

GEOSPATIAL WEB-MAPPING AND APPLICATION DEVELOPMENT FOR THE
SOUTHEAST ARIZONA SUSTAINABLE RECREATION STRATEGY

by

Jessica Little

MASTER OF SCIENCE
GEOGRAPHIC INFORMATION SYSTEMS TECHNOLOGY

THE UNIVERSITY OF ARIZONA

2016

ACKNOWLEDGMENTS

I would like to give a special thanks to Jennifer Psillas, John Danloe and the other members of the Mapping & Data Inventory Team for allowing me to be a part of this project and for their input and assistance throughout the process. Thanks also to Colleen Whitaker and the entire staff at Southwest Decision Resources for their continued commitment to facilitating and maintaining involvement in the Southeast Arizona Sustainable Recreation Strategy. I would also like to thank Zac Ribbing and Terry Austin of the Coronado National Forest for inspiring my initial interest in GIS. Lastly, I would like to thank my friends and parents for their continued support and encouragement.

To everyone I met during my time at the Arizona Conservation Corps.
Your inspirations are limitless.

TABLE OF CONTENTS

ACKNOWLEDGMENTS	2
TABLE OF CONTENTS.....	4
LIST OF TABLES.....	5
LIST OF FIGURES	6
ABSTRACT.....	7
INTRODUCTION	8
Objectives.....	11
METHODS	12
Study Area.....	12
Data	13
Vector Data.....	13
Schema Creation and Data Editing	14
Quality Assurance and Quality Control	15
Assumptions	15
Web Application and Story Map Development	16
RESULTS AND DISCUSSION.....	24
Web Application and Story Map Development	24
An Opportunity for Analysis: Recreation Gap Analysis in Tucson, Arizona.....	24
CONCLUSIONS.....	26
Moving Forward.....	27
APPENDIX A: ATTRIBUTE TABLES AND GEODATABASE DOMAINS	29
Attribute Tables in Alphabetical Order by Feature Class	30
Geodatabase Domains	36
APPENDIX B: GAP ANALYSIS	39
REFERENCES	45

LIST OF TABLES

Table A 1: Activities Attributes.....	30
Table A 2: Administrative Attributes.	30
Table A 3: Camping/Lodging Attributes	31
Table A 4: Closures Attributes	32
Table A 5: Public Land Ownership Attributes	32
Table A 6: Natural Features Attributes	33
Table A 7: Roads Attributes	33
Table A 8: Trailheads Attributes.....	34
Table A 9: Trails Attributes	35
Table B 1: Public transportation availability per 0.5- and 1-mile radii of most visited recreation areas.	44

LIST OF FIGURES

Figure 1: Initial area of focus.....	12
Figure 2: Data Model.....	14
Figure 3: Web Map within ArcGIS Online interface.....	17
Figure 4: App in Web AppBuilder with Splash Screen widget.....	19
Figure 5: Introduction Tab in Map Series.....	21
Figure 6: Recreation Application in Map Series.....	21
Figure 7: USFS Sustainable Recreation Story Map in Map Series.	22
Figure 8: Organization, Volunteer, and Recreation Club Links in Map Series.....	22
Figure 9: Crowdsourced Story Map in Map Series.	23
Figure B 1: Trails within 5 and 10 miles of selected communities in and around Tucson, AZ. ...	40
Figure B 2: Trail miles by use within 5 miles of selected communities.....	41
Figure B 3: Trail miles by use within 10 miles of selected communities.....	41
Figure B 4: Access to parks/open space from Tucson’s ParkScore (Trust for Public Land 2016).	42
Figure B 5: Accessibility of most visited recreation areas by public transportation.	43

ABSTRACT

Within the last decade, the United States Forest Service (USFS) has initiated a nationwide project of Sustainable Recreation as a response to the decreasing amount of resources available to maintain the current recreation infrastructure, including trails, campgrounds, etc. These unmaintained trails and facilities pose a potential safety threat to users and the landscape in which they reside. This smaller pilot project, as part of the Southeast Arizona Sustainable Recreation Strategy, is the second pilot project in the Southwest Region of the USFS aimed at growing the Sustainable Recreation initiative. The main goal of this project is to create the framework for an inter-agency web application of recreation opportunities in Southeast Arizona, with an aim to increase communication between land management agencies, and to increase public participation and conservation of public lands. To achieve this, recreation data were gathered from multiple participating agencies and merged into a new schema to provide useful attribute information. This schema was then uploaded to ArcGIS Online and saved as a web map for internal, agency use. In addition, a public-facing web application and corresponding Story Map were also created. The result better portrays the Sustainable Recreation initiative and provides a one-stop-shop of useful recreation information and links for users who wish to become more involved. This project provides the groundwork for which more data from additional agencies and areas can be added and the participation of both land management agencies and the general public can grow.

INTRODUCTION

The last few decades mark a revival of public lands in the United States. After the Great Depression in the 1930s, the country faced an unprecedented amount of growth in industry and technology, as well as a social and cultural shift from the outdoors to a sedentary life indoors. Prior to the Depression era, large gains were made in the preservation of our natural lands. Perhaps the first well-known naturalist author, Henry David Thoreau, championed the wilderness movement. One of his most popular works, *Walden; or, Life in the Woods*, published in 1854, called for a return to nature and simple living. It was his foresight that our resources could be limited and sustainability would be vital that inspired the “Father of the National Parks,” John Muir, to not only write about his inspirations from nature, but also to become the greatest activist for preserving natural lands within the United States. From advocating for the creation of the first National Park, Yellowstone National Park in 1872, to befriending fellow naturalist President Theodore Roosevelt, Muir brought about an increased awareness to the importance of not only preserving natural lands, but turning them into public lands for ease of access by the public.

After this rapid increase in the conservation of public lands came the Great Depression, and much of the forward momentum stopped. A slice of hope came when President Franklin D. Roosevelt created a variety of public works programs stemming from his New Deal, including the Civilian Conservation Corps (CCC) in 1933. During its ten years of existence, the CCC put young men across the country to work building public infrastructure within National Parks and other federally preserved lands. Much of their work, including, but not limited to, hiking trails, visitor’s centers, employee housing, and fire lookouts, still exists today. However, once the United States entered World War II at the end of 1941, the CCC program was discontinued and

the country began its modern industrial and technological revolution. The country's public lands were now viewed as places to be reaped for resources instead of preserved. We continued this line of thought until the end of the Vietnam War in the mid-1970s. By this time, much of the public was tired of fighting wars and, with the hippie revolution, the ideals of natural living that existed prior to the industrial movement came back. During this time, the United States Forest Service (USFS) marked its transition from the 'Multiple-Use Management Era' to 'The Environmentalism and Public Participation Era' (USFS 2004). This transition marks the beginning of a balancing act between once again preserving our public lands while still allowing public access and resource gathering. Because of its past and present involvement in the timber industry, this balancing act became increasingly important to the Forest Service on a national scale. The agency began a rebranding of its public image, attempting to draw more recreationists to its lands. Prior to this, the National Parks were the go-to for members of the public seeking recreation opportunities. By drawing more people to its National Forests and Grasslands, the USFS then faced the issue of how to ensure that increased usage would not cause increased harm to public lands.

In 2010, the Forest Service released a national-scale document, "*Connecting People with America's Great Outdoors: A Framework for Sustainable Recreation*." This document calls for regions through individual forests to create and implement plans to improve the sustainability of their recreation infrastructure. The most notable areas of focus that add to the importance of this project include restoring and adapting recreation features, enhancing communities, forging partnerships, promoting citizen stewardship, and providing accurate information to the public (USFS 2010). Region 3 of the USFS, which includes Arizona and New Mexico, published its own plan in 2014 in response to the national document. Very broadly, the main goal provided in

this document is “to achieve a sustainable recreation program, essential to advancing the mission of the Forest Service, with a diverse and engaged public that enjoys and actively cares for the National Forests and Grasslands of the Southwest” (USFS 2014, 3). Again, there is a focus on cultivating an active public which can help in creating a sustainable recreation infrastructure for the use of future generations.

But why is this goal important or even necessary? In 2013, the Government Accountability Office (GAO) published a report of its investigation into the Forest Service trails system. They looked at eighteen National Forests within five of the USFS Regions, one of which was the Coronado National Forest in Southeast Arizona that is also included in this project. The report concluded that the Forest Service has more miles of public trails than it can afford to maintain, causing a backlog in maintenance and potentially putting users at risk (GAO 2013). If the Forest Service, along with other land management agencies, cannot afford an adequate number of employees, and consistent training of those employees, they will need to turn to volunteer groups and the general public for assistance. For example, the Coronado National Forest already has a relationship with local volunteer groups and hires crews from modern-day Conservation Corps to assist in a variety of maintenance tasks, especially concerning its hiking trails. However, even this comes with a cost and not all necessary projects can be completed, especially when considering the cyclical nature of most tasks. It would be helpful if these land management agencies could reach out to more of the public and get more everyday users involved in sustaining their local recreation opportunities, even by doing something as simple as reporting maintenance issues that they come across. That is where this project comes into play.

Objectives

The goal of this project is to provide the public with an online resource that contains as many of their local recreation opportunities as possible, regardless of agency, in an easy to navigate interface with detailed and accurate information. The hope is that if an all-inclusive resource such as this is available to the public, they will be more willing to participate in recreation opportunities and potentially become more involved in a volunteer capacity as well. There is also the opportunity to report issues directly to the managing agency, which could help the agencies better respond to needed maintenance tasks. The end result of this project is a web-based application created with Esri's ArcGIS Online and customizable Web AppBuilder. This beginning phase is being created for the Southeast Arizona Sustainable Recreation Strategy, in conjunction with Southwest Decision Resources and participating local land management agencies. These local agencies and parks include the USFS, National Park Service (NPS), Pima County, and other municipalities including the City of Tucson, Town of Marana, and the Town of Oro Valley. The recreation data obtained from these agencies is housed in a geodatabase with a pre-determined schema into which the data is sorted, edited, and displayed. With this schema, there is great potential for the area involved to grow, from Southeast Arizona to statewide and beyond. This project is acting as a pilot initiated by the Southeast Arizona Sustainable Recreation Strategy's Mapping and Inventory Team (Southwest Decision Resources 2016), with the goal of being consumed by Region 3 of the Forest Service to aid in their goal of creating a Sustainable Recreation program.

METHODS

Study Area

The initial area of focus for this project is Southeast Arizona. The region is popular among recreationists of all types because of its unique landscape, which most notably includes the Madrean Sky Islands. These isolated mountain ranges provide a wide range of elevations and therefore a high diversity of vegetation biomes and animal species. From the Sonoran Desert at two thousand feet elevation, to evergreen forests at over ten thousand feet, there exists a variety of recreation activities, most of which can be accessed on a year-round basis (Sky Island Alliance 2016).

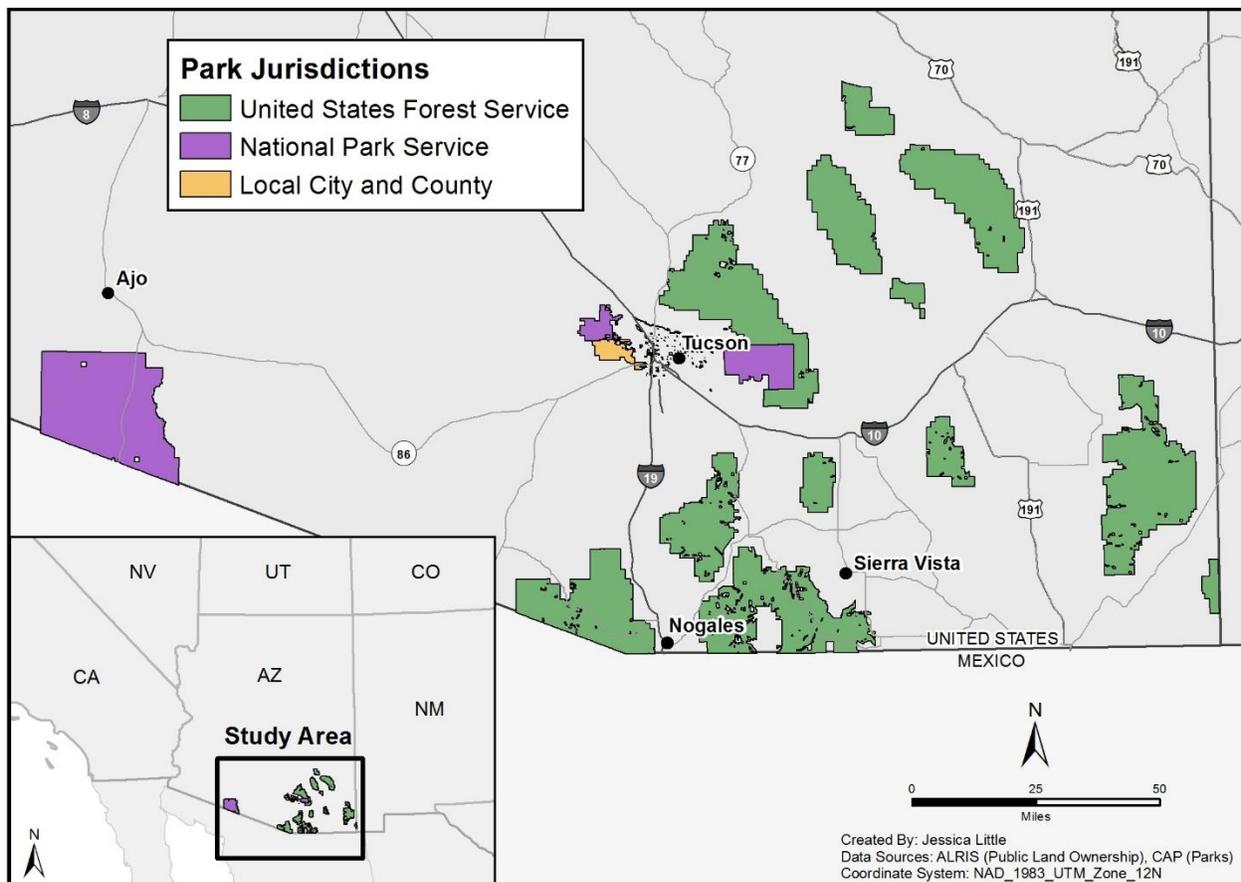


Figure 1: Initial area of focus.

Data

Data for this project were provided by the land managing agencies through a private group in the AZGEO Clearinghouse, managed by the Arizona Geographic Information Council (AGIC). A clearinghouse was chosen as the mode to share data because users need to be approved for whichever group they wish to join. This allows for data, and related metadata, from federal, state, and local agencies to be shared in a secure location. Data posted in the clearinghouse were downloaded and stored in a file geodatabase. All data were projected to NAD83, UTM, Zone 12 North, in units of meters, if not already in that projection. Although this initial area is relatively small, there is potential for the area to grow. Considering this, Transverse Mercator is the preferred projection over State Plane because it can cover a larger area before skewing data visualization. The geodatabase was created using Esri's ArcCatalog 10.3.1 and all geographic information systems (GIS) editing was performed using ArcMap for Desktop 10.3.1.

Vector Data

Data from the USFS includes forest and wilderness boundaries of the Coronado National Forest, and its roads, hiking trails, trailheads, campgrounds, lodging, fee stations and visitor centers, picnic areas, and other recreation activities. The NPS provided data of its park and wilderness boundaries, hiking trails, trailheads, campgrounds, visitor centers and other park buildings, and natural landscape features. Data from Pima County and the City of Tucson included hiking trails, trailheads and trail access points, and parks. All original data were provided as either a point layer for individual features, a polygon layer for boundaries, or a line layer for hiking trails and roads. A public land ownership polygon layer was downloaded from the public group on AZGEO and was combined with other provided boundary layers.

Schema Creation and Data Editing

An important part of this project is the creation of a geodatabase schema into which all recreation data, present and future, can be fit. This provides attribute accuracy and consistency in data that is being provided from various land management agencies, each of which has its own unique way of storing its recreation data. The geodatabase is the basic building block of this project and needs to meet the potential requirements of both the agencies in a private, internal sense, but still provide useful information that the public would need for researching and planning their recreation activities. The initial data was reviewed and ultimately organized into three themed, feature datasets. Each dataset has two to four feature classes that further divide the data into smaller themes, while also considering the geometry of the features in question (Figure 2). Each feature class has an individualized attribute table to provide the most pertinent information related to that feature class (Appendix A – Attribute Tables). In the online interface, the information provided in these tables is what will populate the pop-ups for each individual feature. The geodatabase also contains twelve domains to be applied to as many attribute fields as makes sense (Appendix A – Geodatabase Domains).

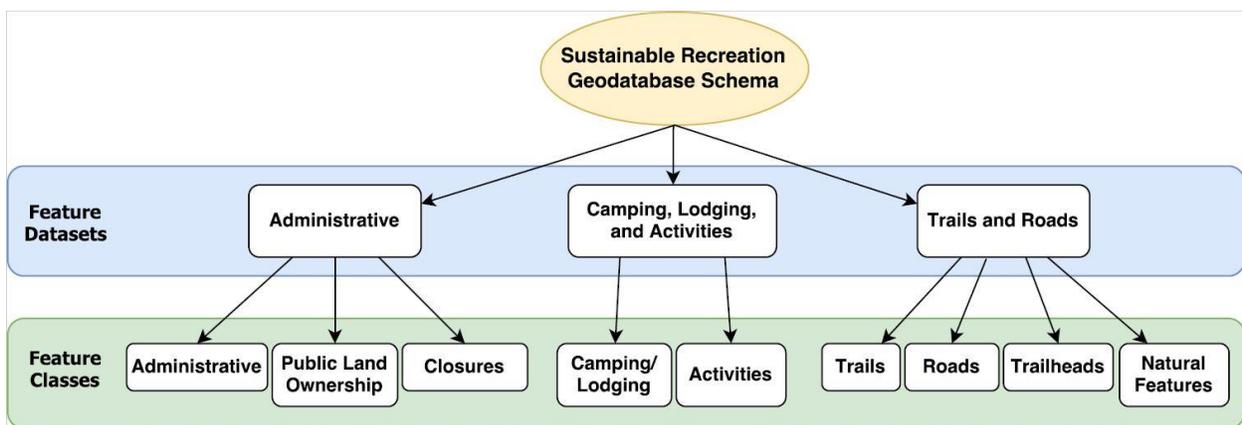


Figure 2: Data Model.

Quality Assurance and Quality Control

For the initial build of this project, all provided recreation data was checked for its attribute accuracy, with the idea being that any new data added in the future would already include attributes to fit into this predetermined schema. The newly created feature classes included many attribute fields that were not present in the original data, or if similar fields were present, further editing still may have been necessary for the information in individual fields to match (Appendix A – Attribute Tables). During the schema creation process, a large emphasis was placed on providing domains wherever feasible. This allows only predetermined options for input into attribute fields, depending on which domain was applied to that field (Appendix A – Geodatabase Domains). This prevents human input error, which becomes especially important during any type of data querying or analysis. In addition to editing attributes of each feature class to match the schema, the topology of hiking trails was also checked. Wherever discernable, the topology of trails was edited so that the line began at a trailhead or access point, with all segments continuing in the same direction until the trail ends or meets at a junction with another trail. This prepares the trail lines for proper display within an elevation profile chart that may be used in the web application in the future.

Assumptions

The two major assumptions recurring throughout this project are that, first, data provided by participating agencies are accurate, both spatially and tabular. It will be the agencies' responsibility to provide data with necessary attributes to fit the data model. The second assumption is that, when more data are added in the future, editing will take place to ensure the data fit into the model described above (Figure 2), with additions made when necessary, such as adding more domains or attribute fields as needs arise.

Web Application and Story Map Development

Once all data topology and attribute editing is completed in ArcMap for Desktop, the zipped geodatabase is uploaded to the user's account ArcGIS Online (AGOL). Within AGOL, products are automatically private until they are ready to be shared to other groups or the public, once again ensuring the privacy of government data until it is ready for public display. The University of Arizona's ArcGIS for Server account was not available for this project as firewalls would have prevented sharing of end products. Data had to be edited as accurately as possible prior to upload to AGOL to limit possible editing with the online environment, and therefore limit potential credit usage.

Once online, the symbology of the feature classes is set by using URLs of icons to provide a more customized look. Services were also brought into the map to provide additional information that will be automatically updated when the owners of the Services make changes. These included current weather conditions (Esri), current wildfire activity (Esri), and the Arizona National Scenic Trail layers (Arizona Trail Association). The map then saved as a Web Map that can be viewed and/or edited by individual users within the Sustainable Recreation group (Figure 3). AGOL will also be the environment for internal use of the data among the various land management agencies. Employees will have the opportunity to perform the basic types of analysis that are included in the functionality of AGOL. It is here that data can also be filtered as either suitable for public display or kept private.

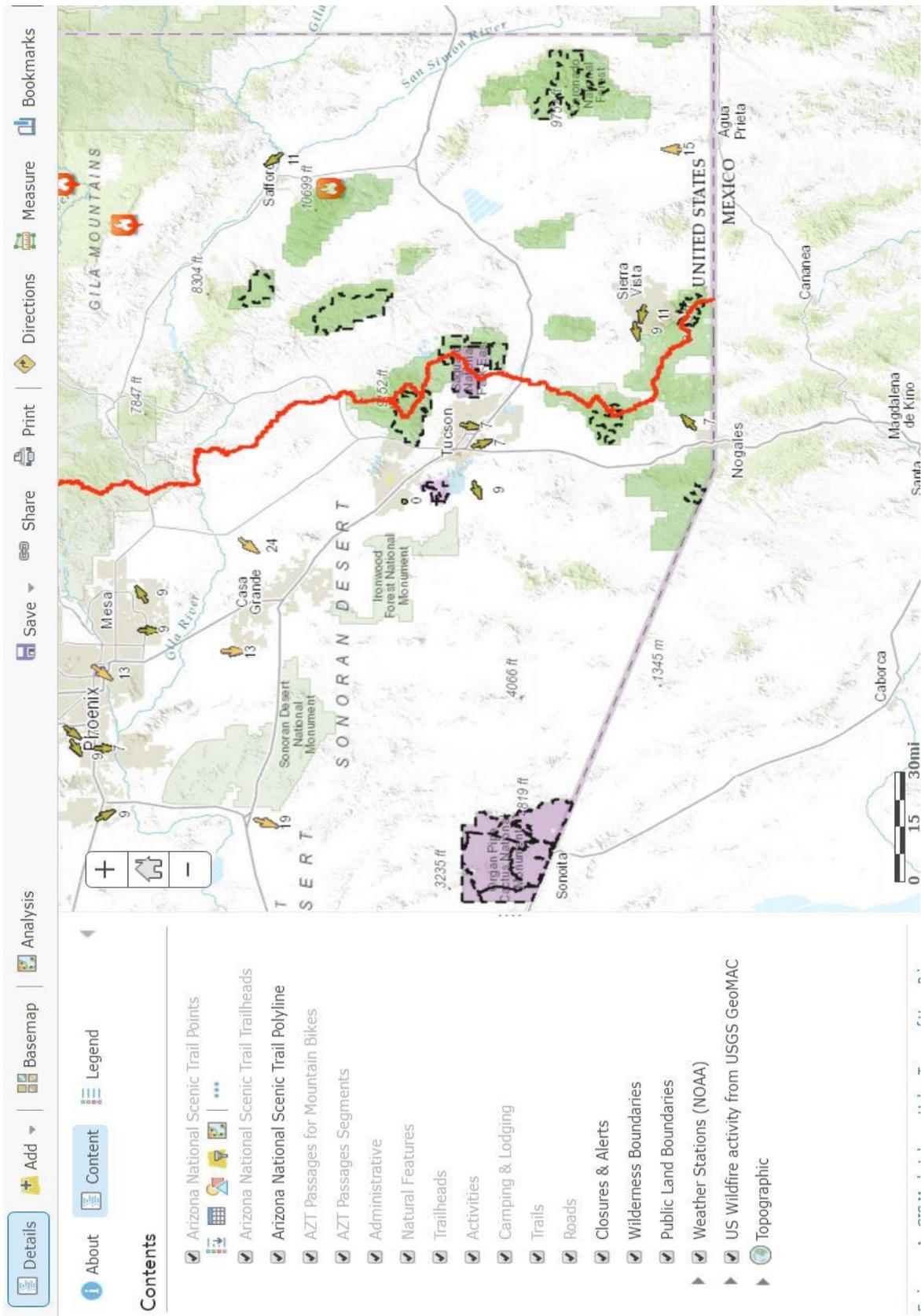


Figure 3: Web Map within ArcGIS Online interface.

The completed web map was then turned into a web application app with Esri's Web AppBuilder for ArcGIS (Figure 4). The Tab Theme was used with four filters added in the sidebar for users to narrow down results specific to their interests:

1. Trails: Filter open trails by permitted uses (hiking, bicycling, equestrian, dogs, OHV), if a restroom and/or potable water is available at the trailhead, if a fee or permit is required for access, trailhead access type, trail surface type, and land management agency.
2. Camping/Lodging: Filter campgrounds or lodging by type, if it is open seasonally or year-round, if a fee or permit is required, if a toilet and/or potable water is available, and land management agency.
3. Activities: Filter by one of eleven activity types (picnicking, fishing, museums, nature trails, etc.), if a fee or permit is required, and land management agency.
4. Administrative: Filter for Info/Fee Stations, Visitor Centers, Ranger Stations, or Supervisor's Offices.

The Legend, Layer List, and Basemap Gallery widgets are added to aid in the display of the data. A Splash Screen was also added to open when a user first accesses the app. It explains the basics of navigating the app and includes a disclaimer that users must agree to before they can access the app. Links to the Sustainable Recreation Strategy webpage, Wilderness regulations, and Leave No Trace ethics were also added into the app for users to explore.

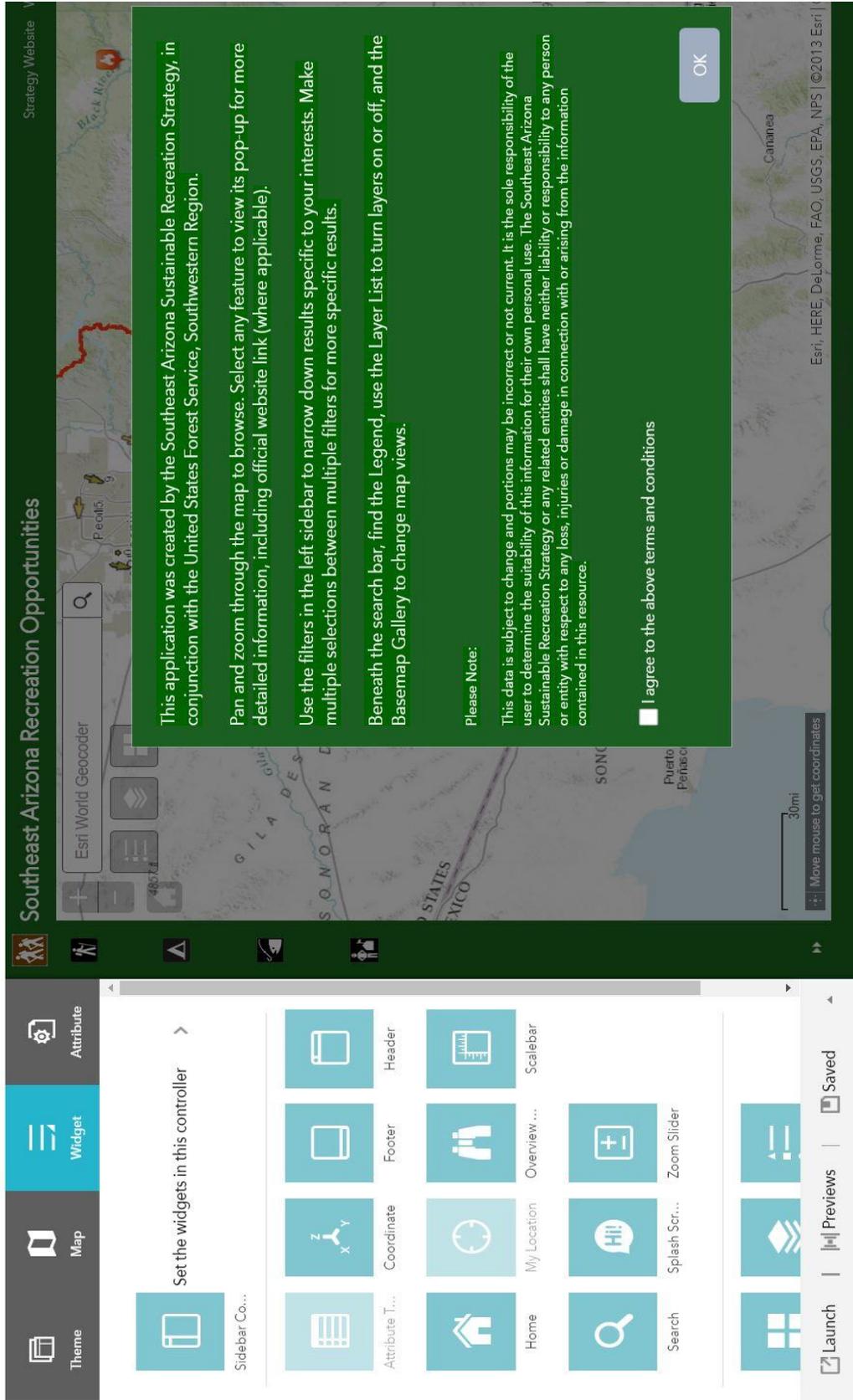


Figure 4: App in Web AppBuilder with Splash Screen widget.

To better tell the story of why Sustainable Recreation is an area of focus for the Forest Service and other agencies, the web application was then added to a Story Map. The Tabbed Map Series template was used, with five tabs:

1. Background information about the Sustainable Recreation project, including links to the two Forest Service Sustainable Recreation publications, and brief descriptions of the rest of the tabs (Figure 5).
2. Embedded recreation application (Figure 6).
3. Embedded Story Map created by the Southwestern Region of the Forest Service about its Sustainable Recreation stories and projects (Figure 7).
4. A list of agency, volunteer groups, and local recreation clubs with links to their websites (Figure 8).
5. Embedded Crowdsourc Story Map where users can upload their own photographs of their outdoor recreation activities (Figure 9).

The Story Map templates provided by Esri allow for easy application development with no coding required unless additional customization is required. The Recreation Application and two Story Maps were embedded in separate tabs by their individual URLs. Any changes or updates made to the individual applications will automatically be reflected in the Story Map the next time is it loaded because the Story Map only needs to recall the URL. The Crowdsourc Story Map is still in its beta version, but Esri notes that anything created in the beta will be transferred to the full version once it is released.

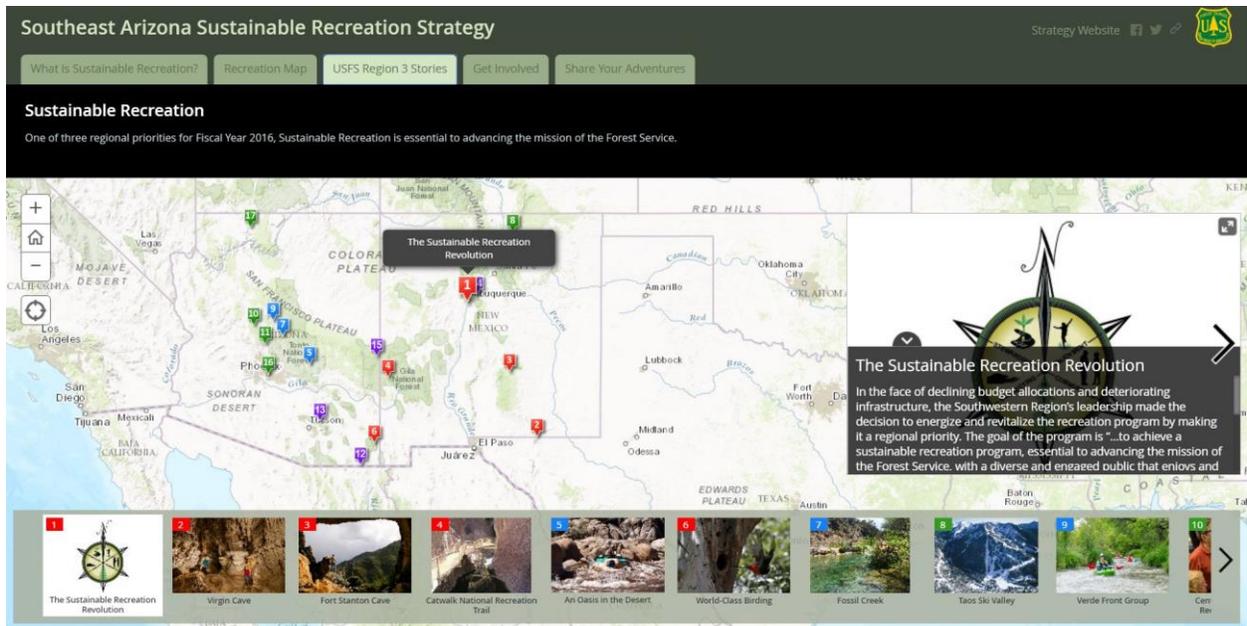


Figure 7: USFS Sustainable Recreation Story Map in Map Series.



Figure 8: Organization, Volunteer, and Recreation Club Links in Map Series.

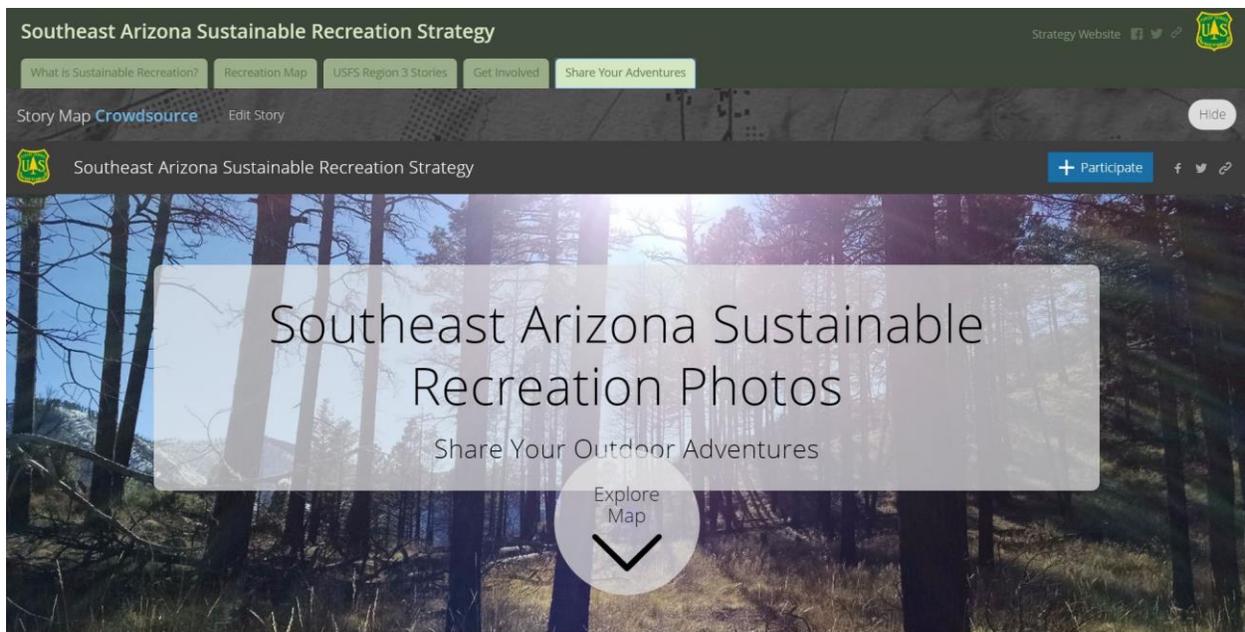


Figure 9: Crowdsourcing Story Map in Map Series.

RESULTS AND DISCUSSION

Web Application and Story Map Development

The goal of the final Story Map, with the embedded Recreation Application and additional Story Maps, is to expose the public to what the Sustainable Recreation Strategy represents, while also providing them with access to groups and organizations if they wish to become more involved.

An Opportunity for Analysis: Recreation Gap Analysis in Tucson, Arizona

Late in the development process, there was an opportunity to use this newly assembled recreation data to explore gaps in access to parks and recreation infrastructure around the Tucson Basin. Public transportation data was gathered and presented together with trails and popular recreation spots around the area. Three maps and additional figures were created (Appendix B). First, the analysis explored miles of trails by use throughout various communities in the area (Figure B 1). The following charts display trail miles by use per community, for both five- and ten-mile buffers (Figures B 2, Figure B 3). The communities displayed in the charts are listed from highest population within the related radius area to lowest population (Population Explorer). The second map looks at Tucson Park Scores (The Trust for Public Land 2016) to find voids in the availability of parks and open spaces within a ten-minute walk of populated areas (Figure B 4). The third and final analysis looks at the availability of public transportation within one half and one mile buffers of popular recreation areas (Figure B 5). The associated table (Table B 1) lists each recreation area, sorted by annual visitation estimates, with the number of bus stops and bus route types with a five- and ten-mile buffer. This shows that the top five of six most visited recreation areas have no access by public transportation.

These analyses were presented to the Greater Tucson sub-team within the Southeast Arizona Sustainable Recreation Strategy to show potential gaps in recreation opportunities and/or public transportation. Although the analysis performed was relatively simple, this serves as the first example of how participating groups can use this inter-agency data to perform analyses that otherwise may have been lacking in region-wide information. It also demonstrated the analysis tools within ArcGIS Online and its capacity as a suitable data storage medium for this project's needs.

CONCLUSIONS

The Sustainable Recreation mission of the Southwestern Region of the U.S. Forest Service aims to “sustain America’s great outdoors and build greater capacity to serve the citizens of the southwest by focusing the recreation program on building strong relationships with our diverse publics...” (USFS 2014, 2). In addition to reassessing how it will maintain its recreation infrastructure in the wake of increased public interest, the Forest Service wants to include the public in the process. The project outlined in this paper was completed for the Southeast Arizona Sustainable Recreation Strategy, a group working in conjunction with the Coronado National Forest, a forest within the Southwestern Region of the Forest Service. The objective of this project was to create a data model in which recreation data from across multiple agencies could be combined in one standardized method.

Once the initial batch of data was gathered from participating agencies, it was analyzed to find logical groupings for the data to be sorted into. After receiving input from those involved in the Mapping and Data Inventory Team, a geodatabase schema, including nine feature classes and necessary domains, was created. Each feature class has its own set of attributes used to relay pertinent information to the end user (Appendix A). All provided recreation data was added to the data model and attributes were edited to fit the schema. Once complete, the geodatabase was uploaded to ArcGIS Online. Saved in a Web Map, the layers were symbolized, pop-ups configured, and data reserved for internal use only was filtered out. The map was used in a Web Application using a template in Esri’s Web AppBuilder. While building the app, widgets and filters were added to allow users to narrow down results specific to their interests. A Tabbed Map Series Story Map was then created and includes the above-mentioned Web Application, and

USFS Region 3 Sustainable Recreation Story Map, links to agencies, volunteer groups, and clubs, and last a Crowdsourcing Story Map to which users can upload photos of their own outdoor activities.

The Story Map is the end product of this project, and its purpose is to orient the public to the mission of the Sustainable Recreation program. If provided with an inter-agency recreation resource with additional information all in one place, the hope is that the public will become more interested in participating in the behind-the-scenes processes of caring for their public lands. The Government Accountability Office report shows that the Forest Service, and most likely other land management agencies, for various reasons are not able to adequately maintain their existing recreation infrastructure, let alone add anything new (GAO 2013). If the public becomes more involved, or at least has more knowledge of the opportunities available, some of the workload can be taken off the agencies. This project only serves as an initial step. More agencies can become involved and the area covered by the recreation application can grow. The data model can expand to better suit future requirements, and the application can increase in complexity and functionality.

Moving Forward

As previously mentioned, this project was just an initial phase of the process. Those involved in the Southeast Arizona Sustainable Recreation Strategy will be looking to find more agencies willing to share their recreation data. The amount of data and the area involved can only grow. The data model will be improved and expanded upon and the end user products will continue to increase in usefulness for the general public. Because this is ultimately a Forest Service project, there is the potential that this data model and resulting products will be absorbed by the Forest Service, either the Coronado National Forest or the Southwestern Region. Once

that occurs, it will be more feasible to include other forests and agencies from other areas. Additionally, the model would then be hosted on a server, which was not available for this initial phase. This would allow for easier editing and updating of data on the back-end without needing to continuously reconstruct the Web Map in ArcGIS Online. It will also allow for better functionality within the Application, including a trail Elevation Profile widget and a Report widget that would permit users to report issues they find, either in the data or in features on the ground, to an administrator on the back-end who could then make the necessary corrections. Any additions made in the future can only serve to improve public awareness of recreation opportunities and challenges, and increase communication between agencies and the public.

APPENDIX A: ATTRIBUTE TABLES AND GEODATABASE DOMAINS

Attribute Tables in Alphabetical Order by Feature Class

Table A 1: Activities Attributes.

Activities (points)			
Field Name	Field Type	Length	Domain
Name	Text	100	
Activity Type	Text	50	Activity_type
Fee/Permit	Text	30	Y/N
Latitude	Double		
Longitude	Double		
Agency	Text	100	Agency
Link	Text	150	
Notes*	Text	150	
Last Updated*	Date		
Updated By*	Text	100	Agency

Table A 2: Administrative Attributes.

Administrative (point)			
Field Name	Field Type	Length	Domain
Name	Text	100	
Type	Text	10	Admin_type
Subtype	Text	50	Admin_subtype
Latitude	Double		
Longitude	Double		
Agency	Text	100	Agency
Link	Text	150	
Notes*	Text	150	
Last Updated*	Date		
Updated By*	Text	100	Agency

Table A 3: Camping/Lodging Attributes

Camping/Lodging (points)			
Field Name	Field Type	Length	Domain
Name	Text	100	
Type	Text	20	Activity_type
Subtype	Text	30	Camp_Lodge_subtype
Fee/Permit	Text	30	Y/N
Seasonal	Text	30	Y/N
Restrictions	Text	100	
Parking	Text	30	Y/N
ADA Parking	Text	30	Y/N
Toilet	Text	30	Y/N
Potable Water	Text	30	Y/N
Latitude	Double		
Longitude	Double		
Agency	Text	100	Agency
Link	Text	150	
Notes*	Text	150	
Last Updated*	Date		
Updated By*	Text	100	Agency

Table A 4: Closures Attributes

Closures (polygon)			
Field Name	Field Type	Length	Domain
Closure Type	Text	10	Closure_type
Area Affected	Text	150	
Begin Date	Date		
Est. End Date	Date		
Summary	Text	150	
Agency	Text	100	Agency
Link	Text	150	
Notes*	Text	150	
Last Updated*	Date		
Updated By*	Text	100	Agency

Table A 5: Public Land Ownership Attributes

Public Land Ownership (polygon)			
Field Name	Field Type	Length	Domain
Name	Text	100	
Wilderness	Text	30	Y/N
Agency	Text	100	Agency
Link	Text	150	
Notes*	Text	150	
Last Updated*	Date		
Updated By*	Text	100	Agency

Table A 6: Natural Features Attributes

Natural Features (points)			
Field Name	Field Type	Length	Domain
Name	Text	100	
Type	Text	20	Land_feature
Latitude	Double		
Longitude	Double		
Agency	Text	100	Agency
Notes*	Text	150	
Last Updated*	Date		
Updated By*	Text	100	Agency

Table A 7: Roads Attributes

Roads (line)			
Field Name	Field Type	Length	Domain
Name	Text	100	
Road ID	Text	10	
Seasonal	Text	30	Y/N
Surface	Text	30	Surface
Vehicle Suitability	Text	50	Vehicle_suitability
Agency	Text	100	Agency
Status*	Text	20	Trail_status
Notes*	Text	150	
Last Updated*	Date		
Updated By*	Text	100	Agency

Table A 8: Trailheads Attributes

Trailheads (point)			
Field Name	Field Type	Length	Domain
Name	Text	100	
Type	Text	20	Trail_access
Fee/Permit	Text	30	Y/N
Seasonal	Text	30	Y/N
Parking	Short		
ADA Parking	Short		
Trailer Parking	Short		
Restroom	Text	10	Y/N
Potable Water	Text	10	Y/N
Ramada	Text	10	Y/N
Picnic Tables	Text	10	Y/N
Latitude	Double		
Longitude	Double		
Agency	Text	100	Agency
Link	Text	150	
Status*	Text	20	Trail_status
Notes*	Text	150	
Last Updated*	Date		
Updated By*	Text	100	Agency

Table A 9: Trails Attributes

Trails (line)			
Field Name	Field Type	Length	Domain
Name	Text	100	
Trail ID	Text	10	
Trail System	Text	50	
Surface	Text	30	Surface
Hiking	Text	30	Y/N
Bicycling	Text	30	Y/N
Equestrian	Text	30	Y/N
Dogs	Text	30	Y/N
OHV	Text	30	Y/N
Agency	Text	100	Agency
Link	Text	150	
Status*	Text	20	Trail_status
Notes*	Text	150	
Last Updated*	Date		
Updated By*	Text	100	Agency

* Denotes internal fields not included in public display.

Geodatabase Domains

For All:

Field Type = Text

Domain Type = Coded Values

Split Policy = Duplicate

Merge Policy = Default

*For explanation purposes, not included in domain

1. Activity_type = Type of recreation activity, sport, or lodging

0 = Campground

1 = Lodging Rental

2 = Picnic Area

3 = Picnic Area, Group

4 = Interpretive Site/Nature Trail

5 = Vista/Observation Site

6 = Historic Building/Site

7 = Museum/Education Center

8 = Boating Site

9 = Fishing Site

10 = Shooting Range

11 = Archery Range

12 = Caving/Spelunking

13 = OHV Site

14 = Rock Climbing Site

15 = Winter Sports

2. Admin_type = Administrative building/feature type; internal or public

0 = Public

1 = Internal

3. Admin_subtype = Specific type of administrative building/feature, noted if public

0 = Visitor Center (*Public)

1 = Fee/Info Station (*Public)

2 = Ranger Station (*Public)

3 = Supervisor's Office

4 = Organization Camp

5 = Building

6 = Operations Building

7 = Fire Operations

8 = Gatehouse

9 = Helibase

10 = Repeater

11 = Weather Station

4. Agency = Data owner responsible for data and recreation feature maintenance

- 0 = U.S. Forest Service
- 1 = National Park Service
- 2 = Bureau of Land Management
- 3 = U.S. Fish and Wildlife Service
- 4 = Arizona Game and Fish Dept.
- 5 = Arizona State Parks
- 6 = Arizona State Land Dept. (State Trust)
- 7 = Pima County
- 8 = City of Tucson
- 9 = Town of Oro Valley
- 10 = Town of Marana
- 11 = Town of Sahuarita
- 12 = University of Arizona
- 13 = Homeowner's Association
- 14 = Unknown
- 15 = Other
- 16 = Private
- 17 = State of Arizona
- 18 = Tribal

5. Camp_Lodge_subtype = Classified by accessibility and likelihood of amenities

- 0 = Established (*accessible by road, amenities likely)
- 1 = Dispersed (*accessible by road, amenities unlikely)
- 2 = Backcountry (*accessible by trail, amenities unlikely)
- 3 = Group Camp (*group sites only, likely Established)
- 4 = Horse Camp (*horse sites only, likely Established or Dispersed)
- 5 = Unknown
- 6 = Summerhome
- 7 = Rental Cabin
- 8 = Hotel, Lodge, Resort

6. Closure_type = Type of closure warning for visitors, add details in 'Summary' field

- 0 = Fire
- 1 = Flooding
- 2 = Wildlife
- 3 = Maintenance
- 4 = Permanent
- 5 = Other

7. Land_feature = Type of natural/man-made feature found in landscape

- 0 = Peak
- 1 = Pass
- 2 = Hill
- 3 = Meadow
- 4 = Mine
- 5 = Spring
- 6 = Dam
- 7 = Tank
- 8 = Falls

8. Surface = Trail/road surface type

- 0 = Natural – Native Material
- 1 = Soft – Gravel, Mulch, etc.
- 2 = Hard – Asphalt, Cement, etc.
- 3 = Unknown

9. Trail_access = Means of accessing a trail

- 0 = Trailhead (*official designation by agency)
- 1 = Access Point (*other trail access, official or unofficial)
- 2 = Pullout/Turnout (*official designation, along a road)

10. Trail_status = Internal use only; display ‘Open’ trails to public

- 0 = Open
- 1 = Concept
- 2 = Planned
- 3 = Unauthorized
- 4 = Decommissioned
- 5 = Unknown
- 6 = Closed

11. Vehicle_suitability = Vehicle use based on road accessibility

- 0 = Suitable for Passenger Cars
- 1 = Moderate Accessibility for Passenger Cars
- 2 = High Accessibility for Passenger Cars
- 3 = High Clearance Vehicles
- 4 = Unknown

12. Yes_No = Yes, no, or unknown options

- 0 = Yes
- 1 = No
- 2 = Unknown
- 3 = Yes, on a leash (*for dogs)

APPENDIX B: GAP ANALYSIS

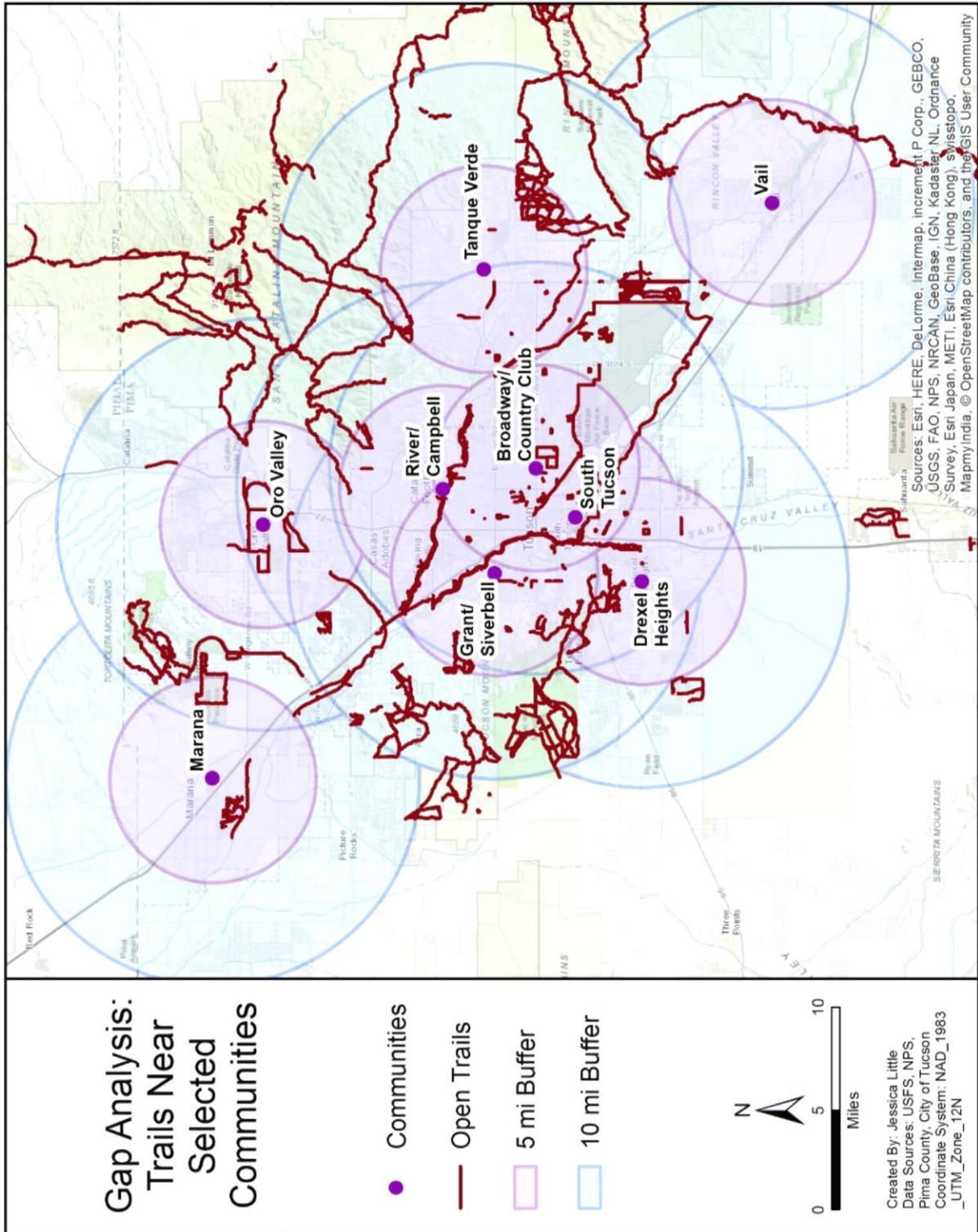


Figure B 1: Trails within 5 and 10 miles of selected communities in and around Tucson, AZ.

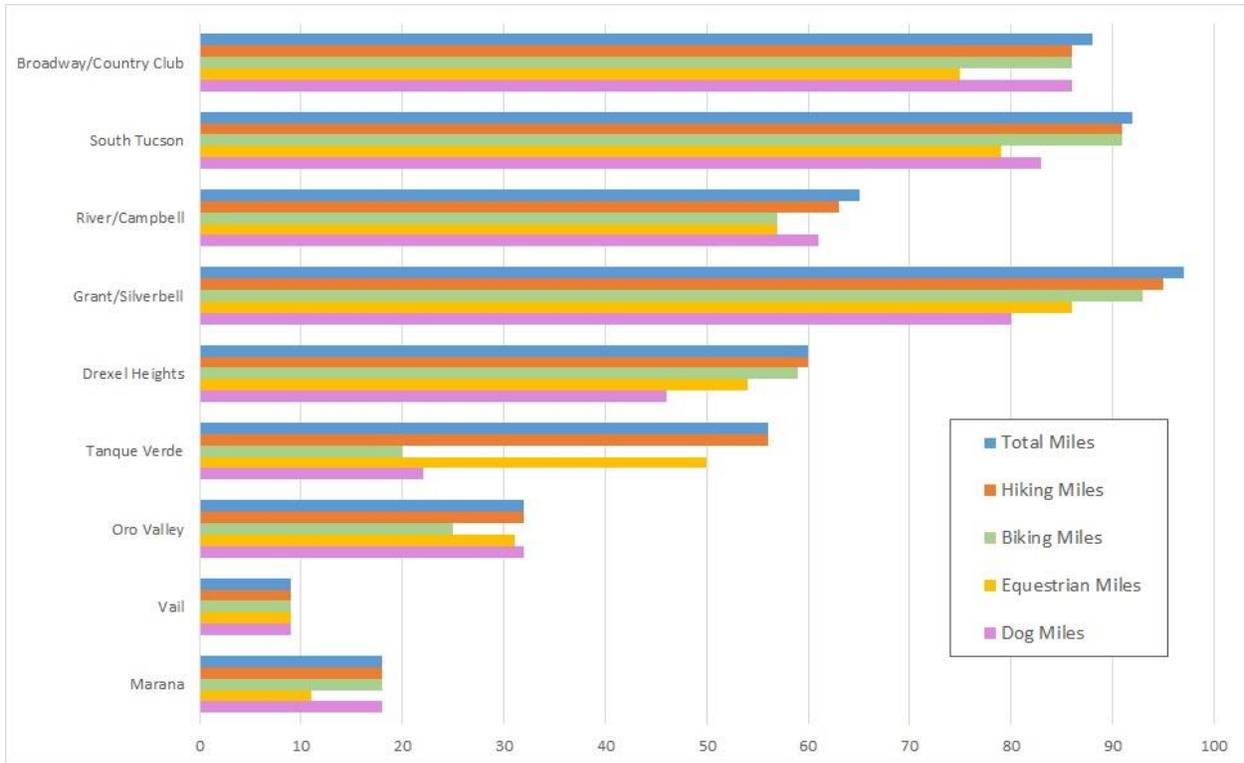


Figure B 2: Trail miles by use within 5 miles of selected communities.

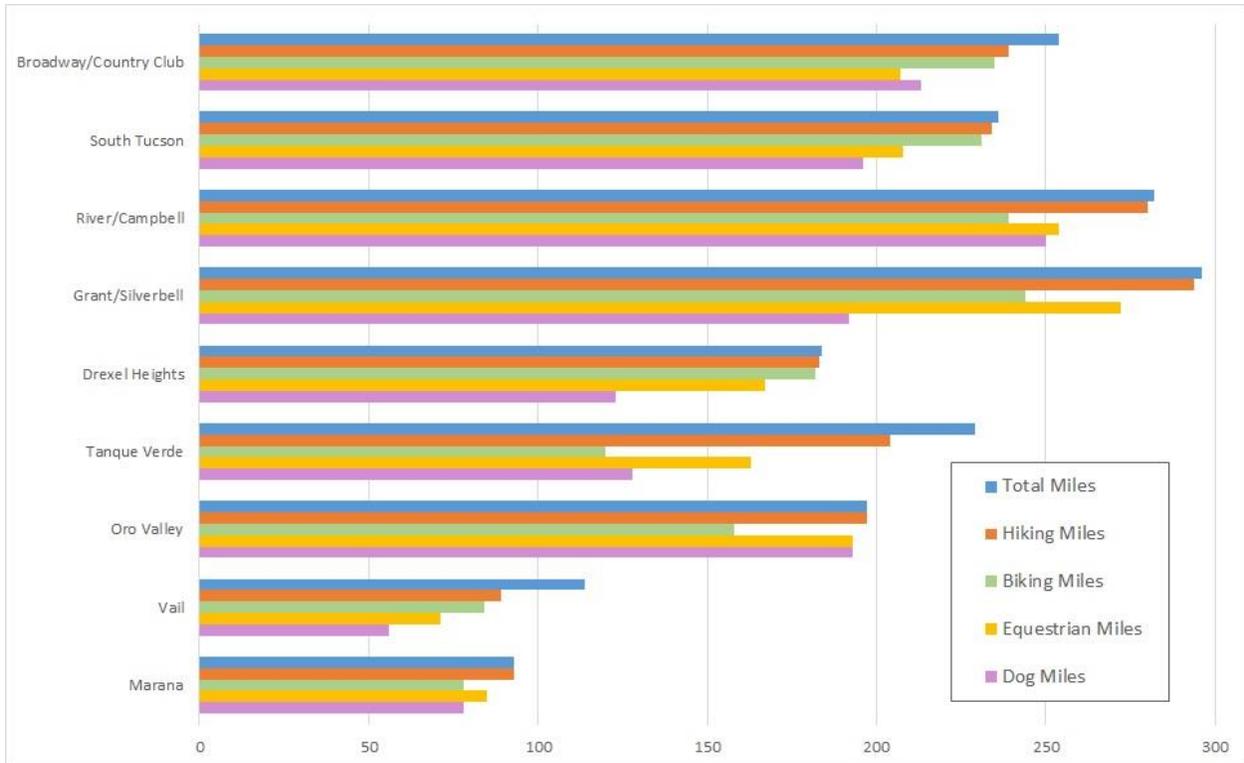


Figure B 3: Trail miles by use within 10 miles of selected communities.

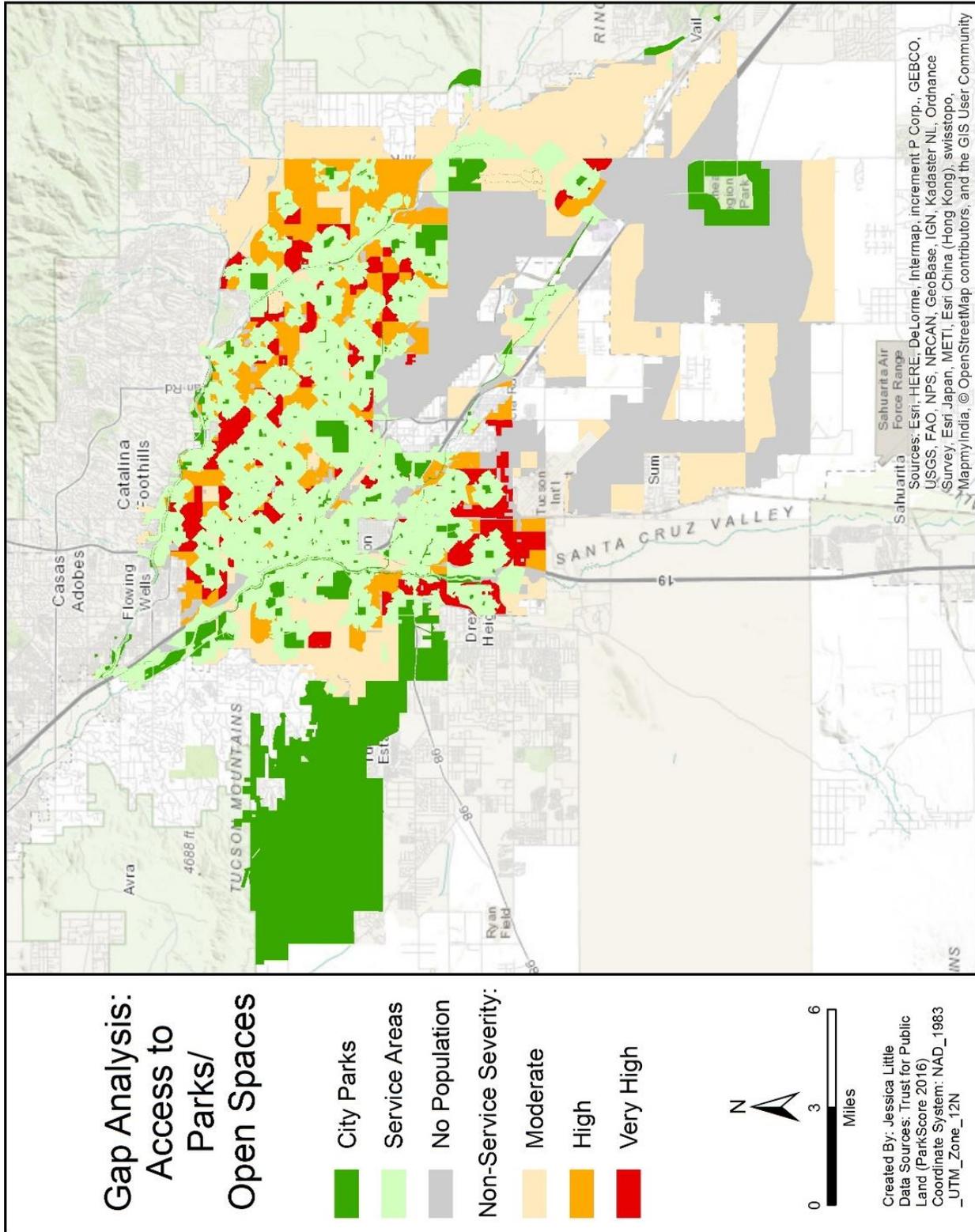


Figure B 4: Access to parks/open space from Tucson’s ParkScore (Trust for Public Land 2016).

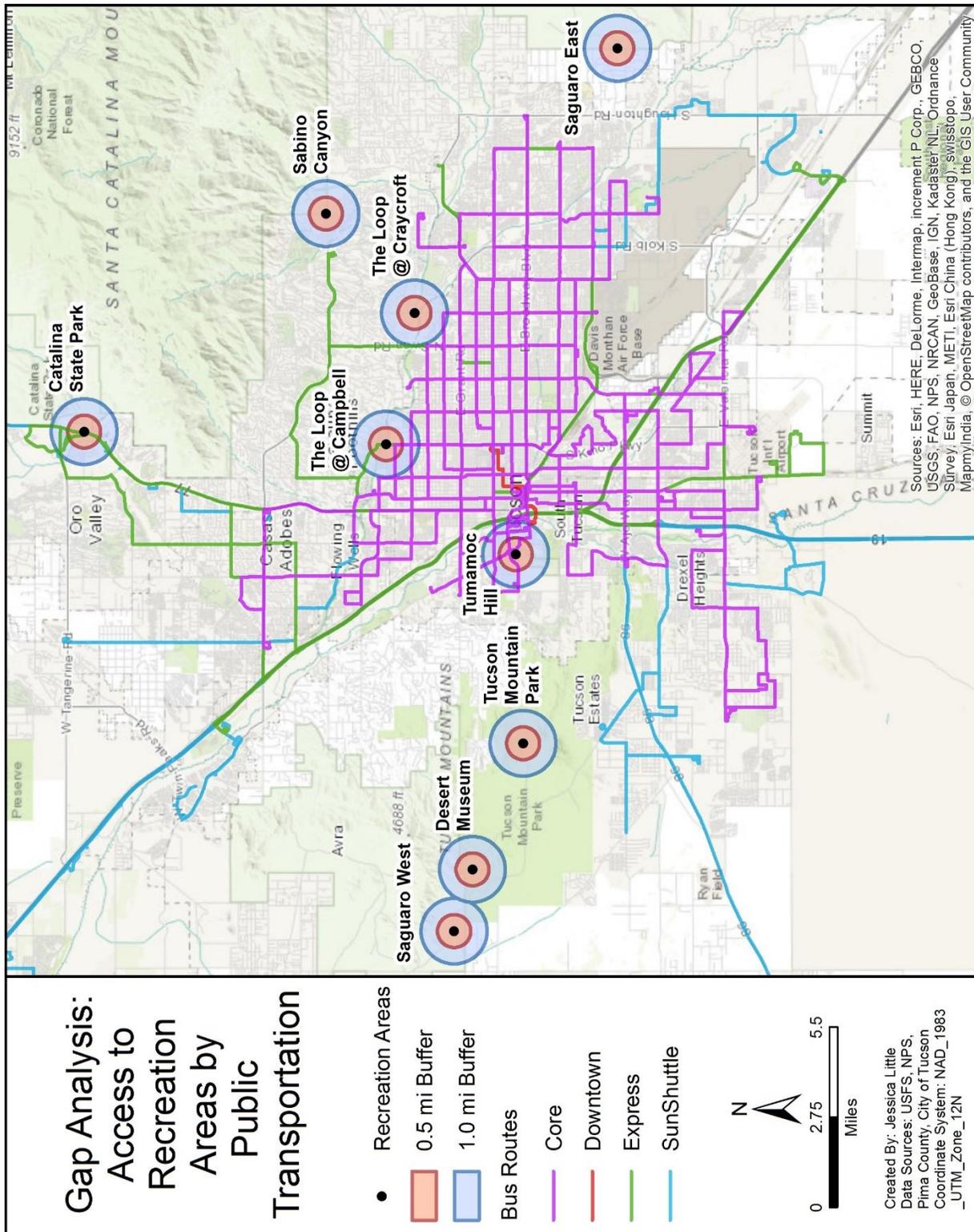


Figure B 5: Accessibility of most visited recreation areas by public transportation.

Table B 1: Public transportation availability per 0.5- and 1-mile radii of most visited recreation areas.

Recreation Area Name	Est. Annual Visits	0.5 mile Radius		1.0 mile Radius	
		No. of Bus Stops	Bus Route Type	No. of Bus Stops	Bus Route Type
Sabino Canyon	1,000,000	0	N/A	0	N/A
Tucson Mountain Park	725,000	0	N/A	0	N/A
Saguaro NP West	518,300	0	N/A	0	N/A
Desert Museum	400,000	0	N/A	0	N/A
Tumamoc Hill	300,000	21	Core	71	Core
Saguaro NP East	235,040	0	N/A	0	N/A
Catalina State Park	171,430	0	Express	4	Express
The Loop @ Campbell	unknown	5	Core, Express	26	Core, Express
The Loop @ Craycroft	unknown	0	N/A	4	Core

REFERENCES

- Arizona Geographic Information Council. 2016. "AZGEO Clearinghouse." Accessed October 17, 2016. <https://azgeo.az.gov/azgeo/>
- Arizona Trail Association (ATA). 2016. "Arizona_National_Scenic_Trail_Layers." Accessed November 15, 2016. http://services3.arcgis.com/IKBBLZOXy58PXgpl/arcgis/rest/services/Arizona_National_Scenic_Trail_Layers/FeatureServer
- Esri_DisasterResponse_DM. 2015. "US Wildfire activity from USGS GeoMAC." Accessed November 15, 2016. http://tmservices1.esri.com/arcgis/rest/services/LiveFeeds/Wildfire_Activity/MapServer
- _____. 2015. "Weather Stations (NOAA)." Accessed November 15, 2016. http://tmservices1.esri.com/arcgis/rest/services/LiveFeeds/NOAA_METAR_current_wind_speed_direction/MapServer
- Kimetrica. 2016. "Population Explorer." Accessed November 18, 2016. <https://populationexplorer.com/>
- Sky Island Alliance. 2016. "The Sky Islands." Accessed October 31, 2016. <http://www.skyislandalliance.org/the-sky-islands/>
- Southwest Decision Resources. 2016. "Southeast Arizona Sustainable Recreation Strategy." Accessed October 31, 2016. <https://sites.google.com/site/sustainablerecskyislands/home>
- Southwestern Region, USFS, USDA. 2016. "Sustainable Recreation." Accessed November 18, 2016. <http://usfs.maps.arcgis.com/apps/MapTour/index.html?appid=ff2d64d8c55442aaa0d9a6744261a571>
- _____. 2014. "Southwestern Region Sustainable Recreation Strategy." Accessed November 17, 2016. www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd495959.pdf
- Thoreau, Henry David. *Walden; or, Life in the Woods*. Boston: Ticknor and Fields, 1854.
- The Trust for Public Land. 2016. "ParkScore 2016, Tucson." Accessed October 31, 2016. <http://parkscore.tpl.org/city.php?city=Tucson>
- United States Forest Service, USDA. 2010. "Connecting People with America's Great Outdoors: A Framework for Sustainable Recreation." Accessed November 17, 2016. www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5346549.pdf
- _____. 2004. "The Greatest Good: A Forest Service Centennial Film; Greatest Timeline." Accessed October 17, 2016. <http://fs.fed.us/greatestgood/goodies/timeline.shtml>

United States Government Accountability Office. 2013. "FOREST SERVICE TRAILS Long- and Short Term Improvements Could Reduce Maintenance Backlog and Enhance System Sustainability." GAO-13-618 Report to Congressional Requesters. Accessed November 18, 2016. www.gao.gov/assets/660/655555.pdf