BARRIERS AND OPPORTUNITIES FOR USING RAIL-TRAILS FOR SAFE TRAVEL IN RURAL, ISOLATED, AND TRIBAL COMMUNITIES

FINAL PROJECT REPORT

by

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for

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16. Abstract This project explored barriers and opportunities for more effectively using rail-trails for safe travel in rural, isolated, tribal, and indigenous communities. We investigated using crowdsourced data from a fitness app to estimate bicycle volumes on trails. For 10 locations this new method produced suitable results, but for 19 locations the method was not satisfactory. Future research could identify situations in which this new method is feasible. We also created a new mapping tool to get demographic data surrounding locations where new rail-trails could be built. We identified 8,616 miles of potential rail-trail in the Pacific Northwest and explored the surrounding demographics for 12 locations in rural communities in Idaho, Oregon, and Washington. We conducted two separate surveys to solicit community member opinions and usage habits of the Trail of the Coeur d'Alenes.			
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SI* (MODERN METRIC) CONVERSION FACTORS

Symbol	When You Know	Multiply By	To Find	Symbol
APPROXIMATE CONVERSIONS TO SI UNITS				
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

Symbol	When You Know	Multiply By	To Find	Symbol
APPROXIMATE CONVERSIONS FROM SI UNITS				
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

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EXECUTIVE SUMMARY

In the United States more than twenty thousand miles of defunct railroads have been converted to trails for pedestrians and bicyclists. This project explored barriers and opportunities for more effectively using rail-trails for safe travel in rural, isolated, tribal, and indigenous communities.

This project had three goals:

1. Create a new mathematical model to estimate trail volumes to help planners identify transportation needs and plan improvements
2. Identify opportunities for new rail-trails in Washington and Idaho that could provide safe and efficient travel opportunities for rural, isolated, and tribal communities
3. Survey trail users and non-users to assess barriers and opportunities for more trail use

The first goal was accomplished through an investigation of using Strava data to estimate bicycle Annual Average Daily Traffic (AADT) on trails. Strava is a fitness app used by millions of people worldwide to record their recreation activity. The fitness app automatically uploads the user's location data as they run, bike, or hike. The proposed method was to use this Strava data to develop temporal adjustment factors that could be combined with short duration counts to estimate AADT. Data were collected from Permanent Traffic Recorders (PTR) at 29 locations to compare "ground truth" adjustment factors with the Strava-derived adjustment factors. The results suggest the Strava data are inadequate. For 19 locations the adjustment factors were not satisfactory and, in some cases, unusable. Future research could identify characteristics of locations where the approach seems to indeed work, as was shown for 10 locations. This study also created a linear regression model that could be used to directly estimate AADT. The model had a good fit with an R-squared of 0.78.

The second goal was achieved by creating a new mapping tool to get demographic data for the area surrounding locations where new rail-trails could be built. The tool could be used by decision makers, engineers, and community planners to prioritize investments for new trail construction. The tool relies on data from the American Community Survey. We also identified all 8,616 miles of vacant railways in the Pacific Northwest where new rail-trails could potentially be built. We selected 12 potential rail-trail locations and used the mapping tool to get surrounding demographic data.

The third goal was accomplished through two surveys. First, an intercept survey of trail users was carried out at locations near Plummer, Chatcolet, and Kellogg. Second, fliers containing a link to an online survey were mailed to residents of three towns located along the trail, namely Plummer, Kellogg, and Wallace. The results of both surveys were compared to gain a better understanding of the trail's role in its community and the opinions of its users. The results of the online and intercept surveys, while they are in response to different sets of questions, both contribute to a better understanding of how the Trail of the Coeur d'Alenes serves its community. The questions in the online survey dealt more with community members' opinions of the trail, while the questions in the intercept survey were better suited to trail usage habits. By examining both sets of responses, interested parties can get more complete impressions of the community's interaction with the Trail of the Coeur d'Alenes.

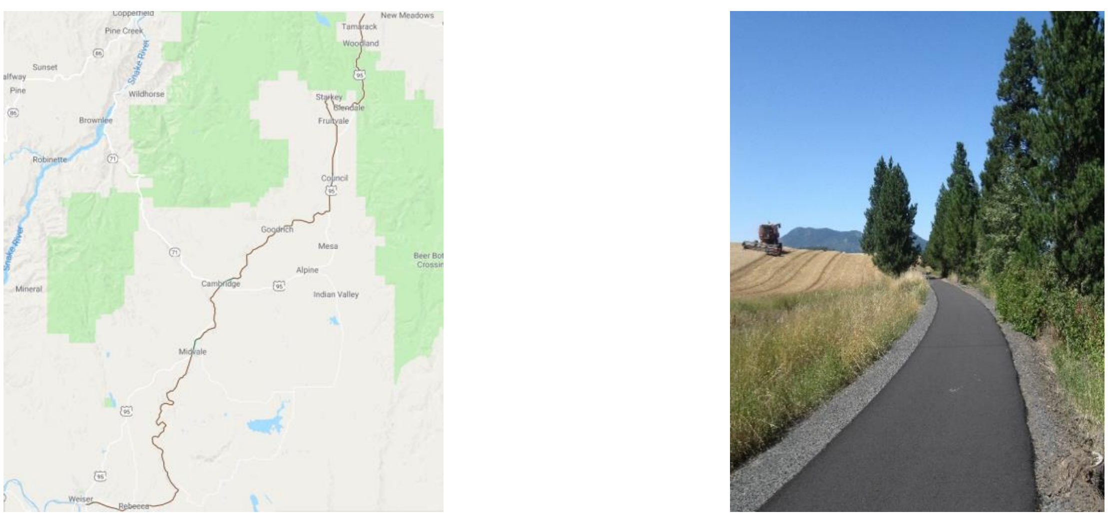
CHAPTER 1. INTRODUCTION

In the United States more than twenty thousand miles of defunct railroads have been converted to trails for pedestrians and bicyclists. Many rail-trails are located near communities that are rural, isolated, tribal, or indigenous, yet often users are not residents, but rather affluent visitors from urban areas using the trails for recreation and tourism. For example, the *Trail of the Coeur d' Alenes* is a 72-mile, paved trail that starts on a tribal reservation and passes through various rural towns. This project explored barriers and opportunities for more effectively using rail-trails for safe travel in rural, isolated, tribal, and indigenous communities.

1.1. Background

After World War II tens of thousands of railroad routes were abandoned in the United States as passenger and freight transportation switched to trucking and personal automobiles. The United States Congress was worried that critical right-of-way would be lost forever to private landowners, so they amended the National Trail System Act in 1983 to allow “railbanking” through which abandoned right-of-way could be preserved for future rail use by converting these routes for exclusive non-motorized (bicycle and pedestrian) travel. In 2018, the Rails-to-Trails Conservancy (RTC) reported that there were 23,346 miles of rail-trails and an additional 8,000 miles under development throughout the United States (RTC, 2018).

Rail-trails often run parallel with state highways and cut through small towns such as the Weiser Trail (84 miles along US 95) or the Latah Trail (12 miles along State Route 8), which are both located in rural Idaho (see Figure 1.1). For some communities, rail-trails provide critical transportation infrastructure for walking and biking. As an example, the rail-trail that services Moscow, Idaho (population 25,000) is an important connector for the University of Idaho, the downtown community, and several residential areas. Everyday hundreds of bicyclists and pedestrians use this trail for commuting and daily activities.



(a) (b)

Figure 1.1 Example Rail-Trails in Rural Idaho (a) 84-mile Weiser Trail and (b) 12-mile Latah Trail.

However, some rail-trails are used primarily by non-locals who have traveled a long distance to enjoy rural scenery. For example, the Trail of the Coeur d'Alenes (see Figure 1.2) is primarily used for recreation and tourism (Idaho State Parks and Recreation, 2020). It is a 72-mile paved trail that passes along a chain of alpine lakes and cuts through various small towns. The trail was built after the Coeur d'Alene Tribe sued the mining companies that had been using the old railroad route and the Environmental Protection Agency deemed the route a Superfund cleanup site due to toxic metal pollution. The trail provides significant opportunity for tourism, but more can be done to make the trail useful for local transportation needs. For example, in the town of Plummer, on the Coeur d'Alene Reservation, the trail stops just a few blocks away from the center of town where the grocery store, school, and other destinations are located.

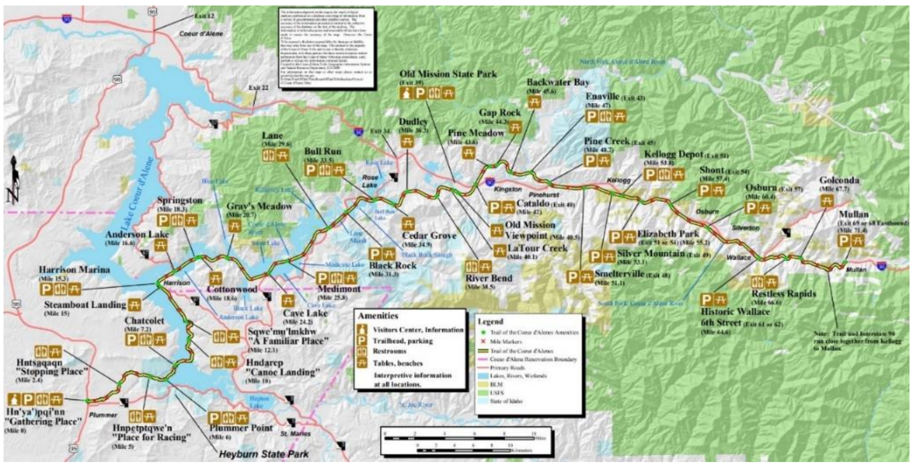


Figure 1.2 Map of the Trail of the Coeur d'Alenes.

1.2. Project Goals

The goals of this project were the following:

- Create a new mathematical model to estimate trail volumes to help planners identify transportation needs and plan improvements
- Identify opportunities for new rail-trails in Washington and Idaho that could provide safe and efficient travel opportunities for rural, isolated, and tribal communities
- Survey trail users and non-users to assess barriers and opportunities for more trail use

1.3. Report Organization

Chapter 2 describes research to investigate the potential for using crowdsourced data from a fitness app to estimate bicycle AADT on trails. Chapter 3 presents a new mapping tool that was created to obtain demographic data surrounding locations where new rail-trails could be built. Chapter 4 describes two surveys that were conducted to assess barriers and opportunities for more trail use. Chapter 5 provides concluding remarks.

CHAPTER 2. ESTIMATING BICYCLE TRAIL VOLUME

2.1. Introduction

Planners and policy makers need information about trail volume, i.e., the number of bicyclists and pedestrians using the trail system, to plan and prioritize trail improvements. Trail volume is very difficult to monitor because users can enter and exit a trail system at dispersed locations. The recommended method is to install Permanent Traffic Recorders (PTR) at key locations to count bicyclists and pedestrians; the data are then used to estimate volumes at other locations throughout the trail system. PTRs use sensing technology, such as infrared, to automatically count passing traffic. PTRs are expensive to install and maintain, so placement is typically very limited. For example, at the time of this study, the Washington State Department of Transportation (WSDOT) maintained only 48 bicycle/pedestrian PTRs statewide compared to over 2,000 automobile PTRs (Trask, 2015). In Idaho, at the time of this study, there were no bicycle/pedestrian PTRs maintained by the state DOT, compared to 175 permanent counters statewide to monitor vehicle volume.

Planners use PTRs to develop “adjustment factors” that represent the proportion of observed volume throughout the day, week, and year. The adjustment factors are combined with a “short-duration count” that has been observed at a nearby location to estimate annual volume (Nordback, et al. 2013; Miranda-Moreno, et al 2013). Short-duration counts can be collected manually by a person equipped with a pen and paper or via a mobile traffic recorder (Lowry et al., 2016b; Lowry, 2017). Short-duration counts should occur for a minimum 2 hours long and preferably 2 days long (Johnstone et al, 2017).

Adjustment factors from a PTR can be compiled into tables and used to estimate Annual Average Daily Traffic (AADT). For example, the following tables show the adjustment factors that we developed for this study for one of WSDOT’s PTRs. Table 2.1 has the Hour-of-Day Adjustment Factors for the summer months and Table 2.2 has the Day/Month Adjustment Factors. Both tables are for bicycle volumes. The factors are based on WSDOT’s PTR located on the Sammamish River Trail. AADT is estimated according to Equation 2.1.

$$AADT = F_{d,m} * \left(\frac{\sum_h v_h}{\sum_h F_{h,d}} \right) \tag{2.1}$$

where v_h is the short-duration count for hours h and the factors $F_{h,d}$ and $F_{d,m}$ are for Hour-of-Day and Day/Month, respectively. d and m are day-of-week and month of the short-duration count, respectively.

For example, suppose a short duration count was observed on Thursday in July for two hours 4pm-6pm. The observed counts were 6 and 14 bicyclists, in the first and second hour, respectively. Then, AADT is calculated as shown in equation 2.2.

$$72 \, \frac{bicyclists}{day} = 0.68 * \left(\frac{6 + 14}{0.08 + 0.11} \right) \tag{2.2}$$

This estimated AADT is then multiplied by 365, which is roughly 26,000 bicyclists per year.

Table 2.1 Hour-of-Day (Summer Months) Adjustment Factors for Sammamish River Trail

Hour	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.01	0.01	0.01	0.01	0.01	0.00	0.00
6	0.03	0.03	0.03	0.03	0.03	0.01	0.01
7	0.04	0.05	0.05	0.05	0.05	0.03	0.03
8	0.05	0.05	0.06	0.05	0.05	0.07	0.06
9	0.06	0.06	0.06	0.05	0.06	0.08	0.08
10	0.06	0.06	0.07	0.06	0.06	0.09	0.10
11	0.06	0.06	0.07	0.06	0.06	0.11	0.11
12	0.06	0.06	0.07	0.06	0.07	0.09	0.10
13	0.05	0.05	0.06	0.05	0.06	0.08	0.09
14	0.05	0.05	0.05	0.05	0.06	0.08	0.09
15	0.06	0.06	0.05	0.06	0.07	0.08	0.08
16	0.07	0.07	0.07	0.08	0.08	0.07	0.07
17	0.11	0.11	0.10	0.11	0.09	0.06	0.06
18	0.10	0.11	0.09	0.11	0.10	0.06	0.05
19	0.10	0.09	0.08	0.10	0.08	0.05	0.04
20	0.06	0.06	0.05	0.06	0.05	0.03	0.03
21	0.02	0.02	0.02	0.02	0.02	0.01	0.01
22	0.00	0.00	0.00	0.00	0.01	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 2.2 Day/Month Adjustment Factors for Sammamish River Trail

month	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
January	1.49	2.28	2.59	2.91	2.55	1.59	1.50
February	1.66	2.16	2.39	2.40	2.73	1.28	1.62
March	1.25	1.31	1.34	1.52	1.47	0.73	0.71
April	0.96	0.99	1.12	1.00	1.19	1.75	0.88
May	0.61	0.73	0.70	0.85	0.80	0.46	0.47
June	0.78	0.67	0.75	0.80	0.88	0.53	0.56
July	0.73	0.65	0.56	0.68	0.63	0.48	0.52
August	0.79	0.91	0.85	0.92	0.83	0.65	0.63
September	0.75	0.89	0.88	1.00	1.06	0.80	0.69
October	1.51	1.25	1.16	1.26	1.35	0.97	0.90
November	1.71	1.51	2.01	1.77	2.31	1.13	1.14
December	1.83	2.66	2.35	2.70	2.52	1.79	2.39

The installation of permanent counters is expensive and can be too costly for rural and tribal communities. This project investigated a novel method to estimate AADT without PTRs. The idea was to use crowdsourced Strava data in place of PTR data. Strava is a fitness app used by millions of people around the world to record their exercise and recreation activities. A person starts the app before an activity and indicates the category of activity, such as hiking, biking, and jogging. The app uploads a GPS stream of the person's travel path to a data cloud. At the time of this study, anonymized GPS data could be purchased from Strava. There are other vendors of similar fitness apps, such as MapMyRide, Google Fit, and TrailForks, but at the time of this study only Strava data could be purchased as far as we know.

Other researchers have purchased Strava data in attempts to directly estimate AADT for bicyclists. However, their results were less than ideal primarily because Strava users represent only about 10% of bicyclists (Jestico, 2016). Our method differs in that we did not attempt to estimate AADT directly, but rather to use the Strava data to create adjustment factors that when applied with short-duration counts could be used to estimate AADT. Our method uses Strava data to estimate the *variation* in volume across each day, week, and year. To validate our proposed method, we purchased Strava data for WSDOT's PTR locations to see if Strava-derived adjustment factors would sufficiently correlate with PTR-derived adjustment factors.

2.2. Study Data

When this project began, WSDOT had 44 PTRs installed throughout the state shown in Figure 2.1. We purchased one year of data from Strava for all 44 locations. However, we later discovered that one year of data was only available for 28 WSDOT locations. Table 2.3 shows information for the 28 locations used for the analysis. The PTR data is a timestamped flag for every passing bicyclist.

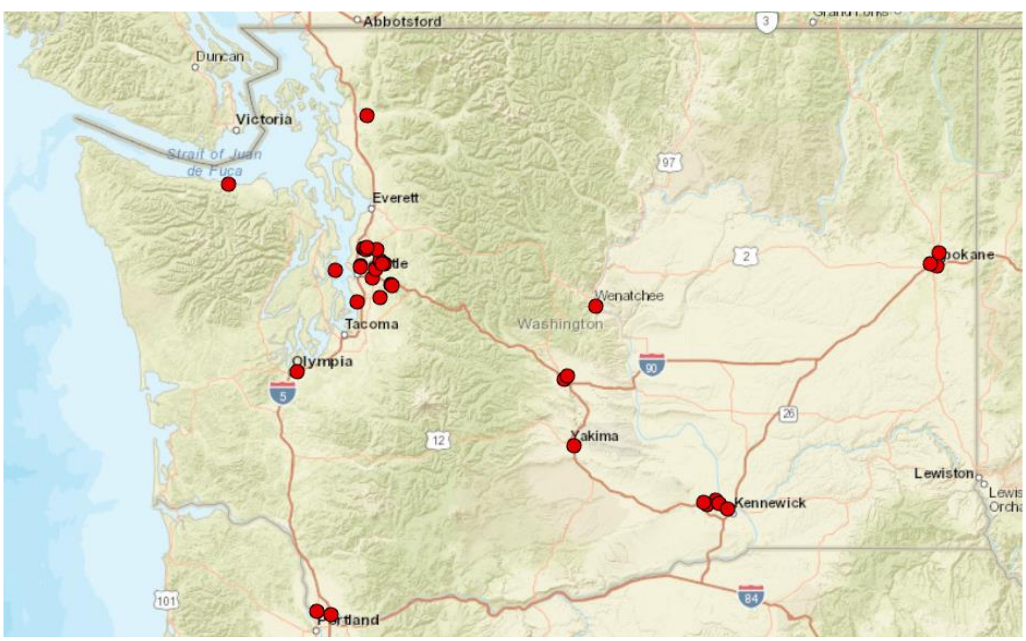


Figure 2.1 Permanent Traffic Recorders managed by WSDOT to monitor bicycle volumes.

Table 2.3 PTR Locations Used in the Analysis

PTR ID	City	Location Description	Latitude	Longitude
id_100038230	Ellensburg	John Wayne Trail	47.01	-120.53
id_100038349	West Richland	Keene Rd 1 (West Richland)	46.27	-119.37
id_100038350	West Richland	Keene Rd 2 (West Richland)	46.26	-119.34
id_100020623	Spokane	BEN BURR TRAIL	47.65	-117.38
id_100127634	Spokane	Children of the Sun Trail_FREYA	47.72	-117.36
id_100030163	Issaquah	EAST LAKE SAMMAMISH TRAIL	47.54	-122.04
id_100021745	Olympia	Woodland Trail West	47.04	-122.84
id_100022293	Port Angeles	Olympic Discovery Trail	48.12	-123.43
id_100038231	Ellensburg	Rotary Park Ellensburg	47.00	-120.56
id_100022294	Richland	HAINS LEVEE TRAIL	46.28	-119.27
id_100033844	Burien	Lake to Sound Trail N/O S 176th St.	47.45	-122.33
id_100038318	Issaquah	Issaquah-Preston Trail	47.53	-122.03
id_100040080	Pasco	SACAJAWEA TRAIL - City of Pasco	46.27	-119.24
id_100020622	Yakima	YAKIMA GREENWAY TRAIL	46.61	-120.48
id_100031003	Vancouver	I-205 Trail E/O SE 23rd St.	45.60	-122.55
id_100030164	Redmond	EAST LAKE SAMMAMISH TRAIL	47.66	-122.10
id_100022292	Spokane	CENTENNIAL TRAIL	47.66	-117.43
id_100033843	Renton	Cedar River Trail E/O 154th PL SE	47.47	-122.14
id_100040081	Pasco	WADE PARK TRAIL - City of Pasco	46.23	-119.16
id_100019136	Bellevue	BELLEVUE SR 520 TRAIL 1	47.63	-122.17
id_100022296	Seattle	UW Transit Center 2 Loops South	47.65	-122.30
id_100019137	Bainbridge	Bainbridge Island Winslow Way	47.62	-122.52
id_100038317	Redmond	Marymoor Connector Trail	47.66	-122.12
id_100040079	Pasco	SACAJAWEA TRAIL - City of Pasco	46.27	-119.24
id_100031002	Woodinville	SAMMAMISH RIVER TRAIL	47.75	-122.16
id_100035377	Kenmore	Juanita Drive SB	47.75	-122.25
id_100031001	Lake Forest	BURKE-GILMAN TRAIL	47.75	-122.28
id_100035378	Kenmore	Burke-Gilman-Kenmore	47.76	-122.24

Our request to Strava was to purchase one year of data (2018) for all bicyclists passing the latitude/longitude point for WSDOT's PTR stations. We were told that for privacy reasons the data would be stripped of any personal information and aggregated into one-hour bins. This seemed satisfactory for our needs because the goal was to create adjustment factors based on one-hour counts. Unfortunately, the data we received from Strava was not as we had expected and proved problematic for this study. Figure 2.2 shows a snippet of the data we received. The first column "edge_id" corresponds to the PTR location and a lookup table was provided by Strava to identify the corresponding latitude/longitude point. The next columns indicate the year, day of the year, and hour. The last column is the count. There are two major problems with this data. First, if the count was less than 5, then it was reported as "0", which meant that we did not know if there were 1, 2, 3, or 4 bicyclists for that hour. The second problem was that all counts were rounded to the nearest multiple of five, that is 5, 10, 15, 20, 25, 30, etc.

	A	B	C	D	E	F
1	edge_id	year	day	hour	athlete_count	
2	6110	2018	1	11	5	
3	6110	2018	1	12	0	
4	6110	2018	1	13	5	
5	6110	2018	1	14	0	
6	6110	2018	1	16	0	
7	6110	2018	2	7	0	
8	6110	2018	2	8	5	
9	6110	2018	2	15	0	
10	6110	2018	2	16	0	
11	6110	2018	2	17	0	
12	6110	2018	3	7	0	
13	6110	2018	3	8	10	
14	6110	2018	3	9	5	
15	6110	2018	3	11	0	
16	6110	2018	3	13	5	
17	6110	2018	3	14	0	
18	6110	2018	3	16	10	
19	6110	2018	3	17	5	
20	6110	2018	3	18	0	
21	6110	2018	3	19	15	
22	6110	2018	4	7	0	
23	6110	2018	4	9	5	
24	6110	2018	4	10	0	
25	6110	2018	4	11	0	
26	6110	2018	4	15	0	
27	6110	2018	4	16	0	
28	6110	2018	4	17	5	
29	6110	2018	4	18	0	
30	6110	2018	5	8	10	
31	6110	2018	5	9	5	

Figure 2.2 Snippet of Strava data received for this study.

We were very disappointed with the data we received from Strava. We disputed the definition of "aggregate". We maintain that aggregating is not the same thing as "rounding", which is what they did to the data. Their data manipulation is problematic because bicycle volumes are generally very low, i.e., less than 10 per hour. Therefore, since the counts have been rounded to multiples of five, the precision of this data is inadequate. Table 2.4 shows the number of occurrences for each reported count. Across all locations, there were 25,249 hours in which the Strava data reports 0 bicyclists; in other words, due to the company's privacy policy means there were 1, 2, 3, or 4 bicyclists. Table 2.4 shows that most of the hours are for counts that are less than 10 bicyclists (We calculated that 10 is the 80th percentile and 20 is the 95th percentile). The largest reported count was 405 bicyclists (which was probably a race or other event because that is an unusually high bicycle volume for one hour). Nevertheless, we proceeded with the analysis and investigation.

Table 2.4 Number of Hours (Occurrences) for each Reported Count

Reported Count	Occurrences
0	25,249
5	13,139
10	14,555
15	5,680
20	2,695
25	1,438
30	772
35	391
40	168
45	99
50	53
55	23
60	17
65	7
70	3
75	3
80	1
90	2
95	1
155	1
175	1
190	1
210	1
380	1
405	1

2.3. Method

We wrote Python scripts for the data analysis. The first step was to calculate AADT for the PTR data and for the Strava data. Theoretically, AADT is the total annual volume in both directions divided by 365 (364 for leap years). However, it is very common for permanent counters to fail for a few hours or a few days throughout the year. Consequently, the American Association of State Highway and Transportation Officials (AASHTO) developed the following equation in case there is missing data for a few days in a year (FHWA, 2016):

$$AADT = \frac{1}{7}\sum_{d}^{7}\left\{\frac{1}{12}\sum_{m}^{12}\left[\frac{1}{n}\sum_{k}^{n}\left(\sum_{h}^{24} v_{d,m,k,h}\right)\right]\right\} \quad (2.3)$$

where

v = bicycle volume for hour *h* for the k^{th} occurrence of day-of-week *d* within month *m*

n = the number of days of that day of the week during that month

The second step was to calculate the adjustment factors for the PTR data and for the Strava data. The hour-of-day factors were calculated for each season: Fall (September, October, and November), Winter (December, January, and February), Spring (March, April, and May), and Summer (June, July, and August). The calculation for each season is

$$F_{h,d} = \frac{1}{3}\sum_{m=s}^{S}\left[\frac{1}{n}\sum_{k}^{n}\left(\sum_{h}^{24} v_{w,m,k,h}\right)\right] * AADT \tag{2.4}$$

where *s* is the starting month number for the season and *S* is the ending month number. The month and day-of-week factors were calculated as follows

$$F_{d,m} = \frac{AADT}{\frac{1}{n}\sum_{k}^{n}\left(\sum_{h}^{24} v_{d,m,k,h}\right)} \tag{2.5}$$

The third step was to compare results between the PTR data and Strava Data. We compared the maximum hour and maximum day recorded by PTRs and by Strava. Next, we compared AADT values and correlated the PTR-derived AADT with the Strava-derived AADT using linear regression. Finally, we compared the PTR-derived adjustment factors and the Strava-derived adjustment factors. We plotted the adjustment factors and made visual comparisons.

2.4. Results

Table 2.5 provides a comparison of the PTR data and Strava data. The maximum hour is the highest one-hour count during the year. The PTR maximum and Strava maximum do not necessarily correspond to the same hour. However, we inspected a handful of these values and discovered that often they are from the same hour. In general, the PTR data is likely more accurate, but there are a few times that we suspect the Strava data is more accurate. For example, the last row shows values for a location on the Burke-Gilman Trail in Seattle near the University of Washington campus. At that location, the PTR recorded a maximum value of 245 bicyclists, but Strava recorded a maximum of 405 bicyclists. We inspected these values and discovered they are indeed for the same hour. It seems there was an event happening that evening. The Strava count should always be less than or equal to the true number of bicyclists. Our conclusion is that the PTR machine miscounted due to a well-known phenomenon called occlusion in which the infrared sensor does not detect cyclists who are behind other cyclists.

The maximum day exhibits even less correlation between the PTR data and Strava data. As expected, the Strava values are lower because the Strava fitness app is used by only a small percentage of bicyclists. The undercount for maximum day is also due to how the data was rounded as described earlier, i.e., anything less than 5 was counted as 0.

Table 2.5 Observed Maximums and Calculated AADT

	WSDOT PTR			Strava		
PTR ID	**Max Hour**	**Max Day**	**AADT**	**Max Hour**	**Max Day**	**AADT**
id_100038230	63	107	40.2	5	5	0.1
id_100038349	38	86	35	5	10	0.9
id_100038350	56	98	26.2	5	15	2.7
id_100020623	106	136	48.5	10	10	1.6
id_100127634	89	264	30.2	10	20	3.1
id_100030163	58	150	46.6	10	25	4.2
id_100021745	179	447	145.8	10	40	10.6
id_100022293	203	609	227.8	10	60	5.7
id_100038231	52	123	22.8	15	25	0.6
id_100022294	507	2589	265.9	15	70	26.6
id_100033844	501	1292	33.9	20	30	1.2
id_100038318	45	117	49	20	55	11.6
id_100040080	167	529	59.5	20	50	15.7
id_100020622	344	1081	146	20	40	7.6
id_100031003	30	151	65.3	20	85	20.7
id_100030164	872	1670	303.1	30	200	56.3
id_100022292	186	859	319	35	80	14.8
id_100033843	136	555	116.2	50	190	27.9
id_100040081	322	1650	107.2	55	110	14.9
id_100019136	79	376	142.1	55	250	97.3
id_100022296	532	2602	904.5	65	340	158.2
id_100019137	74	306	122.9	70	385	18.9
id_100038317	323	999	286.2	70	410	92.5
id_100040079	146	438	48.9	155	125	13.8
id_100031002	303	2023	678.4	95	510	152.9
id_100035377	193	1363	398.5	190	600	51.7
id_100031001	248	1762	598.5	210	800	181.8
id_100035378	245	1675	568	405	775	163.8

Also as expected, the AADT values are much smaller for the Strava data, due to the known low percentage of bicyclists using the Strava fitness app. However, across all locations the AADT values exhibit moderate correlation. Figure 2.3 shows a plot of PTR-derived AADT vs Strava-derived AADT. The linear relationship has an R-Squared value of 0.78, which is suggests that Strava data can be a good predictor of AADT. The equation to estimate AADT directly from Strava data is

$$\mathrm{AADT} = 61.4 + 3.6(\mathrm{AADT}_{\mathrm{Strava}}) \tag{2.6}$$

However, as mentioned earlier we propose that a better way to estimate AADT is to use Strava-derived adjustment factors combined with a short-duration count for the same location. Table 2.6 and Table 2.7 show Strava-derived adjustment factors.

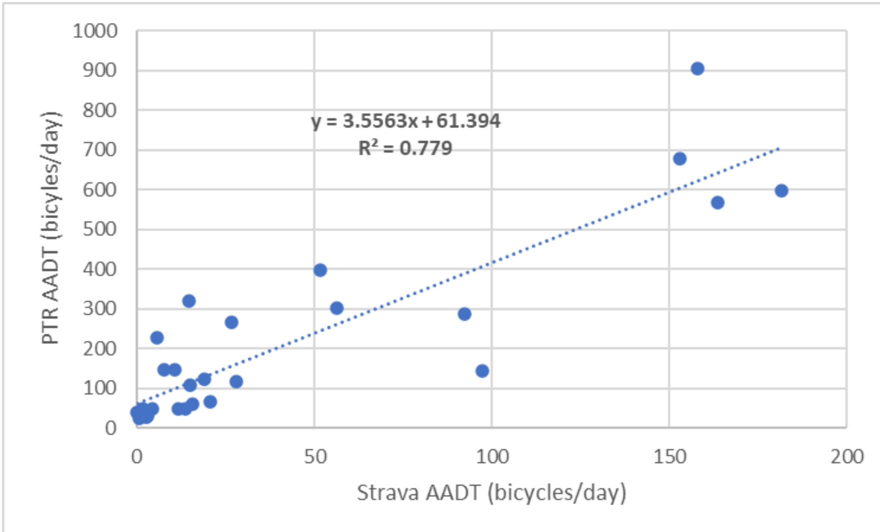


Figure 2.3 AADT correlation for PTRs vs Strava.

Table 2.6 Strava-Derived Hour-of-Day (Summer Months) Adjustment Factors

Hour	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.01	0.00	0.00	0.00	0.00	0.00
5	0.01	0.01	0.02	0.01	0.02	0.00	0.00
6	0.04	0.05	0.04	0.05	0.05	0.02	0.02
7	0.07	0.07	0.07	0.06	0.07	0.05	0.04
8	0.07	0.07	0.08	0.07	0.07	0.08	0.08
9	0.05	0.04	0.05	0.05	0.05	0.10	0.08
10	0.04	0.03	0.05	0.03	0.05	0.11	0.12
11	0.03	0.03	0.05	0.03	0.05	0.10	0.13
12	0.04	0.04	0.05	0.04	0.05	0.11	0.11
13	0.04	0.04	0.04	0.04	0.06	0.09	0.09
14	0.03	0.04	0.04	0.03	0.06	0.08	0.08
15	0.06	0.05	0.04	0.06	0.07	0.07	0.07
16	0.09	0.08	0.08	0.09	0.08	0.06	0.06
17	0.14	0.15	0.12	0.14	0.11	0.06	0.06
18	0.13	0.13	0.12	0.14	0.10	0.03	0.03
19	0.09	0.09	0.08	0.10	0.06	0.02	0.02
20	0.05	0.05	0.05	0.04	0.03	0.01	0.01
21	0.01	0.01	0.01	0.01	0.01	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 2.7 Strava-Derived Day/Month Adjustment Factors

month	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
January	1.86	3.24	2.59	3.97	3.66	1.40	1.53
February	2.07	2.40	2.78	2.63	4.05	1.14	1.78
March	1.30	1.46	1.57	1.74	1.95	0.60	0.64
April	0.96	0.95	1.18	0.95	1.16	1.61	0.76
May	0.58	0.63	0.60	0.75	0.64	0.35	0.39
June	0.84	0.63	0.70	0.76	0.88	0.42	0.45
July	0.72	0.63	0.51	0.64	0.67	0.39	0.45
August	1.02	1.15	1.04	1.05	0.97	0.64	0.57
September	1.00	1.19	1.11	1.19	1.37	0.87	0.83
October	1.84	1.53	1.25	1.50	1.65	0.82	1.20
November	1.92	1.79	2.51	2.22	2.98	1.06	1.16
December	2.00	3.66	2.81	3.52	2.79	1.53	2.63

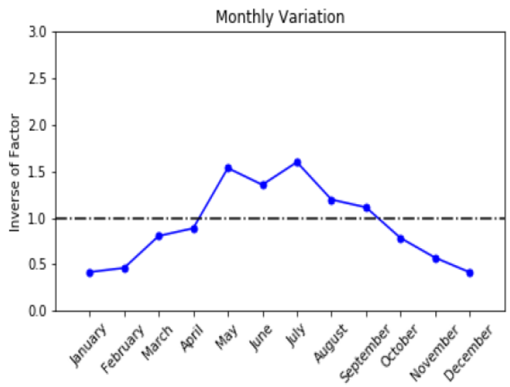
Table 2.6 and Table 2.7 show adjustment factors for the exact same location as Table 2.1 and 2.2. These Strava-derived adjustment factors can be used in the same way. The example calculation presented in the Introduction can be done with these factors. Suppose a short duration count was observed on Thursday in July for two hours 4pm-6pm. The observed counts were 6 and 14 bicyclists, in the first and second hour, respectively. Then, AADT is calculated as

$$56 \frac{bicyclists}{day} = 0.64 * \left(\frac{6 + 14}{0.09 + 0.14}\right) \tag{2.7}$$

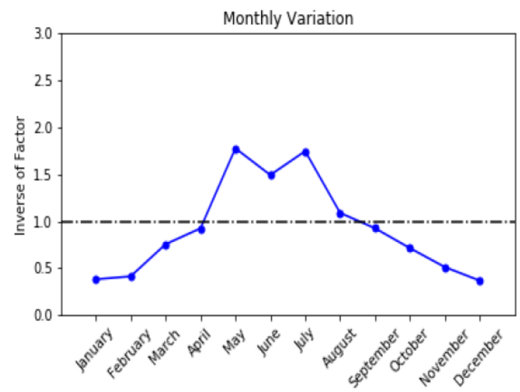
For this example, the PTR-derived factors estimate 72 bicyclists/day, while the Strava-derived factors estimate 56 bicycles/day. The difference is clearly within the same order of magnitude.

We visually compared plots of the adjustment factors for all locations. Some locations exhibit strikingly similar patterns. However, many suggest the Strava data are inadequate. The following figures will show the plots for selected figures. First, we present a selected location where the Strava-derived factors correspond well with the PTR-derived factors. Next, we present a selected location where the correlation is inadequate.

One of the locations where the PTR-derived adjustment factors and Strava-derived adjustment factors are similar is on the Sammamish River Trail in Woodinville, Washington. These factors were shown previously for the PTR data in Table 2.1 and Table 2.2; and for the Strava data in Table 2.6 and Table 2.7. When adjustment factors are plotted, the plots illustrate the temporal variation in the data. Figure 2.4 shows the monthly variation from the PTR data and the Strava data. The monthly variation is similar, suggesting that the two sets of adjustment factors would produce similar AADT estimates. Figure 2.5 shows the weekly variation from the PTR data and the Strava data. The weekly variation is also similar between the datasets. Figures 2.6 to 2.9 show the hourly variation for different seasons. The hourly variation is similar between the two sets of adjustment factors and would produce similar AADT estimates.

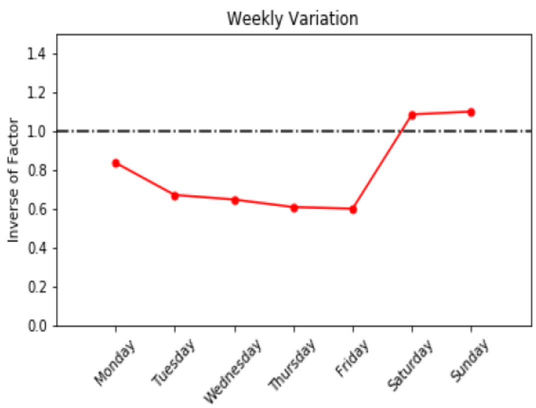


(a)

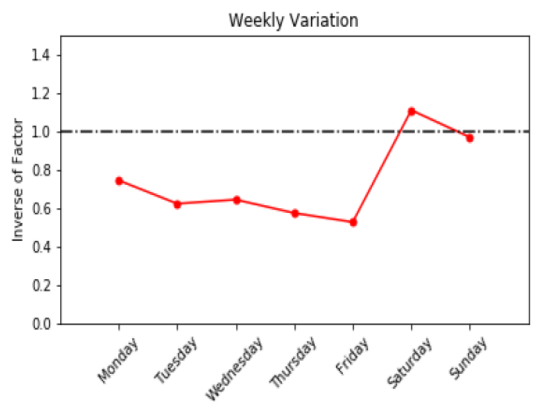


(b)

Figure 2.4 Monthly variation from (a) PTR data and (b) Strava data for Sammamish River Trail.

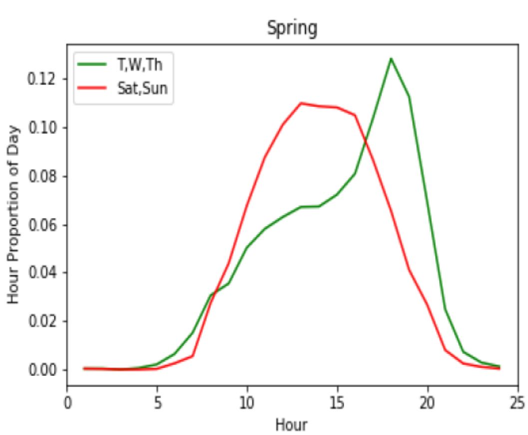


(a)

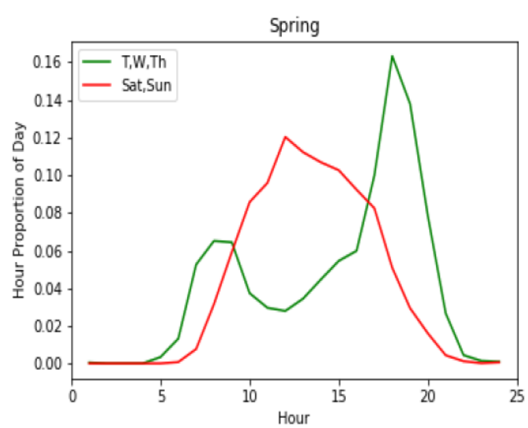


(b)

Figure 2.5 Weekly variation from (a) PTR data and (b) Strava data for Sammamish River Trail.



(a)



(b)

Figure 2.6 Spring hourly variation (a) PTR data and (b) Strava data for Sammamish River Trail.

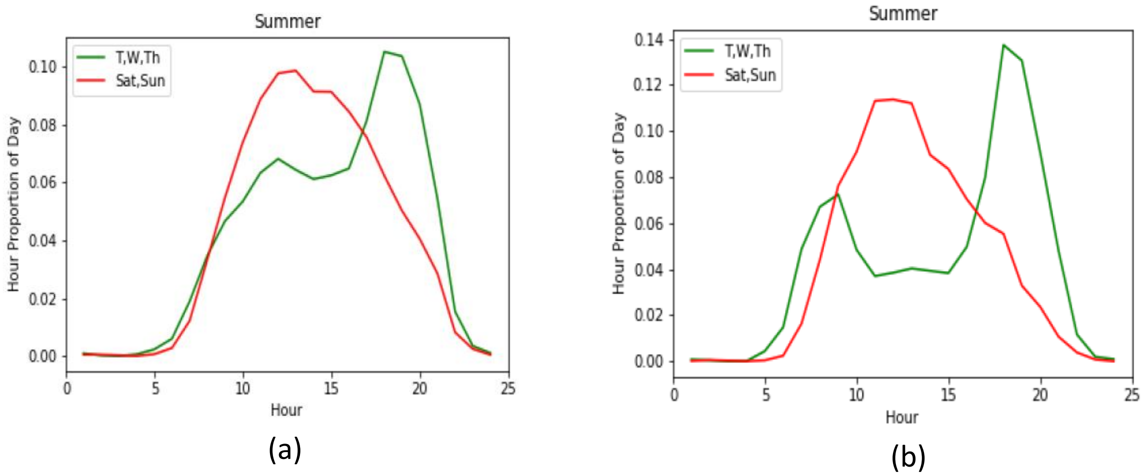


Figure 2.7 Summer hourly variation (a) PTR data and (b) Strava data for Sammamish River Trail.

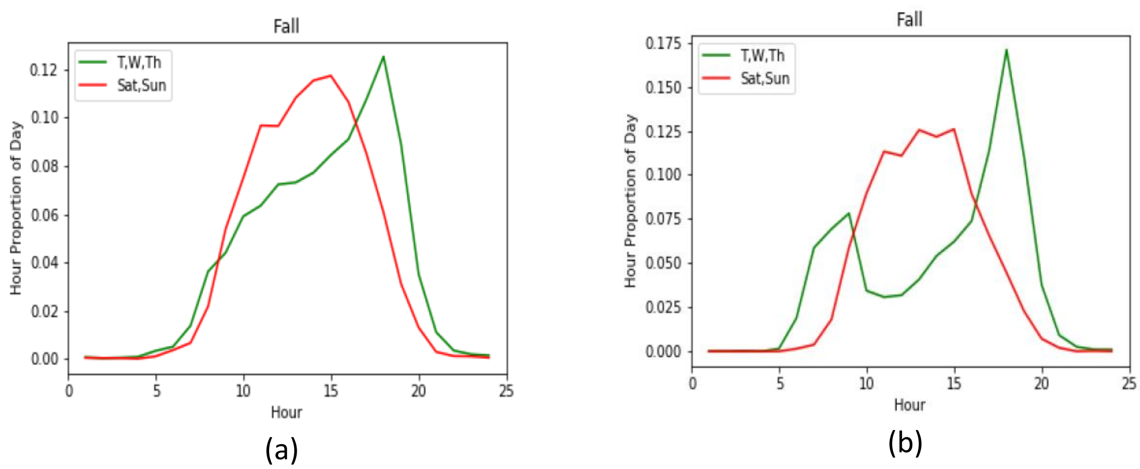


Figure 2.8 Fall hourly variation (a) PTR data and (b) Strava data for Sammamish River Trail.

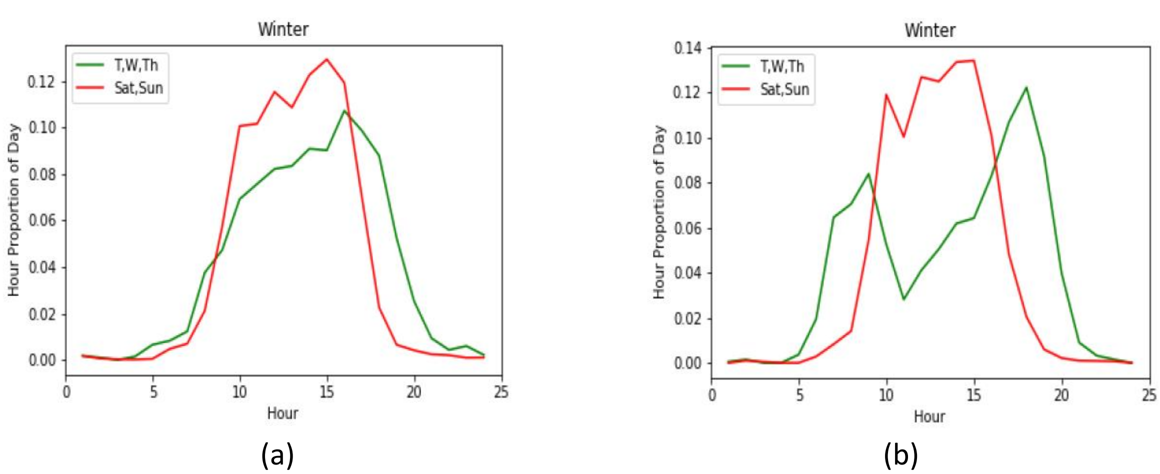


Figure 2.9 Winter hourly variation (a) PTR data and (b) Strava data for Sammamish River Trail.

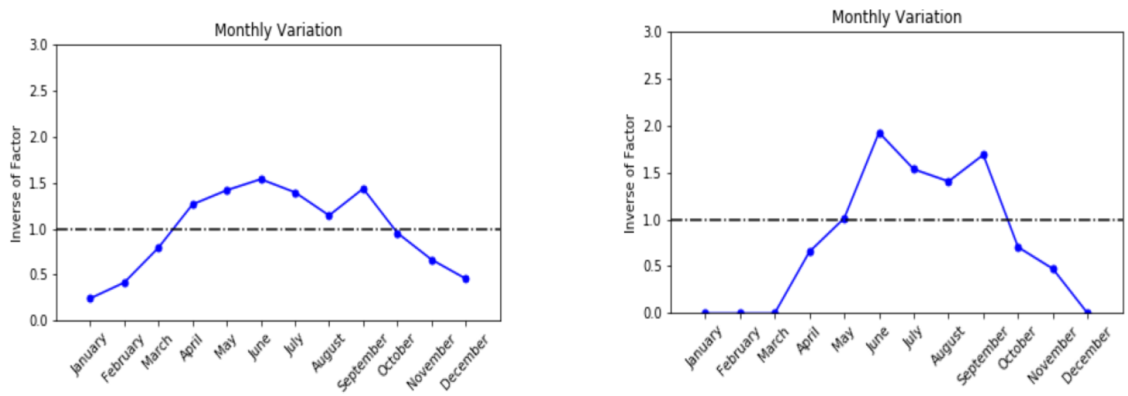
For the location on the Sammamish River Trail, the variation in the Strava-derived adjustment factors is similar to the variation from the PTR-derived adjustment factors. The variation follows the expected patterns for bicycle traffic:

- The summer months exhibit the highest volume.
- The weekends exhibit higher volume compared to the weekdays.
- Weekday hourly variation exhibits a bimodal distribution, with a morning peak and an evening peak. These peak periods are presumably the result of commuting or recreation before and after the workday.
- Weekend hourly variation exhibits a unimodal distribution, with a lunch time peak. This peak period is presumably the result of lunch traffic or recreation during lunch break.
- Volume is essentially zero at night.

The comparison for this location suggests that the Strava-derived adjustment factors could be satisfactorily used to estimate AADT with short duration counts.

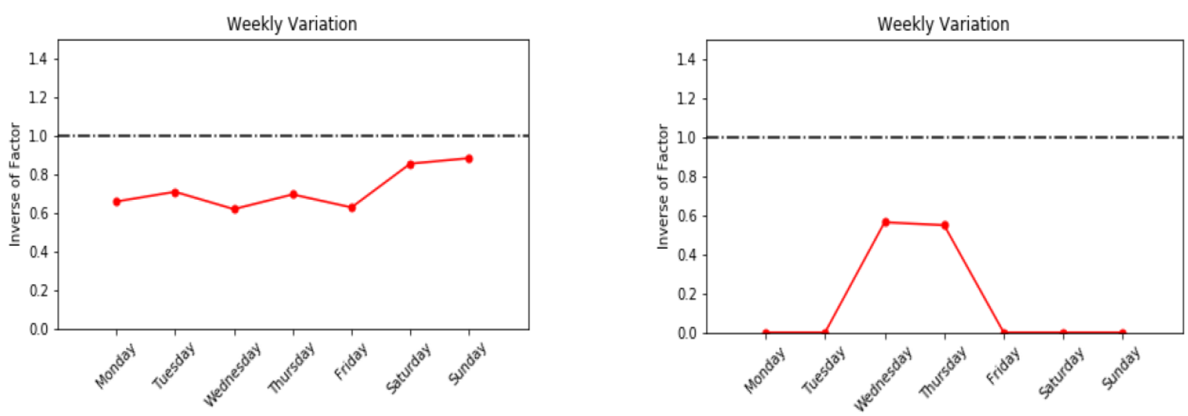
Unfortunately, this similarity was only observed in 10 of the 29 locations. For 19 locations the Strava-derived adjustment factors were not similar to the PTR-derived adjustment factors. Furthermore, for some of the locations the Strava-derived adjustment factors were not even viable.

For example, Figures 2.10 to 2.15 are plots for the adjustment factors for a location on the Ben Burr Trail in Spokane, Washington. The plots show the monthly, weekly, and hourly variation from the PTR data and the Strava data. In general, the Strava-derived adjustment factors are "less stable". In other words, they fluctuate dramatically and often are equal to zero. Consequently, it is not possible to reliably estimate AADT using the Strava-derived adjustment factors. For example, the monthly variation shown in Figure 2.10 exhibits adjustment factors equal to zero for the winter months. Likewise, Figure 2.11 shows the adjustment factors are zero for Monday, Tuesday, Friday, Saturday, and Sunday. Finally, Figures 2.12 to 2.15 show that the hourly factors fluctuate excessively. Similar patterns were found for 19 of the 29 locations that were studied.



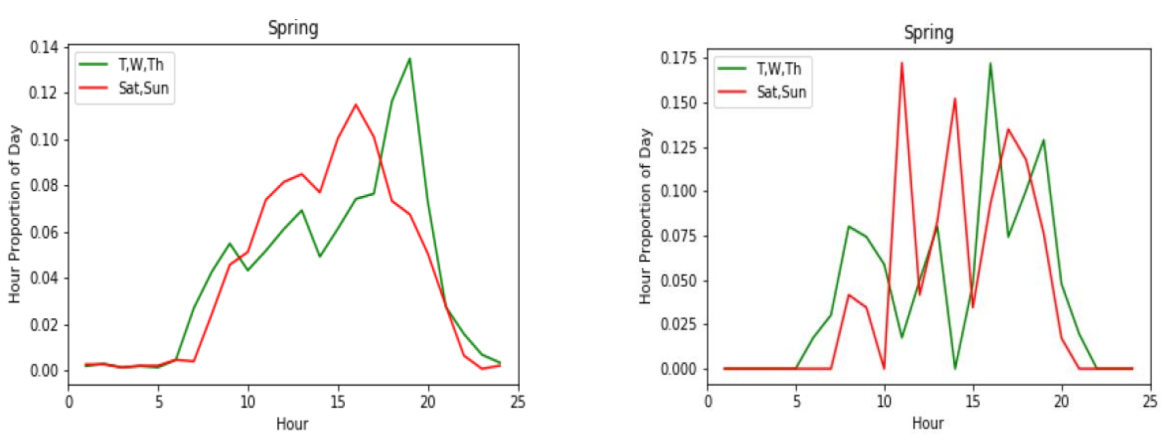
(a) (b)

Figure 2.10 Monthly variation from (a) PTR data and (b) Strava data for Ben Burr Trail.



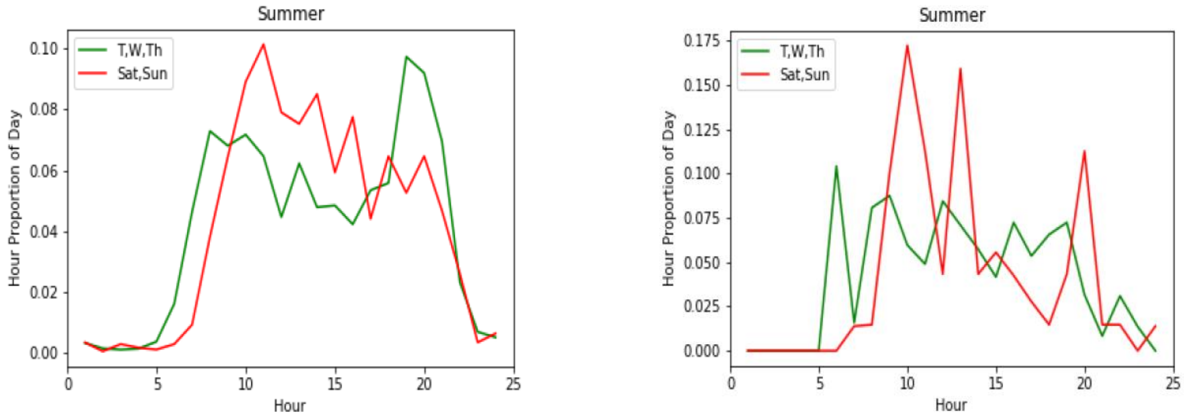
(a) (b)

Figure 2.11 Weekly variation from (a) PTR data and (b) Strava data for Ben Burr Trail.



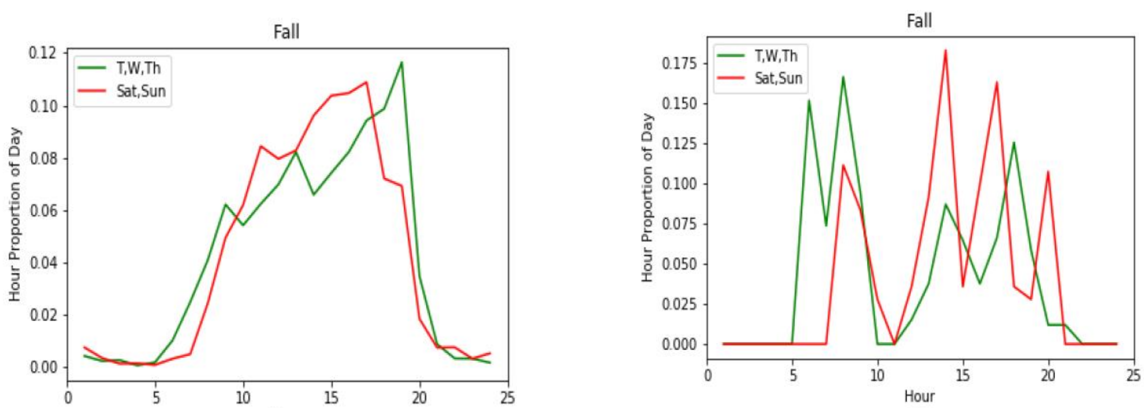
(a) (b)

Figure 2.12 Spring hourly variation (a) PTR data and (b) Strava data for Ben Burr Trail.



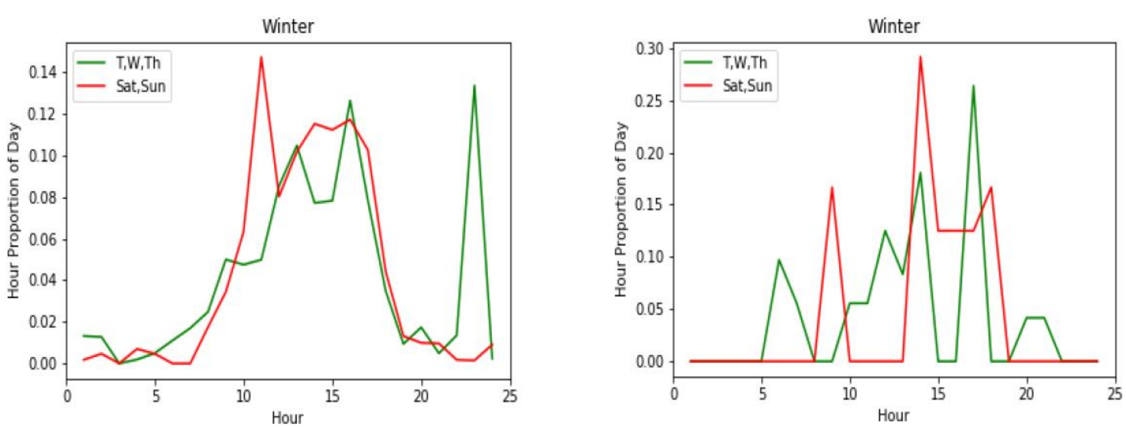
(a) (b)

Figure 2.13 Summer hourly variation (a) PTR data and (b) Strava data for Ben Burr Trail.



(a) (b)

Figure 2.14 Fall hourly variation (a) PTR data and (b) Strava data for Ben Burr Trail.



(b)

(a)

Figure 2.15 Winter hourly variation (a) PTR data and (b) Strava data for Ben Burr Trail.

2.5. Conclusion

This chapter described a study that was done to investigate the potential for using Strava data to estimate bicycle AADT on trails. Strava is a fitness app used by millions of people worldwide to record their recreation activity. The app automatically uploads the user's GPS location data as they run, bike, or hike. The proposed method is to use this Strava data to develop temporal adjustment factors that could be combined with short duration counts to estimate AADT. Data were collected from PTRs at 29 locations to create "ground truth" adjustment factors for comparison with the Strava-derived adjustment factors. The results suggest less than ideal potential for the proposed method. For 10 locations the adjustment factors were comparable. However, for 19 locations the adjustment factors were not satisfactory and, in some cases, unusable. Future research could investigate the reasons for this outcome. One possible explanation is the lack of precision with the data provided by Strava. The company rounded hourly counts to multiples of 5 and did not fully report any count less than five in order to protect their customer privacy. This likely distorted the analysis since hourly bicycle volumes are typically very low, less than 10 bicyclist per hour. Future research could identify characteristics of locations where the approach seems to indeed work, as was shown for 10 locations. This study also created a linear regression model that could be used to directly estimate AADT. The model from this data had a relatively good fit with an R-squared of 0.78.

CHAPTER 3. IDENTIFYING OPPERTUNITIES FOR NEW TRAILS

3.1. New GIS Tool for Surrounding Demographics

This chapter presents a new mapping tool that was created to obtain demographic data surrounding locations where new rail-trails could be built. The tool could be used by decision makers, engineers, and community planners to prioritize investment in new trail construction. The tool provides a means to determine the surrounding population. The tool could be used for equity analysis to determine which trails will have the greatest impact.

The tool was programmed using open-source Python computer code as a tool for ArcGIS Pro, a premier geographic information system (GIS) software. The tool connects to the online database for the American Community Survey (ACS) managed by the US Census Bureau (US Census, 2020). The ACS is an annual survey soliciting demographic data, including race, age, family size, education attainment, and employment information. The data collected annually are a sample of the population. Each year the US Census Bureau produces an extrapolated, running 5-year estimate for all census tracts, block groups, and blocks.

Figure 3.1 shows the tool interface and the various parameters that are required to run the tool. The first input parameter is a Line Feature Class representing the potential rail trail location. Next, the user provides the desired buffer distance for analysis and the output folders.

When the tool is run, a buffer is created around the proposed rail-trail and the ACS online database is accessed to get block-level demographic data. The data are scaled for the buffer area. The tool produces results as an output Polygon Feature Class and an Excel file. Figure 3.2 shows example output for a potential rail-trail in Moscow, Idaho.

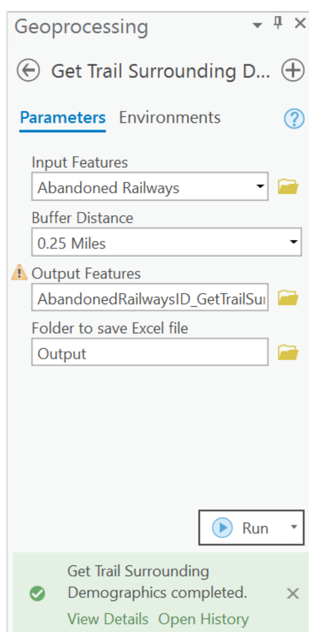


Figure 3.1 Tool Interface.

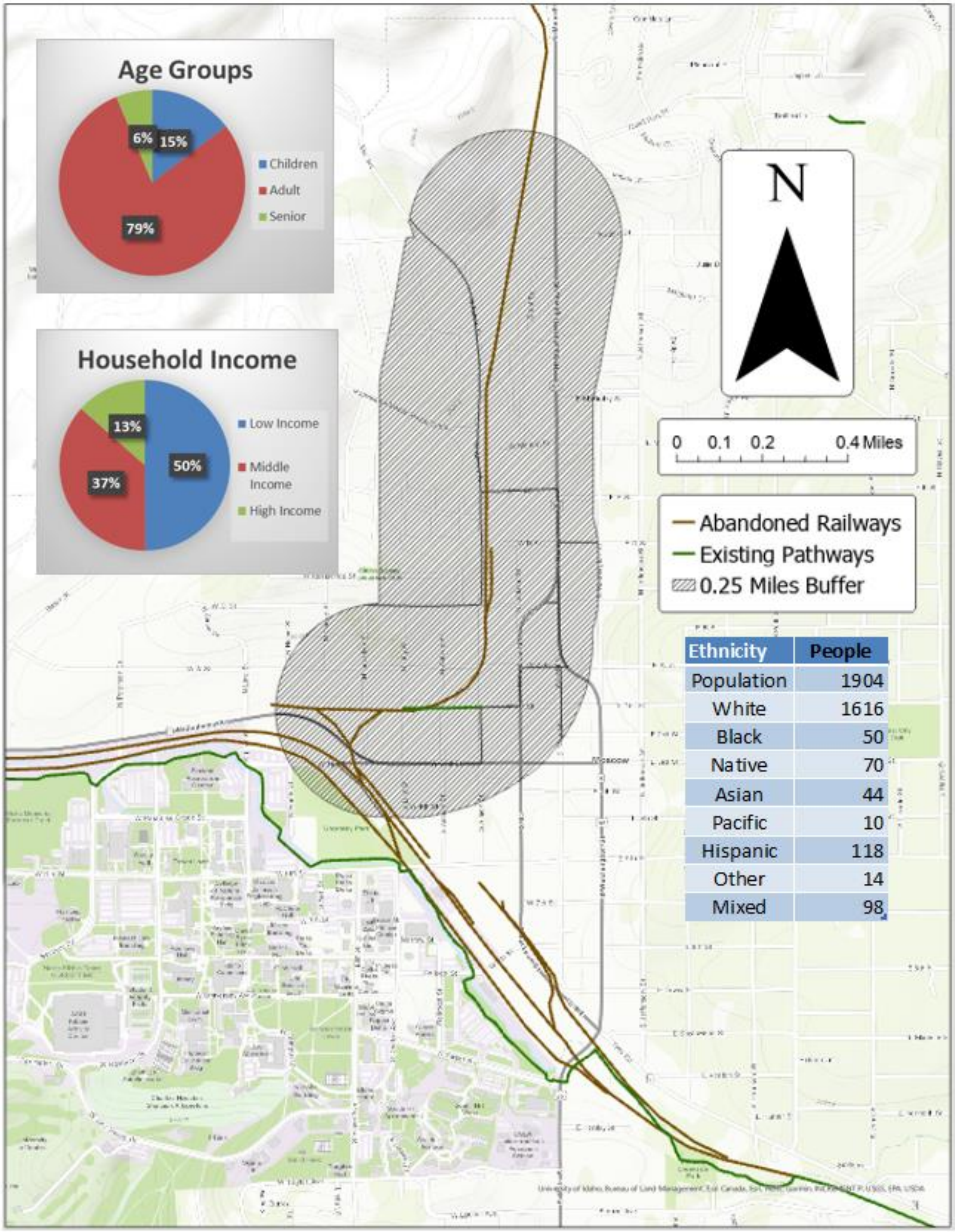


Figure 3.2 Example Tool Output.

3.2. Potential Rail-Trails in the Pacific Northwest

Figure 3.3 is a map of all vacant railways in the Pacific Northwest (OSM, 2020). Table 3.1 summarizes the types of railway vacancy. Abandoned railways are those in which track ties, ballasts, and embankments remain present. Disused railways are those in which the railway owner indicates potential return to use. Razed are those in which track ties and ballasts have been removed. There are 8,616 miles of potential rail-trail that could be built. Washington has the most miles of vacant railway.

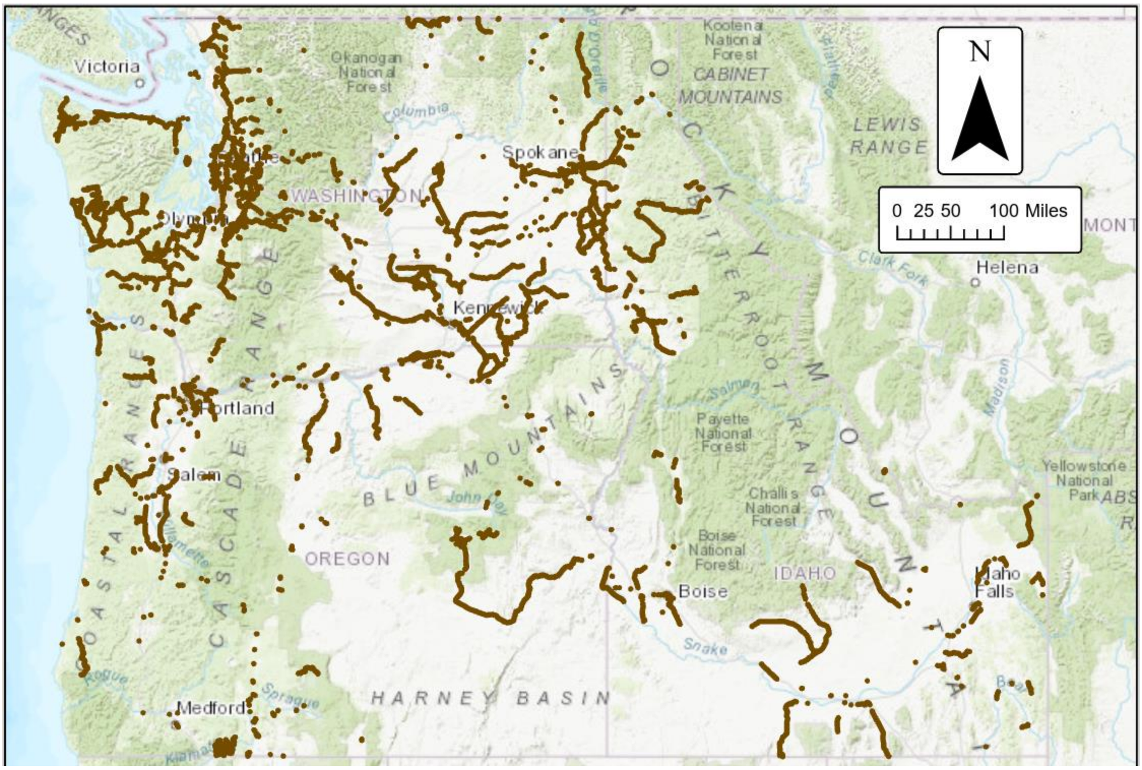


Figure 3.3 Vacated Railways in the Pacific Nortwest.

Table 3.1 Miles of Vacated Railways

Status	WA	OR	ID	Total
Abandoned	3791	1363	830	5984
Disused	338	121	259	1718
Razed	589	90	235	914
Total	4718	1574	1324	8616

3.3. Demographics for Selected Locations

This section presents the results (tool output) for twelve selected locations in rural communities in the Pacific Northwest. Figures 3.4 to 3.7 are for locations in Idaho. Figures 3.8 to 3.11 are for locations in Oregon. Figures 3.12 to 3.15 are for locations in Washington.

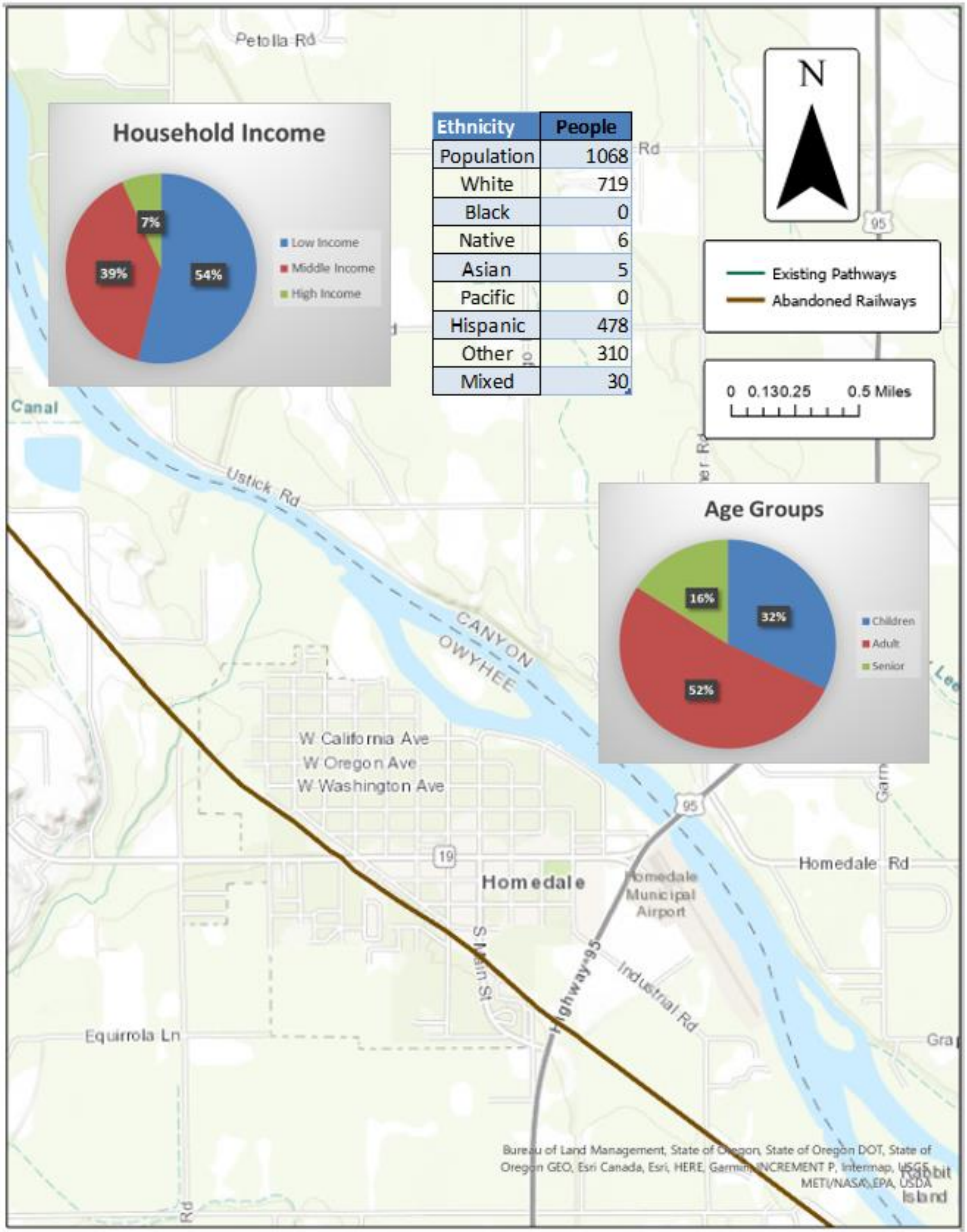


Figure 3.4 Homedale, Idaho

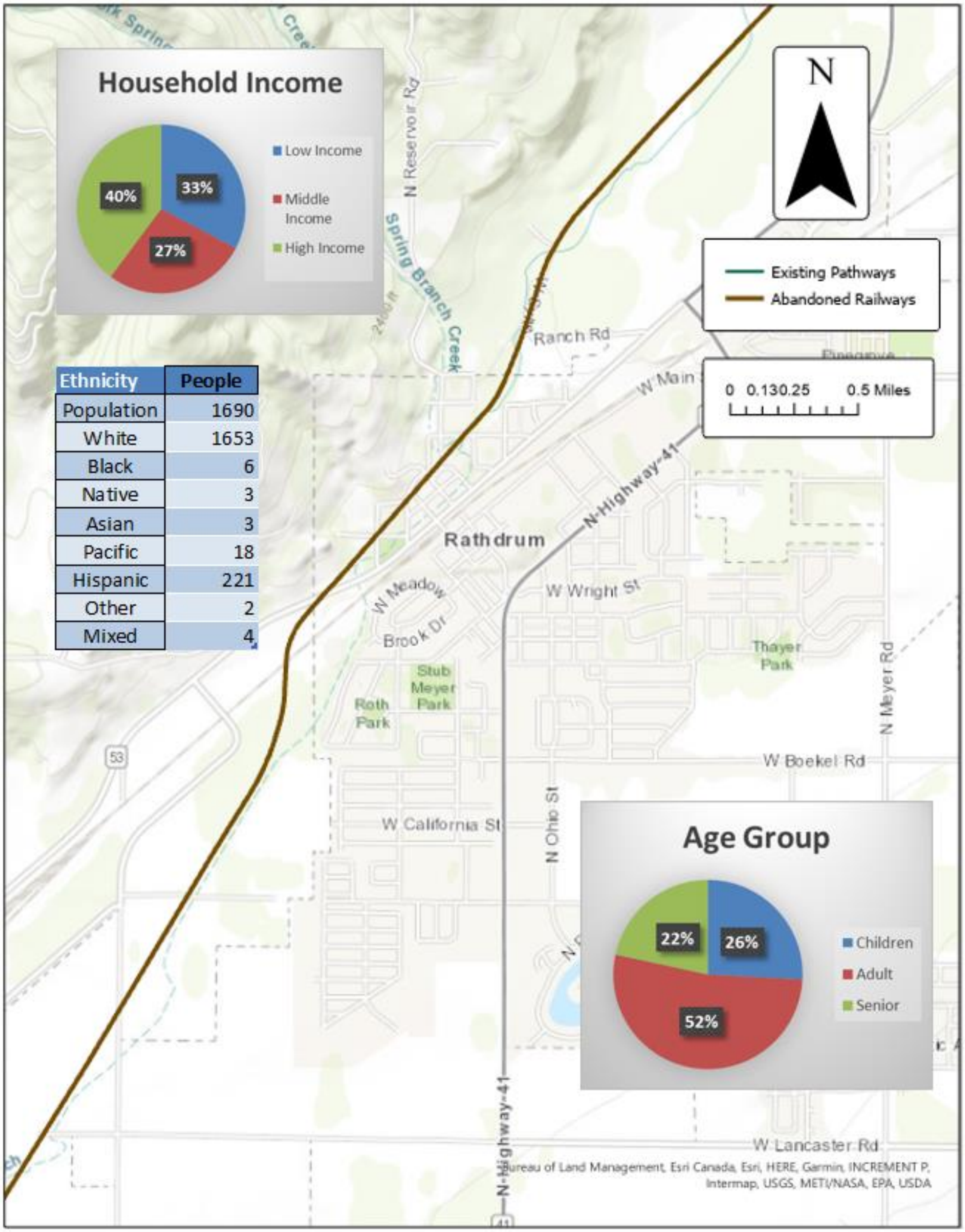


Figure 3.5 Rathdrum, Idaho

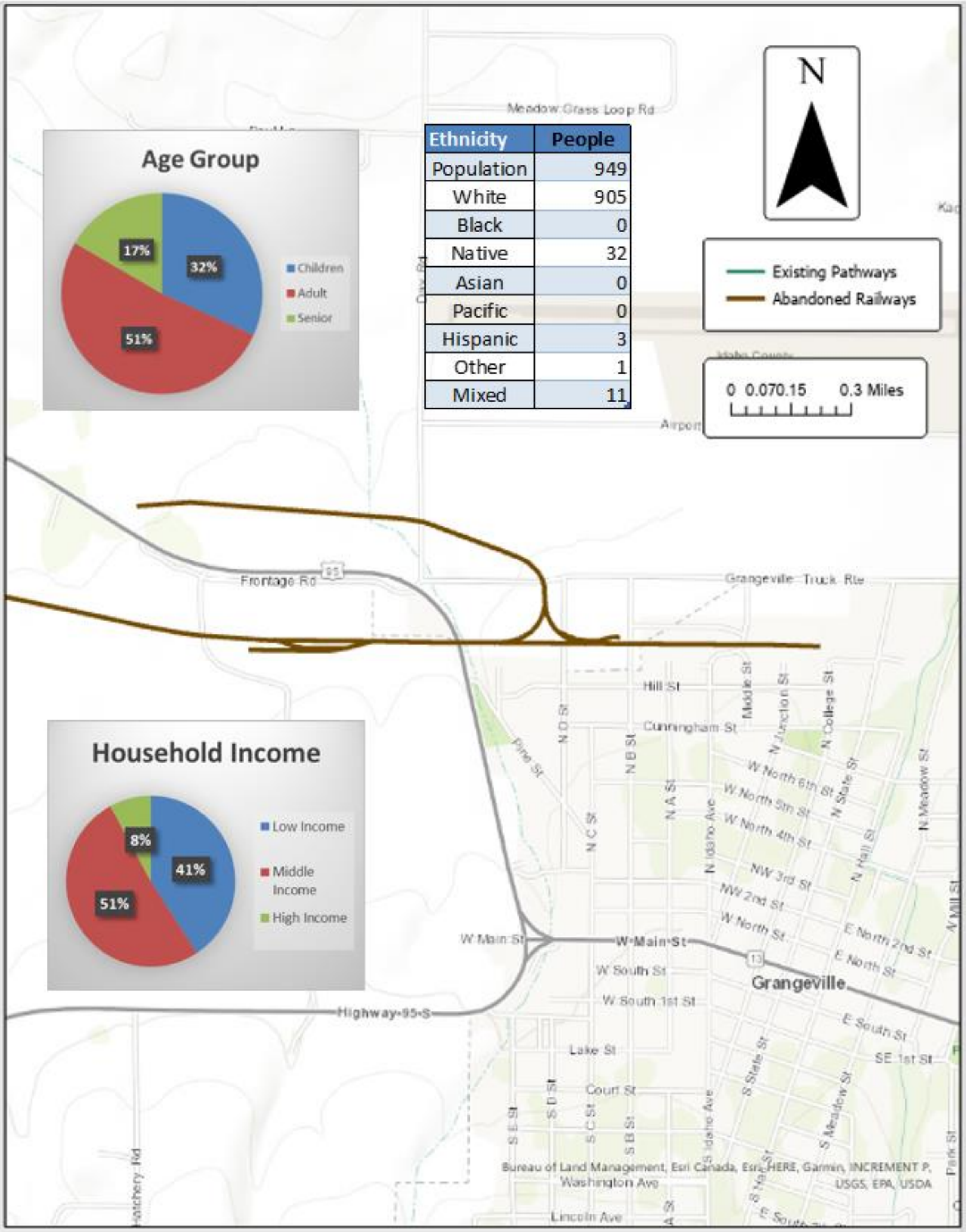
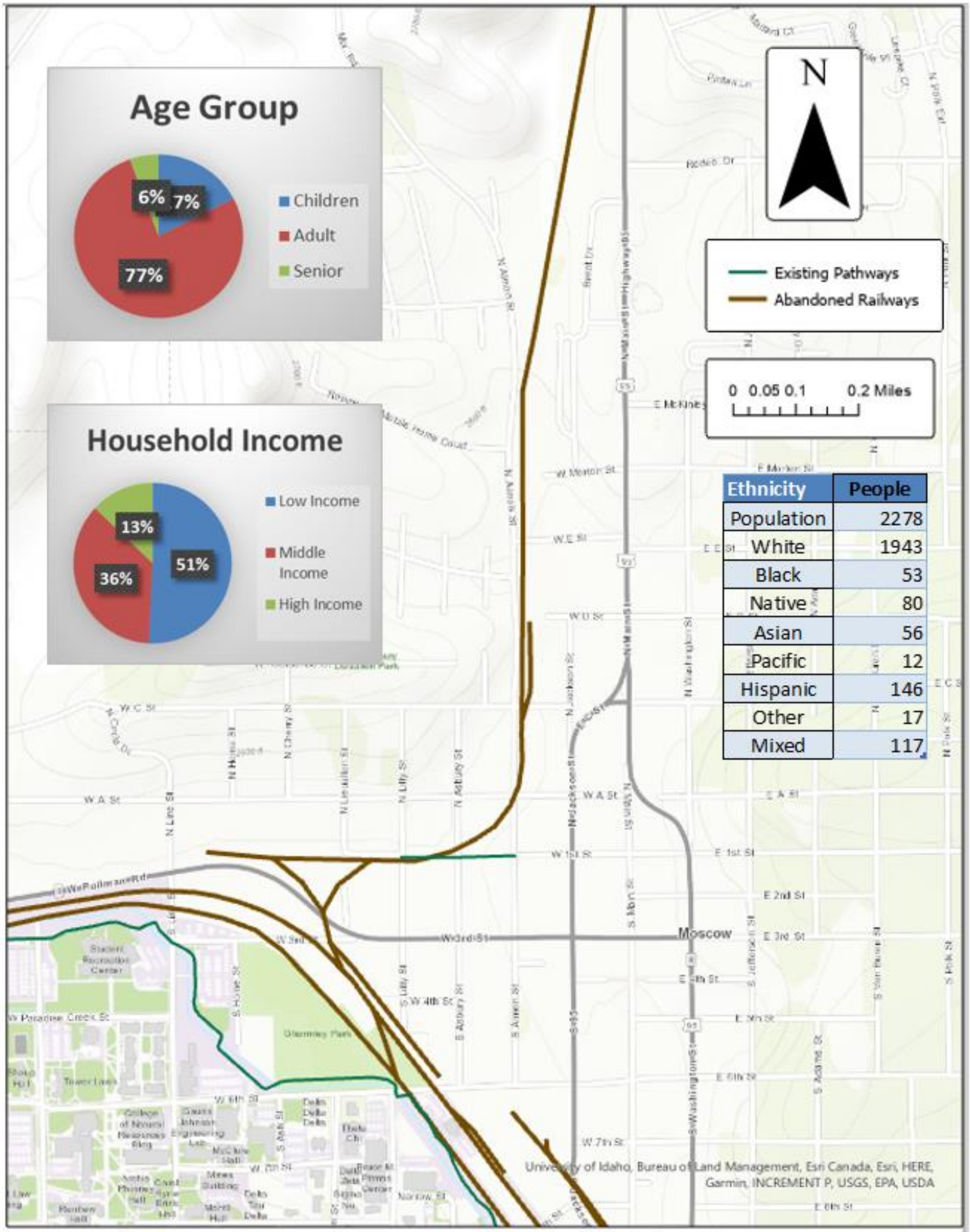


Figure 3.6 Grangeville, Idaho



Ethnicity	People
Population	2278
White	1943
Black	53
Native	80
Asian	56
Pacific	12
Hispanic	146
Other	17
Mixed	117

Figure 3.7 Moscow, Idaho

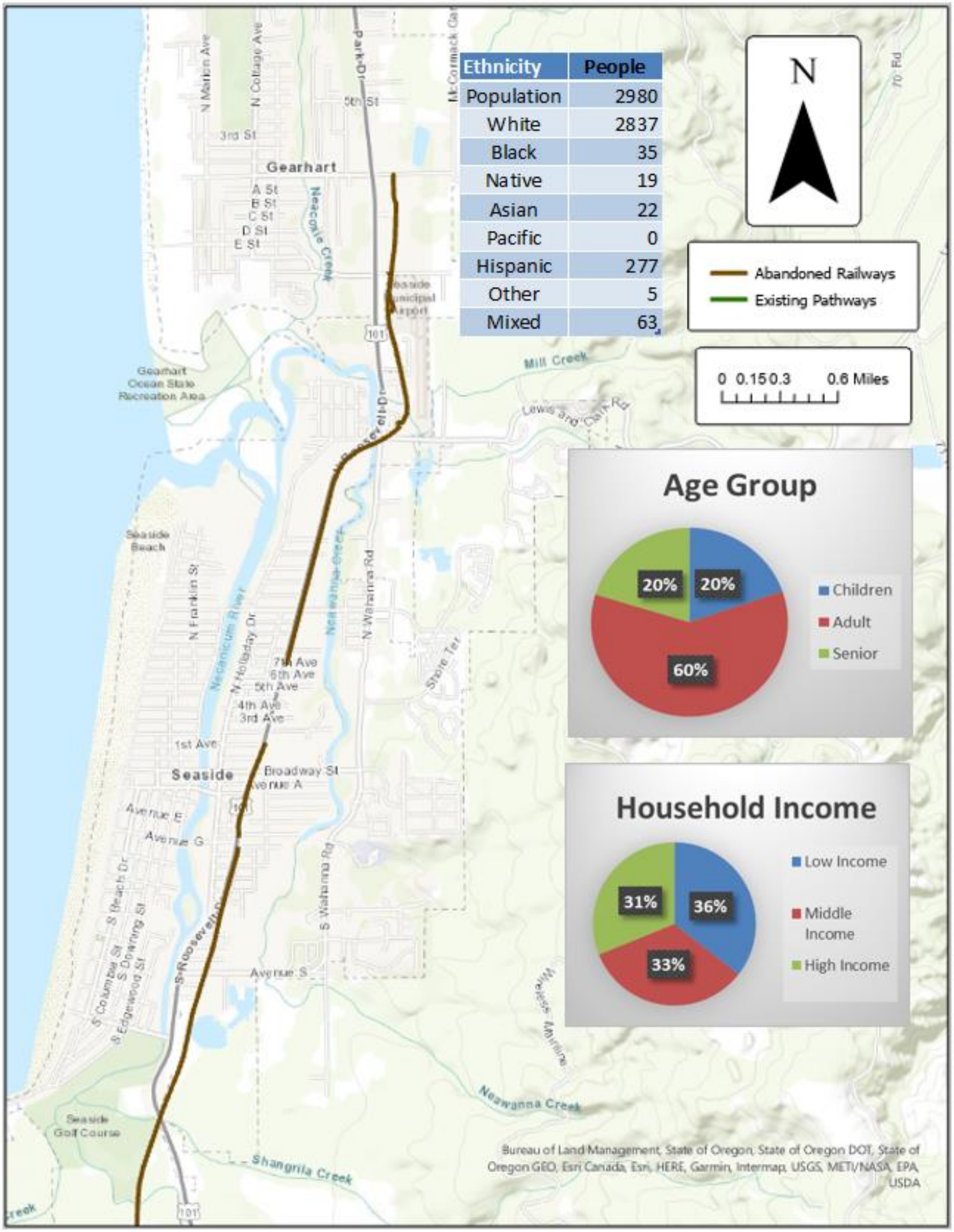


Figure 3.8 Seaside and Gearhart, Oregon

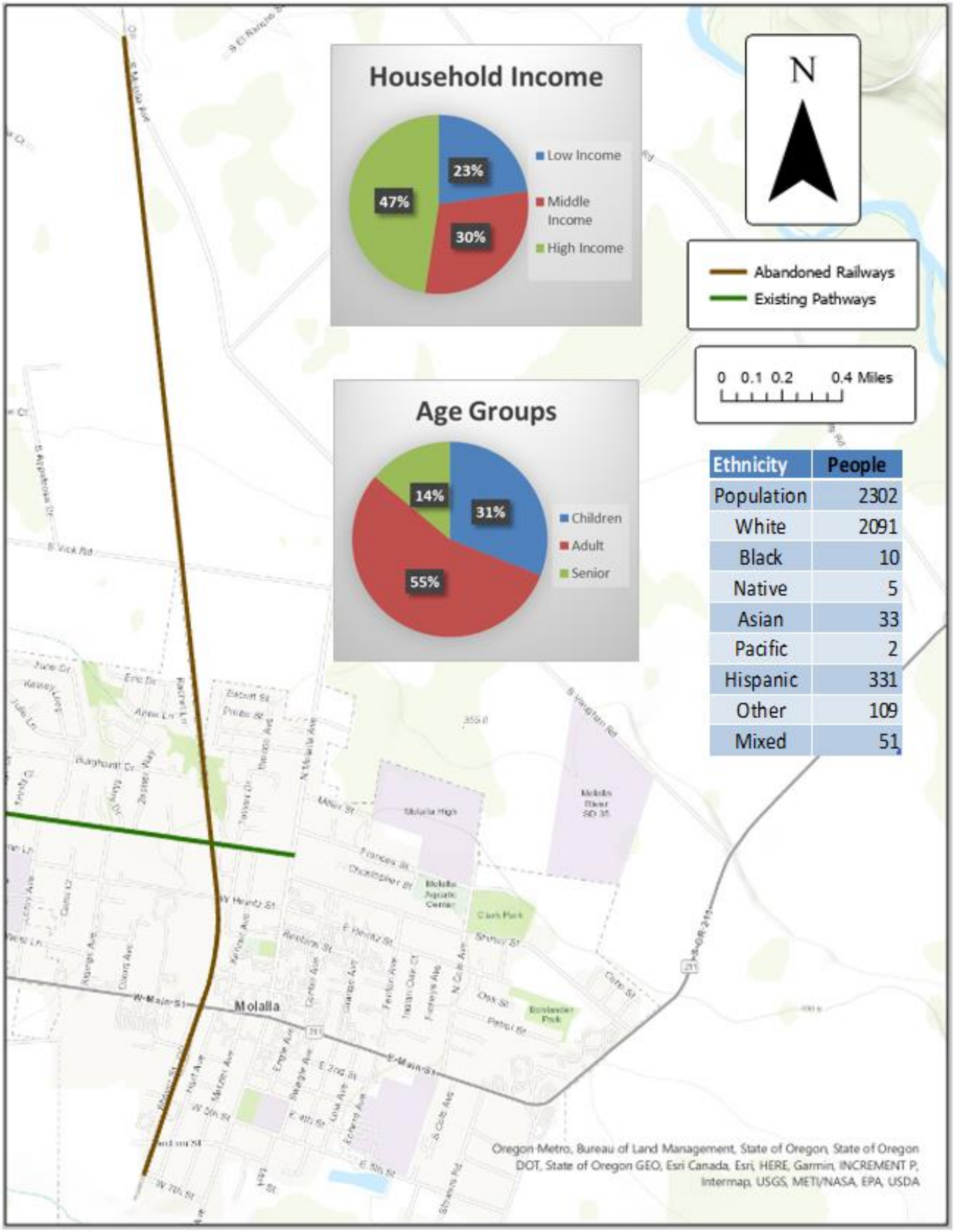


Figure 3.9 Molalla, Oregon

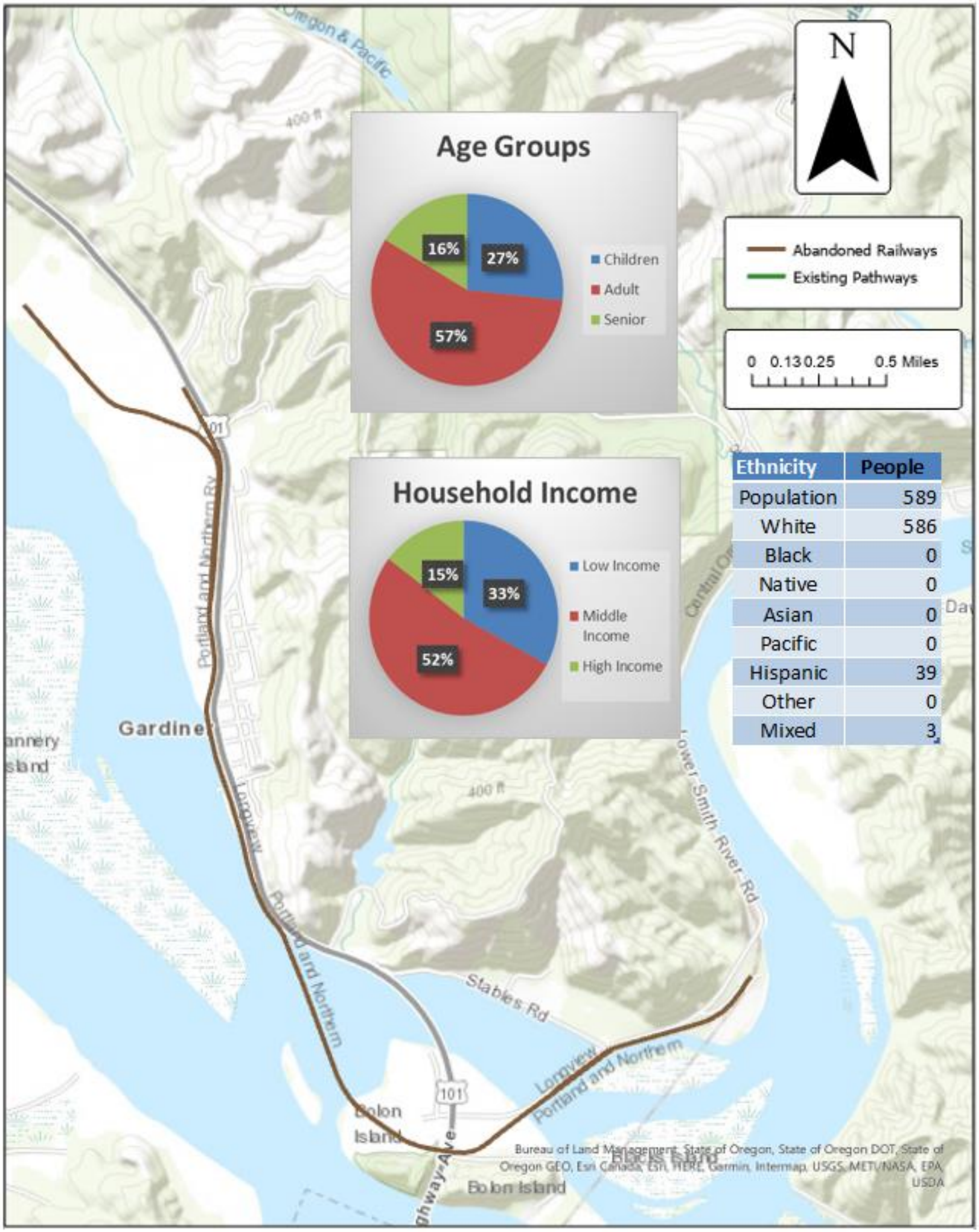


Figure 3.10 Gardine, Oregon

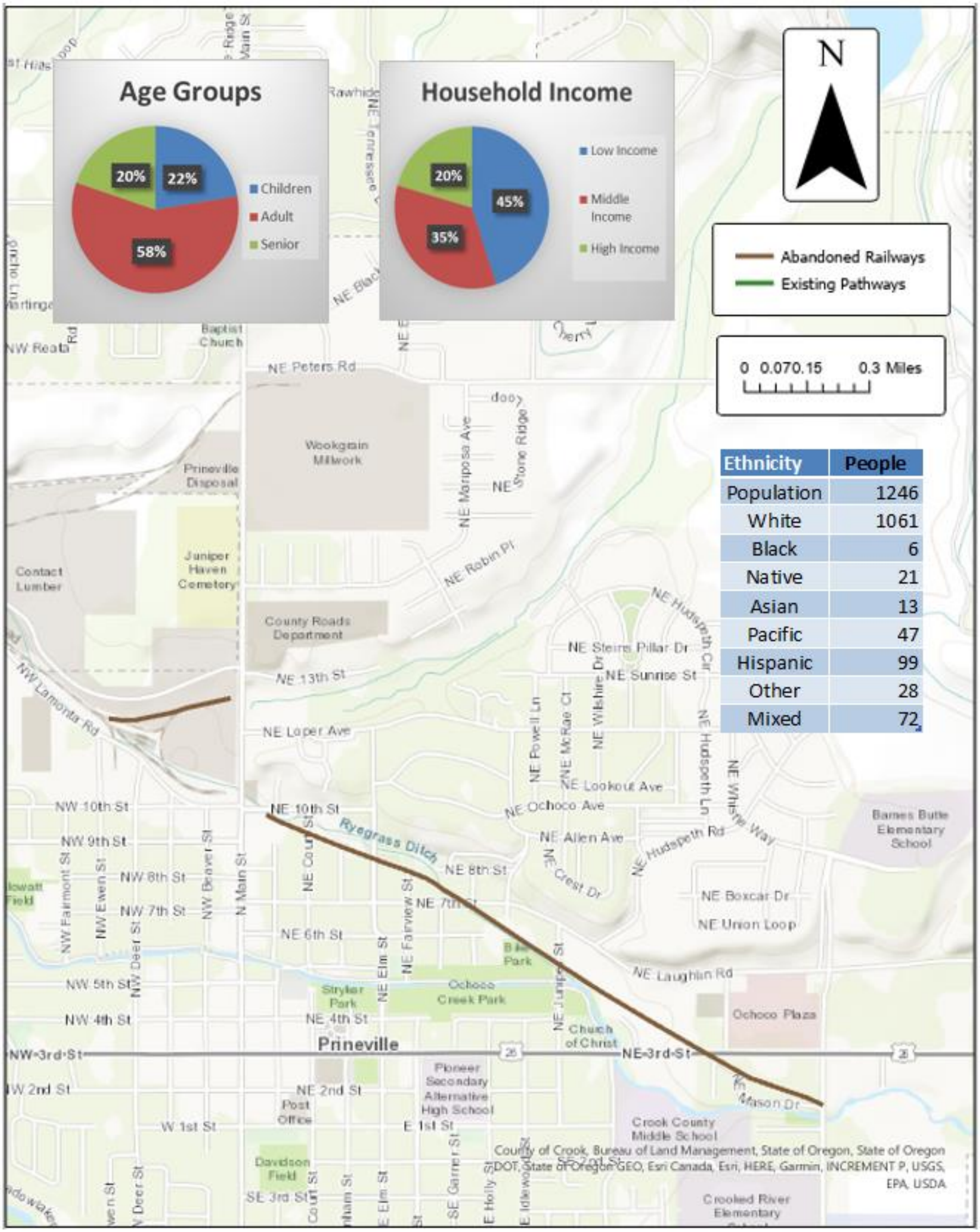
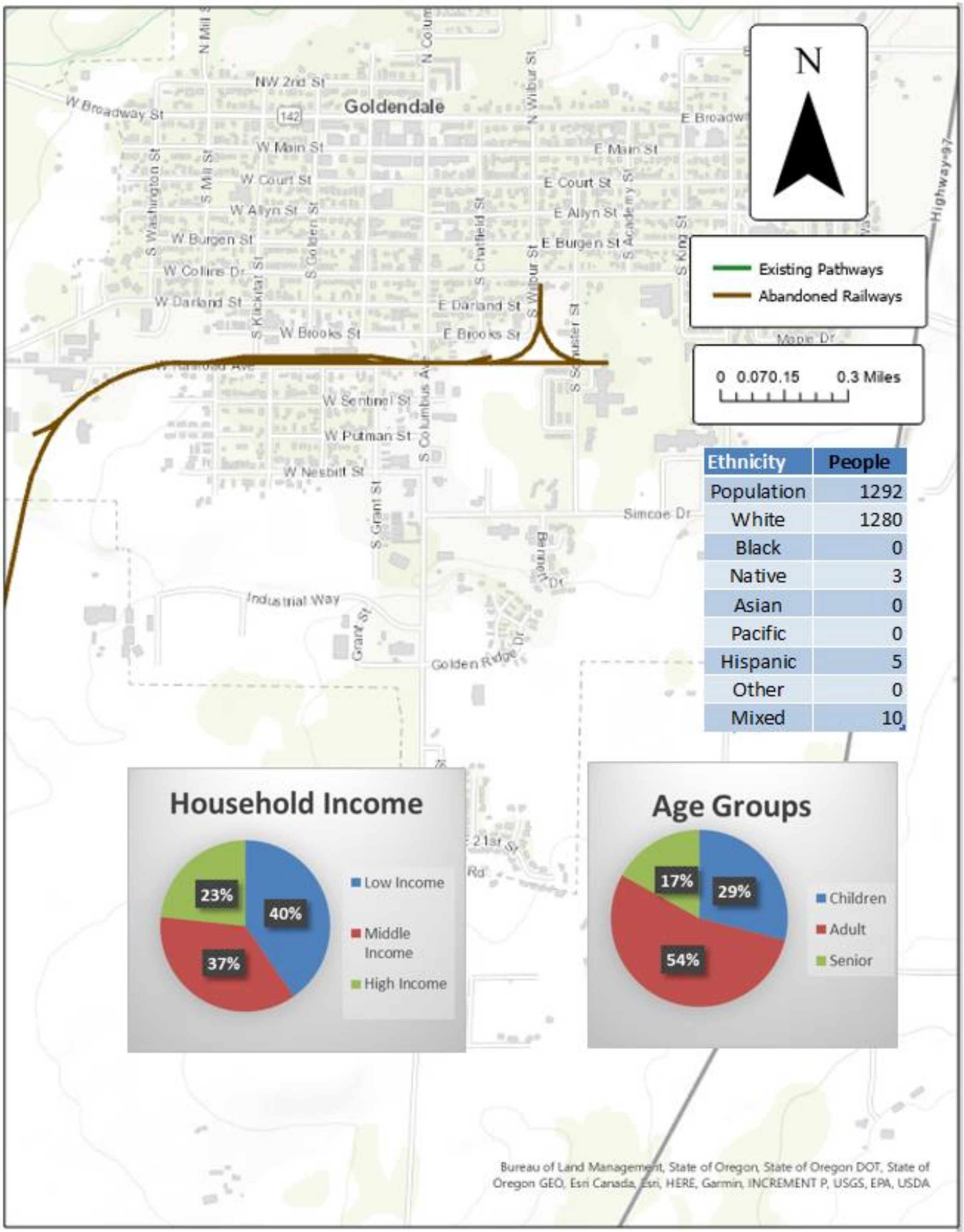


Figure 3.11 Prineville, Oregon



Ethnicity	People
Population	1292
White	1280
Black	0
Native	3
Asian	0
Pacific	0
Hispanic	5
Other	0
Mixed	10

Figure 3.12 Goldendale , Washington

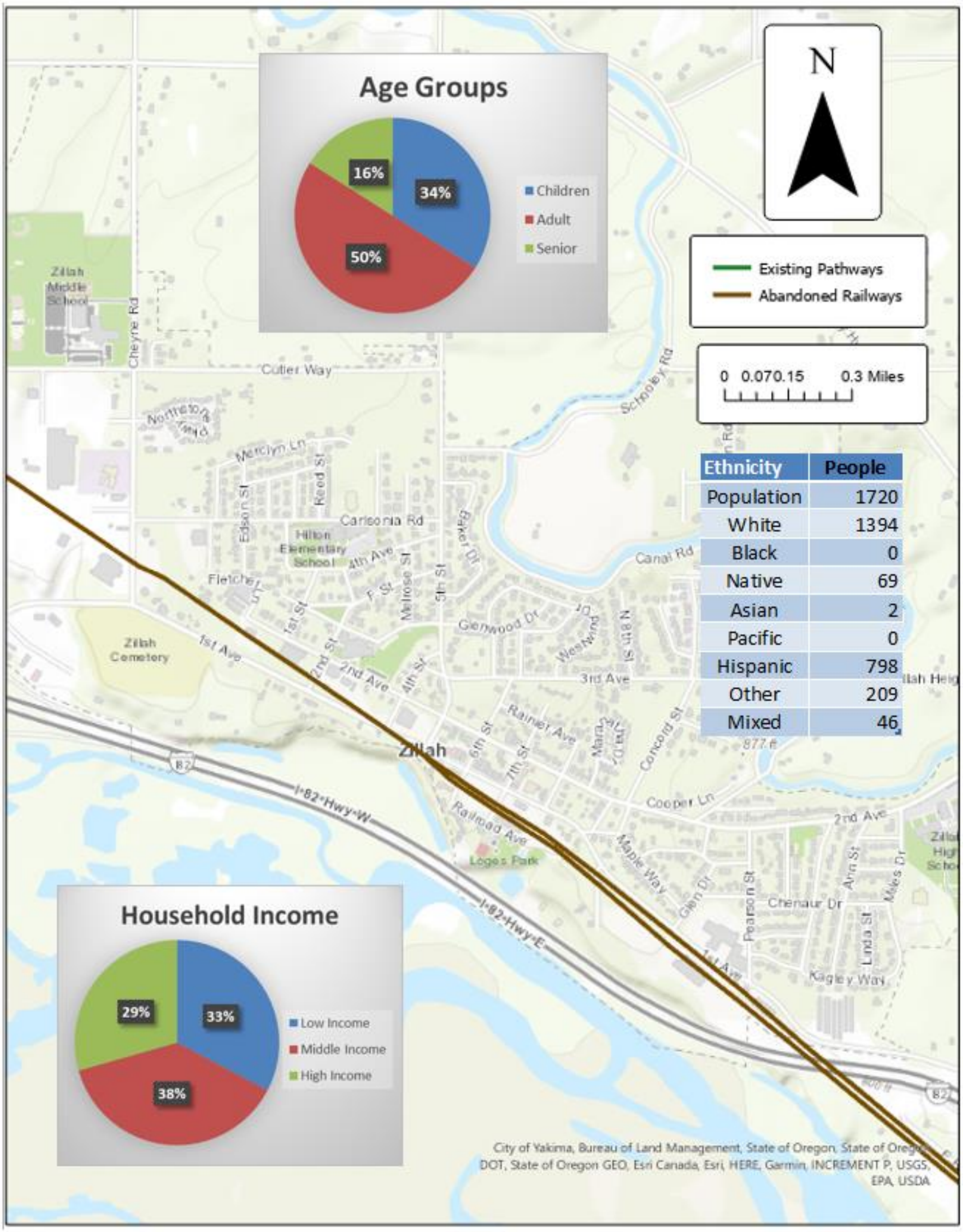


Figure 3.13 Zillah, Washington

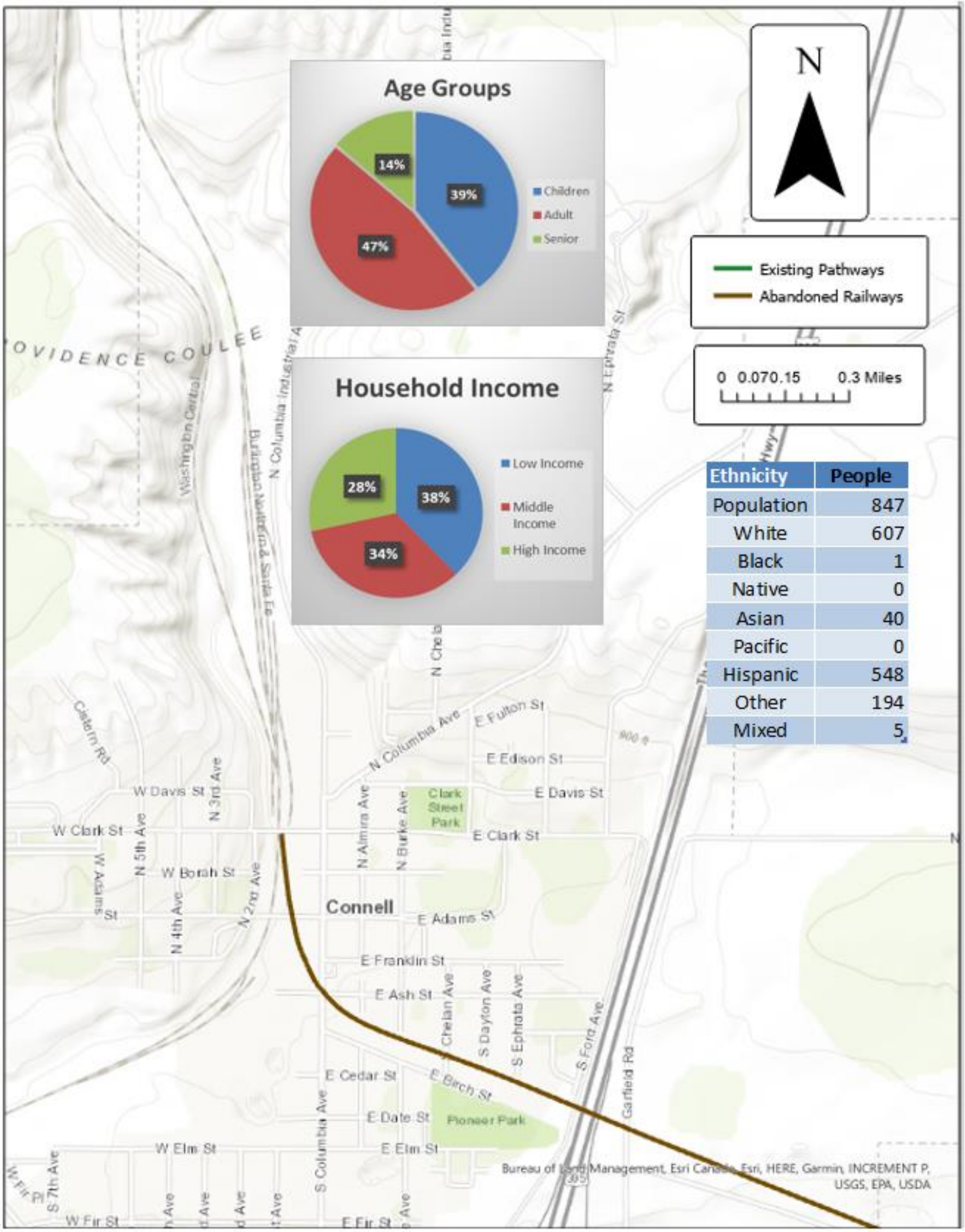


Figure 3.14 Connell, Washington

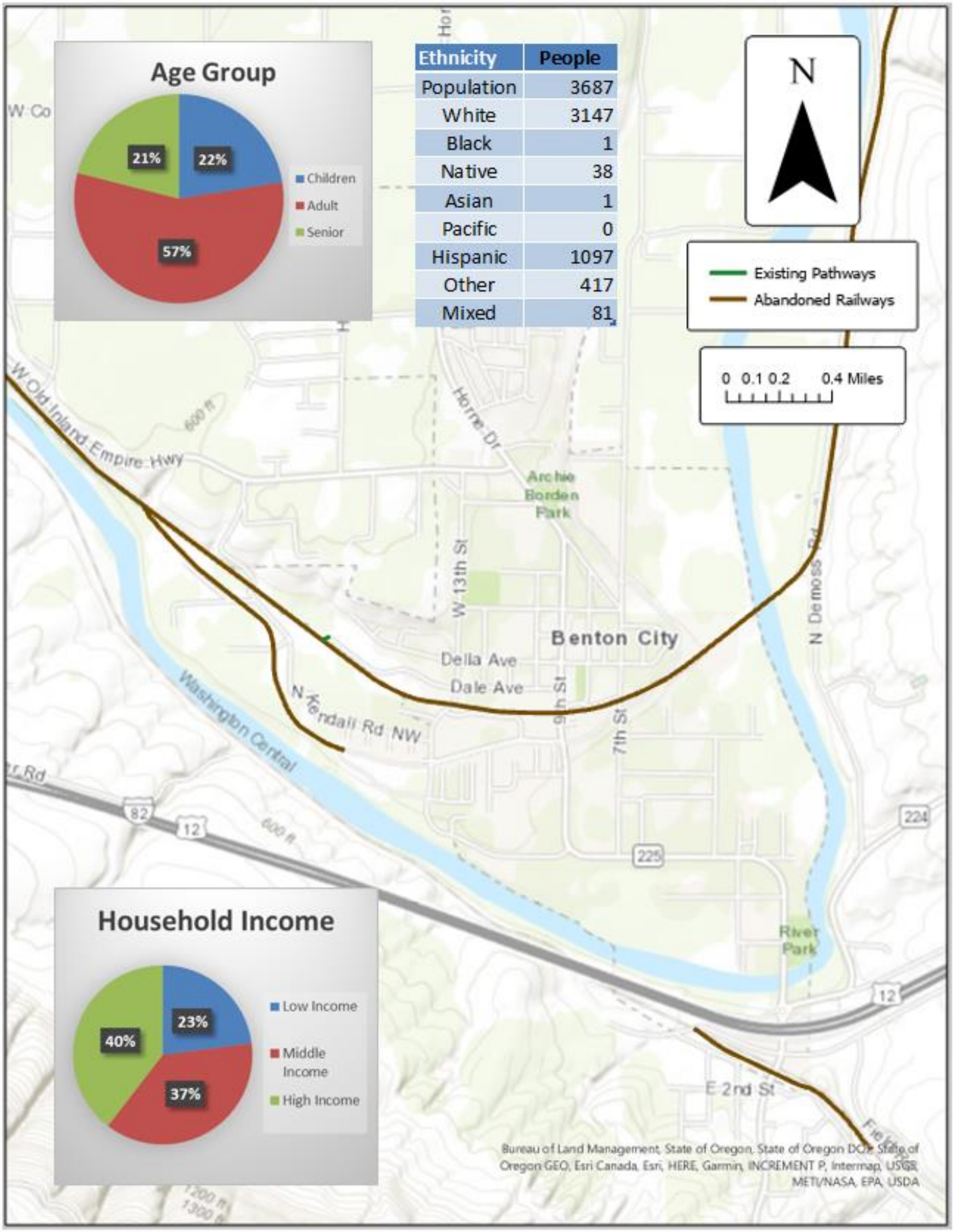


Figure 3.15 Benton City, Washington

CHAPTER 4. TRAIL SURVEYS

The research team conducted two separate surveys to solicit community member opinions and usage habits of the Trail of the Coeur d'Alenes. First, an intercept survey of trail users was carried out at locations near Plummer, Chatcolet, and Kellogg, Idaho. Second, fliers containing a link to an online survey were mailed to residents of three towns located along the trail, namely Plummer, Kellogg, and Wallace, Idaho. The results of both surveys were compared to gain a better understanding of the trail's role in its community and the opinions of its users.

4.1. Study Area

This study sought to better understand how the Trail of the Coeur d'Alenes serves its community. Located in northern Idaho, the paved multiuse trail follows a former Union Pacific railroad right-of-way through the Coeur d'Alene Basin, extending from Plummer, Idaho in the west to Mullan, Idaho in the east. In addition to providing a host of new recreational opportunities, the trail's 2004 opening also represented a significant environmental cleanup effort for the region, as the railroad bed that the trail was built over had been contaminated by potentially toxic and harmful metals from years of transporting mining debris from the Silver Valley.

When rail operations ceased, the Union Pacific Railroad, United States government, the State of Idaho, and the Coeur d'Alene Tribe collaborated on a partnership to design and construct this new non-motorized facility. To permanently cap the contaminants from the surrounding area, a thick layer of asphalt and gravel along both sides of the trail were utilized (Wikipedia, 2020). Today, the Trail of the Coeur d'Alenes is a 10-foot wide, 73.2-mile asphalt paved trail that passes along a chain of alpine lakes and through various small towns in the northern panhandle of Idaho.

4.2. Trail Intercept Survey

A trail intercept survey was conducted in August 2019. The purpose of this activity was to "intercept" trail users and gather information from them. A copy of the intercept survey instrument is shown below.

1. Where was your starting point on the trail today?
   ____

2. How did you get to the trail?
   - Automobile
   - Walked/Jogged/Ran
   - Bus
   - Other

3. How much time do you plan to spend on the trail?
   - Less than 30 minutes
   - 30 minutes to an hour
   - 1 to 2 hours
   - More than 2 hours

4. Were you travelling from home or some other location to reach the trail?
   - Home
   - Some other location
     - *Please specify:*
       ____

5. What is your home and other location (if applicable) zip code?
   Home: ______________________
   Other location: ________________

6. How many miles did you travel to get to the trail today?
   ______________ miles

7. What is the group's primary method of transportation on the trail?
   - Bike (Human Powered)
   - e-Bike (Electronically Assisted)
   - e-Scooter
   - Walked/Jogged/Ran
   - Skateboard/Rollerblade/Other

8. On this trip, please estimate how much your group spent on each of the following:
   Gas: $____________
   Food: $____________
   Lodging: $____________
   Other: $____________
   (please specify) ________________

9. What is your primary reason for using the trail?
   - Recreation
   - Commuting
   - Daily Activities (Errands, Visit Friends, etc.)

10. In the past 12 months, including today, how many times did you visit The Trail of the Coeur d'Alenes?
    - 1
    - 2
    - 3-5
    - 6-10
    - 11-30
    - 31-60
    - 61 or more

11. In the past 12 months, have you used similar trails to this one?
    - Yes
    - No

12. How often do you use similar trails? (Including the Trail of the Coeur d'Alenes)
    - Everyday
    - 2-3 times a week
    - Once a week
    - Once a month
    - Rarely or never

13. How many people are in your group for the following three categories? (Please write a number for each category.)

    A. Gender
    _____ Male
    _____ Female
    _____ Other
    _____ Prefer not to specify

    B. Ethnicity
    _____ White
    _____ Black or African American
    _____ Asian
    _____ Latino
    _____ Other
    _____ Prefer not to specify

    C. Age Range
    _____ Under 18 years
    _____ 19 – 35 years
    _____ 36 – 65 years
    _____ Over 65 years
    _____ Prefer not to specify

14. What was your household income before tax last year?
    - Less than $35,000
    - $35,000 - $50,000
    - $51,000 - $80,000
    - $81,000 - $110,000
    - $111,000 and over
    - Prefer not to specify

THE UNIVERSITY OF IDAHO 1889

Figure 4.1 Trail Intercept Survey.

Groups of trail users near Plummer, Chatcolet, and Kellogg were stopped and asked to take a brief survey, which contained mostly different questions than were asked in the online survey. A report of the survey responses is presented in the Appendix.

4.2.1. Trail Access and Zip Code Information

One of the first questions the intercept survey posed to respondents concerned the way in which they got to the trail. The most popular method was "Automobile", which accounted for 70.7% of responses (n=70). "Walked/jogged/ran" and "Other" each had 10.1% of responses (n=10), "Bike" accounted for 8.1% (n=8), and 1.0% of respondents reported taking the bus to the trail (n=1). Just under 63% of respondents (n=61) answered that they were traveling from home to reach the trail, with the remaining 37.1% (n=36) selecting the option of traveling from some other location.

Respondents were asked to provide their home zip code whether they were coming to the trail from home or some other location. The results from respondents who said they were coming from home are shown below in Figures 4.2, 4.3, and 4.4. Responders who provided zip codes outside of the three main regions identified in the figures below were not included in this final analysis; of the 52 total responses, 46 are represented in Figures 4.2, 4.3, and 4.4.

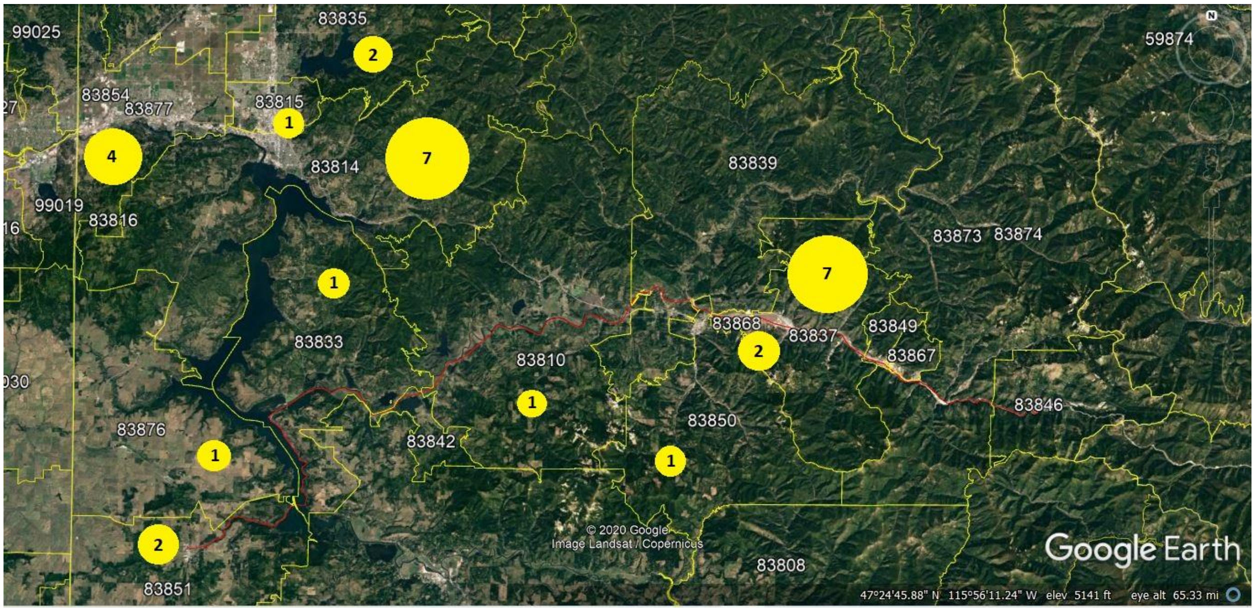


Figure 4.2 Home zip codes of trail users coming from home in North Idaho.

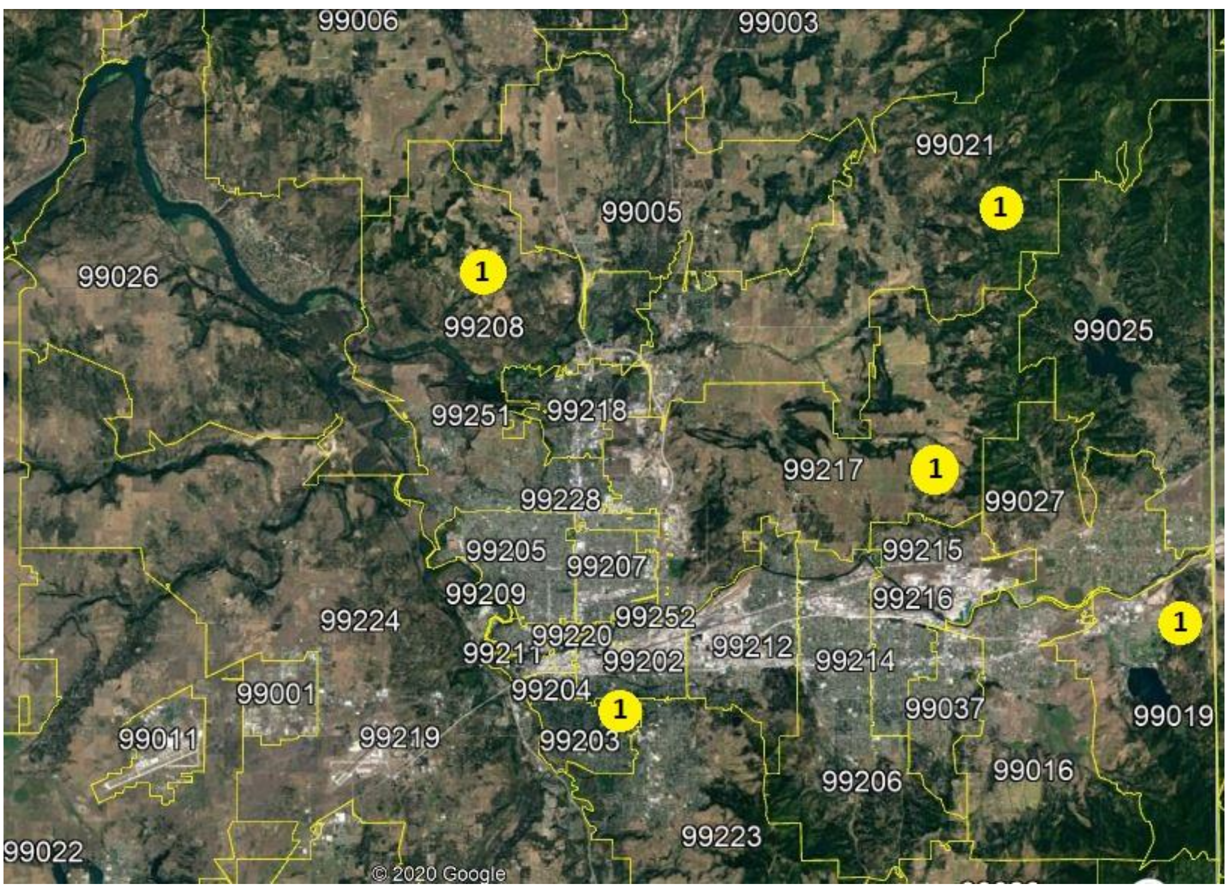


Figure 4.3 Home zip codes of trail users coming from home in Eastern Washington.

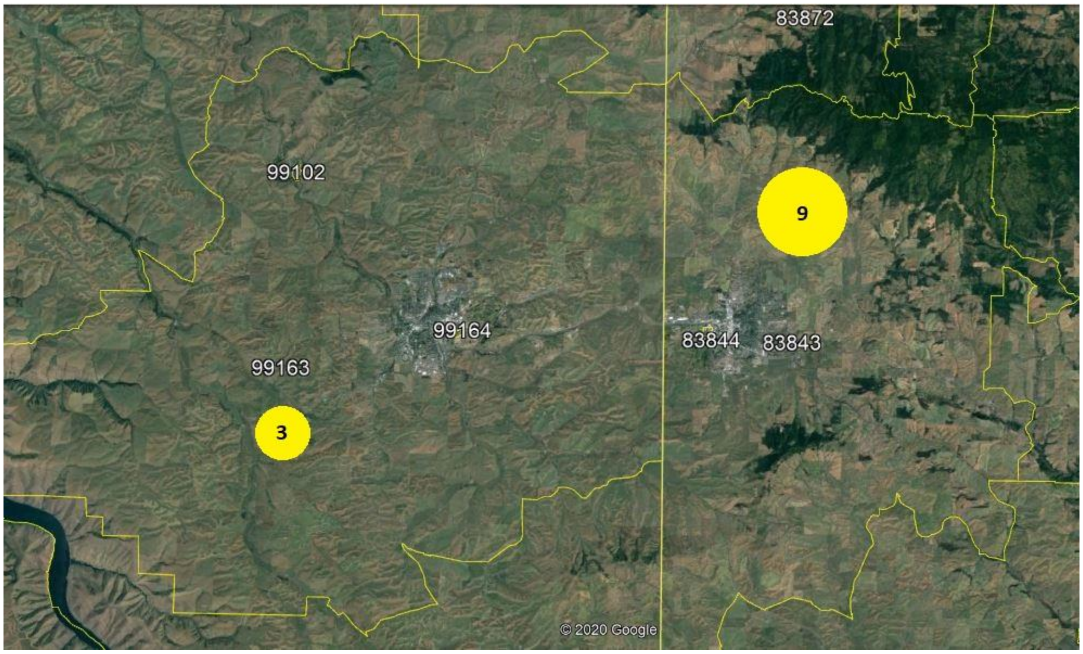


Figure 4.4 Home zip codes of trail users coming from home in the Palouse.

Respondents who answered that they were coming to the trail from a location other than home were also asked to provide their home zip codes. These results were divided by state and summarized in Figure 4.5. Full individual responses to this question can be reviewed in the Appendix.

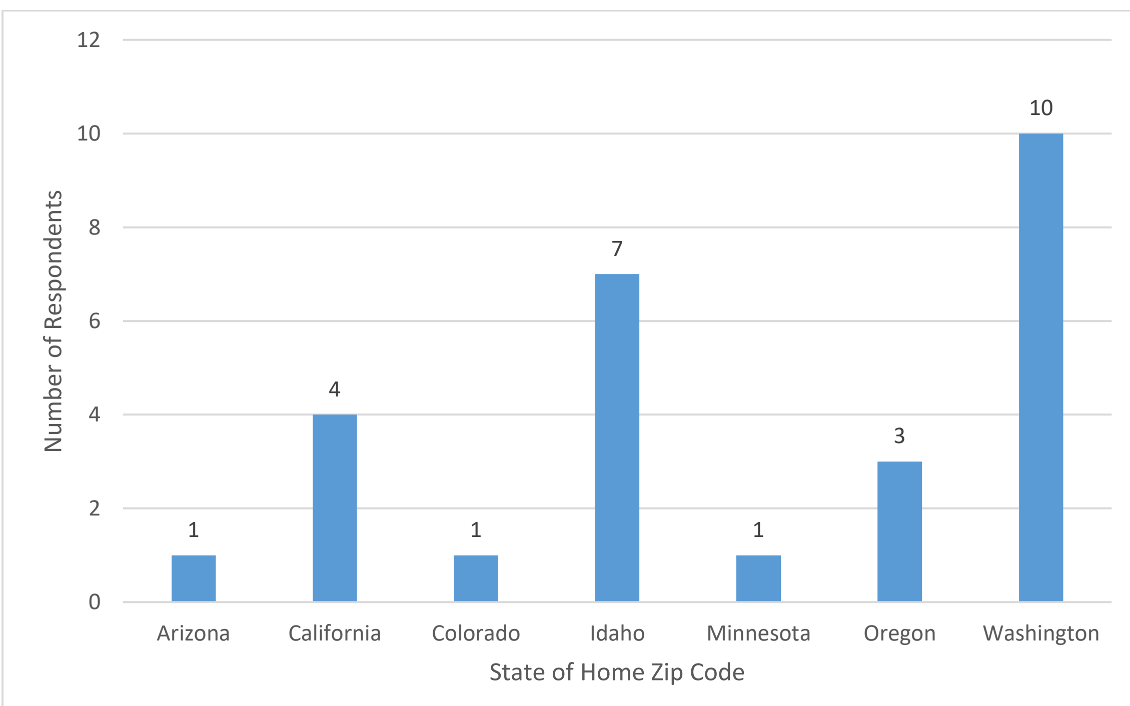


Figure 4.5 Home state of respondents visiting the area and trail.

As a follow-up question, the survey asked respondents to report how many miles they had traveled to get to the trail. The greatest number of respondents reported traveling less than ten miles to get to the trail, as 28.9% (n=28) submitted a distance of less than 10 miles. Twenty-four of those respondents reported traveling less than five miles to the trail. The next most popular distance ranges were greater than 100 miles, which accounted for 15.5% of responses (n=15), 30-39 miles, which accounted for 14.4% of responses (n=14), and 60-69 miles, which had 13.4% of responses (n=13). It is worth noting that two respondents left this question blank, so those responses were not considered.

Respondents were also asked to identify their starting point on the Trail of the Coeur d'Alenes. Because the survey was administered at four different locations along the trail – Plummer, Chatcolet, Kellogg, and the Kellogg City Park – the responses varied with the locations at which they were gathered. Several responses did not have a location associated with them, so those answers to this question were not considered. At the Plummer intercept survey location, 50.0% of respondents (n=4) reported starting from Plummer, with 25.0% (n=2) saying they started from Coeur d'Alene and 12.5% (n=1) each starting from Wallace and Kellogg. At the Chatcolet location, 58.2% of respondents (n=32) reported starting from Chatcolet and 12.7% (n=7) each started from Plummer and Harrison. The Kellogg survey location saw 55.6% of respondents (n=10) starting from Kellogg and 11.1% (n=2) reporting they started from Mullan. And at the Kellogg City Park location, 70.0% of respondents (n=7) reported starting from Kellogg. Full individual responses to this question can be seen in the Appendix.

4.2.2. Trail Usage Information

The most popular mode of transportation among the parties surveyed was a human-powered bicycle, which was the primary method of transportation for 75% of respondents (n=72). The next most popular was walking/jogging/running, which accounted for 21.9% of respondents (n=21). The remaining 3.1% (n=3) used an e-Bike. When asked what their primary reason for using the trail was, 96.0% of respondents answered that it was for recreation (n=95), with the commuting and daily activities categories each accounting for 2.0% of respondents. When asked how much time they planned to spend on the trail, 65.3% of respondents (n=64) reported that they planned to use the trail for more than 2 hours. The next most popular option was from 1 to 2 hours, with 22.5% of responses (n=22), while the "30 minutes to an hour" option had 7.1% (n=7) and the "less than 30 minutes" option had 5.1% (n=5).

The intercept survey also included several questions about the frequency of respondents' trail use. When asked how many times they had visited the Trail of the Coeur d'Alenes in the past 12 months (including the day of the survey), the highest percentage of respondents (39.4%, n=39) answered once; this means that the day of the survey was the only day in the past year they had used the trail. The next most common number of visits was 3-5, with 16.2% of respondents (n=16) choosing that option. And the third most common number of visits was 2, with 15.2% of respondents (n=15) selecting that answer. Respondents were also asked if they had used similar trails in the past 12 months, to which 78.1% of respondents (n=75) answered yes. A follow-up question asked how often respondents used similar trails (including the Trail of the Coeur d'Alenes); the most common usage rate was monthly, which accounted for 29.4% of respondents (n=27). 2-3 times per week was the next most popular, gaining 22.8% of the responses (n=21), and once a week was the third most common usage rate, accounting for 19.6% of respondents (n=18).

4.3. Trail Impact Survey

To assess the perspectives from residents who currently live along or adjacent to the Trail of the Coeur d'Alenes, an online survey was developed using the Qualtrics platform. (The survey questions are provided in the Appendix.)

Utilizing a delivery service offered by the United States Postal Service (USPS), three postal routes in the communities of Plummer, Wallace, and Kellogg were identified. In August 2020, fliers with information about the survey project and a link to the survey were distributed along one postal route in each of these three towns by the USPS; an example of the flier is presented below as Figure 4.6. A total of 1,634 residents were reached using this method, and the information provided on each postcard included a link to access the online survey.

PRSRT STD
ECRWSS
U.S.POSTAGE
PAID
EDDM Retail

LOCAL POSTAL CUSTOMER

(a)

Researchers from the University of Idaho's Department of Civil and Environmental Engineering are interested in learning more about your *perceptions of and travel habits along the Trail of the Coeur d'Alenes.*

We have developed a short three to five minute online survey that we are asking you to complete. As a token of our appreciation, two respondents will be selected to win either a $25 WALMART or AMAZON gift card.

To complete the survey please go to: **tinyurl.com/trailcda**

(b)

Figure 4.6 Trail Postcard Mailer (a) front side and (b) back side.

Based on all of the fliers distributed, the survey received 71 responses, resulting in a response rate of 4.4%. The survey questions covered a variety of different topics but were primarily focused on revealing respondents' usage and opinions of the Trail of the Coeur d'Alenes. A screenshot of the survey user interface is shown in Figure 4.7.

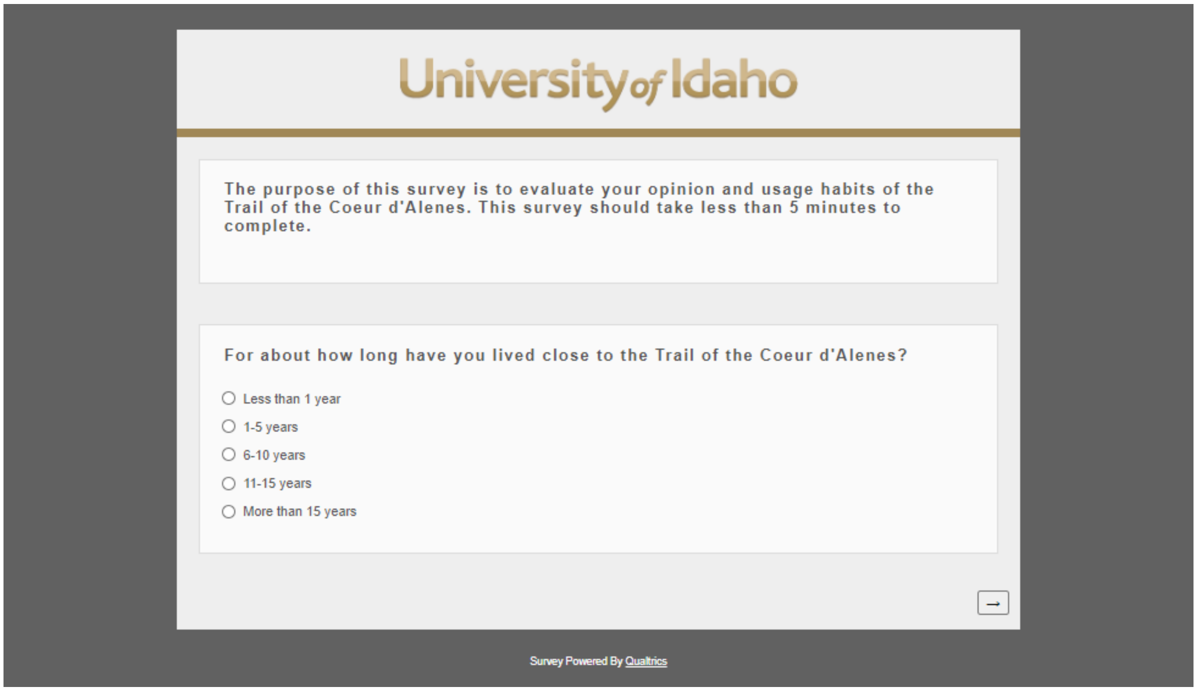


Figure 4.7 Example of the online survey user interface.

A report of the survey responses generated by Qualtrics is presented in the Appendix.

4.3.1. Trail Usage Habits

Of the 71 respondents, 67 reported that they had used the trail within the last two years. Those 67 respondents were then directed to answer a series of questions about their trail usage habits. One such question asked respondents to describe their usage of the trail for each of the four seasons based on several predetermined usage ranges. Summer had the most respondents in the "Frequently (2-3 times per week)" and "Occasionally (3-4 times per month)" categories, with 32.8% in each (n=22). Fall's two most common usage ranges were "Frequently (2-3 times per week)" and "Infrequently (1-2 times per season)", which were selected by 32.8% (n=22) and 28.4% (n=19) of respondents, respectively. Winter's two most common ranges were "Infrequently (1-2 times per season)" and "Never", with 28.4% (n=19) and 44.8% (n=30), respectively. The two most common ranges for spring were "Frequently (2-3 times per week)" and "Occasionally (3-4 times per month)", with 29.9% (n=20) and 26.9% (n=18) of respondents, respectively.

The most popular activities the 67 respondents reported they used the trail for were bicycling, which was selected by 57 respondents, and walking, which was selected by 54. These activities were followed in terms of popularity by dog-walking (26 respondents) and jogging/running (22 respondents). When asked if they had started doing any of the activities from the previous question because of the trail, 40.3% of respondents (n=27) answered yes.

The survey found that 26.9% of respondents (n=18) had used the trail to commute to work. Summer and spring were found to be the two seasons in which those respondents used the trail to commute most frequently. The three most popular options for who the respondents usually use the trail with were "Myself", with 50 respondents, "Significant Other/Family", with 46, and "Friends", which had 39 respondents select it. At this point in the survey, the number of responses for each question dropped to 65, of which 75.4% (n=49) said they used the trail on both weekdays and weekends, with 15.4% (n=10) only using it on weekdays and 9.2% (n=6) only using it on weekends.

When asked how far they usually travel when using the trail, 46.2% of respondents (n=30) answered "0-5 miles", which was the highest-percentage answer. The next-highest percentage chose the next-shortest distance option, which was "6-15 miles" (30.8%, n=20). Respondents were also asked which segments of the trail they had been on; the most popular stretch was from Kellogg to Wallace, with 30 of 65 respondents selecting it. This stretch was followed by Cataldo to Kellogg, which had 27 selections, and Wallace to Mullan, which had 22.

4.3.2. Opinions of the Trail

The next series of questions focused on respondents' opinions of the Trail of the Coeur d'Alenes and attempted to identify areas of the trail that may need improvement. Asking respondents to rate the trail on certain characteristics yielded largely positive results; the two areas with the highest percentages of Very Good responses were "Scenery", with 87.7% (n=57), and "Ease of access from home to trail", with 72.3% (n=47). Respondents gravitated more toward Good or No Opinion/Neutral on areas like "Maintenance/Cleanliness", "Safety/Security", and "Ease of access from trail to commercial destinations", with "Safety/Security" having 6.2% of respondents (n=4) rate it as being Poor.

When asked how the trail had affected property/home values, crime levels, noise levels, and traffic volumes in their communities, responses were largely neutral. The neutral option was the most commonly selected for each of the four factors, although property/home values saw only 39.1% (n=27) of the 69 respondents choose No Effect/Neutral, 36.2% (n=25) choose Positively, and 24.6% (n=17) choose Very Positively, making it the factor in which the most respondents thought the trail had a positive effect. Traffic volumes was the factor that had the most negative responses, albeit by a much smaller margin, as 10.1% of respondents (n=7) chose Negatively.

Another question asked respondents about certain qualitative impacts of the trail. As with the rating question discussed above, results were largely positive, with the Strongly Agree option having the highest percentage of responses for each of the impacts in question. The statement with which the largest percentage of respondents generally agreed was that the trail promotes recreational opportunities, with 71.0% of 69 respondents (n=49) choosing to Strongly Agree and an additional 29.0% (n=20) choosing to Agree. The statement that the trail promotes health and wellness in the community saw similar levels of agreement, with 65.2% of respondents (n=45) choosing to Strongly Agree and 31.9% (n=22) choosing to Agree. The statement that the trail provides more access to nearby destinations (grocery stores, banks, restaurants, etc.) was the least agreed with and saw 14.5% of respondents (n=10) choose to Disagree. Additionally, the statement that the Trail of the Coeur d'Alenes has had a worthwhile environmental impact saw nearly as many respondents chose to Neither Agree nor Disagree (29.0%, n=20) as they did to Agree (26.1%, n=18) or Strongly Agree (30.4%, n=21).

A final opinion question provided a list of potential changes to the trail and asked respondents if there were any that would encourage them to use the trail more often. The most commonly selected change was that the trail be plowed more in winter, with 28 respondents selecting it. Other popular changes were more restrooms (23 respondents), more trash receptacles (22 respondents), and more benches/seating along the trail (20 respondents).

4.3.3. Demographic Information

Much like the online survey, the intercept survey concluded with several questions related to group demographics. Each respondent answered questions about the gender, age, and ethnicity of the different members of their group by reporting how many members belonged to the different categories for each question. For this report, the percentages of each group for each category were averaged to give an idea of the demographics of an average group. On average, groups were 58.7% male, 41.1% female, and 0.2% other. The average age distribution among members of the groups surveyed was 6.7% under 18 years old, 19.0% aged 19-35, 47.9% aged 36-65, and 26.4% over age 65. The average ethnic makeup among members of the groups surveyed was 93.5% white, 2% Latino, and 1.4% Other, with an average of 3.0% of respondents selecting the “Prefer not to specify” option.

When asked about their household income before tax in the previous year, 31.8% of respondents (n=28) reported an income of $111,000 or over, which was the highest percentage of responses. 22.7% of respondents (n=20) chose $51,000 - $80,000, 15.9% (n=14) chose $81,000 - $110,000, 11.4% (n=10) chose $35,000 - $50,000, and 10.2% (n=9) selected the “Less than $35,000” option. Only 8.0% of respondents (n=7) selected the “Prefer not to specify” option.

4.3.4. Respondent Comments

Respondents were also given the option to provide free-format additional comments at the end of the survey. The remarks were overwhelmingly positive, with nearly every respondent citing either their personal enjoyment of the trail or its positive impacts on their community. The issue of allowing e-bikes and other motorized vehicles on the trail proved divisive, as several comments were submitted both in support of and in opposition to motorized vehicles using the trail. Additionally, several respondents commented on areas of tree root damage along the trail. The complete comments are included in the Appendix as part of the online Qualtrics survey results.

4.3.5. Demographic Information

The survey also included several questions on respondent demographics. 56.5% of 69 respondents were female (n=39), with 37.7% (n=26) being male and 5.8% (n=4) selecting the “Prefer not to answer” option. In terms of respondent age, the categories of 65 or older and 18-44 had similarly high percentages, with the former making up 36.2% of respondents (n=25) and the latter accounting for 34.8% (n=24). 27.5% of respondents (n=19) were between the ages of 45 and 64, and one respondent was under the age of 18 (1.45%). The ethnic makeup of respondents was predominantly white, as 91.3% (n=63) selected that option for their ethnicity in the survey. American Indians or Alaskan Natives made up 4.4% of responses (n=3), and there was one response each (1.5%) for the Asian/Pacific Islander, Hispanic/Latino, and Multiple/Other options. A final demographics question asked for respondent’s annual household income. 37.7% of respondents (n=26) reported an annual household income lower than $50,000, 30.4% (n=21) answered that their household income was from $50,000 and $99,999, and 20.3% (n=14) replied that their income was over $100,000 annually. 11.6% (n=8) of respondents selected the “Prefer not to answer” option.

4.3.6. Home Zip Code Information

Respondents to the online survey were also asked to provide their home Zip code. Figure 4.8 depicts the number of survey responses from each zip code.

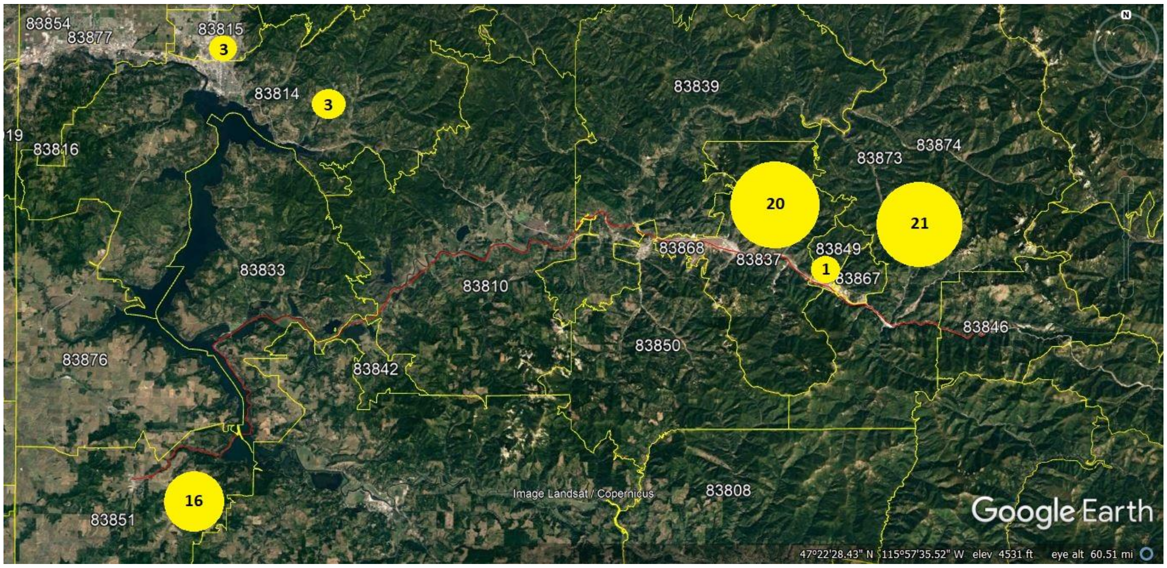


Figure 4.8 Graphic showing the number of survey responses per zip code.

Several responses that were either too far from the location to be shown on a map or were most likely typos were omitted: the values on the graphic account for 64 of 68 total responses. The three most common respondent zip codes by a large margin were 83873, 83837, and 83851. Full details on the responses can be found in the Appendix.

4.4. Survey Outcomes

The results of the online and intercept surveys, while they are in response to different sets of questions, both contribute to a better understanding of how the Trail of the Coeur d'Alenes serves its community. The questions in the online survey dealt more with community members' opinions of the trail, while the questions in the intercept survey were better suited to trail usage habits. By examining both sets of responses, interested parties can get more complete impressions of the community's interaction with the Trail of the Coeur d'Alenes.

CHAPTER 5. CONCLUSION

This project explored barriers and opportunities for more effectively using rail-trails for safe travel in rural, isolated, and tribal communities.

We explored the potential for using Strava data to estimate bicycle AADT on trails. Unfortunately, the results suggest less than ideal potential for the proposed method. For 10 locations the method seemed to work, but for 19 locations the method was not satisfactory. Future research could investigate the reasons for this outcome. Additionally, future research could identify characteristics of locations where the approach seems to indeed work, as was shown for 10 locations. This study also created a linear regression model that could be used to directly estimate AADT. The model had a relatively good fit with an R-squared of 0.78.

We successfully created a new mapping tool to obtain demographic data surrounding locations where new rail-trails could be built. Furthermore, we identified and mapped 8,616 miles of potential rail-trail in the Pacific Northwest. We used the new mapping tool to explore population information surrounding 12 potential rail-trail locations in rural communities in Idaho, Oregon, and Washington.

We conducted two separate surveys to solicit community member opinions and usage habits of the Trail of the Coeur d'Alenes. The results contribute to a better understanding of how the Trail of the Coeur d'Alenes serves its community. The questions in the online survey dealt more with community members' opinions of the trail, while the questions in the intercept survey were better suited to trail usage habits. By examining both sets of responses, interested parties can get more complete impressions of the community's interaction with the Trail of the Coeur d'Alenes.

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APPENDIX A: TRAIL PHOTOS

The following photos showcase the Trail of the Coeur d'Alenes and illustrate the various types of landscape and land use along this trail.

Figure 0.1 Trail of the Coeur d'Alenes – Plummer, ID (West Terminus).

Figure 0.2 Trail of the Coeur d'Alenes – Plummer, ID parking lot (West Terminus).

Figure 0.3 Trail of the Coeur d'Alenes – Chatcolet.

Figure 0.4 Trail of the Coeur d'Alenes – Kellogg, ID.

Figure 0.5 Trail of the Coeur d'Alenes – Kellogg, ID (City Park).

Figure 0.6 Trail of the Coeur d'Alenes – Wallace, ID.

Figure 0.7 Trail of the Coeur d'Alenes – Mullan, ID parking lot (East Terminus).

APPENDIX B: SURVEY INSTRUMENT

Trail of the Coeur d'Alenes Survey

Start of Block: Default Question Block

Q1 The purpose of this survey is to evaluate your opinion and usage habits of the Trail of the Coeur d'Alenes. This survey should take less than 5 minutes to complete.

Q2 For about how long have you lived close to the Trail of the Coeur d'Alenes?

- ◯ Less than 1 year (1)
- ◯ 1-5 years (2)
- ◯ 6-10 years (3)
- ◯ 11-15 years (4)
- ◯ More than 15 years (5)

Display This Question:
If For about how long have you lived close to the Trail of the Coeur d'Alenes? = More than 15 years

Q3 What was your opinion of the trail project prior to construction?

- ◯ Very Unfavorable (1)
- ◯ Unfavorable (2)
- ◯ No Opinion/Neutral (3)
- ◯ Favorable (4)
- ◯ Very Favorable (5)

Display This Question:
If For about how long have you lived close to the Trail of the Coeur d'Alenes? = More than 15 years

Q4 What is your current opinion of the trail?

- Very Unfavorable (1)
- Unfavorable (2)
- No Opinion/Neutral (3)
- Favorable (4)
- Very Favorable (5)

Q5 Did the Trail of the Coeur d'Alenes influence your decision to move to your current residence?

- Yes, it influenced my decision (1)
- No, it did not influence my decision (2)
- No, I moved to my current residence before the trail existed (3)
- No Opinion/Not Applicable (4)

Q6 Are you a year-round or seasonal/temporary resident?

- Year-round (1)
- Seasonal/Temporary (2)

Q7 How many people currently live at your residence?

- 1 (Myself) (1)
- 2 (2)
- 3 (3)
- 4 (4)
- 5 or more (5)

Q8 How many people at your residence are children under the age of 18?

- 0 (1)
- 1 (2)
- 2 (3)
- 3 or more (4)

Q9 How many of each of the following modes of transportation do you own at your residence?

	None (1)	One (2)	Two (3)	Three or more (4)
Automobile (1)	○	○	○	○
Motorcycle/Motorized Scooter (2)	○	○	○	○
Bicycle (non-motorized) (3)	○	○	○	○
e-Bike/e-Scooter (electronically assisted) (4)	○	○	○	○
Snowmobile/Snow Vehicle (5)	○	○	○	○

Q10 Have you used the Trail of the Coeur d'Alenes within the last two years?

- Yes (1)
- No (2)

Display This Question:
If Have you used the Trail of the Coeur d'Alenes within the last two years? = Yes

Q11 How often do you use the trail? Choose the option that best describes your usage for each season.

	Very Frequently (Daily) (1)	Frequently (2-3 times per week) (2)	Occasionally (3-4 times per month) (3)	Infrequently (1-2 times per season) (4)	Never (5)
Summer (June-August) (1)	○	○	○	○	○
Fall (September-November) (2)	○	○	○	○	○
Winter (December-February) (3)	○	○	○	○	○
Spring (March-May) (4)	○	○	○	○	○

Display This Question:

If Have you used the Trail of the Coeur d'Alenes within the last two years? = Yes

Q12 Which of the following activities do you use the trail for? Select all that apply.

- ▢ Walking (1)
- ▢ Bicycling (2)
- ▢ Jogging/Running (3)
- ▢ Dog-walking (4)
- ▢ Roller Skating/Roller Blading (5)
- ▢ Snowshoeing (6)
- ▢ Cross-Country Skiing (7)
- ▢ Birding/Wildlife Viewing (8)
- ▢ Other (9)

Display This Question:

If Have you used the Trail of the Coeur d'Alenes within the last two years? = Yes

Q13 Did you begin doing any of these activities because of the trail?

- Yes (1)
- No (2)

Display This Question:
If Have you used the Trail of the Coeur d'Alenes within the last two years? = Yes

Q14 Have you ever used the trail to commute to work?

- Yes (1)
- No (2)

Display This Question:
If Have you ever used the trail to commute to work? = Yes

Q15 How often do you use the trail to commute to work? Choose the option that best describes your usage for each season.

	Very Frequently (Daily) (1)	Frequently (2-3 times per week) (2)	Occasionally (3-4 times per month) (3)	Infrequently (1-2 times per season) (4)	Never (5)
Summer (June-August) (1)					
Fall (September-November) (2)					
Winter (December-February) (3)					
Spring (March-May) (4)					

Display This Question:
If Have you used the Trail of the Coeur d'Alenes within the last two years? = Yes

Q16 Who do you usually use the trail with? Select all that apply.

- ▢ Myself (1)
- ▢ Significant Other/Family (2)
- ▢ Friends (3)
- ▢ Guests/Visitors (4)
- ▢ Other (5)

Display This Question:
If Have you used the Trail of the Coeur d'Alenes within the last two years? = Yes

Q17 When do you typically use the trail?

- ○ Weekdays (1)
- ○ Weekends (2)
- ○ Both (3)

Display This Question:
If Have you used the Trail of the Coeur d'Alenes within the last two years? = Yes

Q19 How far do you usually travel when using the trail? Choose the answer that best describes your typical distance traveled.

- ○ 0-5 miles (1)
- ○ 6-15 miles (2)
- ○ 16-30 miles (3)
- ○ 31 miles and up (4)

Display This Question:
If Have you used the Trail of the Coeur d'Alenes within the last two years? = Yes

Q20 How many different sections of the trail have you been on? Select all applicable areas below.

- ▢ Entire Trail (1)
- ▢ Plummer to Heyburn State Park (2)
- ▢ Heyburn State Park to Harrison (3)
- ▢ Harrison to Medimont (4)
- ▢ Medimont to Dudley (5)
- ▢ Dudley to Cataldo (6)
- ▢ Cataldo to Kellogg (7)
- ▢ Kellogg to Wallace (8)
- ▢ Wallace to Mullan (9)
- ▢ Unsure/Not Applicable (10)

Display This Question:

If Have you used the Trail of the Coeur d'Alenes within the last two years? = Yes

Q21 In your opinion, how would you rate the trail on the following?

	Very Poor (1)	Poor (2)	No Opinion/Neutral (3)	Good (4)	Very Good (5)
Ease of access from home to trail (1)	○	○	○	○	○
Ease of access from trail to commercial destinations (2)	○	○	○	○	○
Maintenance/Cleanliness (3)	○	○	○	○	○
Safety/Security (4)	○	○	○	○	○
Scenery (5)	○	○	○	○	○

Q22 In your opinion, how has the trail affected the following in your community?

	Very Negatively (1)	Negatively (2)	No Effect/Neutral (3)	Positively (4)	Very Positively (5)
Property/Home Values (1)	○	○	○	○	○
Crime Levels (2)	○	○	○	○	○
Noise Levels (3)	○	○	○	○	○
Traffic Volumes (4)	○	○	○	○	○

Q23 In your opinion, the Trail of the Coeur d'Alenes:

	Strongly disagree (1)	Disagree (2)	Neither agree nor disagree (3)	Agree (4)	Strongly agree (5)
Promotes health and wellness in the community. (1)	○	○	○	○	○
Promotes recreational opportunities. (2)	○	○	○	○	○
Offers a place for social interaction with the community. (3)	○	○	○	○	○
Adds aesthetic value to the community. (4)	○	○	○	○	○
Provides more access to nearby destinations (grocery stores, banks, restaurants, etc.) (5)	○	○	○	○	○
Has had a worthwhile environmental impact. (6)	○	○	○	○	○

Q24 What changes would encourage you to use the trail more often? Select all that apply.

- Less busy (1)
- More access points (2)
- More restrooms (3)
- More benches/seating (4)
- More trash receptacles (5)
- Better signage along trail (6)
- Plowed more during winter (7)
- Plowed less during winter (8)
- Wider trail (9)
- Other (10)
- None of the above (11)

Q25 What is your gender?

- Male (1)
- Female (2)
- Other (3)
- Prefer not to answer (4)

Q26 How old are you?

- Under 18 (1)
- 18-44 (2)
- 45-64 (3)
- 65 or older (4)

Q27 What is your ethnicity?

- White/Caucasian (1)
- American Indian or Alaskan Native (2)
- Asian/Pacific Islander (3)
- Black or African American (4)
- Hispanic/Latino (5)
- Multiple/Other (6)

Q28 What is your home zip code?

____

Q29 What is your approximate household yearly income?

- Less than $50,000 (1)
- $50,000 to $99,999 (2)
- Over $100,000 (3)
- Prefer not to answer (4)

Q30 Feel free to provide any additional comments here.

____

Q30 Thank you for completing this survey. If you would like to be entered to win a gift card, please enter your name and email address below.

- Name: (1) ____
- Email Address: (2) ____

End of Block: Default Question Block