were preselected only if they fell within the optimal biking distance of 25-55 miles between destinations.
- Duration: moving time and total time

The following data were recorded and given score:

- Moving Speed: this was calculated as the moving speed for the entire route tested.
    - 1 = <3mph, 2 = 3-5mph, 3 = 5-7mph, 4 = 7-9mph, 5 = >9mph

- Physical Demand: This is a ratio of each route tested by taking the amount of required time pedaling, divided by the total moving time in minutes.
    - 1 = >0.75, 2 = 0.6-0.75, 3 = 0.45-0.6, 4 = 0.3-0.45, 5 = <0.3
- Dismounts: Dismount must be caused by rear tire slippage or difficult terrain such as boulders or washed out sections of the route. Rated as percentage determined by total dismounts divided by length of route (miles).
    - 1 = >0.3, 2 = 0.2-0.3, 3 = 0.1-0.2, 4 = 0.01-0.1, 5 = 0
- Technical Difficulty: This is subjective and relates to the type of bike I would consider optimal for the route.
    - 1 = full-suspension bike with mountain tread tire, 2 = front suspension bike with mountain tread tire, 3 = mountain tread tire of at least 2-inch (~50mm) width, 4 = gravel tread tire of at least 45mm width, 5 = gravel tread tire of at least 35mm width
- Traffic: This considers all motorized vehicles, including on-highway and OHV activity. This is an estimate as a counter was not used to record this data. This value is based on a ratio determined by dividing the estimated number of motorized vehicles by the total moving time in minutes.
    - 1 = >0.3, 2 = 0.2-0.3, 3 = 0.1-0.2, 4 = 0.01-0.1, 5 = 0
- Presence of Bike Lane: This was only considered for paved sections of routes tested. Bike lanes were only considered if the speed limit was greater than 25 mph and the shoulder lacked enough room to remove handlebars from traffic lanes. Gaia GPS was used to estimate the length of areas where these conditions were present. This value was determined by taking the number of miles where these conditions existed, divided by the number of total miles of the test route.
    - 1 = >50%, 2 = 36-50%, 3 = 21-35%, 4 = 6-20%, 5 = <6%

- Exposure to Weather/Temp.: This was determined by the abundance of natural features such as trees and rocks and manmade features such as buildings, tunnels, and overpasses to take shelter from weather such as sun, rain, and lightning. This was an estimate and took into account the mile with the least features.
    - 1 = <1 per 5 miles, 2 = 1-3 per 5 miles, 3 = 4-7 per 5 miles, 4 = 8-12 per 5 miles, 5 = >12 per 5 miles

GIS Analysis

A least-cost corridor and accompanying least-cost path analysis was conducted between destinations. A LCC produces a raster in which a value is determined for each cell in the raster. The value is based on what it would cost to get from that cell to two target destinations considering selected criteria (e.g., slope). The cost corridor can then be classified by values to show a corridor that meets certain value thresholds. A least cost path analysis determines a path between an origin and destination that also considers selected criteria such as slope and roads. This path is only one cell wide and represents the cells with the lowest cumulative cost in the cost raster.

Three criteria were considered for the analyses. Smath and the SCTA determined that the SCT should, if possible, not have a prolonged slope of more than 9% grade and ideally use existing roads and trails. It was also determined that the Sun Corridor Trail should not route through specific land designations such as private land, state trust land, and designated Wilderness. However, the study area has significant areas of private and state trust land, and prioritizing preexisting public roads and trails provides access to these lands without trespassing. In addition, there is very little designated Wilderness in the study area that lie between destinations, and some are bifurcated with designated road access. Furthermore, by

considering slope in the analysis, many of these areas were ruled out due to their steep, mountainous terrain.

A 30-meter digital elevation model (DEM) of the United States was obtained from ESRI's Living Atlas and clipped to the study area extent to improve processing speed. The DEM was used to create a slope raster using ArcGIS Pro's slope tool. In addition, a USA Roads vector layer which contains a road classification ranking was also obtained from ESRI's Living Atlas. This vector layer was converted to a raster layer based on the road classification. Similarly, a surface management vector layer was obtained from the BLM Geospatial Business Platform and converted to a raster layer. A power of 2 (2^n) was used to reclassify values of slope percentage, road classes, and surface management type (Table 1). This ensured steeper slopes and less desirable road classes and surface management types inherited high values and were more likely to be avoided in analysis results.

	Slope	**Road class**	**Surface management type**
Value	*In degrees*		
2	0-2	Walkway, trail, vehicular trail	USFS, BLM, NPS
4	2-5	Rural road, service drive	Local gov., FWS
8	5-9	Parking lot, secondary, US census use	DOE, USBR, ST, BIA, Undetermined
16	9-15	Private road	Private, FAA
32	>15	Primary, ramp, NODATA	DOD, Army

Table 1: Reclassified values

Point shapefiles containing cities and towns were downloaded for Arizona cities. The points representing target destinations were selected and exported to a point-type destination feature class, and then each destination was further exported to later be used for the source and/or destination data in the LCC and LCP analyses. Finally, a square polygon feature class was created around each section.

After data was created and processed, ArgGIS Pro's ModelBuilder was used to create a model for streamlining the analysis of each section (Figure 2). The model reclassified the slope and road (raster) and created a cost raster by adding the values of each raster together which was clipped to the target section. Then, the model used the cost raster and each destination in the target section to generate 2 cost distance rasters. Using these spatial data, the model generated a corridor and cost path for each section. The cost path (raster) was transformed into a polyline feature class for better viewing.

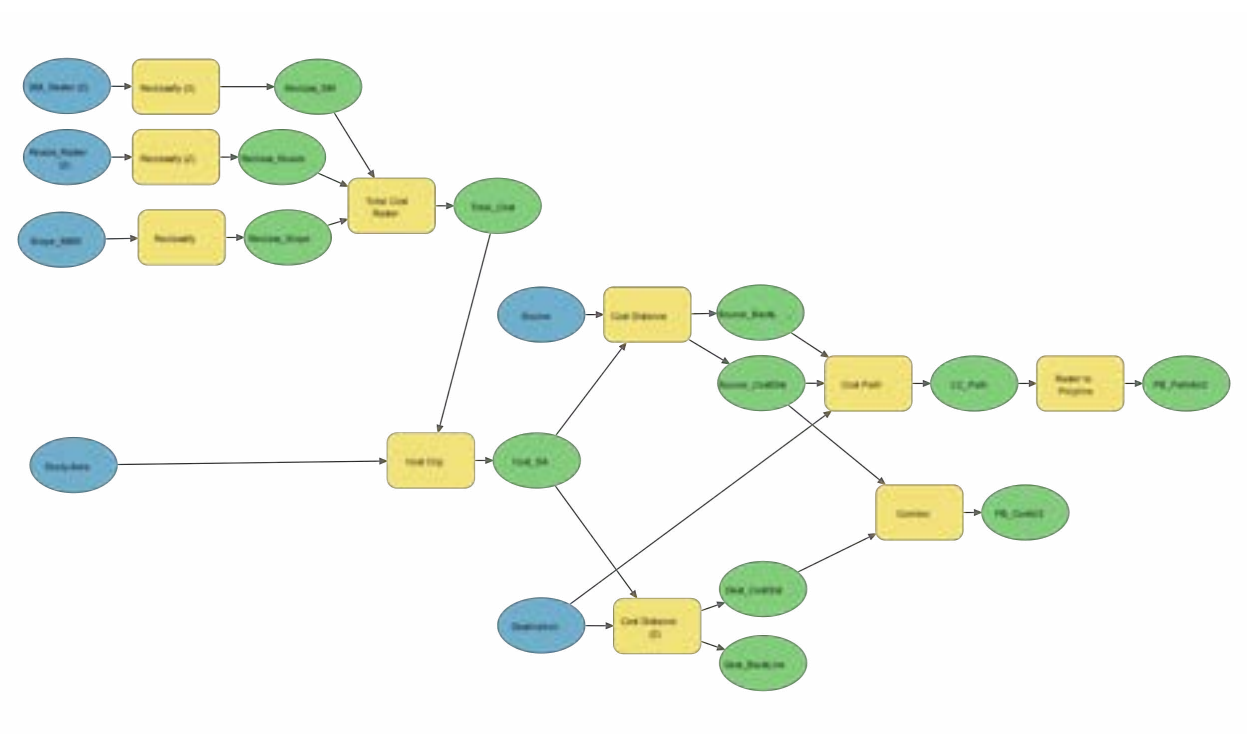


Figure 2: Least-Cost Path and Least-Cost Corridor Model

Route Reports

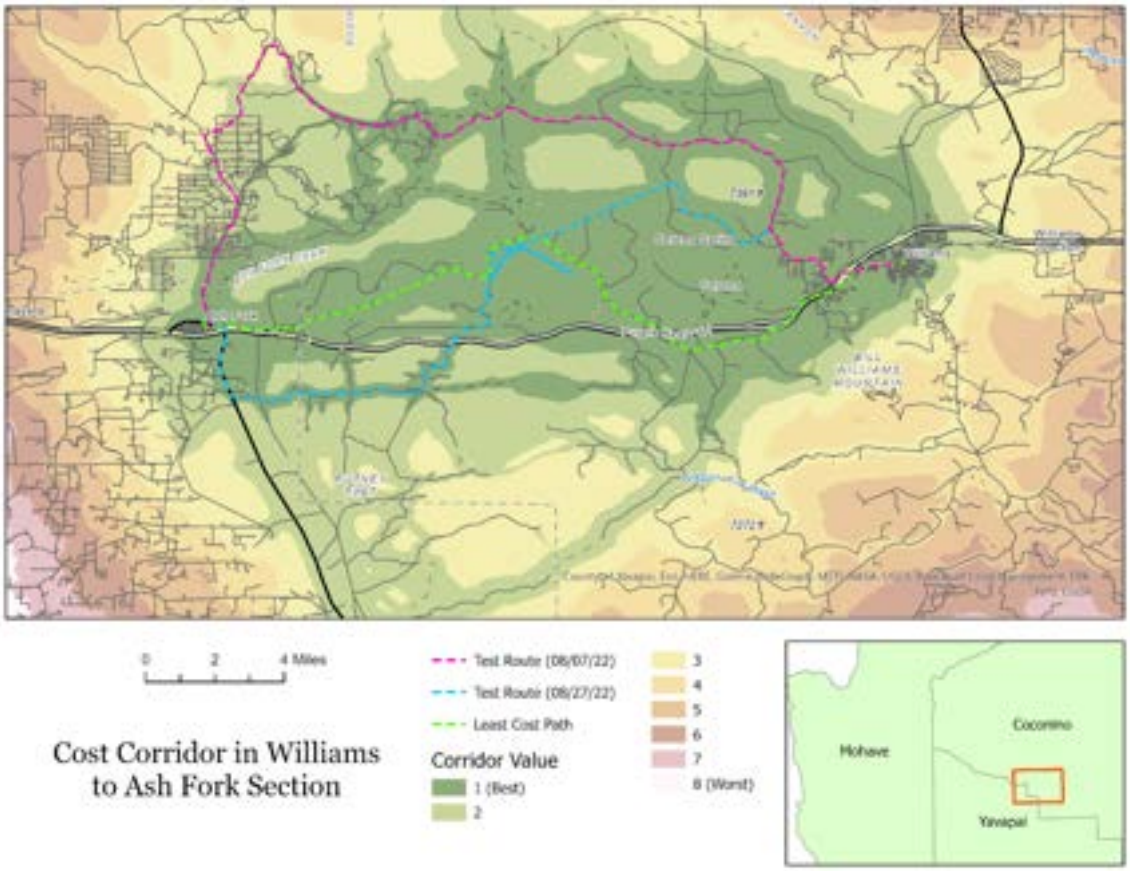
A report for each section was created once routes were field tested and data was collected. The report for each section includes the LCP and LCC generated in the GIS analyses for that section, the route or routes tested, and the ratings for each criterion of the route or routes in the section. A description of the directions as well as unscored and scored criteria are included in the report with a table outlining the criteria data.

As mentioned, the results of this research will assist the SCTA in determining a possible route through the northwest segment of the trail. The results of this research are presented in a similar manner to previous research to keep the format submitted for routes similar to previously studied and future study areas of the SCT. Recommendations for each section are outlined in the discussion section.

Results

The results of this study are organized by section starting with the Williams to Ash fork section, moving west, and ending with the Kingman to Bullhead City section. Each section includes a map depicting the least-cost path and least-cost corridor analyses as well as the routes tested and labeled by the date they were tested. This is followed by a description of the directions of the test route with a breakdown of the assessed criteria and a table showing the criteria scores for that test route. To sum up the results, a map showing all routes tested is provided as well as a summary of the criteria scores of each section.

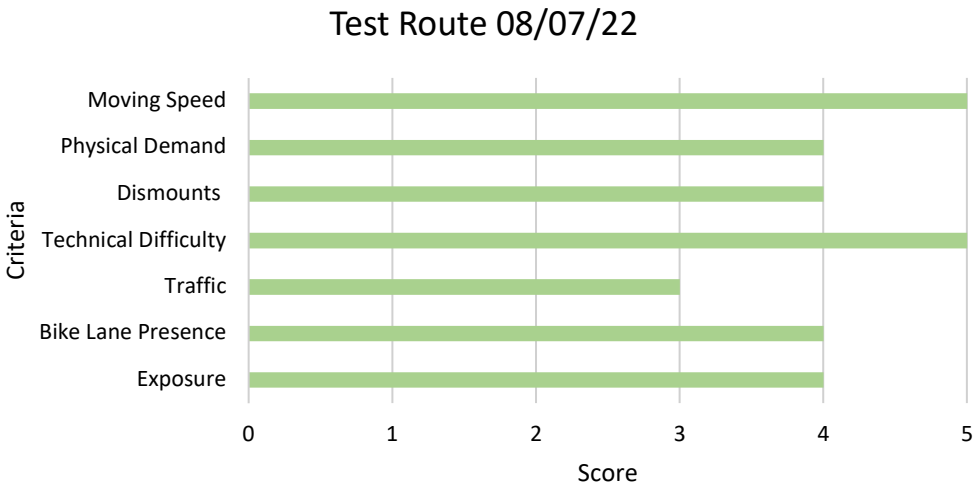
Williams to Ash Fork Section



Test Route 08/07/22

Directions: This route started at Monument Park on the west side of Williams and headed west on Historic Route 66 over Interstate 40. After crossing the interstate, the route briefly follows Frontage Road with and then turns north onto Country Club Road, both of which have little to no shoulder but a low speed limit. About 3 miles from the start, the road becomes dirt and gravel which is the start of County Road 124, also known as Forest Road 124 and Double A Ranch Road. Roughly 23 miles from the start, County Road 124 enters a community north of Ash Fork where the route is again paved. Then the route turns left (south) onto Double A Ranch Road for the final 6 miles on a high speed road with little to no shoulder before terminating at the Shell gas station in Ash Fork.

Criteria: The first portion of this route traveled through ponderosa pine forest that turned to a juniper dominated landscape as the elevation decreased. The route offered expansive views and passed multiple tanks, or ponds, as well as an active train track. The length of this route was 30.3 miles, and the moving time was 2 hours, 44 minutes with a total time of 3 hours, 16 minutes. The route ascended 517 feet and descended 2,149 feet in a mostly downhill trend, and the average moving speed was 11.0 mph. A few short but steep, sandy, and/or rocky sections necessitated dismounts, but most of the route could be ridden on gravel tires with ease. Vehicle traffic on this route varied from little-to-no traffic on the dirt portion, to light-to-moderate traffic on the paved portions. The paved section accounted for roughly 30 percent of the route and was mostly devoid of a bike lane with high-speed traffic occurring in the portion near Ash Fork. There were primarily trees, rock outcroppings, and a few tunnels to take shelter from weather, and they were abundant.

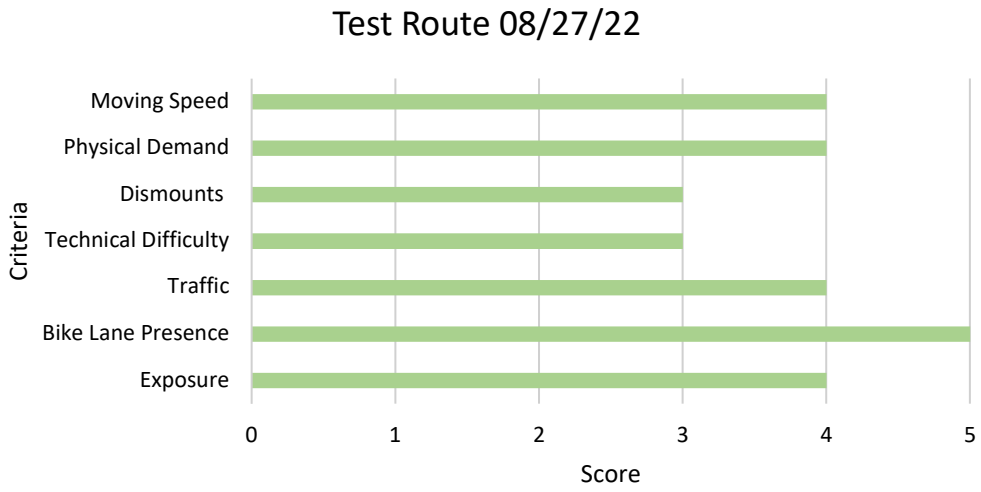


Test Route 08/27/22

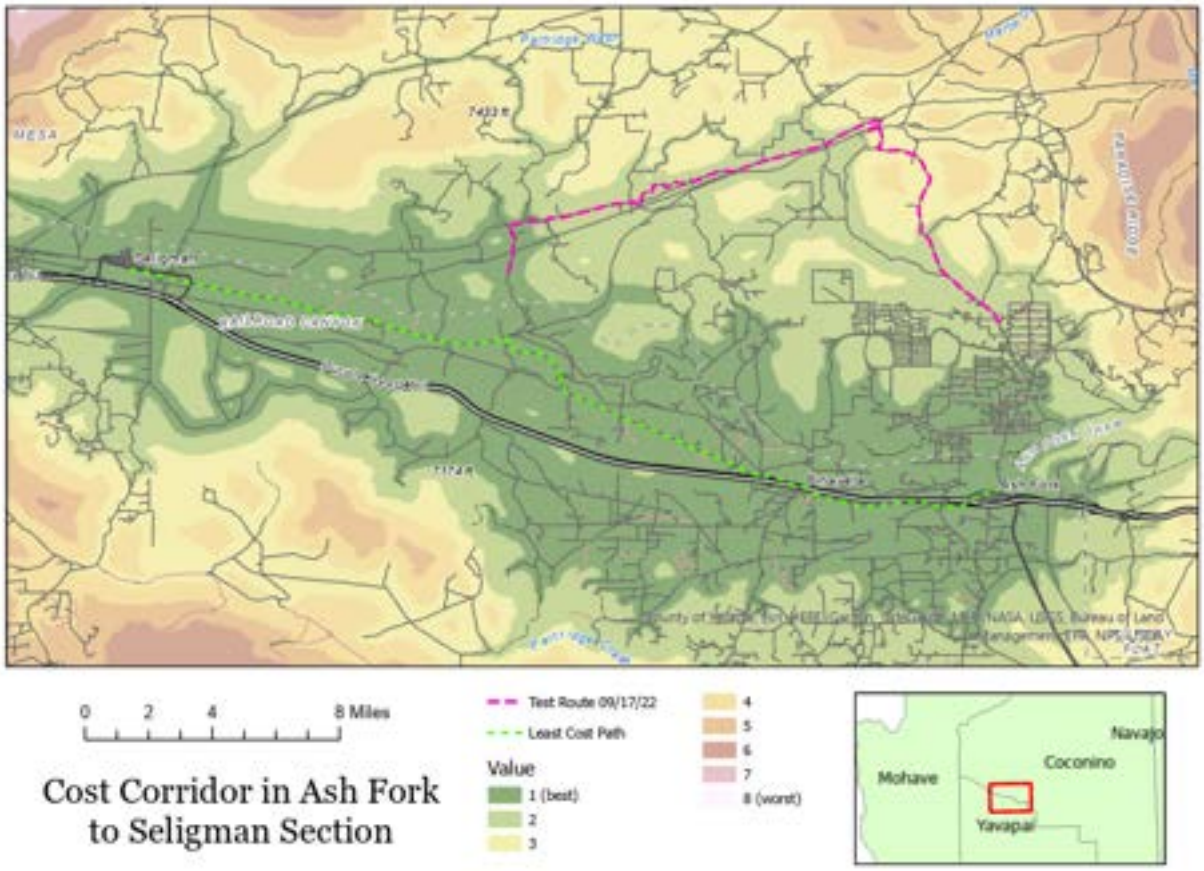
Directions: This route started where Forest Road 15 meets County Road 124. Within a few hundred yards of the start, the route veers right at a fork to stay on Forest Road 15 (unmarked). The route then turns left (west) onto Gas Pipeline Road, also known as Forest Road 796. Gas Pipeline Road crosses a railroad where an unlocked gate is encountered. About 9 miles from the start, a left (south) is taken on Forest Road 6, also known as Corva Road. Another left (east) is taken on an unmarked road about 0.5 miles after turning onto Forest Road 6 which is an out-and-back 4-mile detour to Johnson Railroad Tunnel. The route continues south on Forest Road 6, then veers right at a fork onto an unmarked and paved piece of Route 66, before quickly veering left back onto Forest Road 6. The route goes under Interstate 40 at the Welch Road exit before turning left (south) onto Forest Road 35, also known as Welch Road. The route then turns right (west) onto Forest Road 114 until reaching Arizona Highway 89 where a right (north) takes the route the final 2 miles before terminating at the Shell gas station in Ash Fork.

Criteria: This route started in a dense ponderosa pine forest, but after turning onto Gas Pipeline Road, the pines give way to junipers. Gas Pipeline Road is an extensive cleared swath ranging from 50 – 500 feet wide. While it offers expansive views, there's also indications that the road is

also used by pipeline and rail workers. The Johnson Railroad Tunnel and Johnson Crater were notable points of interest. This route was 26.8 miles long, and the moving time was 3 hours, 24 minutes with a total time of 3 hours, 45 minutes. The route ascended 451 feet and descended 2,334 feet in a downhill trend, and an average moving speed of 7.8 mph was maintained. Forest Road 15 and Forest Road 114 were quite rough and required a slower pace and higher degree of skill to navigate. There were also sections of Gas Pipeline Road near Forest Road 6 that necessitated dismounts due to steep grades and loose gravel. These factors suggest the technical difficulty may be more appropriate for a mountain bike tire. Most of the vehicle traffic on this route was encountered in the final 2 miles on Arizona Highway 89, where there was also significant shoulder to remove a bike from the vehicle travel lanes. There were trees, rock outcroppings, and tunnels to take shelter from adverse weather and/or heat.



Ash Fork to Seligman Section

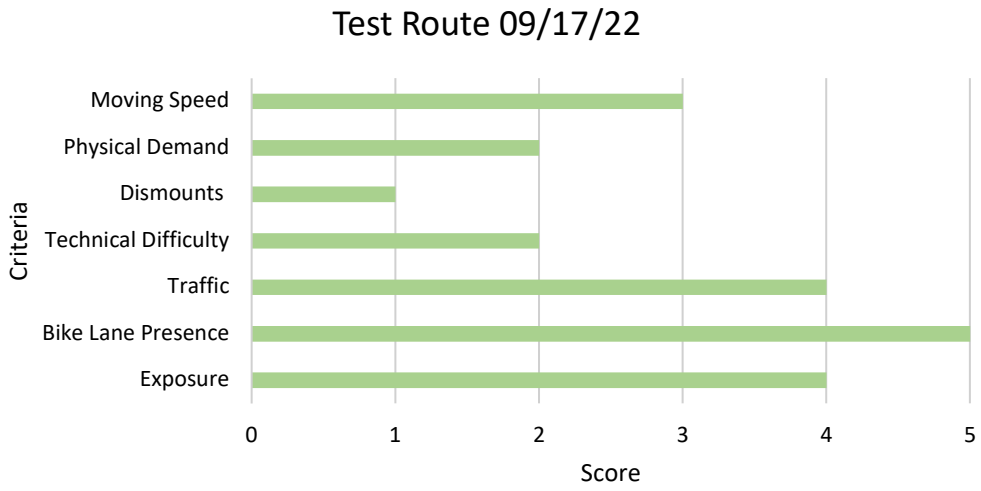


Cost Corridor in Ash Fork to Seligman Section

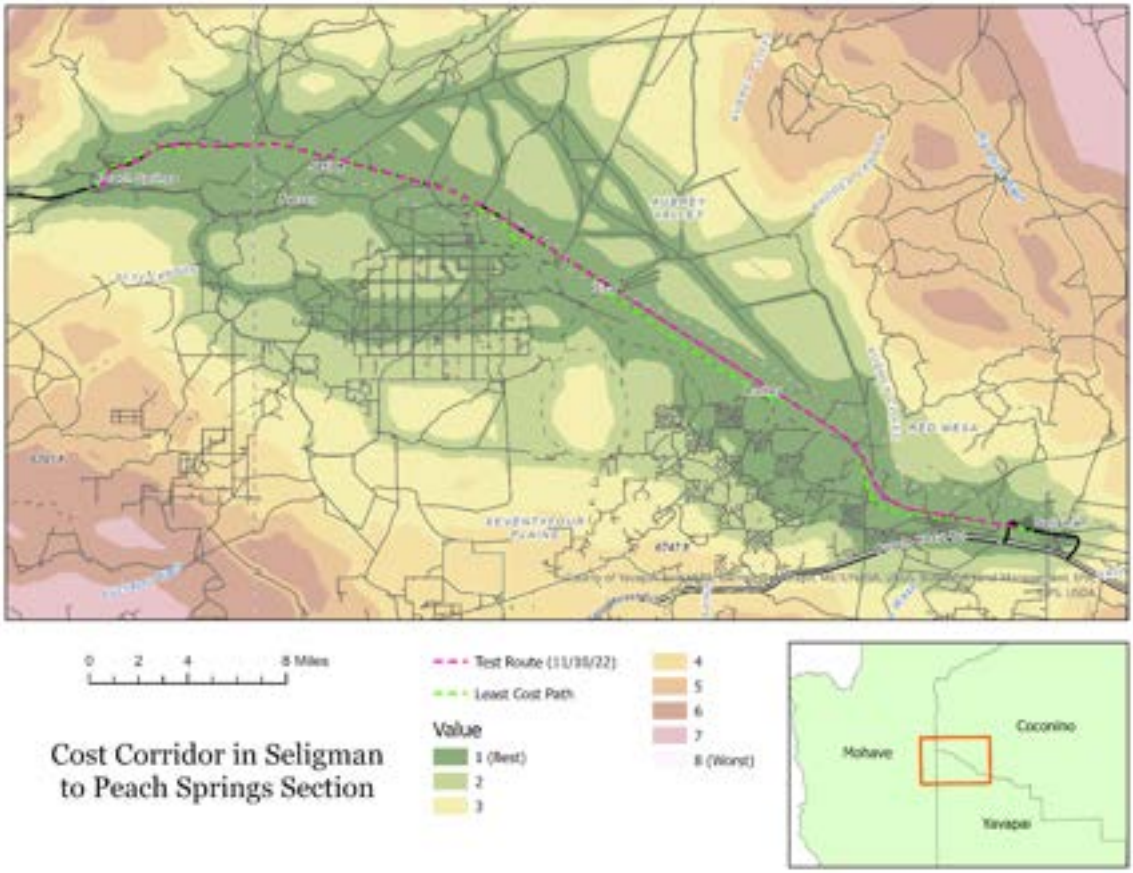
Test Route 09/17/22

Directions: This test route started at the intersection of Sevens Ranch Road and Double A Ranch Road (both also County Road 142) roughly 6 miles north of Ash Fork. About a mile from the start, the road enters Kaibab National Forest, and the paved road becomes a 2-lane gravel road. Just over 8.5 miles from the start, the route turns left (west) onto Cable Road shortly after going through a tunnel under BNSF railroad. After traveling 11.0 miles on Cable Road, the route turns left (south) onto Ranch Road. It was here that the researcher suffered two flat tires and walked another 1.5 miles before ending the field test.

Criteria: Most of this route travels through juniper forest, and as the route climbs toward Cable Road, there are views of cliffs, a pond (tank), distant mountains, and expansive landscapes. Cable Road continues to offer expansive views and follows the active BNSF railroad where multiple trains passed during the field test. This route was 21.3 miles in length and the moving time was 4 hours, 5 minutes with a total time of 4 hours, 20 minutes. The route trended uphill ascending 1,048 feet and descending 440 feet, and it had a moving speed of 5.2 mph. While Sevens Ranch Road (County Road 142) had a wash-boarded surface, reasonable uphill speed was maintained. However, Cable Road was significantly rougher with fist-size or larger rocks, causing numerous dismounts and, ultimately, two flat tires–suggesting a more capable mountain bike may be necessary. There were very few vehicles encountered on Sevens Ranch Road and no vehicles were encountered on the 11.0 miles of Cable Road. Trees, underpasses, and rock outcroppings offered numerous places to escape inclement weather.



Seligman to Peach Springs

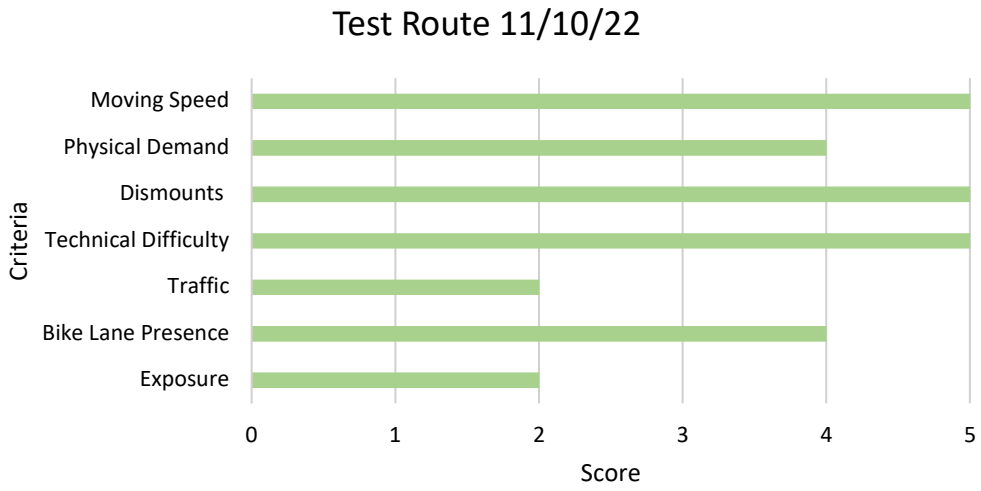


Test Route 11/10/22

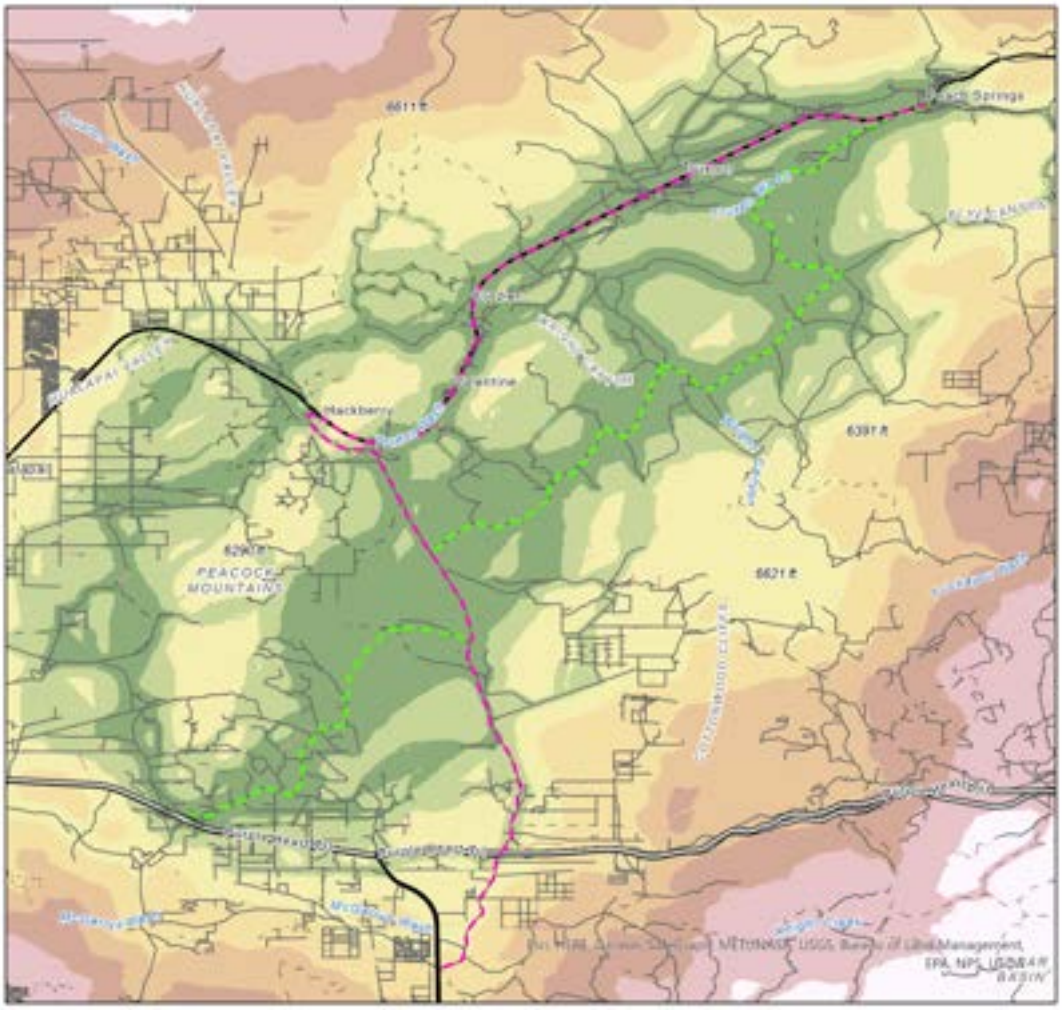
Directions: This route started at the West end of Seligman, AZ on Historic Route 66. The route continues west for 36.7 miles on Historic Route 66 until reaching Peach Springs, AZ. The entire route is paved and mostly along a 2-lane, 65 mph road.

Criteria: While this route follows Historic Route 66 which is paved, it offers the rider the ability to focus on the views which are vast scenes of distant mountains. The route also passes Burma Shave signs which have sayings such as (1)"Don't lose your head" (2) "to save a minute" (3) "you need your head" (4) "your brains are in it". Around mile 24, the route passes the Grand Canyon Caverns which has a motel, minimart, and cavern tours. Tourism relics from Historic Route 66

can also be seen, including old cars and dinosaur sculptures where a dilapidated mini-golf course once was. This route was 36.7 miles long, and the moving time was 4 hours, 7 minutes with a total time of 4 hours, 46 minutes. This route trended slightly downhill, ascending 971 feet and descending 496 feet with an average moving speed of 8.9 mph. However, it was later determined that the front brake may have been slightly engaged for the entirety of the route, making it more difficult to pedal. Because this route is entirely paved and trends downhill, the average moving speed may be over 11 mph. This route can be ridden with a road bike and no obstacles or strenuous sections make dismounts necessary. Although Historic Route 66 has a speed limit of 65 mph, most of the route has a wide shoulder of about 6 feet, and traffic was light to moderate. As the route enters Peach Springs, there is about a mile-long section that has a passing lane and the shoulder becomes non-existent. There are very few places along this route to escape extreme weather, but there is a higher probability of flagging down help if needed.



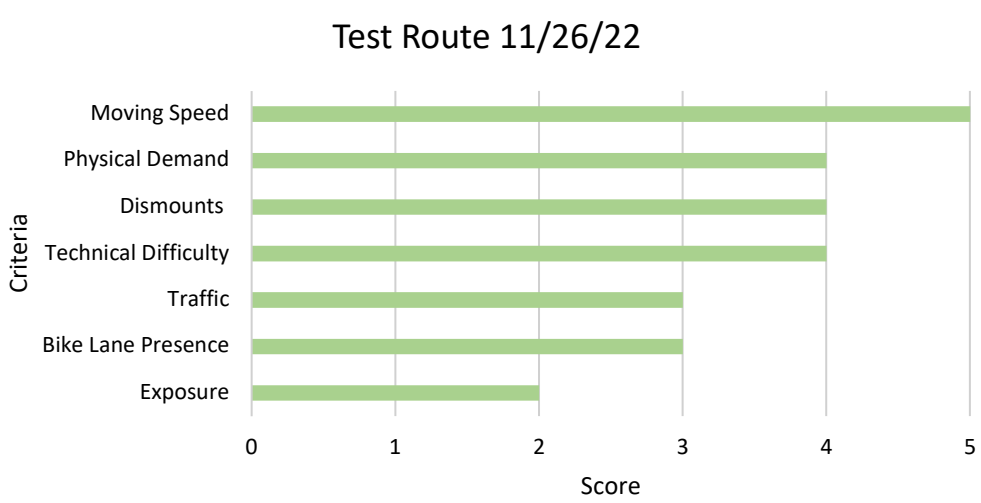
Peach Springs to Blake Ranch Road



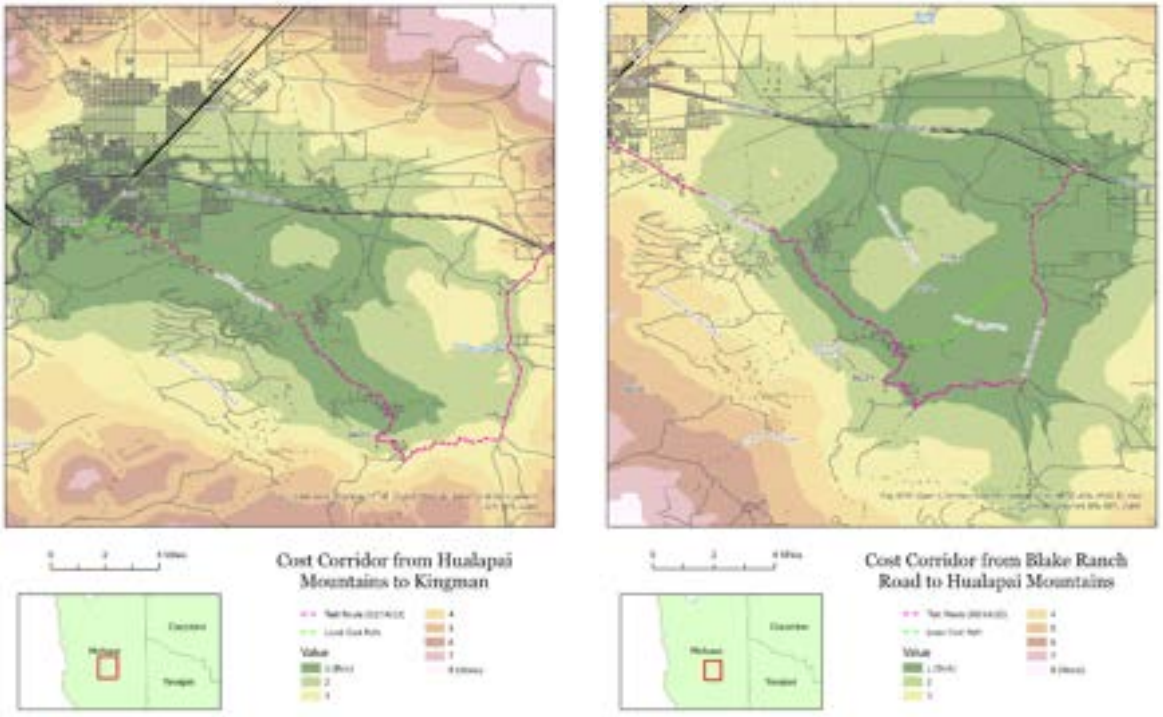
Test Route 11/26/22

Directions: This route starts in Peach Springs and heads west on Historic Route 66. While on Historic Route 66 the route passes through the small community of Truxton, Crozier Ranch camping area, Keepers of the Wild Nature Park, and the nearly-ghost town of Valentine. After 21 miles, the route passes Hackberry Road before coming to the Hackberry General Store and turning left (west) onto an unmarked dirt road with a paved entrance called Old Trails Highway. The route descends under a railroad pass and then veers left (southeast) into the community of Hackberry. At a 3-way junction with a tractor as a centerpiece, the route stays left to continue onto Main Street. Just over 2 miles from the 3-way junction the route turns right (south) onto Hackberry Road. Hackberry Road turns to pavement just before it passes under I-40. After about 4 miles on a rough paved road, the route ends at Hwy 93.

Criteria: This route passes the small communities of Truxton, Valentine, and Hackberry that show evidence of when Historic Route 66 was the only major highway in the region. There are numerous old cars and occasional run-down motels. There is a gas station in Truxton, a store at the Keeper of the Wild Nature Park, and the Hackberry General Store to refuel at. The route also travels through a shallow canyon. Along Hackberry Road, the route borders the Cottonwood Mountains to the east and the Peacock Mountains to the west. This route is 45.9 miles long, and the moving time was 4 hours, 11 minutes with a total time of 5 hours, 12 minutes. The route trended downhill, ascending 446 feet and descending 1,916 feet with a moving speed of 10.9 mph. There were a few sandy sections in the town of Hackberry and as the route neared I-40 that necessitated a few dismounts. A bike with larger tires would help, but these sandy sections were short, and a larger gravel tire was sufficient for most of the route. Hackberry Road did require considerable pedaling, affecting the higher moving speed average that was attained on Historic Route 66. Most of the traffic that was encountered was on Historic Route 66, which was light to moderate, and there was a significant portion of Historic Route 66 that had an established passing lane and lacked a bike lane. There were a few places to find refuge from inclement weather along Historic Route 66, but those places decreased along Hackberry Road.


Test Route 11/26/22
Moving Speed
Physical Demand
Dismounts
Technical Difficulty
Traffic
Bike Lane Presence
Exposure
Criteria
0
1
2
3
4
5
Score

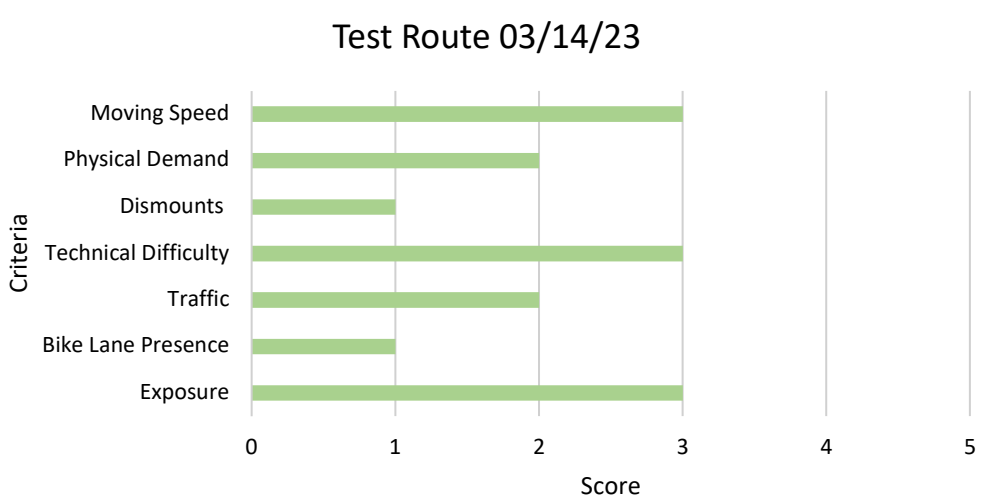
Blake Ranch Road to Kingman via Hualapai Mountains



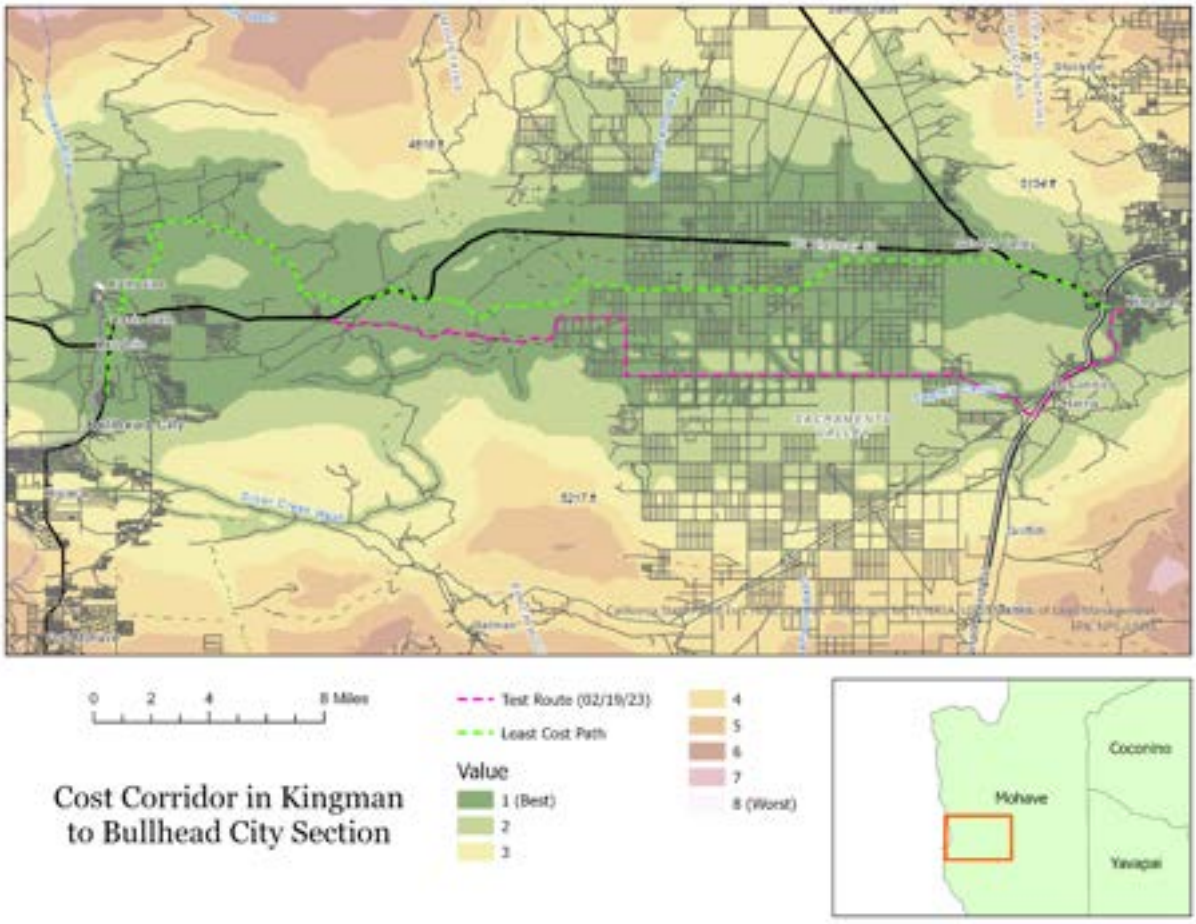
Test Route 03/14/23

Directions: This route started at the Petro gas station located at the I-40 exit at Blake Ranch Road. From the gas station the route goes south under I-40 and continues south on Blake Ranch Road. After 2 miles the paved road becomes a 2-lane dirt road. 7 miles from the start, the route goes through private land, and about 1 mile later it turns right (west) onto Antelope Wash Road. Antelope Wash Road becomes Hualapai Mountain Road at about mile 13. Hualapai Mountain Road then becomes Flag Mine Road as it enters the community of Pine Lake. Pavement is reached as the route nears the 17 miles mark, and a left (northwest) is taken on Hualapai Mountain Road. The route climbs a few hundred feet before descending to Kingman and ending after 27.6 miles at the intersection of Hualapai Mountain Road and Washington Street.

Criteria: This route starts at an elevation of 4,200 feet and is dominated by mesquite and scrub brush vegetation. As the route climbs, junipers start to dot the landscape and then pinyons. Near the top of the Hualapai Mountains, oak and ponderosa pines dominate the landscape before reversing the pattern as the route descends into Kingman. Notable points of interest include Yellow Pine Ranch and its pond, Wild Cow Campground and wild cow spring, Hualapai Mountain Resort, and Hualapai Mountain Park. As this route ascends the Hualapai Mountains, numerous views can be seen, including the Aquarius Mountains to the east, continuing Hualapai Mountains to the south, and the city of Kingman. This route is 27.6 miles long, and the moving time was 4 hours, 33 minutes with a total time of 4 hours, 55 minutes. The first (eastern) half of the route trended uphill, ascending 3,336 feet before descending 3,926 feet in the latter (western) half of the route. The moving speed was quite slow in the first half of the route due to walking but picked up considerably during the downhill latter half of the route, with an overall moving speed of 6.0 mph. While there weren't many obstacles that required a dismount, the continued steepness of the route necessitated nearly 3 total miles of hike-a-bike. A larger mountain tire may give better traction when climbing the gravel roads with a low climbing gear. Most of the traffic encountered on this route was on the paved section between Hualapai Mountain Resort and Kingman. The amount of traffic was moderate, and then higher as the route neared Kingman with a speed limit between 25 and 45 mph. On this paved section there is no bike lane for about 10 miles until the route enters Kingman.


Test Route 03/14/23
Moving Speed
Physical Demand
Dismounts
Technical Difficulty
Traffic
Bike Lane Presence
Exposure
Criteria
0
1
2
3
4
5
Score

Kingman to Bullhead City

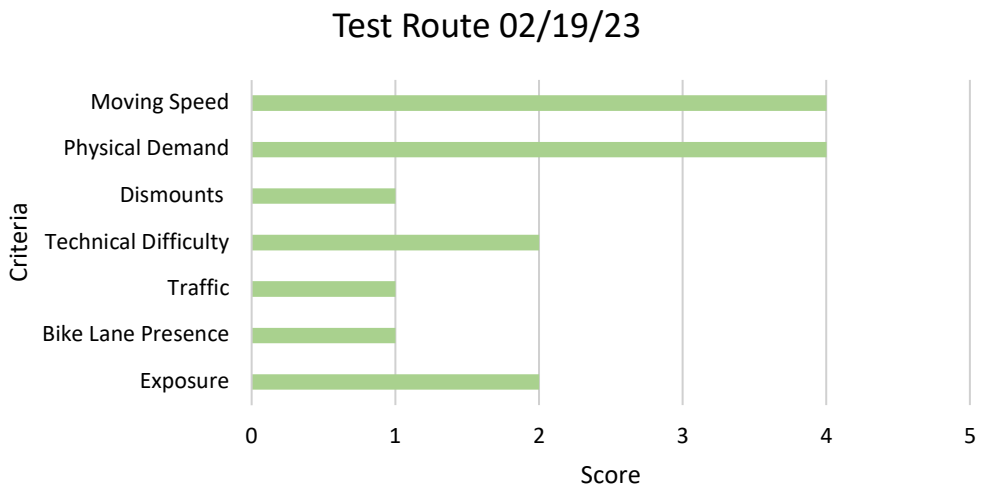


Test Route 02/19/23

Directions: This route started at Locomotive Park in downtown Kingman. The route goes west on Historic Route 66, also known as Andy Devine Avenue. The route quickly makes a left at a T-intersection to stay on Historic Route 66. The route continues southwest for about 5.5 miles before coming to a stop sign. A right (northwest) is taken at the stop sign which goes under Interstate 40 before becoming Shinarump Road. After a mile on Shinarump Road, the road continues straight and becomes Prescription Road. About 18 miles from the start the route turns right (north) onto Egar Road. 2 miles later the route turns left (west) onto Bolsa Drive, a gravel road. After another 2 miles, the route turns left (south) onto Ganado Road. 0.4 miles later the

route makes a slight right to merge onto BLM land and route 7752. A little more than a mile later the route turns right (west) onto route 7758. Roughly 6 miles later the route turns right (north) onto Buckwash Road. The route terminates after 29.7 miles near Arizona Highway 68, about 7 miles from Bullhead City.

Criteria: This route started at Locomotive Park across from the Powerhouse Visitors Center and Museum which showcases the history of Route 66. The route winds through a small canyon before entering Golden Valley which is relatively devoid of vegetation. There are views of towering cliffs as the first half of the route approaches Mount Nutt Wilderness. Once the route enters BLM land, there are numerous cliffs and buttes, and as the route crests the high point of the route, views of the Colorado River and Bullhead City can be seen. There is also a rock arch as the route descends toward Bullhead City. This route is 29.7 miles long, and the moving time was 3 hours, 47 minutes with a moving time of 4 hours, 44 minutes. The route trended downhill, with a descent of 2,375 feet and ascent of 1,245 feet. However, after entering BLM land the route became very difficult which necessitated many dismounts due to sand and large rocks. Due to these obstacles, the quicker moving speed observed in the mostly paved and downhill first half of the route was reduced to an average moving speed of 7.8 mph for the entire route. The BLM section of the route also suggested that a front or even full suspension bike with larger mountain tread tires may be necessary. The first 5 miles of this route follows Historic Route 66 and has significant traffic with no bike lane. The following 15 miles is also paved with no bike lane, but the traffic is light to moderate with a speed limit of 45 mph. The vegetation along the first half of this route is small desert vegetation and there are very few places to escape exposure to weather. However, there are multiple rock outcroppings on the BLM section of the route to escape sun and inclement weather.


Test Route 02/19/23
Moving Speed
Physical Demand
Dismounts
Technical Difficulty
Traffic
Bike Lane Presence
Exposure
Criteria
0
1
2
3
4
5
Score

Test Route Date	08/07/22	08/27/22	09/17/22	11/10/22	11/26/22	02/19/23	03/14/23
Distance (miles)	30.3	26.8	21.3	36.7	45.9	29.7	27.6
Moving Time	2h, 44m	3h, 24m	4h, 5m	4h, 7m	4h, 11m	3h, 47m	4h, 33m
Moving Speed	11.0 mph	7.8 mph	5.2 mph	8.9 mph	10.9 mph	7.8 mph	6.0 mph
Scored Criteria							
Moving Speed	5	4	3	5*	5	4	3
Physical Demand	4	4	3	4	4	4	2
Dismounts	4	3	1	5	4	1	1
Technical Diff.	5	3	2	5	4	2	3
Traffic	3	4	4	2	3	1	2
Bike Lane	4	5	5	4	3	1	1
Exposure	4	4	4	2	2	2	3
Total	29	27	22	27	26	15	15

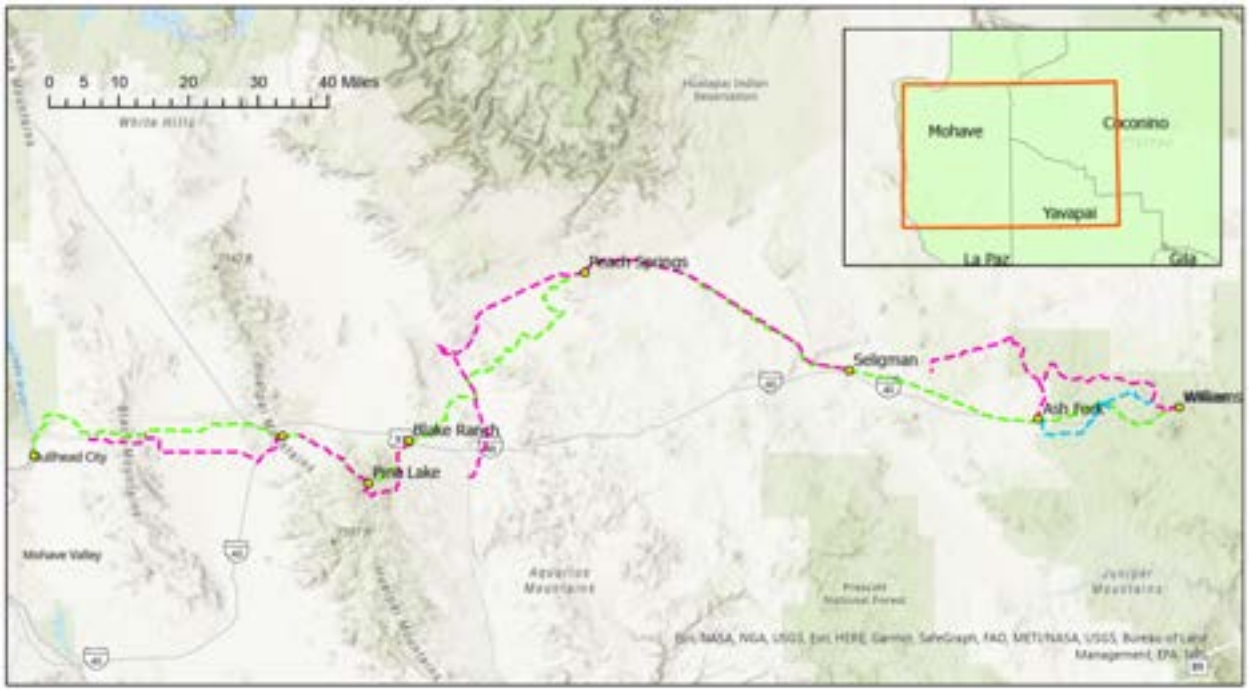


Figure 3: Study area, routes tested (pink dashed line), and results of least cost path (green dashed line). Blue dashed line is a secondary route tested in the Williams to Ash Fork section.

Discussion

GIS Analysis

The factors influencing the least-cost path and least-cost corridor analysis were existing roads and trails, slope, and surface management. These were determined based on criteria identified by the SCTA and in previous research by Smath (2020).

Least-Cost Corridor

The results of the corridor analysis did produce clear results of where to look for existing connections. Equal weighting was given to each factor; however, the SCTA and future trail planners may find it necessary to give higher weights to certain factors or add or remove factors. For instance, the SCTA may determine that the existence of a road or trail is more important than the land management or ownership type and slope. Modifying the weight given to each factor would also change the results of the LCP analysis.

I found that the results didn't limit the possibilities enough for one researcher to be able to investigate due to the scope of the study and the time allotted for this project. If additional destinations-including destinations that don't offer amenities such as points of interest-were added to each section, it would reduce the size of the area being analyzed, and the results of the LCC would be more precise. Additionally, each corridor is based on a value threshold, and reducing this value would also produce more precise results.

Least-Cost Path

In general, the test routes selected for this project did not follow the least-cost paths produced in the analysis. Importing the paths into Gaia GPS produced erratic elevation gain and loss charts, and inspection of Gaia GPS's ESRI satellite imagery layer and accompanying Google Maps imagery showed that there were many disconnected or highly degraded roads selected by

the LCP. It was determined that other routes should be selected for field test purposes due to the method of field testing, but may be beneficial to check the accuracy of what was seen through satellite imagery by other means of field testing such as by vehicle or by foot.

The least-cost paths, based on the factors provided, produced clear paths between target destinations. Due to the size of the study area and each section, there were many possibilities for roads. While the road values were reclassified to prioritize smaller/dirt roads and trails (away from traffic), the analysis didn't include the roads' maintenance level or surface type. In addition, the roads dataset was so large that proper maintenance and updating would be difficult. What this produced was a LCP that followed some roads that were extremely degraded and potentially difficult to traverse with a bike or even an OHV. Additionally, some roads that were not designated as private in the dataset had locked gates or regulations that prevented access.

The least-cost paths in the analysis may be more relevant to finding equestrian, hiking, and OHV use paths. In addition, the results may be more useful if destinations were closer together and the study area was reduced. Adding additional factors such as viewshed, road maintenance level, and/or road speed may make the results of a LCP more beneficial to determining a test route.

Route Recommendations

As can be seen from the results, most routes that were tested would need to be significantly modified to be considered a desirable or even viable route. These modifications include trail building, construction of bike lanes, and road grading and maintenance, and building structures to reduce exposure to weather. Some of the routes tested were on double track trails that could be outfitted with gates to regulate motorized users on these parts of the route. With significant road grading and maintenance, more of these double track trails could be

utilized to cater to non-motorized use. All routes were traversable; however, the Blake Ranch to Kingman via Hualapai Mountains and the Kingman to Bullhead City required significant walking. Walking over the Hualapai Mountains was due to extreme elevation gain and slope while walking in the BLM section of the Kingman to Bullhead City route was due to rough, technical terrain. Recommendations for improving each section are provided below.

The 08/07/22 route from Williams to Ash Fork scored the highest based on the test criteria, and required few upgrades to make the route highly desirable for a gravel-bike user. Construction of bike lanes, especially the 6 miles near Ash Fork on Double A Ranch Road, would improve safety and enjoyment of gravel bike, credit-card (GRCC) tourists. The 08/27/22 route was also one of the most highly scored routes. Road grading and maintenance on Forest Road 15 and 144 would improve rideability. In addition, it might be worth looking into alternatives to Gas Pipeline Road (Forest Road 796), as establishing a route on this road may be contrary to other activities such as pipeline maintenance and railroad use. One option may be able to connect the 08/07/22 route and 08/27/22 route via Forest Road 6. This would also include Johnson Railroad Tunnel and crater as points of interest.

In the Ash Fork to Seligman section, the 09/17/22 test route scored lower due to dismounts, physical demand, and technical difficulty. All of these scores were influenced by factors encountered on Cable Road. Cable Road cuts a straight line through the landscape as opposed to following contours of the landscape. There are extreme fluctuations in slope, and rough, rocky surfaces to navigate. To be viable, this road would need significant grading and maintenance as well as trail building along landscape contours.

The only route tested (11/10/22) for the Seligman to Peach Springs section was along Historic Route 66. It may be worth investigating the many off-highway roads that dissect the landscape; however, this section is entirely checkerboarded state trust and private land, which may limit recreational use. The test route did score relatively high, but due to high-speed traffic,

installation of a barrier to separate GBCC users and traffic would improve safety and potentially offer users a more enjoyable experience. This section is also significantly exposed to adverse weather conditions and would benefit from the development of intermittent shelters.

Similar to the previous section, the 11/26/22 test route in the Peach Springs to Blake Ranch section could benefit from a bike lane and/or barrier between the bike lane and road traffic. This route was also quite exposed to weather and could additionally benefit from constructing shelters or landscaping to provide protection from adverse weather. It may be worth investigating some of the roads selected by the LCP for this section. The part of the LCP that heads southwest from Blake Ranch Road directly to Blake Ranch RV Park would reduce the length of the route by roughly 9 miles. This would also provide users with the option to continue 15 miles to lodging at Hualapai Mountain Resort if the one cabin at Blake Ranch RV Park isn't available.

The final two sections scored the lowest of all routes tested. However, these routes did provide some of the most impressive views, and the destinations provided some of the best options for lodging and cultural tourism. The 02/19/23 test route started on Historic Route 66, which lacked a bike lane and had considerable traffic. Continuing onto Shinarump Road that becomes Prescription Road, the route also lacked a bike lane but had a lower volume of traffic. Establishing a bike lane would improve safety. It may also be desirable to include a barrier along the more trafficked section of Historic Route 66. Prescription Road seems to be a well-used thoroughfare for the Golden Valley community, and the road system in this community is gridded, so there are other possible routes that parallel the test route and may alleviate some of the safety concerns. Once this route enters BLM land, the terrain becomes difficult to ride due to large rocks and sandy soil. This may be partly due to heavy OHV use in this area. There are numerous BLM roads in this area that could be viable for biking, but the route may be improved by limiting it to non-motorized use and grading or resurfacing the route. However, limiting non-

motorized use in this area would be difficult because it would take away from current recreational users, so building a new trail or finding a different route may be preferable. Finally, this route is rather exposed to adverse weather, especially considering this is one of the hottest environments that the SCT would route through. Constructing shelters or other means of escaping weather may improve the user's experience.

The 03/14/23 test route from Blake Ranch RV Park to Kingman via the Hualapai Mountains also scored low. This route has a high physical demand as it ascends roughly 4,000 feet over a relatively short distance. Constructing connecting trails with switchbacks would increase the user's experience, especially for novice riders. The route has a few sections that are steep enough to cause slippage of the rear tire. From Hualapai Mountain Resort to Kingman, the route is paved and significantly trafficked with no shoulder. An addition of a bike lane would increase safety, especially for users heading uphill in this section. This paved section would also benefit from a connecting trail with switchbacks as the route nears Hualapai Mountain Resort. Additionally, while the route is mostly traversable to GBCC users, Antelope Wash Road is relatively rough and could use grading.

Biking and User Alternatives

While one of my goals was to determine if it was possible to create a route for the Sun Corridor Trail which could cater to Credit Card Bike Tourists, bikepackers would have more options in the sections which have limited lodging options. For instance, leaving Seligman, there are currently only 4 lodging options for roughly 120 miles. But if you have the ability to set up camp, that provides additional options near Truxton-roughly 50 miles from Seligman- and east of the Hualapai Mountains-about 50 miles from Hackberry.

While one of the objectives of the SCTA is to create a front-country trail, if the user of this segment were to bikepack, there is ample opportunity to camp on public lands. Bikepacking

can cater to gravel cyclists in addition to touring and mountain bikes, and this doesn't necessarily negate a front-country experience. Between Ash Fork and the Hualapai Mountains much fewer options for lodging exist. However, there is a KOA in Seligman that offers tent camping, and there is some BLM land between Truxton and Hackberry as well as Crozier Ranch which is managed by Arizona Game and Fish. In addition, a few camp spots located on private land were advertised on Airbnb, VRBO, and Hipcamp. This would open up options for users to carry more equipment or stick to destinations that allowed them to shed equipment.

Furthermore, alternative bike types may make the routes tested. For instance, a mountain bike with suspension and wider tires may positively affect the score of criteria such as dismounts and technical difficulty. However, this type of bike may go against the goals of the purpose of the Sun Corridor Trail. Similarly, gravel e-bikes may positively influence the physical demand and moving speed criteria. Although the Sun Corridor Trail Alliance looks to promote non-motorized use, nearly all the route options for the northwest segments of the SCT allow motorized use. This may be partially due to the low population of a large geographic area, less demand from residents for these types of trails, and types of land management and ownership. Allowing for certain types of electric bikes could also attract novice bikers and recreators as well as aging recreators that may benefit from assisted pedaling.

Alternative Users

The SCT will also cater to hikers and equestrian users. While the routes tested for this project do not restrict these uses, many parts of the tested routes make non-cycling recreation activities less desirable and/or more dangerous. For example, the Seligman to Peach Springs section is entirely along Historic Route 66, which is a paved highway with a speed limit of 65 mph. This may present greater danger for users on foot or horseback and be less attractive for these types of users. In addition, long distance hiking would be challenging as there are currently no designated places to camp along this 37-mile section, and most of the surrounding

area is private and state trust land, which also makes building a new trail difficult. These other users may find certain sections or locales more accommodating, such as parts of the SCT that route through national forest or near larger populations where there is a higher concentration of multi-use trails. In addition, the average hiker moves at between 2 and 2.5 miles per hour (CITE), making 'credit-card hiking' an impossible form of tourism in Northern Arizona, where towns would need to be spaced out at most 15-20 miles.

Conclusion

The purpose of this practicum project was to investigate route options of the northwest segment of the proposed Sun Corridor Trail and make recommendations related to the findings of the GIS analysis and field-testing components. Previous research was conducted by Adam Smath (2020) in the Coconino National Forest between Sedona and Williams, AZ via Flagstaff, AZ, and the findings and methods of his research influenced this project. Major differences that shaped this project were the significant variation in land management and ownership, and lack of maintenance of existing roads and trails.

Least-cost corridor and least-cost path analyses were conducted for each section to attempt to narrow down possible routes to consider and recommend for the SCT. While the results from these analyses did provide insight, they were too generalized to provide a clear route or area to test. In addition, the results of the LCP proved difficult to field test with the equipment chosen for the field-testing part of this research. Many of the LCP's had short segments (<0.25 miles) that didn't follow a road or trail, crossed a fence or interstate, and/or followed an unmaintained path. The LCP results could be investigated by other modes of transportation such as by foot and vehicle. The parameters considered in the LCP analyses could be modified to include additional factors or weighted differently based on changes in importance of various criteria. Furthermore, LCP results could be improved by analyzing shorter

distances or adding other destinations such as attractions, water sources, and viewpoints to effectively shorten distances.

The area studied for this project holds significant cultural, historical, and environmental value. The challenge is finding existing roads and trails for recreationists to experience these aspects of the northwest segments of the SCT. Field testing showed that while it is possible to connect the destinations outlined on suncorridortrail.org, improvements to the routes tested would make the experience safer and more attractive to users. All the test routes in this project were tested with a bicycle with gravel bike tires, and changing the type of bike used or mode of transportation would likely produce different results. However, the results of this project provide insight to the northwest segments of the SCT and complement previous and concurrent research into the SCT. Finally, further research and fieldwork could provide alternatives that better fit the criteria and objectives desired by the SCTA, and the criteria and methods used in this research may be reused or modified as needed to further study the area considered in this project as well as other segments of the SCT.

Appendix – Photos

A1 – test route 08/07/22

A1.1

Double A Ranch Road looking west toward Ash Fork.

A1.2

Button Tank on the north side of Double A Ranch Road.

A1.3

Double A Ranch Road becomes rougher before entering a small community north of Ash Fork.

A1.4

There is no bike lane or shoulder on Double A Ranch Road north of Ash Fork.

A2 – test route 08/27/22

A2.1

Rougher double track terrain on Forest Road 15

A2.2

Cobbles on Forest Road 15 making travel difficult. Vegetation has become dominated by Junipers.

A2.3

Looking west on Pipeline Road.

A2.4

An active railroad crossing on Pipeline Road.

A2.5

Rough, steep terrain along Pipeline Road.

A2.6

Johnson Railroad Tunnel.

A2.7

A low point along Forest Road 6 that floods from an upstream drainage.

A2.8

Rough and rocky terrain along Forest Road 114.

A2.9

A wide shoulder on Highway 89 looking north toward Ash Fork.

A3 – test route 09/17/22

A3.1

A tank along Sevens Ranch Road (County Road 124).

A3.2

Signage warning of an AT&T underground cable along Cable Road.

A3.3

Rocky terrain on Cable Road, making it nearly impossible to pass without suspension and wide mountain bike tires.

A3.4

Steep and rocky terrain along Cable Road.

A3.5

View from Cable Road looking southwest toward Seligman.

A4 – test route 11/10/22

A4.1

A wide shoulder but 65 mph speed limit on Historic Route 66. Looking west toward Peach Springs.

A4.2

Evidence of previous bikers along Historic Route 66.

A4.3

Grand Canyon Caverns attraction, Caverns Inn, and café about 25 miles from Seligman.

A4.4

A passing lane diminishes the road shoulder entering Peach Springs.

A5 – test route 11/26/22

A5.1

Historical sign entering Truxton along Historic Route 66.

A5.2

A gas station and general store along Historic Route 66 west of Truxton.

A5.3

Crozier Ranch camping west of Truxton.

A5.4

A long section (2+ miles) along Historic Route 66 with no shoulder.

A5.5

Keepers of the Wild Nature Park along Historic Route 66. Their gift shop also has snacks and drinks.

A5.6

Hackberry General Store is an attraction along Historic Route 66 that also sells snacks and souvenirs.

A5.7

Sandy section along Hackberry Road. My tire track and footprints are visible which shows how soft the surface is.

A5.8

The east side of the Hualapai Mountains are visible in the distance. Taken from a rough but paved section of Hackberry Road near Highway 93.

A6 – test route 02/19/23

A6.1

Looking southwest on Historic Route 66 near Kingman where there is little to no shoulder for more than 5 miles.

A6.2

Looking west on Prescription Road along the Arizona Peace Trail, an Arizona OHV trail. This photo illustrates the 45 mph along a stretch of road with little to no shoulder. Views of the Mount Nutt Wilderness are on the horizon.

A6.3

OHV activity as the route enters BLM land.

A6.4

OHV use, washes, and soil type contribute to the sandy terrain of this route. Views of rock formations persist through this section of the route.

A6.5

Looking west toward Bullhead City. Although difficult to see in this photo, there are views of the Colorado River from this vantage point.

A6.6

An extremely rocky section of BLM Route 7758 that necessitated about a mile of walking. A few slow-moving OHV's were encountered along this section.

A6.7

A secluded rock arch along BLM Route 7758.

A6.8

Another rough section of BLM Route 7758. Impressive rock formations in the background.

A7 – test route 03/14/23

A7.1

Blake Ranch Road where the pavement turns to a dirt road.

A7.2

A moderately rough and steep section of Antelope Wash Road as it ascends the Hualapai Mountains.

A7.3

Views looking north near the top of the Hualapai Mountains on Hualapai Mountain Road.

A7.4

Snow at the top of the Hualapai Mountains in mid-March.

A7.5

Looking northwest toward Kingman on Hualapai Mountain Road. This is part of the Arizona Peace Trail which is an Arizona OHV trail. There is no shoulder along this steep, paved section with speed limits as high as 45 mph.

A7.6

Coming into Kingman on Hualapai Mountain Road.

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