Overview of Data Sources

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July 7, 2022

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The goal of this consulting project is to develop a predictive model of trail use. The aim is to inform policy/methods adopted by land management agencies (Forest Service); also good for local decision makers.

For our analysis, we will use count data obtained from trail counters deployed at a subset (33) of all trails (35) in the Bridger Mountains outside of Bozeman, MT. These data will be used to create a predictive model for trail use over time for all trails in the Bridger Mountain range.

1 Sources of Data

1. Headwaters Economics Counter Data
2. Strava Data (aggregated)
3. Weather covariates
4. Trail characteristics

1.1 Counter Data

From Headwaters Economics website:

> These data were collected using infrared counters rotated across 20 trails throughout the Bridgers. The counters record a use each time the beam is broken and were installed to minimize inaccurate counts from dogs or vegetation. Because this method measures total traffic, on a trail where use predominately is out-and-back the number of users will be approixmately half of the total traffic. Counters were installed for anywhere from 13 to 61 days, with an average of 29 days at each site. To ensure sufficient data were collected, counters were installed longest on trails that were more remote or had relatively low use.

In Figure 1 we have time series plots for daily trail use counts separated by deployed counter IDs (fill color by trail names). Several counters seem to be placed on the same trails and capturing similar trail use information. For example, counter IDs 4, 5, 6, 7, and 9 are all located on Bridger Ridge and while the total counts for each counters are different (see Table 1) the time series plots show very similar patterns of use of time indicating non-independent counts. We need to be very clear about the scale of interest, the delineation between trails and trail segments, and how we use the different counters in any model. Should just the max value for a trail be used per day (assuming other counters pick up a subset of those total people/trips further down a trail)?

In Table 1 we provide a summary of trail use recorded for each counter deployed along trails in the Bridger Mountains. In addition to total counts for each counter, the deployment dates and duration of each trail counter camera (as determined by the first and last date of data provided) and average daily trail use over this deployment duration is reported.

Notable:

- Two counters (ID #s 26 and 27) are located along the Corbly Gulch trail for nearly non-overlapping time periods.
- Counter ID 25 seems to only have been deployed for a single day (South Fork Flathead Creek)
- Counter ID 24 was only deployed for 3 days (Shafthouse Hill - Upper Shafthouse).

See Figure 2 for locations of trail cameras.

Table 1: Total Number of Trail Camera Counts (2021)

| counterid	trailname	subsectionname	count	start	end	deployment	Mean Count per Day
1	Fairy Lakeshore	NA	3412	07-25	07-31	7 days	487.43
2	Fairy Creek	NA	376	08-05	09-07	34 days	11.06
3	College M	NA	4493	08-14	08-25	12 days	374.42
4	Bridger Ridge	Baldy to Bridger	1261	07-06	12-31	179 days	7.04
5	Bridger Ridge	Baldy to Bridger	1844	07-06	12-31	179 days	10.30
6	Bridger Ridge	Bridger	1689	07-06	12-31	179 days	9.44
7	Bridger Ridge	Bridger to Ross Pass	1582	07-06	12-31	179 days	8.84
8	Bridger Ridge	M to Baldy	2635	08-07	09-12	37 days	71.22
9	Bridger Ridge	Ross Pass to Sacagawea Peak	1508	07-06	12-31	179 days	8.42
10	Bridger Ridge	Ross Pass to Sacagawea Peak	310	07-12	12-31	173 days	1.79
11	Bridger Ridge	Steep Way	10122	08-27	09-26	31 days	326.52
12	Sacagawea Pass	NA	5192	08-05	09-09	36 days	144.22
13	Sacagawea Pass	NA	9485	07-12	12-31	173 days	54.83
14	Horsethief Mountain	NA	628	07-13	09-09	59 days	10.64
15	Carroll Creek	NA	757	08-07	09-09	34 days	22.26
16	Felix Canyon	NA	146	07-29	08-01	4 days	36.50
17	Raptor View	NA	158	07-13	08-09	28 days	5.64
18	Sypes Canyon	NA	3868	08-13	09-08	27 days	143.26
19	Bridger Foothills	College M to Sypes	834	08-14	08-25	12 days	69.50
20	Truman Gulch	NA	1585	08-12	08-28	17 days	93.24
21	East Bridger South	NA	321	07-13	08-09	28 days	11.46
22	East Bridger North	NA	780	07-13	08-09	28 days	27.86
23	Shafthouse Hill	Lower Shafthouse	687	07-03	09-09	69 days	9.96
24	Shafthouse Hill	Upper Shafthouse	303	07-03	07-05	3 days	101.00
25	South Fork Flathead Creek	NA	91	07-03	07-03	1 days	91.00
26	Corbly Gulch	NA	1766	06-27	07-26	30 days	58.87
27	Corbly Gulch	NA	165	07-13	12-31	172 days	0.96
28	North Cottonwood	North Cottonwood to Johnson Canyon	662	07-28	09-10	45 days	14.71
29	North Cottonwood Access	NA	2124	08-13	09-08	27 days	78.67
30	Ross Pass	NA	1246	07-13	08-09	28 days	44.50
31	Middle Cottonwood	NA	9060	06-27	08-16	51 days	177.65
32	Johnson Canyon Jeep Trail	NA	573	08-13	09-08	27 days	21.22
33	Benchmark Rd	NA	244	07-13	08-02	21 days	11.62
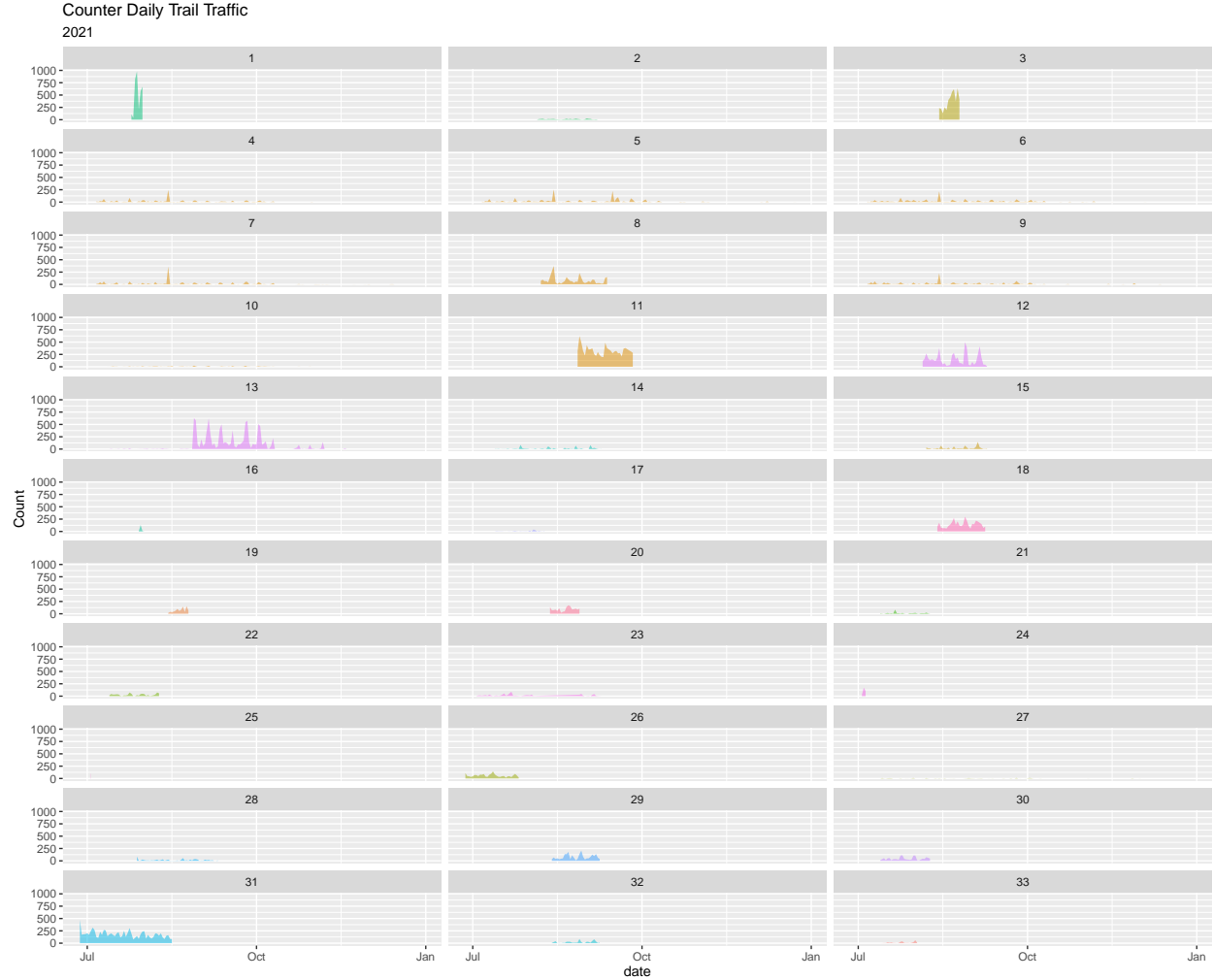
Figure 1: Timeseries plots of daily trail camera counts over time in the Bridger Mountains.

1.2 Strava Data

Strava count data are made available through Strava Metro. Data are binned (intervals of 5 with ceiling rounding) and aggregated on multiple scales (daily, monthly, annual). Counts are available as "total trips" and "total people". Total trips should always be larger than the total people count as people sometimes make multiple passes of a single trail (e.g. M laps). Strava trails are subdivided into "edges". Edge IDs (for the trailhead edge?) are available in the Counter data. Strava count data are available for the entire year of 2021 (not just summer monitoring as in the counter data). These data also include the overarching trail name and number (e.g. 511 - Bridger Foothills) that also correspond to the counter data provided by HE.

It is important to note that when considering Strava data at the Trail scale (rather than edge scale) you are propagating rounding errors for each segment forward (+_ 1-4 for each edge?). Similarly, aggregating the data in the daily data frame to a monthly timescale will likely not match the information provided in the monthly data frame.

Table 2: Total Number of Strava Counts (2021)

| trailname	count	start	end	edges
Benchmark Road	50	01-01	01-01	8
Bridger Foothills	61185	01-01	01-01	30
Bridger Ridge	56395	01-01	01-01	40
Carrol Creek	625	01-01	01-01	10
College M	27420	01-01	01-01	4
Corbly Gulch	12010	01-01	01-01	13
E Bridger North	4150	01-01	01-01	15
E Bridger South	70	01-01	01-01	4
Fairy Creek	2130	01-01	01-01	16
Fairy Lake	15	01-01	01-01	1
Fairy Lake Shortcut	305	01-01	01-01	1
Fairy Lakeshore	640	01-01	01-01	4
Felix Canyon Rd	885	01-01	01-01	7
Felix Canyon Trail	50	01-01	01-01	2
Flathead Pass Rd	755	01-01	01-01	18
Horsethief Mountain	30	01-01	01-01	3
Johnson Canyon Jeep Trail	160	01-01	01-01	11
M shortcut	5700	01-01	01-01	3
Middle Cottonwood	16135	01-01	01-01	8
New World Gulch	2140	01-01	01-01	6
North Cottonwood	4170	01-01	01-01	16
North Cottonwood Access	2525	01-01	01-01	4
Raptor View	570	01-01	01-01	4
Ross Pass	1600	01-01	01-01	4
S Fork Brackett Creek	280	01-01	01-01	3
S Fork Flathead Creek	5	01-01	01-01	1
Sacagawea Pass	2350	01-01	01-01	2
Shafthouse Hill	1640	01-01	01-01	9
Sypes Canyon	25575	01-01	01-01	11
Truman Gulch	7185	01-01	01-01	6
Upper Brackett Creek	430	01-01	01-01	6
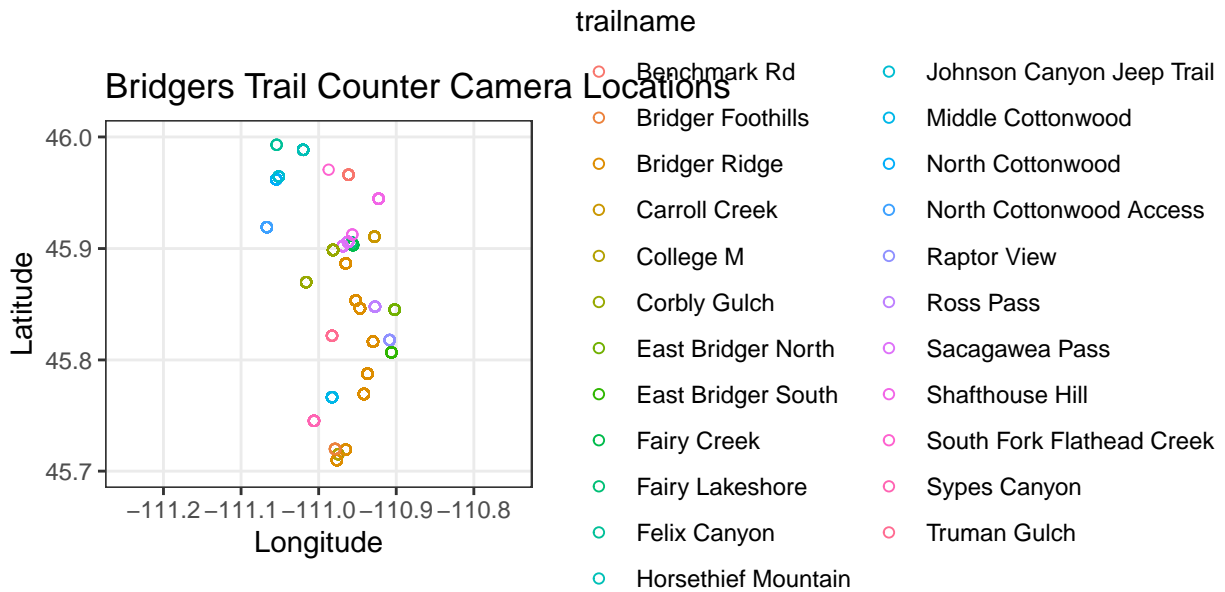
Figure 2: Trail Camera Locations in Bridgers
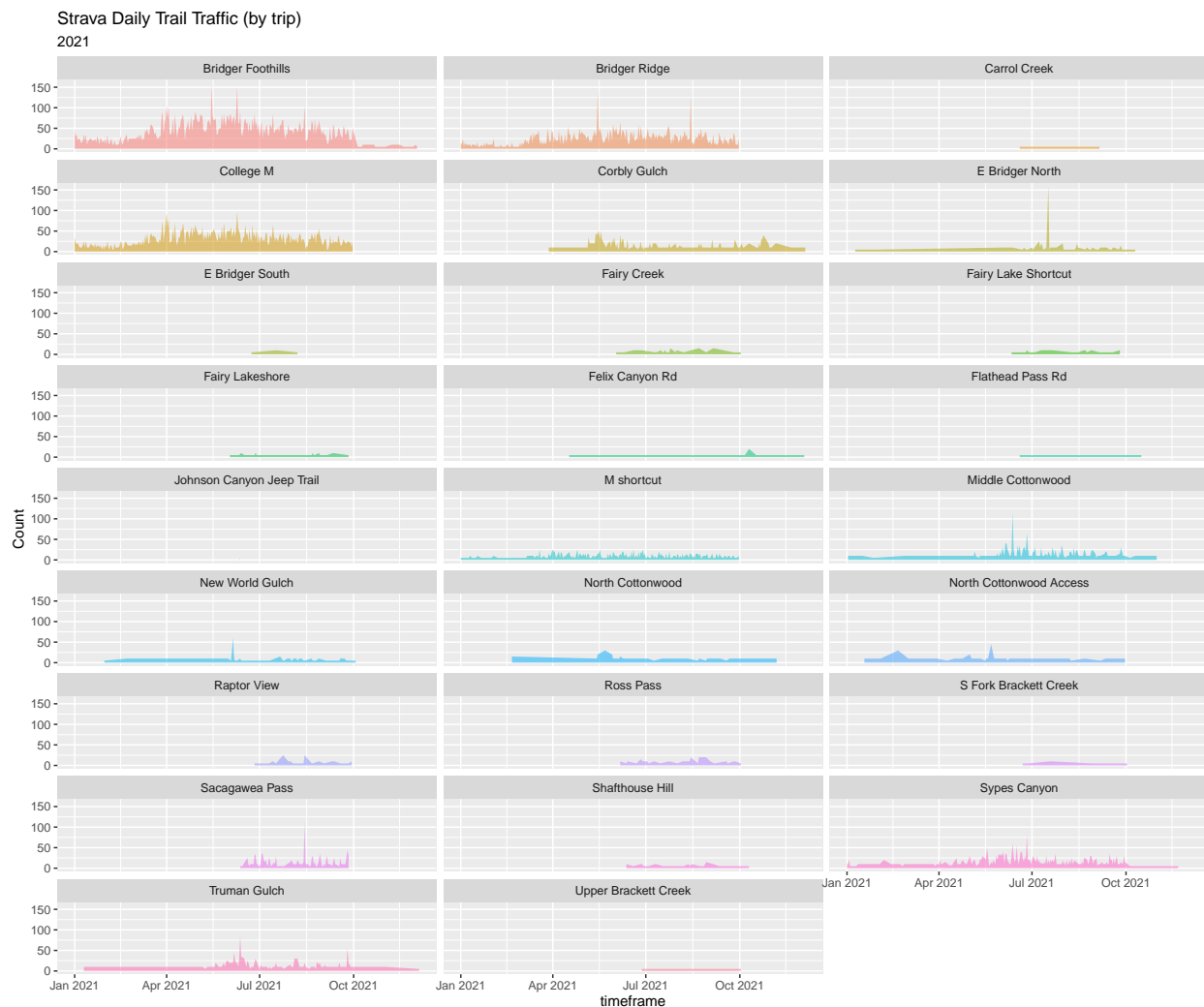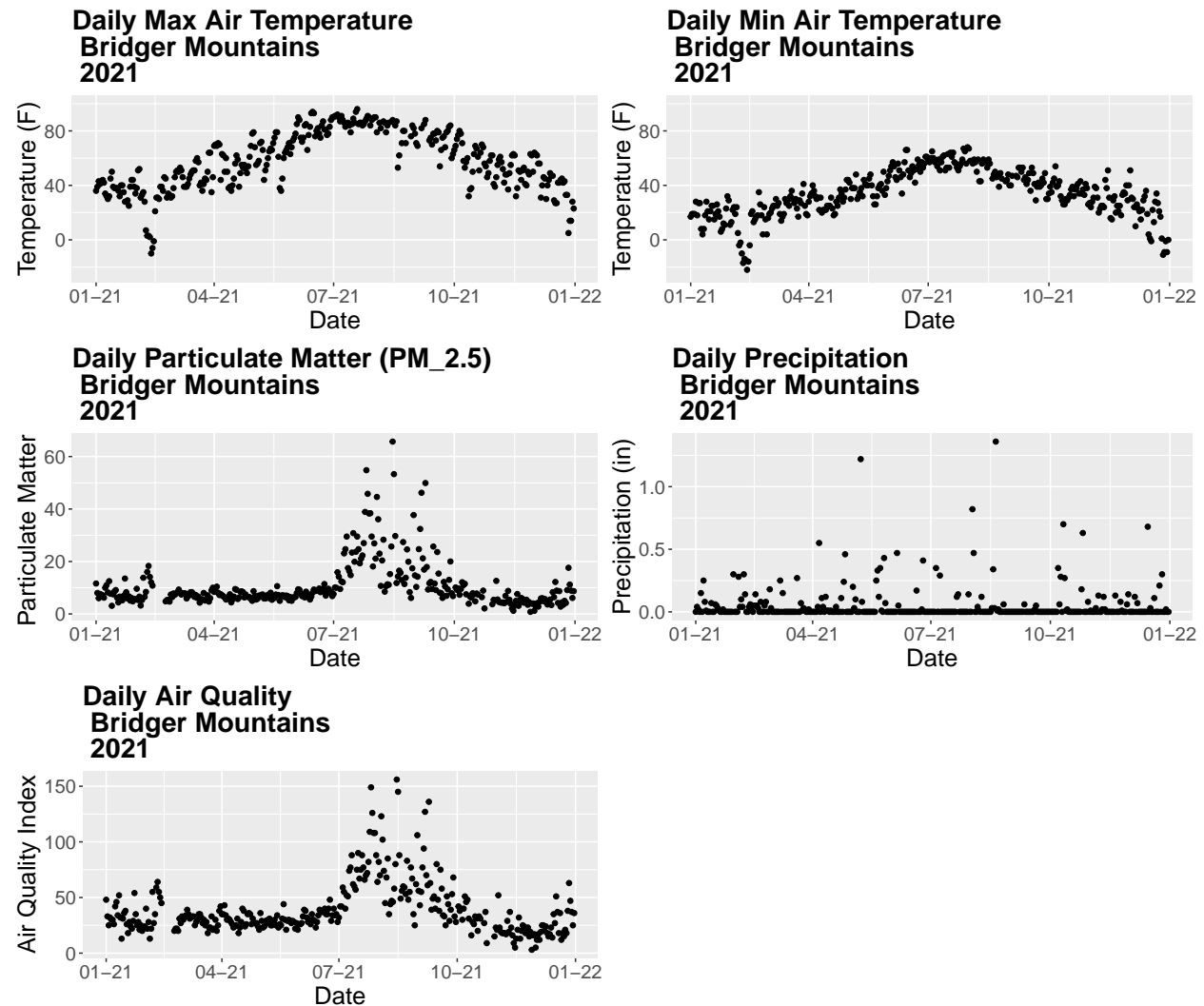
1.3 Weather Covariates

The following weather covariates are available on a daily basis:

1. Precipitation (in.)
2. Temperature Max (degrees Fahrenheit)
3. Temperature Min (degrees Fahrenheit)
4. Mean Air Quality (AQI)
5. Mean PM_25 Concentration (micrograms per cubic meter)

These data do not vary spatially only temporally (i.e. the resolution is not fine enough to parse out different weather between trails on a given day).

Missing data (days):

- Precipitation: 0
- Max Temp: 13
- Min Temp: 6
- AQI: 6
- Particulate Matter: 6

Daily Max Air Temperature — Bridger Mountains 2021

Daily Min Air Temperature — Bridger Mountains 2021

Daily Particulate Matter (PM_2.5) — Bridger Mountains 2021

Daily Precipitation — Bridger Mountains 2021

Daily Air Quality — Bridger Mountains 2021

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1.4 Trail Characteristics

The following characteristics are provided at the trail level.

- Latitude/Longitude (of trailhead?)
- Time/Distance from Town
- Parking lot size (as three-level factor)
- Description/Class (4-level factor of development)
- Motorized vehicle use (3-level factor)
- Indicators for use of the following:
    - Dirt bikes
    - ATVS
    - Hiking
    - Pack/Saddle
    - Bicycle

To request: total trail distance and elevation (gain/change?)

2   Questions

1. At what resolution is prediction desired? (e.g. at trail segment level or at entire trail level. The latter is more likely with available data.)
2. Have the count numbers for the deployed cameras already been halved for out-and-back trails? Are there any loop trails?
3. To confirm: no outlier counter data in this dataset have been altered?
4. Is there data for trail length (or trail segment/edge length for Strava)? Also information for total elevation change?
5. Is there hourly information for the trail counter data?
6. Do the edge IDs in trail_count correspond to the trailhead edge segments?
7. Shapefile with (coarse scale - full trail no edges) full trail location?
8. Need to think about time scales for different trails and counter data vs strava data.
9.

Future: how many people double track hikes with Strava and AllTrails. (likely more often for long, technical trails that require navigation)