

# WILDLIFE AND RECREATION ON THE ARIZONA NATIONAL SCENIC TRAIL

A COMPREHENSIVE REPORT ON RECREATIONAL & WILDLIFE  
OCCURRENCES ON THE ARIZONA TRAIL FROM 2017-2023



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**Picture 1:** *Picture of a Gray Fox by Camera Trap, Superstition Wilderness, Passage 19, Arizona Trail, 2021*



Camera Name 35F1°C

01-28-2021 07:12:45

# 1. Executive Summary

The Arizona National Scenic Trail (AZNST) is one of 11 National Scenic Trails in the US, attracting both domestic and international visitors each year. AZNST is 1,290 kilometers long and passes through various land ownerships, such as Federal, State, local agencies, and also private (Arizona Trail Association, n.d.; USDA & Forest Service, 2024).

This report provides a summary of information on human and wildlife activities detected by camera traps across the AZNST from 2017 to 2023 to better inform management decisions. It is the first wildlife camera study conducted along the AZNST, providing information on the various wildlife species that inhabit the AZNST and the three different human uses of the trail: hikers, mountain bikers, and horseback riders. This information indicates which species, in addition to humans, use the trail and which sections of the trail experience higher visitor use. Camera traps were deployed beginning in 2017, and data were collected from October 21, 2017, through November 7, 2023.

## 1.1 AZNST Location and Use

The AZNST is a contiguous trail stretching from Mexico to Utah through Arizona and covers a diversity of landscapes and ecosystems with different cultural, historical, and ecological traits. While the main sections of the AZNST had already been used since the 1980s, Congress designated it a National Scenic Trail in 2009 (USDA & Forest Service, 2024). Recreational use along the trail is primarily non-motorized, with motorized activities permitted only on segments that are co-located with dirt roads.

## 1.2 Management Implications

The data and information provided in this comprehensive report can be utilized for the conservation of wildlife and also the management of human users in the trail. Using this information, the managers can better plan for resource allocation, including the number of staff required for maintenance, monitoring, and safety purposes for both wildlife and humans. The result of these operations can lead to better adaptive management, improved experience for visitors interested in the AZNST, and a safer and less disturbed environment for the various species that inhabit the trail. More importantly, this is essential information for improving the balance between human and wildlife use of the trail.

Further details on how the report can assist practitioners are outlined in the "Suggestions and Implications" section.

## 2. Methodology

### 2.1 Data Collection

The data for this study was collected using 67 camera traps along 19 passages of the AZNST from October 21, 2017, to November 7, 2023. Throughout the study, eight of the 67 cameras set up in the area malfunctioned, thus only 59 cameras were used for data analysis. Cameras were rotated to different passages throughout the study period, and were not active at the same time. Therefore, the camera effort was different, with the active days varying between 35 - 800 days and covering a wide range of elevations from 615 m above sea-level to 2,751 m (mean: 1,781 m, SD = 660.53 m). A 60-second and 10-second delay was set for cameras to avoid taking pictures of the same wildlife and humans respectively. All cameras were set to operate continuously on a 24-hour cycle and were equipped with passive infrared (PIR) sensors with adjustable sensitivity settings. Cameras were set at knee-height to prevent taking pictures of human faces. Cameras were placed along the trail to maximize the chances of detecting wildlife while also respecting the privacy of trail users.

The team created maps using ArcGIS Pro 3.1.0 (Figures 1 and 2) to illustrate the geographic distribution of all camera trap locations deployed along the AZNST between 2017 and 2023. Each point on the map represents an individual camera trap, labeled with unique identifiers (e.g., AZT\_01\_01). The first number indicates the passage number, and the second number denotes the camera number within each passage, collectively spanning a wide range of ecological zones. The density and spread of these points across various trail passages reflect the extent of spatial coverage, which supports comprehensive monitoring of both recreational use and wildlife presence. The line stretching from Mexico to Utah is the route of the Arizona Trail.



Figure 1: Map of the Arizona Trail and the Camera Trap Locations from 2017-2023 created on ArcGIS Pro





**Figure 2:** A Closer Look at the Camera Trap Locations on the Arizona Trail

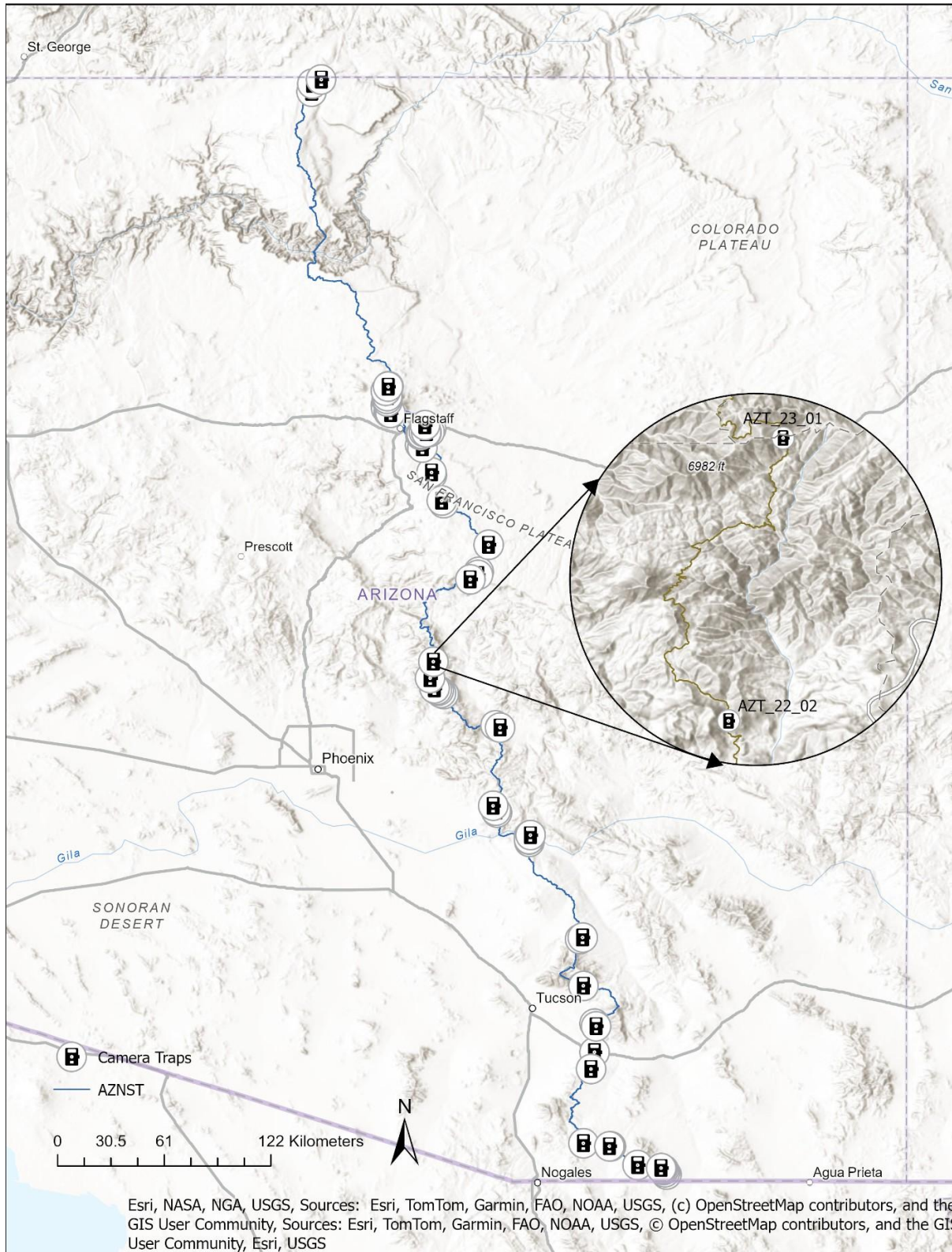
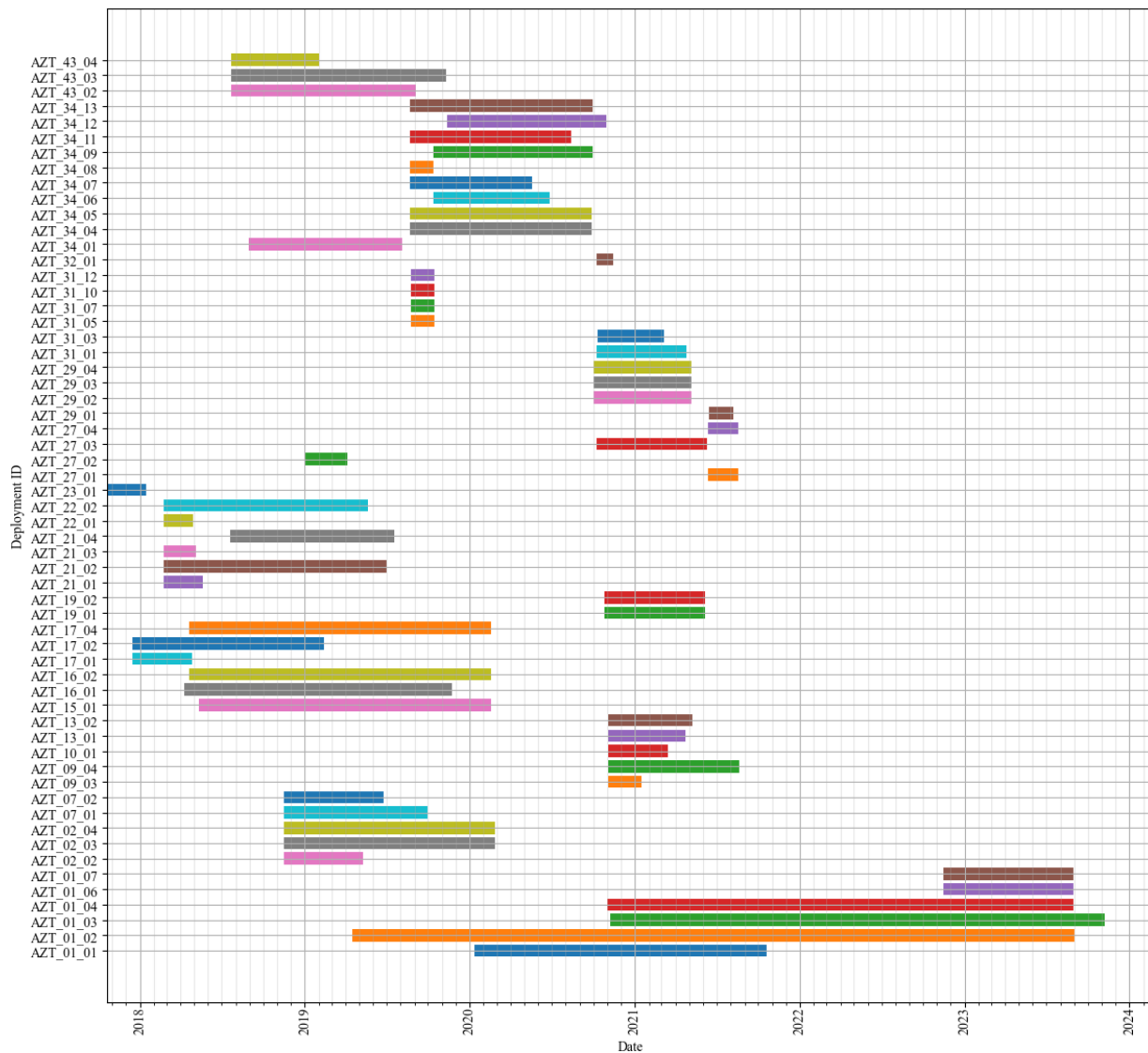




Figure 3 illustrates the camera effort across all the cameras on the AZNST, spanning from late 2017 to early 2023. Camera effort varied across cameras, with some cameras active for long periods and others deployed for shorter periods. The study area was a lengthy transect requiring a large team to place all the cameras. In early 2020, the COVID-19 pandemic protocols disrupted field activities, which, together with battery and SD card issues, explain why many cameras have a different activity period.

**Figure 3:** Activity period for each wildlife camera trap along the AZNST from 2017 to 2024.



The dataset provided in Table 1 includes detailed information for each camera trap, including start and stop times, geographic coordinates, and elevation, for camera traps installed



along the Arizona Trail. The cameras also covered a wide elevation range, from 566 meters (AZT\_16\_04) to 2751 meters (AZT\_34\_10 and AZT\_34\_01), and a broad geographic gradient from southern Arizona (Passage 1) to northern Arizona (Passage 43).

**Table 1: Details of Each Camera Trap across the AZNST**

Camera Number	Start Date	End Date	Latitude	Longitude	Elevation(m)
AZT_01_01	1/11/2020	10/20/2021	31.416333	-110.430933	1689
AZT_01_02	4/16/2019	8/31/2023	31.367133	-110.282867	2373
AZT_01_03	11/7/2020	11/7/2023	31.379867	-110.2912	2571
AZT_01_04	11/1/2020	8/30/2023	31.39155	-110.2972	2749
AZT_01_06	11/15/2022	8/30/2023	31.39549	-110.30421	2644
AZT_01_07	11/15/2022	8/30/2023	31.40126	-110.31066	2612
AZT_02_02	11/17/2018	5/11/2019	31.52848	-110.70993	1294
AZT_02_03	11/17/2018	2/27/2020	31.51217	-110.56883	1660
AZT_02_04	11/17/2018	2/26/2020	31.51331	-110.57621	1656
AZT_07_01	11/16/2018	9/29/2019	31.99623	-110.652752	1067
AZT_07_02	11/16/2018	6/25/2019	31.909872	-110.670666	1237
AZT_09_03	11/4/2020	1/15/2021	32.14202	-110.65308	987
AZT_09_04	11/3/2020	8/21/2021	32.12955	-110.64458	947
AZT_10_01	11/3/2020	3/16/2021	32.337	-110.71015	1422
AZT_13_01	11/4/2020	4/22/2021	32.576167	-110.7261	1391
AZT_13_02	11/4/2020	5/8/2021	32.585333	-110.713883	1315
AZT_15_01	5/12/2018	2/17/2020	33.07592	-110.98679	748
AZT_16_01	4/9/2018	11/22/2019	33.10711	-110.9887	615
AZT_16_02	4/20/2018	2/17/2020	33.08728	-110.98933	653
AZT_16_03	6/1/2019	11/22/2019	33.09024	-110.98973	644
AZT_16_04	4/9/2018	4/13/2018	33.11037	-110.98204	566
AZT_17_01	12/15/2017	4/27/2018	33.227317	-111.152467	971
AZT_17_02	12/15/2017	2/13/2019	33.236367	-111.1593	924
AZT_17_04	4/20/2018	2/17/2020	33.261067	-111.17375	768
AZT_19_01	10/25/2020	6/6/2021	33.67464	-111.16203	716
AZT_19_02	10/25/2020	6/6/2021	33.66335	-111.13773	736
AZT_21_01	2/23/2018	5/20/2018	33.833967	-111.42685	1135
AZT_21_02	2/23/2018	7/1/2019	33.840083	-111.44175	1075
AZT_21_03	2/23/2018	5/6/2018	33.851767	-111.4528	1017
AZT_21_04	7/21/2018	7/19/2019	33.8573	-111.4623	1068
AZT_22_01	2/23/2018	4/28/2018	33.86398	-111.47488	1069
AZT_22_02	2/23/2018	5/22/2019	33.9166	-111.49696	1260
AZT_23_01	10/21/2017	1/14/2018	34.00139	-111.48058	1864
AZT_27_01	6/11/2021	8/17/2021	34.463733	-111.247333	2190
AZT_27_02	1/3/2019	4/6/2019	34.446383	-111.251967	2048



AZT_27_03	10/9/2020	6/9/2021	34.6014	-111.197183	2104
AZT_27_04	6/11/2021	8/17/2021	34.423833	-111.291117	1877
AZT_29_01	6/13/2021	8/8/2021	34.96006	-111.48846	2255
AZT_29_02	10/1/2020	5/6/2021	34.97294	-111.48975	2240
AZT_29_03	10/1/2020	5/6/2021	34.81495	-111.42638	2308
AZT_29_04	10/1/2020	5/6/2021	34.82831	-111.43769	2279
AZT_31_01	10/9/2020	4/25/2021	35.19625	-111.49273	1994
AZT_31_03	10/10/2020	3/6/2021	35.11353	-111.54934	2189
AZT_31_04	10/10/2020	10/20/2020	35.10146	-111.5368	2206
AZT_31_05	8/24/2019	10/15/2019	35.18138	-111.50037	2031
AZT_31_07	8/24/2019	10/15/2019	35.16587	-111.54582	2046
AZT_31_08	8/25/2019	9/29/2019	35.16972	-111.54185	2094
AZT_31_09	8/24/2019	9/8/2019	35.17134	-111.54019	2076
AZT_31_10	8/24/2019	10/15/2019	35.1777	-111.51484	2054
AZT_31_12	8/24/2019	10/15/2019	35.18131	-111.52963	2068
AZT_31_13	8/24/2019	10/15/2019	35.17974	-111.51627	2054
AZT_32_01	10/9/2020	11/13/2020	35.215679	-111.523893	2037
AZT_34_01	8/31/2018	8/4/2019	35.35103	-111.71838	2751
AZT_34_03	8/31/2018	8/23/2019	35.41633	-111.7101	2371
AZT_34_04	8/23/2019	9/28/2020	35.3195	-111.72413	2674
AZT_34_05	8/23/2019	9/28/2020	35.30263	-111.723	2560
AZT_34_06	10/14/2019	6/27/2020	35.28934	-111.70937	2392
AZT_34_07	8/23/2019	5/18/2020	35.28113	-111.70861	2339
AZT_34_08	8/23/2019	10/14/2019	35.27785	-111.70022	2335
AZT_34_09	10/13/2019	9/29/2020	35.33744	-111.7173	2747
AZT_34_10	10/13/2019	9/29/2020	35.35103	-111.71839	2751
AZT_34_11	8/23/2019	8/12/2020	35.36407	-111.71718	2707
AZT_34_12	11/13/2019	10/30/2020	35.39191	-111.72452	2473
AZT_34_13	8/23/2019	9/29/2020	35.41294	-111.71247	2382
AZT_43_02	7/23/2018	9/3/2019	36.927933	-112.105683	1970
AZT_43_03	7/23/2018	11/9/2019	36.96835	-112.101233	1958
AZT_43_04	7/23/2018	2/1/2019	36.990467	-112.056567	1836

For each camera site, the distance to the nearest road and gateway community was calculated (see Table 2). A gateway community is a community located in close proximity to a trail that may be affected by the trail and related management decisions, while also influencing its development and use (NPS, 2024). Gateway communities often provide accommodations for trail workers and visitors, as well as other goods and services (NPS, 2024). Additionally, residents of these communities are also potential users of nearby trails, making the distance of the trails from these communities an important factor to study.

The terrain ruggedness index (TRI) was also calculated, which measures the elevation difference between each grid cell of the digital elevation model (DEM) and its neighbors, using ArcGIS Pro 3.1.0. Lower TRI values indicate relatively flat terrain, whereas higher TRI values indicate more rugged, topographically complex landscapes. TRI was calculated from a 30-m



resolution DEM and summarized within 200 m and 400 m buffers around each camera location.

These details are presented in Table 2. The ruggedness patterns did not show significant differences between the two different TRI scales of 200 and 400.

To summarize basic patterns, such as wildlife richness, which refers to the number of different species in each camera, Camera Sweet tools (<https://smallcats.org/camerasweet/>) were utilized to summarize basic patterns such as wildlife richness and activity patterns.

**Table 2:** Distance of Each Camera Trap from the Main Road, and Nearest Gateway Community, Species Richness, Terrain Ruggedness with 400 and 200 Buffer Zones, and the Population of the Nearest Gateway Community

Camera Number	Road Distance	Gateway Distance	Richness	TRI400	TRI200	Near Gateway Population
AZT_01_01	5.92	19.54	6	0.418892	0.408267	44598
AZT_01_02	5.38	20.85	8	0.512418	0.526196	44598
AZT_01_03	5.33	19.38	11	0.564587	0.575448	44598
AZT_01_04	5.48	18.06	6	0.5696	0.582912	44598
AZT_01_06	6.08	17.62	10	0.547242	0.541484	44598
AZT_01_07	6.65	16.99	4	0.614892	0.646009	44598
AZT_02_02	3.67	4.50	4	0.36232	0.363636	837
AZT_02_03	4.85	17.99	10	0.312781	0.295326	837
AZT_02_04	5.07	17.27	5	0.398499	0.437528	837
AZT_07_01	0.02	7.96	11	0.518811	0.501047	13470
AZT_07_02	0.86	15.76	8	0.465251	0.476631	13470
AZT_09_03	13.76	11.81	8	0.458098	0.498403	13470
AZT_09_04	13.18	11.04	6	0.474598	0.461187	13470
AZT_10_01	23.08	12.17	7	0.372754	0.336357	7679
AZT_13_01	5.76	5.65	9	0.464729	0.469914	3620
AZT_13_02	5.37	6.00	7	0.494718	0.497872	3620
AZT_15_01	4.88	7.47	16	0.393216	0.373434	1953
AZT_16_01	2.00	9.22	7	0.356137	0.352226	1953
AZT_16_02	3.81	8.14	13	0.413437	0.433182	1953
AZT_17_01	5.44	9.09	12	0.465253	0.452506	2804
AZT_17_02	4.74	8.71	10	0.411937	0.380485	2804
AZT_17_04	1.71	8.14	13	0.432575	0.440639	2804
AZT_19_01	0.20	2.75	8	0.409051	0.433977	28
AZT_19_02	0.45	0.60	7	0.439492	0.428094	28
AZT_21_01	3.88	32.84	6	0.362048	0.345295	28
AZT_21_02	2.44	34.36	8	0.298398	0.282094	28
AZT_21_03	1.52	35.93	5	0.294934	0.262681	28
AZT_21_04	0.90	37.01	9	0.403502	0.407812	28
AZT_22_01	0.16	38.39	7	0.353836	0.376777	28
AZT_22_02	3.86	38.30	8	0.42915	0.405072	16104
AZT_23_01	7.16	29.23	5	0.465571	0.490803	16104
AZT_27_01	10.02	20.96	4	0.492469	0.491563	1676
AZT_27_02	10.76	19.83	4	0.422076	0.387987	1676
AZT_27_03	0.70	33.71	3	0.417366	0.444295	1676

AZT_27_04	9.65	15.63	10	0.415637	0.407894	1676
AZT_29_01	14.79	6.21	3	0.415536	0.429849	109
AZT_29_02	15.12	7.59	7	0.336315	0.343777	109
AZT_29_03	15.09	10.87	10	0.510591	0.545555	109
AZT_29_04	14.36	9.16	7	0.351506	0.341828	109
AZT_31_01	0.88	14.37	8	0.469161	0.457792	75227
AZT_31_03	10.86	13.15	10	0.625798	0.665916	75227
AZT_31_05	2.64	13.80	5	0.54508	0.551214	75227
AZT_31_07	5.25	10.19	8	0.665819	0.673458	75227
AZT_31_10	3.26	12.56	10	0.710459	0.736184	75227
AZT_31_12	3.20	11.17	6	0.502094	0.486756	75227
AZT_32_01	0.33	11.70	4	0.396795	0.374721	75227
AZT_34_01	5.74	18.05	8	0.430199	0.416569	75227
AZT_34_04	4.39	15.03	9	0.476503	0.469155	75227
AZT_34_05	3.31	13.33	5	0.515678	0.510123	75227
AZT_34_06	2.32	11.45	5	0.517668	0.537101	75227
AZT_34_07	1.42	10.62	5	0.471858	0.476681	75227
AZT_34_08	1.26	9.93	4	0.49012	0.497281	75227
AZT_34_09	5.25	16.60	7	0.471832	0.483662	75227
AZT_34_11	5.23	19.38	9	0.399975	0.359031	75227
AZT_34_12	2.95	22.52	8	0.389449	0.350917	75227
AZT_34_13	3.92	24.48	8	0.4521	0.455138	75227
AZT_43_02	15.90	25.75	5	0.582453	0.57896	4861
AZT_43_03	19.04	30.07	5	0.564592	0.568077	4861
AZT_43_04	23.62	33.86	5	0.580843	0.587219	4861

An overview of the camera deployments and total images collected across different passages of the AZNST can be viewed in Table 3. The number of cameras varied widely by location, reflecting differences in trail length, accessibility, and research needs. For example, Passage 34 (San Francisco Peaks) had the highest concentration with 10 cameras, generating over 107,000 images, while some other passages, such as Passage 23 (Mazatzal Divide), had only a single camera, yielding just 285 images.

Several other passages also produced especially large datasets, including Passage 1 (Huachuca Mountains) with 67,280 images from six cameras, Passage 16 (Gila River Canyons) with nearly 59,000 images from four cameras, and Passage 31 (Walnut Canyon) with 10 cameras capturing more than 58,000 images. In contrast, smaller deployments, such as Passage 22 (Saddle Mountain) with two cameras and Passage 43 (Buckskin Mountain) with three cameras, generated fewer than 10,000 images each.

**Table 3:** AZNST passages where camera traps were set up, camera effort: total days cameras were



*active, number of images, including blanks*

Passage Name	Passage Number	Number of Cameras	Camera effort	Number of Images (including blanks)
Huachuca Mountains	1	6	2757	67280
Canelo Hills	2	3	1108	1387
Las Cienegas	7	2	538	4591
Rincon Mountains	9	2	363	30749
Redington Pass	10	1	133	28549
Oracle	13	2	354	46062
Tortilla Mountains	15	1	646	16176
Gila River Canyons	16	2	1260	58984
Alamo Canyon	17	3	1226	17332
Superstition Wilderness	19	2	448	22017
Pine Mountain	21	4	1014	30325
Saddle Mountain	22	2	517	9650
Mazatzal Divide	23	1	85	285
Blue Ridge	27	4	470	5883
Mormon Lake	29	4	707	11941
Walnut Canyon	31	6	553	58766
Elden Mountain	32	1	35	8955
San Francisco Peaks	34	10	3182	107032
Buckskin Mountain	43	3	1074	7136

## 2.2 Analysis

It is important to consider both human and wildlife presence in the maintenance and management of the AZNST. Since these two groups can influence each other in multiple ways (Miller et al., 2022), understanding both is critical for effective monitoring and management. Accordingly, the following two sections will present wildlife data and human data, respectively. This research identified and analyzed small- to large-sized mammals. For the analysis, we applied multiple methods. To identify the images and clean the data, we utilized Wildlife Insight (<https://www.wildlifeinsights.org/>), a cloud-based AI platform. After uploading photos, the blank images were separated, and then we identified the images with species. Species were identified using Wildlife Insight and then manually confirmed twice by a group of six students. The exported result from Wildlife Insight was used in Camera Sweet (<https://smallcats.org/camerasweet/>) tools to analyze the details of each image, including the time of capture and location. We also calculated some environmental features and created a map of the study area using ArcGIS Pro 3.1.0. All figures were made with R and Jupiter Python.



### 3. Findings

The findings of this report are represented in two main categories: wildlife and human. Each section will provide an overview of the number of pictures captured by the 59 camera traps and the corresponding activity patterns.

#### 3.1 Wildlife on the AZNST

The camera trap data were used to calculate species richness of small, medium, and large mammals, defined as the number of unique species larger than 1kg detected at each camera location (Moore, 2013). To account for differences in camera operation time, species richness was standardized by dividing it by camera effort.

**Picture 2:** *Picture of a Mountain lion (Puma concolor), Huachuca Mountains, Passage 1, Arizona Trail, 2021*



Records of species diversity are crucial for tracking how ecosystems respond to environmental changes (Dorph et al., 2021). Factors like climate change, land development, and recreational use can significantly influence species richness in a given area ((Barcelos et al., 2022; Dorph et al., 2021). Monitoring these changes offers valuable insights into effective management and a deeper understanding of the impact of these environmental pressures.



**Picture 3:** *Picture of an Elk (Cervus canadensis), San Francisco Peaks, Passage 34, Arizona Trail, 2019*



In total, the dataset includes 5,401 independent images of small- to large-sized mammal detections across camera deployments. In total, we identified 25 different small-sized to large mammals. Figure 4 highlights the differences in mammal species richness across camera trap locations along the AZNST. Each line represents a camera site, with its length showing the number of unique species recorded, ranging from as few as 1 to as many as 17 for each camera. Most sites fall somewhere in the middle, detecting between 4 and 10 species, which suggests moderate diversity is fairly common across the trail. A few sites stand out with notably high richness; conversely, some sites with low richness may simply reflect limited camera effort or suboptimal placement, meaning the true diversity of mammals in those areas could be underestimated. By ordering sites by richness, Figure 4 provides a clear picture of which areas might warrant closer monitoring due to limited data, as well as which locations may deserve conservation attention because of their relatively high diversity.



Figure 4: The Variation in Mammal Species Richness along the AZNST

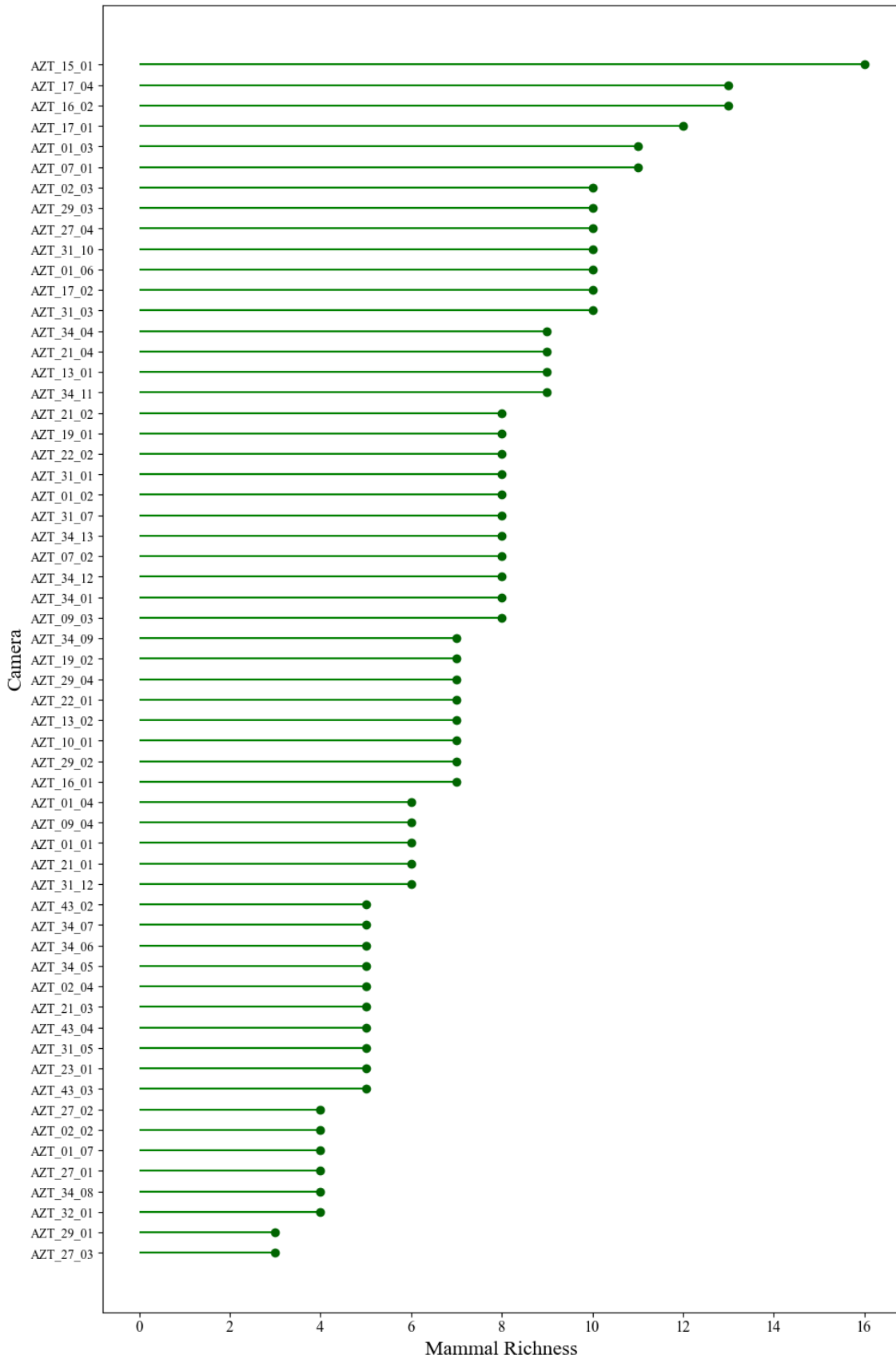


Table 4 highlights just how much species richness varies across the Arizona Trail. Some cameras picked up only a handful of species. For example, one site (AZT\_16\_04) recorded just a single mammal, while others captured a much wider variety, with AZT\_15\_01 detecting 16 species, the highest overall. Several other cameras also showed strong diversity, such as AZT\_16\_02, and AZT\_17\_04, which had 13 species. At the other end of the spectrum, several sites logged only 4–5 species. When adjusting for camera effort, the values ranged from very low (0.009) to strikingly high (0.192), showing that in some places even a small number of detections still reflected meaningful richness per camera effort (Figure 5).

**Table 4:** *Species Richness per Camera*

Camera	Mammal Richness	Mammal Richness / Camera Effort
AZT_01_01	6	0.009
AZT_01_02	8	0.026
AZT_01_03	11	0.014
AZT_01_04	6	0.014
AZT_01_06	10	0.035
AZT_01_07	4	0.014
AZT_02_02	4	0.023
AZT_02_03	10	0.021
AZT_02_04	5	0.011
AZT_07_01	11	0.035
AZT_07_02	8	0.036
AZT_09_03	8	0.111
AZT_09_04	6	0.021
AZT_10_01	7	0.053
AZT_13_01	9	0.053
AZT_13_02	7	0.038
AZT_15_01	16	0.025
AZT_16_01	7	0.012
AZT_16_02	13	0.019
AZT_17_01	12	0.090
AZT_17_02	10	0.024
AZT_17_04	13	0.019
AZT_19_01	8	0.036
AZT_19_02	7	0.031
AZT_21_01	6	0.070
AZT_21_02	8	0.016
AZT_21_03	5	0.069
AZT_21_04	9	0.025
AZT_22_01	7	0.109
AZT_22_02	8	0.018
AZT_23_01	5	0.059
AZT_27_01	4	0.060
AZT_27_02	4	0.043
AZT_27_03	3	0.012
AZT_27_04	10	0.149



AZT_29_01	3	0.054
AZT_29_02	7	0.032
AZT_29_03	10	0.046
AZT_29_04	7	0.032
AZT_31_01	8	0.040
AZT_31_03	10	0.068
AZT_31_05	5	0.096
AZT_31_07	8	0.154
AZT_31_10	10	0.192
AZT_31_12	6	0.115
AZT_32_01	4	0.114
AZT_34_01	8	0.024
AZT_34_04	9	0.022
AZT_34_05	5	0.012
AZT_34_06	5	0.019
AZT_34_07	5	0.019
AZT_34_08	4	0.077
AZT_34_09	7	0.020
AZT_34_11	9	0.025
AZT_34_12	8	0.023
AZT_34_13	8	0.020
AZT_43_02	5	0.012
AZT_43_03	5	0.011
AZT_43_04	5	0.026



**Figure 5:** *The Variation in Mammal Species Richness per Camera Effort along the AZNST*

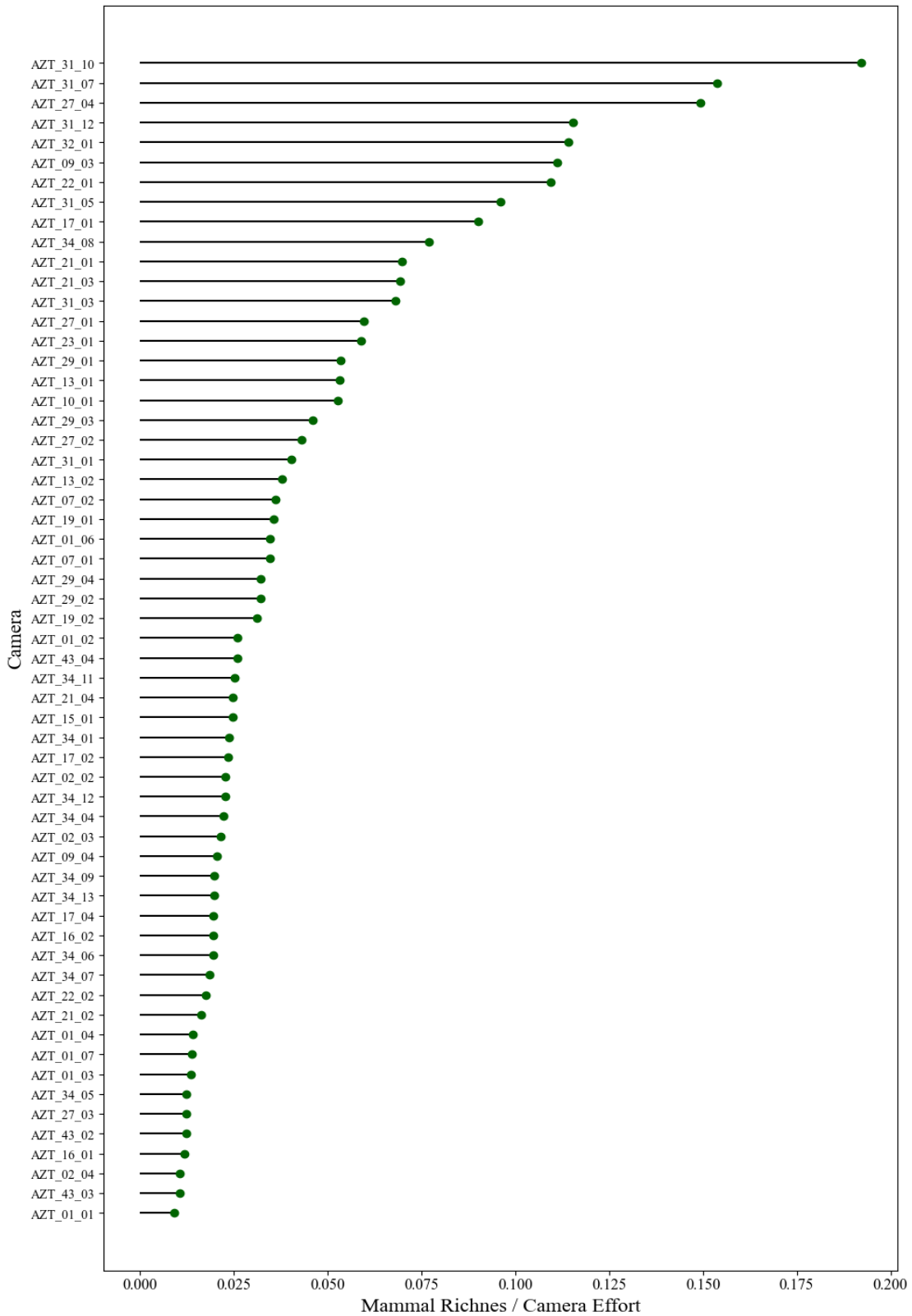




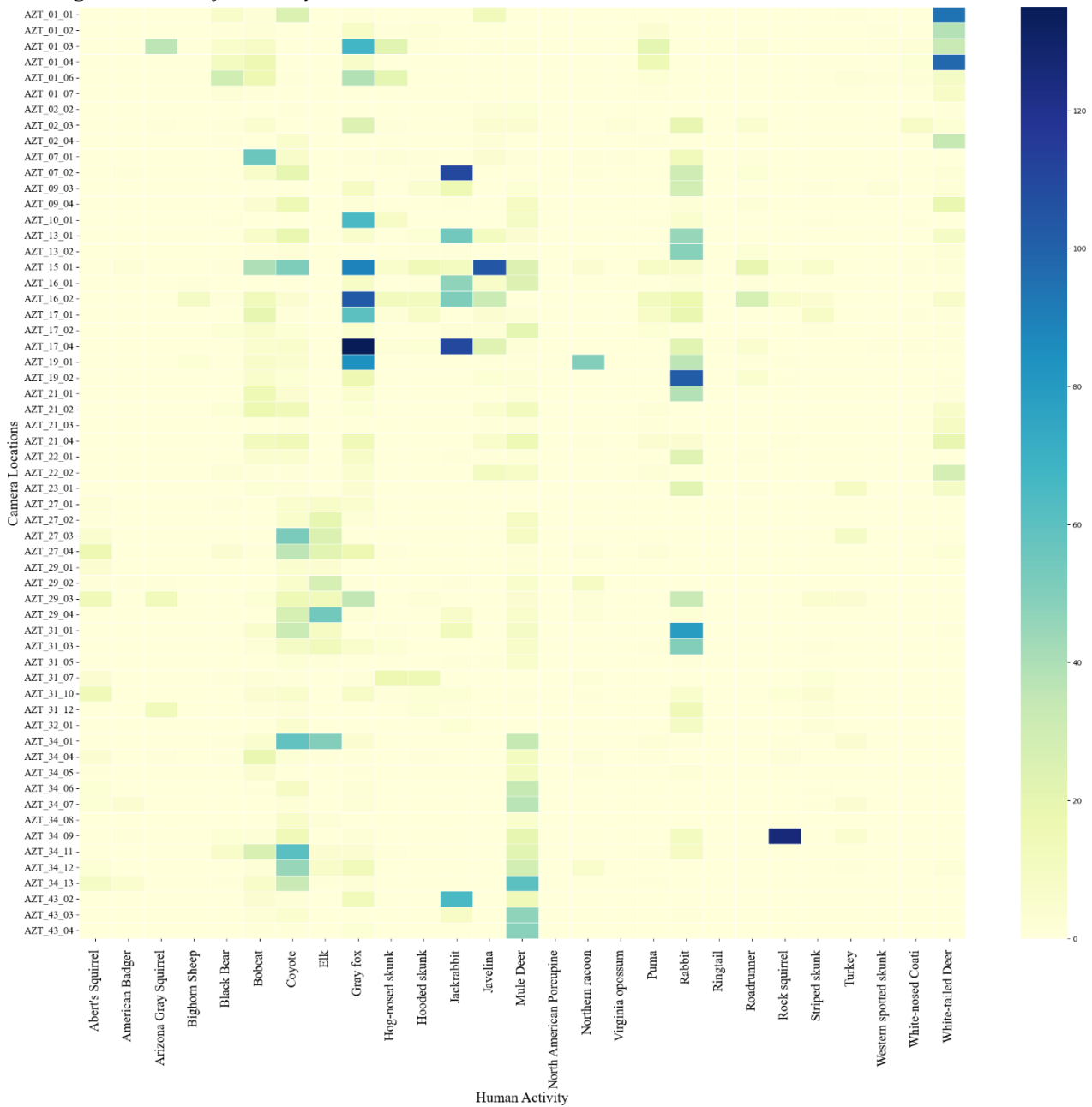
Figure 6 shows how wildlife activity overlaps across camera trap sites on the AZNST. Each row represents a camera location, and each column a species, with colors ranging from light yellow to dark blue to reflect detection frequency. Some species, like gray fox, have been present in most locations but have a higher frequency in some passages in the middle passages of the trail. White-tailed deer were more frequent in the southern passages, whereas mule deer were more common in the northern passages. Beyond highlighting general overlap patterns, the heatmap reveals how wildlife distributed along the AZNST based on camera trap data. This spatially uneven distribution of co-use highlights opportunities for targeted management, including identifying areas where recreational use may warrant closer monitoring and locations that may serve as important refugia or movement pathways for less frequently detected species. Overall, the visualization highlights where wildlife most often share space and provides insight into species distributions that can guide both management decisions and future camera placements.

**Picture 4:** *Picture of a Black Bear, Huachuca Mountains, Passage 1, Arizona Trail, 2023*





Figure 6: Wildlife Activity across the AZNST



Note: A North American porcupine was recorded at camera AZT\_34\_10 but is not included in Figures 6 and 7 due to a camera angle issue that likely captured off-trail activity. These data were excluded from the heatmap, though the detection confirms the species' presence at this site. We included some other species, like turkey, here as information to show which cameras detected these species.



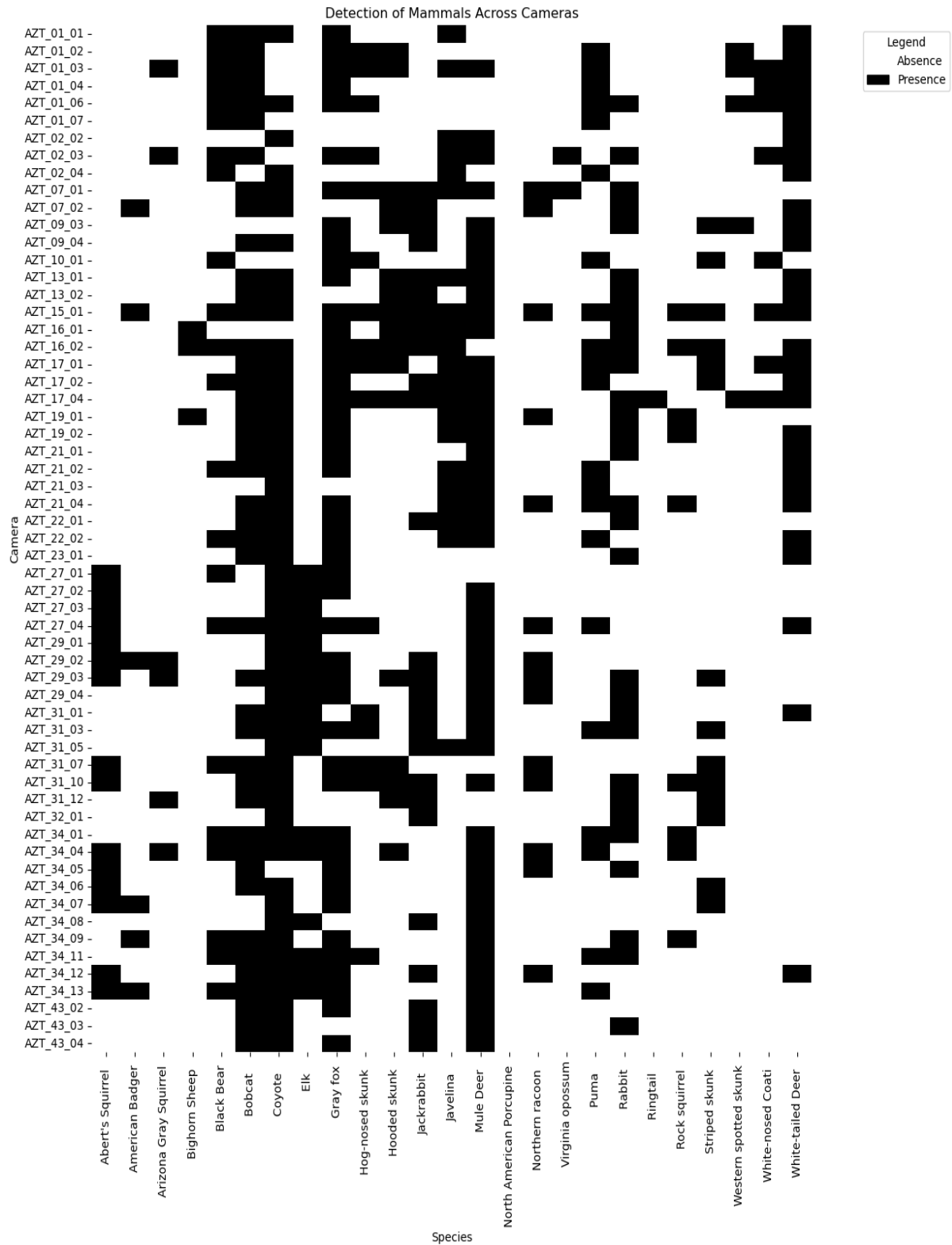
Figure 7 provides a simple snapshot of where different mammal species were detected along the AZNST. Each row represents a camera site, and each column a species, with black cells showing a detection during the entire study period and white cells showing none. Importantly, absence in this figure reflects non-detection by camera traps rather than true absence, as it is based solely on the images captured during the sampling period. From this view, some species, like coyotes, mule deer, and gray foxes, stand out as being recorded at many locations, reflecting wide habitat use across the trail. In contrast, species such as bighorn sheep, javelina, and North American porcupine appear only rarely, suggesting they may be more specialized, less common, or harder to detect. The heatmap also shows variation among camera sites: some locations, such as AZT\_31\_03 and AZT\_34\_03, recorded a rich mix of species, while others, like AZT\_01\_02 or AZT\_22\_02, detected very few or none. These differences likely reflect a combination of habitat conditions, landscape features, and camera placement. Overall, the visualization highlights biodiversity hotspots and gaps, offering useful guidance for both conservation planning and decisions about where to deploy cameras in the future.

**Picture 5:** *Picture of a White-nosed Coati, Huachuca Mountains, Passage 1, Arizona Trail, 2023*





Figure 7: The Detection of Each Species across AZNST from 2017-2023



### 3.1.1 Species Frequency

Figure 8 gives an overview of detection data for 25 mammal species recorded by camera traps along the Arizona Trail. The chart shows the number of passages where each species was detected, how many camera locations they appeared at, and the total number of independent detections. Coyotes and gray foxes stood out as the most widespread, showing up in all 19 passages, with coyotes also topping the list in total detections (673). Jackrabbits, mule deer, and rabbits were also frequently recorded, reflecting their strong presence along the trail. At the other end of the spectrum, species like the ringtail, North American porcupine, and Virginia opossum were each captured just once, suggesting they are either rare in the area or highly localized. The wide variation across species highlights how some mammals are broadly distributed across the trail, while others are far less common. In total, the dataset includes 5,401 independent images of small- to large-sized mammals' detections across camera deployments.

Due to the limited number of North American porcupine detections, the species was included in Figure 8 to illustrate its occurrence across camera sites. However, it was excluded from the heatmap analysis (Figures 6 and 7) because the corresponding camera (AZT\_34\_10) had an angle issue that likely captured off-trail activity. To ensure consistency and data reliability, this camera was excluded from the heatmap analysis.

**Figure 8:** Summary of Species Frequency across the AZNST

Species	Number of Passages Detected In	Number of Unique Camera Locations	Total Independent Detections
Coyote	18	55	673
Gray Fox	18	48	578
Bobcat	17	46	376
Mule Deer	17	50	578
Rabbit	17	34	486
White-tailed Deer	15	29	421
Jackrabbit	12	30	607
Black Bear	11	23	105
Javelina	11	23	251
Puma	11	21	94
Hog-nosed Skunk	10	19	102
Hooded Skunk	10	17	74
Striped Skunk	9	14	40
Northern Raccoon	8	14	85
Rock Squirrel	6	10	135
Arizona Gray Squirrel	5	6	64
White-nosed Coati	5	8	19
Abert's Squirrel	4	17	95
Elk	4	21	256
American Badger	3	6	14
Western Spotted Skunk	3	5	6
Bighorn Sheep	2	3	13
Virginia Opossum	2	2	3
North American Porcupine	1	1	1
Ringtail	1	1	1
<b>Total</b>	<b>220</b>	<b>503</b>	<b>5401</b>

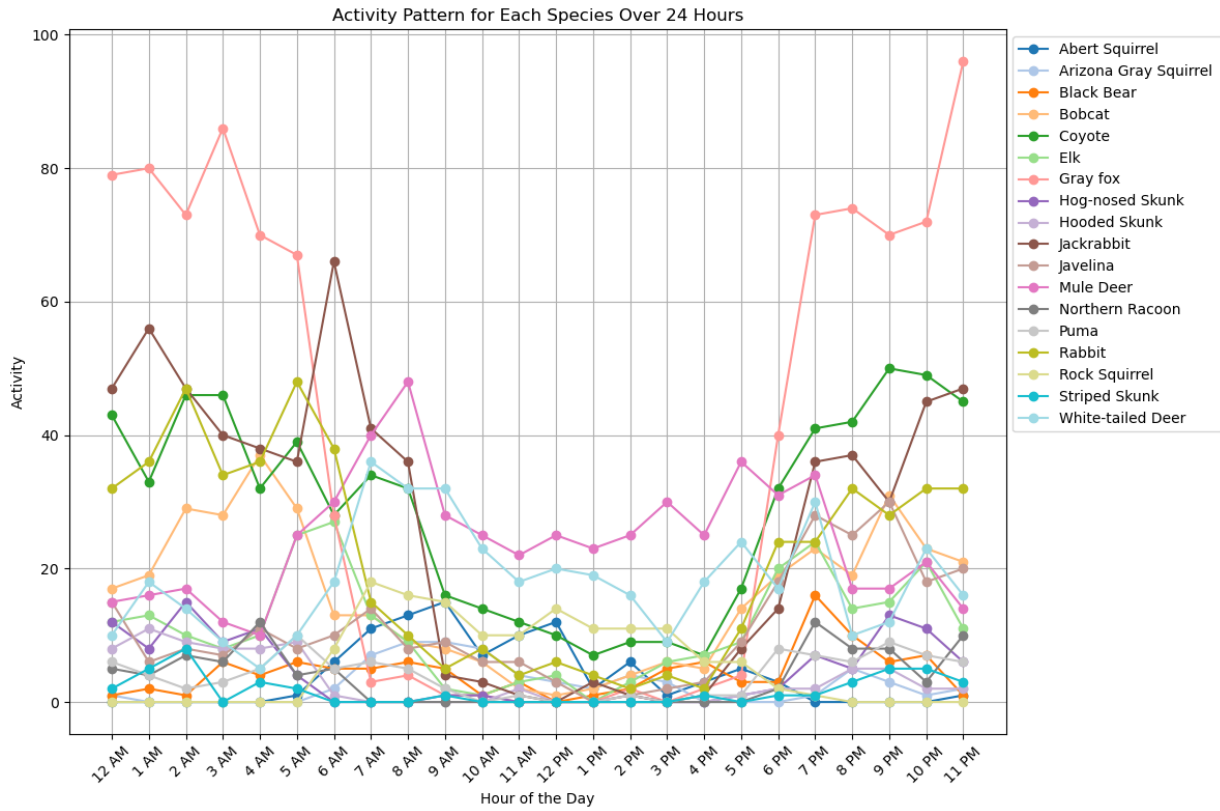


Figure 9 shows the daily activity patterns of different mammal species recorded by the camera traps, offering a snapshot of how each species uses the 24-hour cycle. The patterns highlight clear differences in behavior, with some species active mainly at night, others during twilight, and a few mostly in daylight. Coyotes stand out with distinct peaks of activity between 3 and 5 AM and again just after sunset, reflecting their strong nocturnal and crepuscular habits(Andelt & Gipson, 1979). White-tailed deer and mule deer follow a similar rhythm, with most movement concentrated in the early morning and evening, classic crepuscular activity that likely helps them avoid both predators and the heat of the day(Ager et al., 2003; Higdon et al., 2019). Rabbits and jackrabbits also favored these twilight hours, showing bursts of movement before sunrise and again at dusk(Smith, 1990).

Day-active species, such as rock squirrels and Abert's squirrels, are most active from mid-morning through the early afternoon, then quiet down as evening approaches (*US Forest Service Research and Development, 2025*). Black bears show a more balanced pattern, with activity spikes around 6 AM and 6 PM. Other species, like bobcats and skunks, keep a steady but relatively low profile throughout the night, while pumas appear only occasionally, with sparse and irregular activity. These patterns not only capture the daily rhythms of wildlife along the trail but also provide valuable ecological insights. Understanding when species are most active helps explain how they balance foraging, predator avoidance, and environmental pressures(Kronfeld-Schor & Dayan, 2003), knowledge that can support conservation and management decisions.



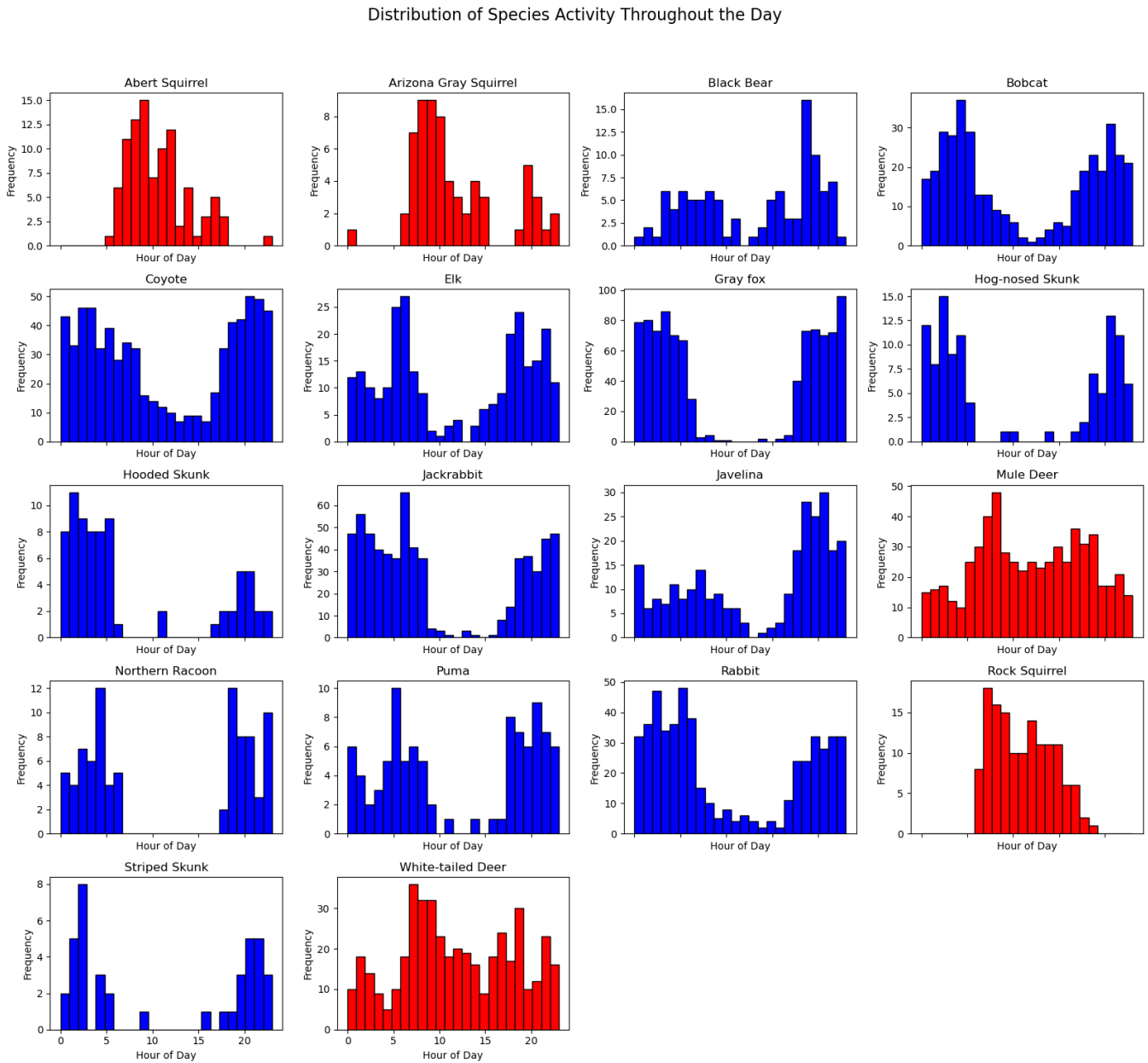
**Figure 9:** Activity Pattern for Each Species over 24 Hours



The histograms in Figure 10 illustrate the hourly activity patterns of different mammal species, offering a clear view of their activity. Nocturnal animals such as gray foxes, jackrabbits, and bobcats are most active at night, with activity tapering off sharply during midday. Crepuscular species, including white-tailed deer, mule deer, and coyotes, show distinct peaks at dawn and dusk, a likely strategy to avoid both predators and the heat of the day (Iii et al., 2006).

These patterns reveal how species share time as much as space, using different parts of the daily cycle to reduce competition and conflict (Kronfeld-Schor & Dayan, 2003). This temporal partitioning underscores the importance of diel activity in species coexistence and offers valuable insights for conservation and wildlife management.

**Figure 10:** *Distribution of Species Activity throughout the Day across AZNST, with red indicating higher daytime activity and blue indicating higher nighttime activity.*



### 3.2 Human Use of the Trail

An important part of understanding the trail is looking at how people actually use it. Since motorized use is not allowed on the AZNST, this report focuses only on non-motorized recreation, though a few motorized activities were still recorded in some passages. Figure 11 shows the number of independent images of different trail users, including hikers, mountain bikers, and horseback riders. Hikers clearly dominate, with 27,225 images, followed by bikers at 12,651 images. Horseback riders were much less common, appearing in only 478 images. This pattern highlights that hiker use is by far the most frequent activity on the trail, while



horseback riding is relatively rare compared to hiking or biking.

**Figure 11:** *The Number of Independent Images of Humans*

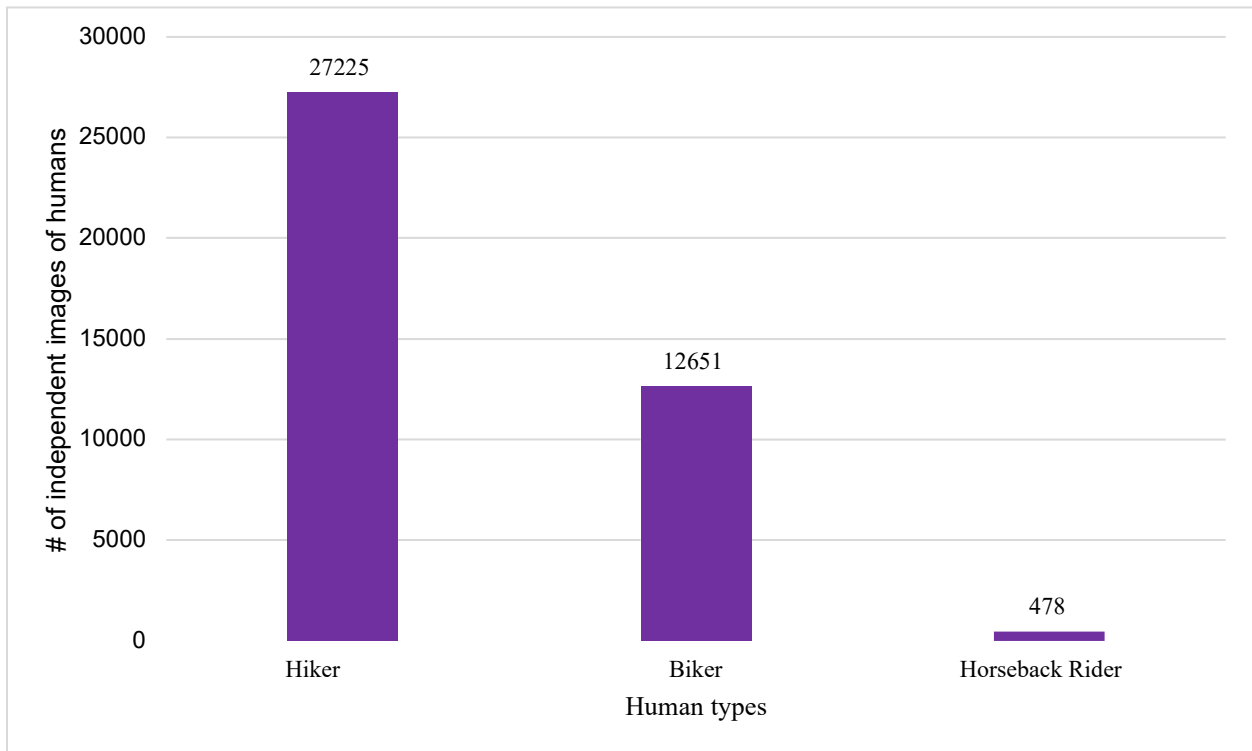
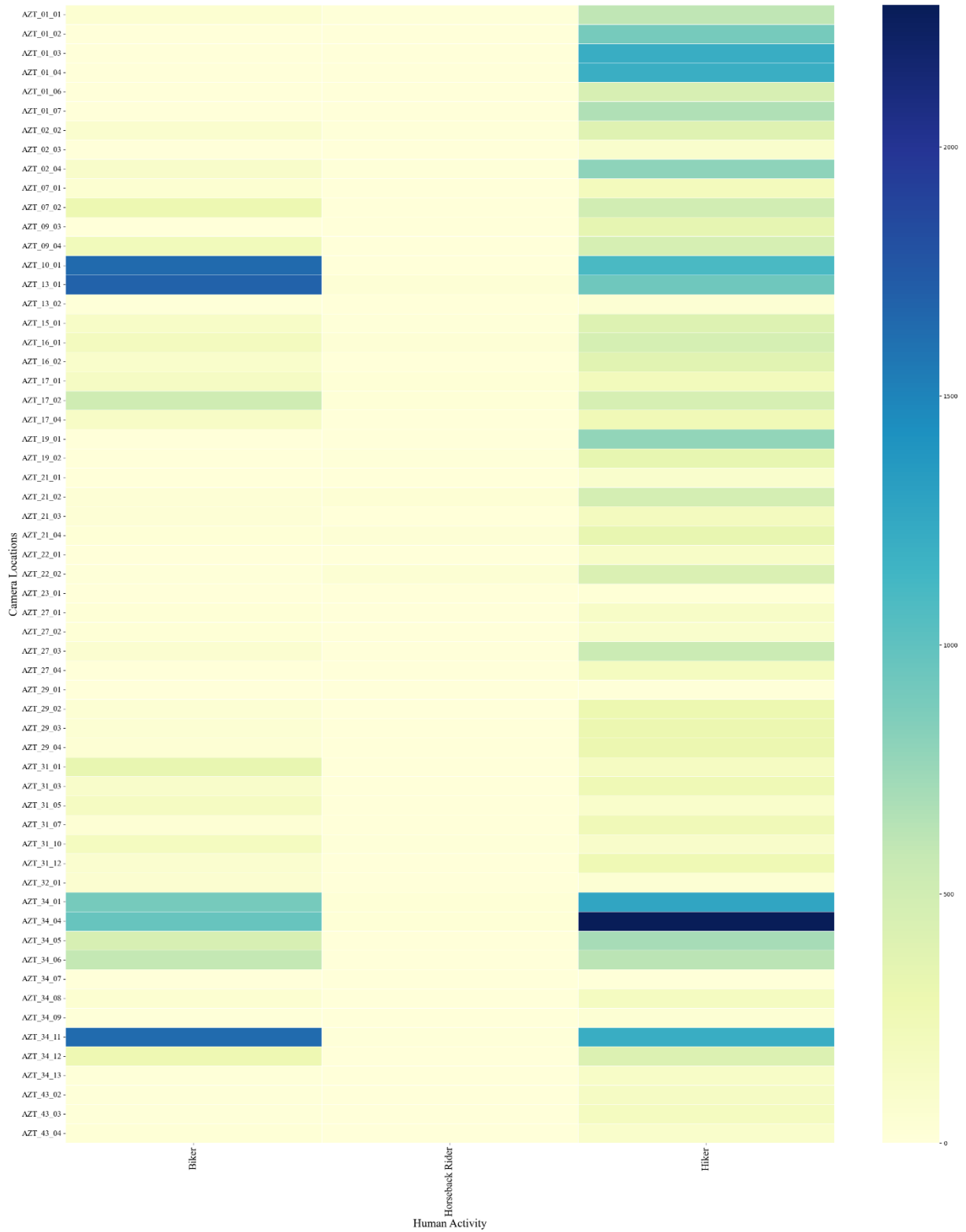


Figure 12 shows how different types of human activity, hiking, biking, and horseback riding, are distributed across camera sites on the trail. The busiest location is AZT\_34\_04, where both hiker and biker traffic are especially heavy, marking it as a clear hotspot of use. AZT\_34\_11 also emerges as a multi-use area, with high numbers of bikers and horseback riders in addition to hikers. In contrast, sites like AZT\_34\_07, AZT\_31\_04, and AZT\_32\_01 record very little activity of any kind, suggesting these areas remain relatively undisturbed. Horseback riding stands out as the least common activity overall, showing up in only a handful of places such as AZT\_22\_02, AZT\_13\_01, and AZT\_17\_02. These patterns highlight how hiking and biking activity dominate much of the trail, while equestrian use is sparse and highly localized. Identifying these high-use areas alongside quieter stretches is valuable for understanding where recreation pressure is concentrated and where wildlife may find more refuge.



Figure 12: Different Types of Human Activity across the AZNST

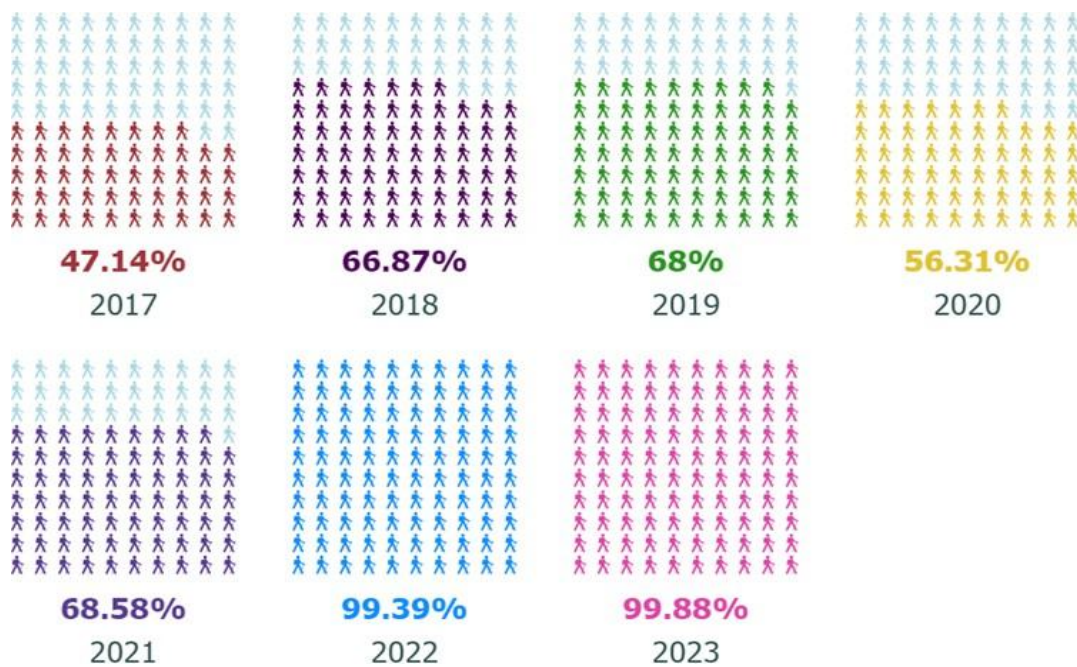




Figures 13, 14, and 15 illustrate the distribution of different types of trail users, including hikers, bikers, and horseback riders, on the AZNST between 2017 and 2023. While the percentages provide useful insights, they must be interpreted with caution, as many cameras were inactive during the COVID-19 pandemic. The cameras that did remain active in 2022 and 2023 were located in areas that historically did not capture bikers, which likely explains the apparent absence of bike activity in those years. This means the sharp declines in biker and horseback rider percentages may reflect gaps in camera coverage rather than true changes in use. One exception is the zero percent horseback rider detection in 2017, which is considered reliable since the same camera later recorded horseback riders in 2018 but not in 2017, confirming their absence at that time.

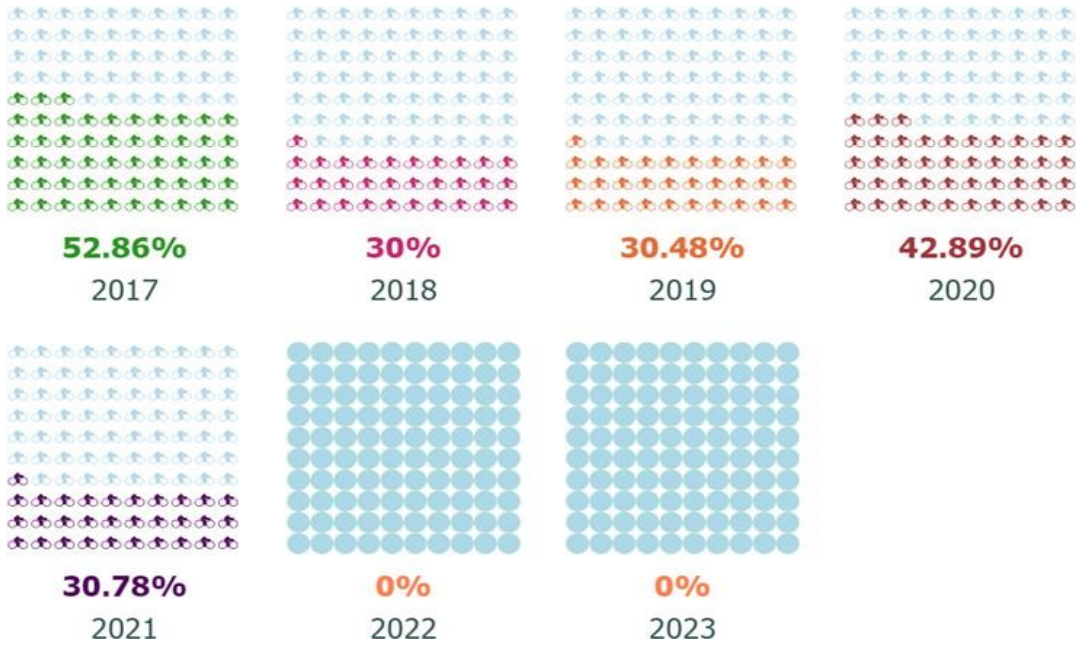
Looking across the entire period, hikers became increasingly dominant among human activity, rising from 47.14% of detections in 2017 to over 99% in both 2022 and 2023. Biker activity was fairly strong in the earlier years, ranging from 30% to 53% between 2017 and 2020, but then dropped sharply to 0% after 2020. Horseback riders consistently made up the smallest share of users, never exceeding 3.12% and falling below 1% in recent years. Overall, the patterns suggest that hikers are by far the most frequent users of the trail, but the recent drop in bikers and horseback riders may be partly due to limitations in data collection and camera placement, underscoring the need for careful interpretation of these trends.

**Figure 13** :The Percentage of Hikers Compared to Bikers and Horseback Riders across AZNST per Year, from 2017-2023

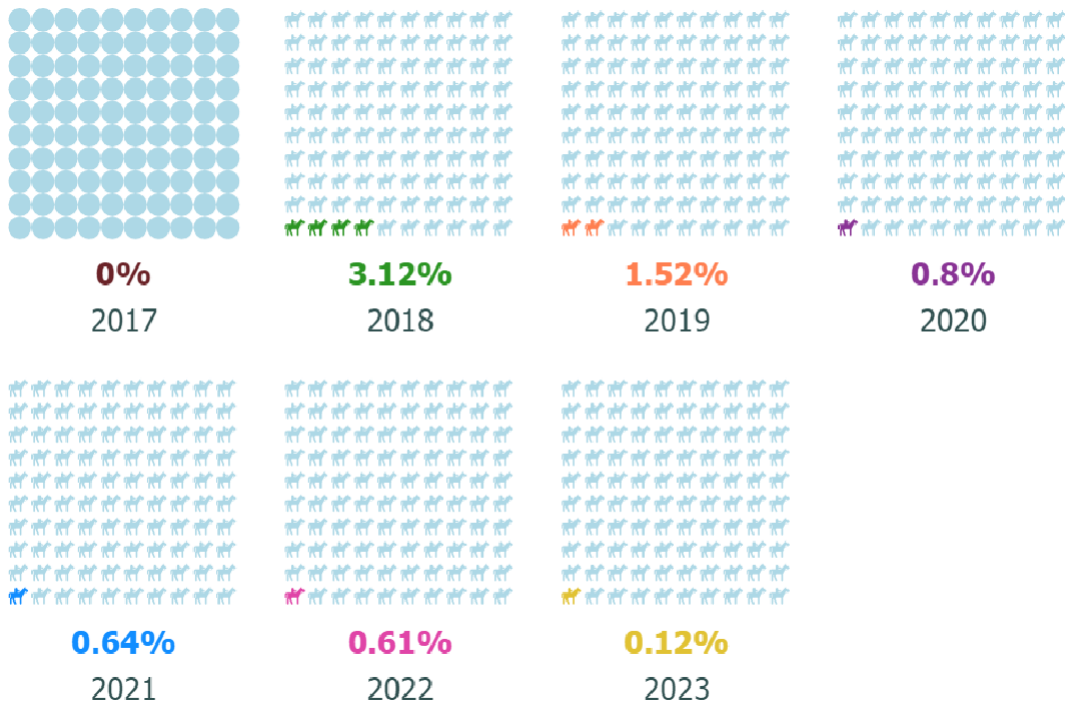




**Figure 14:** *The Percentage of Bikers Compared to Hikers and Horseback Riders across AZNST per Year, from 2017-2023*



**Figure 15:** *The Percentage of Horseback Riders Compared to Hikers and Bikers across AZNST per Year, from 2017-2023*



### 3.2.1 Human Activity Patterns

Understanding when and how people use the AZNST is also important for effective trail management. Knowing peak times of use, by hour, day, or season, helps managers plan the resources needed to keep the trail in good condition while also ensuring visitors have a safe and enjoyable experience. Breaking down use by hikers, bikers, and horseback riders is especially valuable, since each group has unique needs and can create different challenges. For example, bikers can pose safety risks to equestrians, while horses can spread invasive plants. Having accurate information on the mix of users along different trail sections makes it easier to manage these impacts and prevent conflicts among user groups.

The graph in Figure 16 demonstrates how human activity varies with the seasons. Hiking is most popular in the spring and fall, when weather conditions are milder, and drops off in the summer heat and during the coldest parts of winter. Biking stays more consistent throughout the year but tends to be higher in the cooler fall and winter months, with many riders likely shifting north during the summer. Horseback riding peaks in spring and winter, when conditions are more comfortable for both riders and animals. These seasonal patterns reflect how Arizona’s weather and landscapes shape the way people use the trail, offering valuable guidance for balancing recreation with conservation.

**Figure 16:** Seasonal Activity Pattern of Hikers, Bikers, and Horseback Riders across AZNST

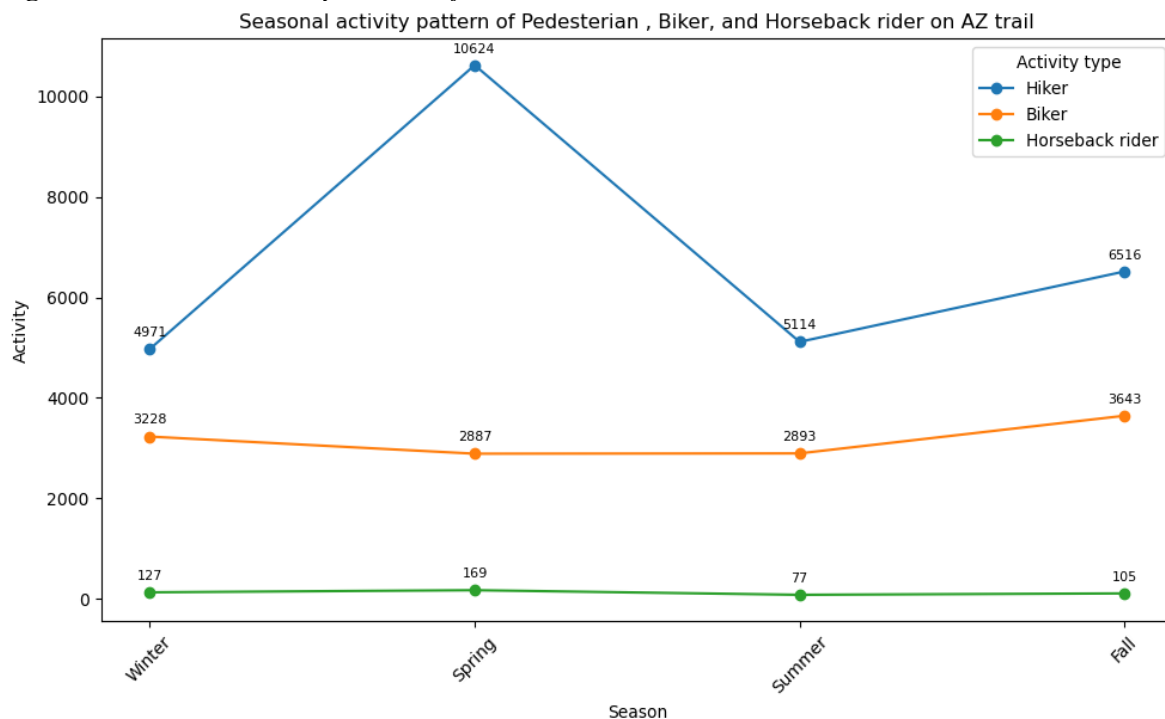


Figure 17 shows how trail use on the AZNST shifts across the days of the week. As expected, activity climbs on weekends, with clear spikes in detections of hikers, bikers, and horseback riders on Saturdays and Sundays, reflecting the greater free time people have outside of the workweek. Weekdays are noticeably quieter, especially Tuesdays and Wednesdays, when



trail use is at its lowest. This weekly rhythm highlights how recreation on the trail closely follows people’s schedules, with weekends serving as the prime time for outdoor activity.

**Figure 17:** Daily Activity Pattern of Hikers, Bikers, and Horseback Riders on AZNST

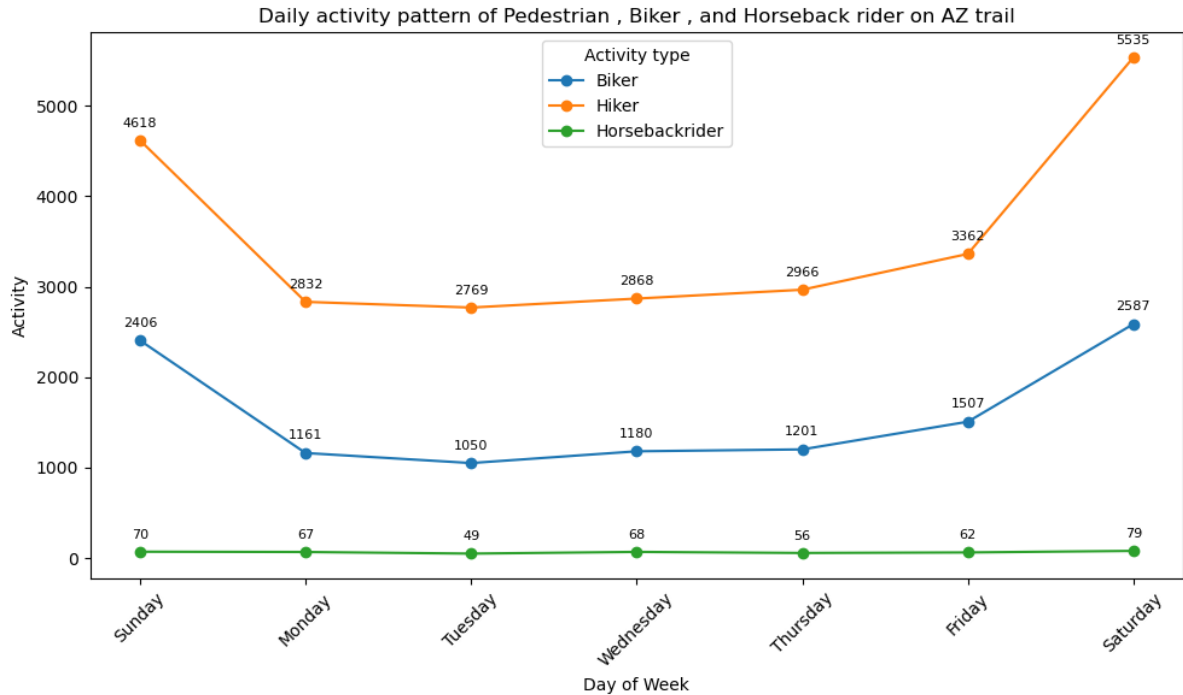
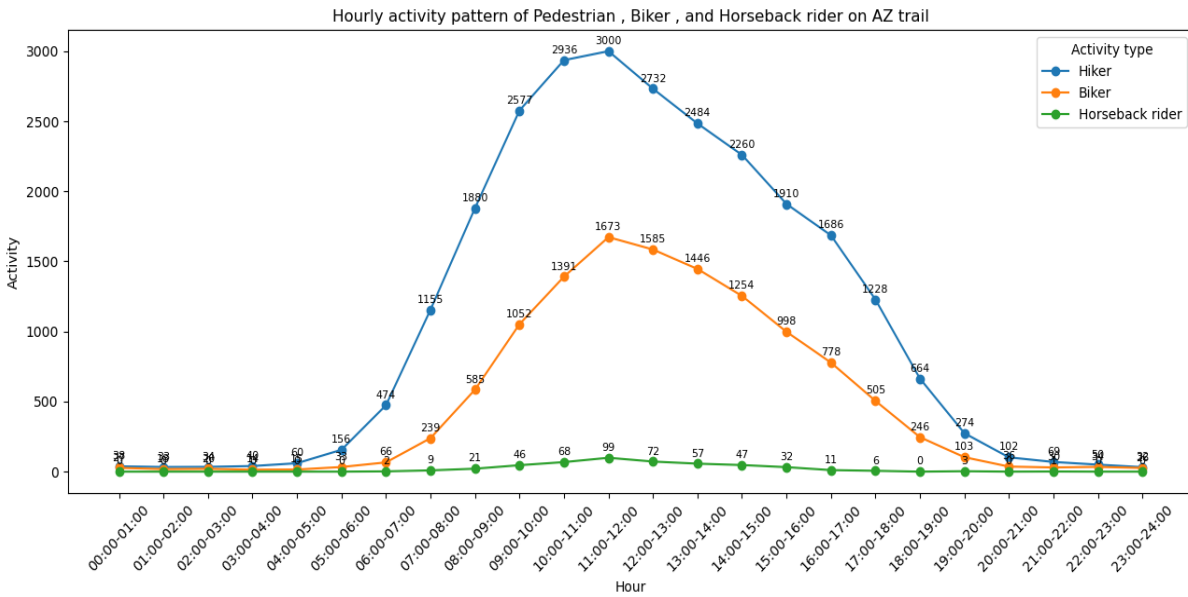


Figure 18 shows the daily activity patterns of hikers, bikers, and horseback riders on the AZNST based on camera trap detections. Most activity takes place during the middle of the day, with a clear peak between 10:00 AM and 12:00 PM and generally high use from 9:00 AM to 4:00 PM. Early mornings and evenings see far less traffic, reflecting a preference for daylight hours when conditions are more comfortable and visibility is better. This pattern aligns with typical recreation habits, as most people choose to hike, bike, or ride horses when the trail is safest and most accessible.

**Figure 18:** *The Temporal Activity Patterns of Hikers, Bikers, and Horseback Riders across AZNST*



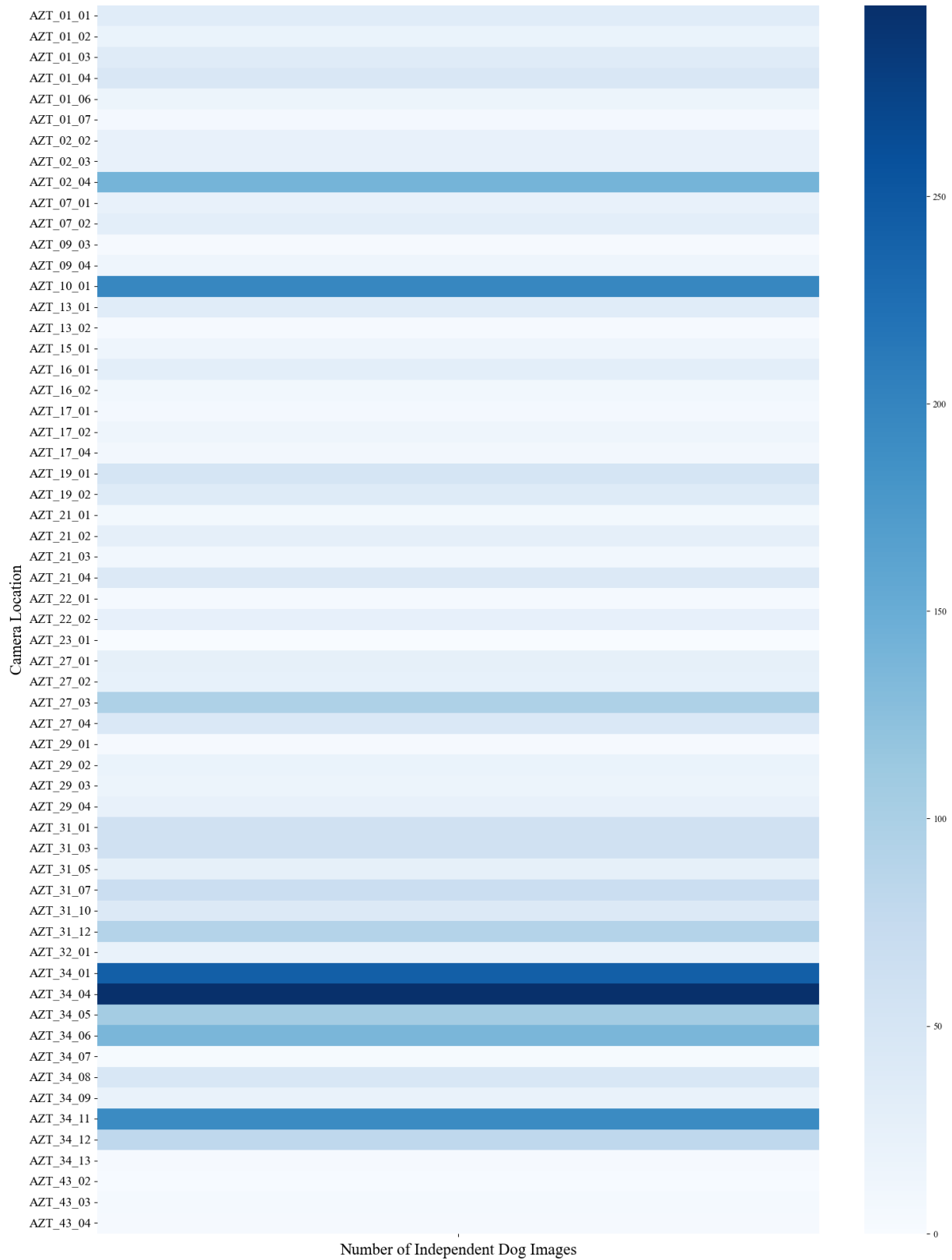
### 3.2.2 Pet Activity

Many visitors to the AZNST bring their pets, most often dogs, along with them. While dogs can make the trail experience more enjoyable for their owners, they also have the potential to affect both wildlife and other recreationists (Banks & Bryant, 2007). Dogs may disturb or scare wildlife, sometimes acting as perceived predators, and can create safety concerns for other trail users (Banks & Bryant, 2007). For this reason, pet regulations are in place to protect the trail environment and ensure a safe, positive experience for everyone. Additionally, in certain areas, such as National Parks and habitats with populations of Desert bighorn sheep, dogs are strictly prohibited. Tracking the number and distribution of dogs is also useful for trail managers as they consider future policies on pet access and evaluate the impacts of pets on the trail.

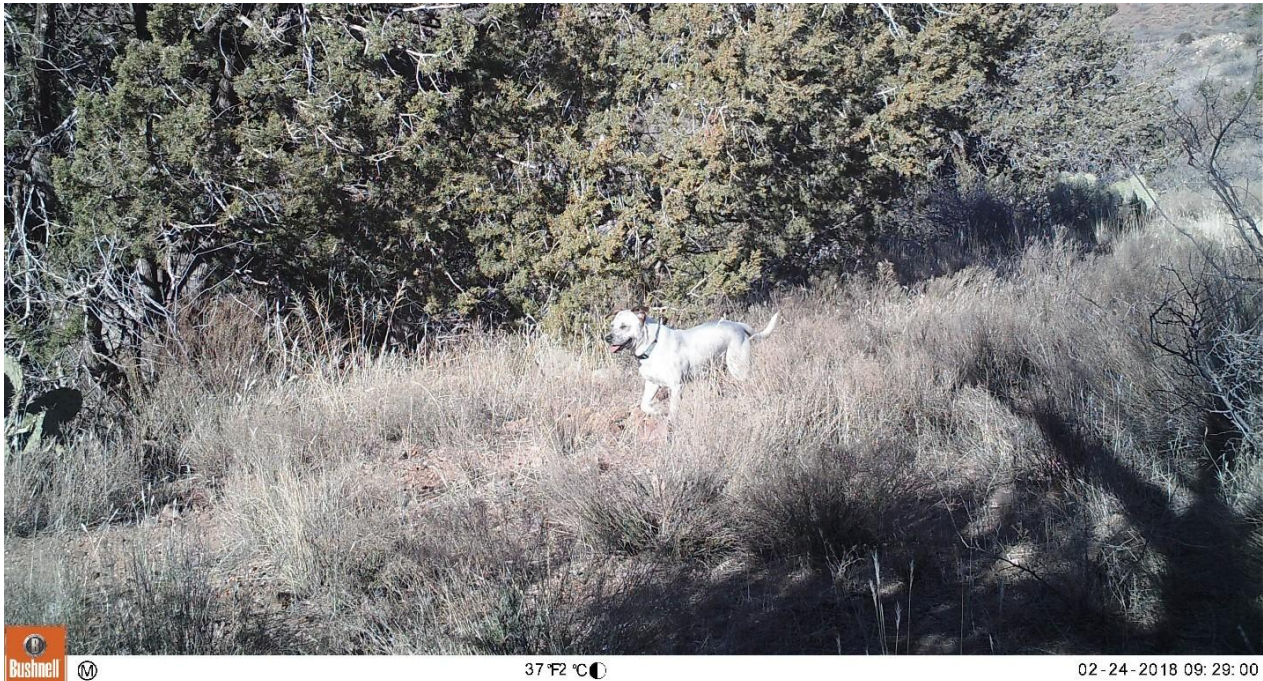
Figure 19 provides details of dog frequency across AZNST. Although pets are not permitted on four passages of the AZNST (Passages 1, 9, 37, 38, and 39), our cameras still detected 158 independent images of dogs in Passage 1 and 19 in Passage 9. The heatmap in Figure 19 shows where domestic dogs were observed across the trail. The highest detections occurred at AZT\_34\_04, AZT\_34\_01, AZT\_10\_01, AZT\_34\_11, AZT\_02\_04, AZT\_34\_06, and AZT\_34\_05. Many of these sites also recorded heavy hiker use, suggesting that dogs were most common in areas with high visitor traffic. Most of these cameras were located in Passage 34 (San Francisco Peaks), which stood out as the section with the greatest overall number of dog detections compared to the rest of the trail.



**Figure 19:** *The Heatmap of the Frequency of Dogs across AZNST per Camera Trap*



**Picture 6:** *Picture of a dog, Pine Mountain, Passage 21, Arizona Trail, 2018*



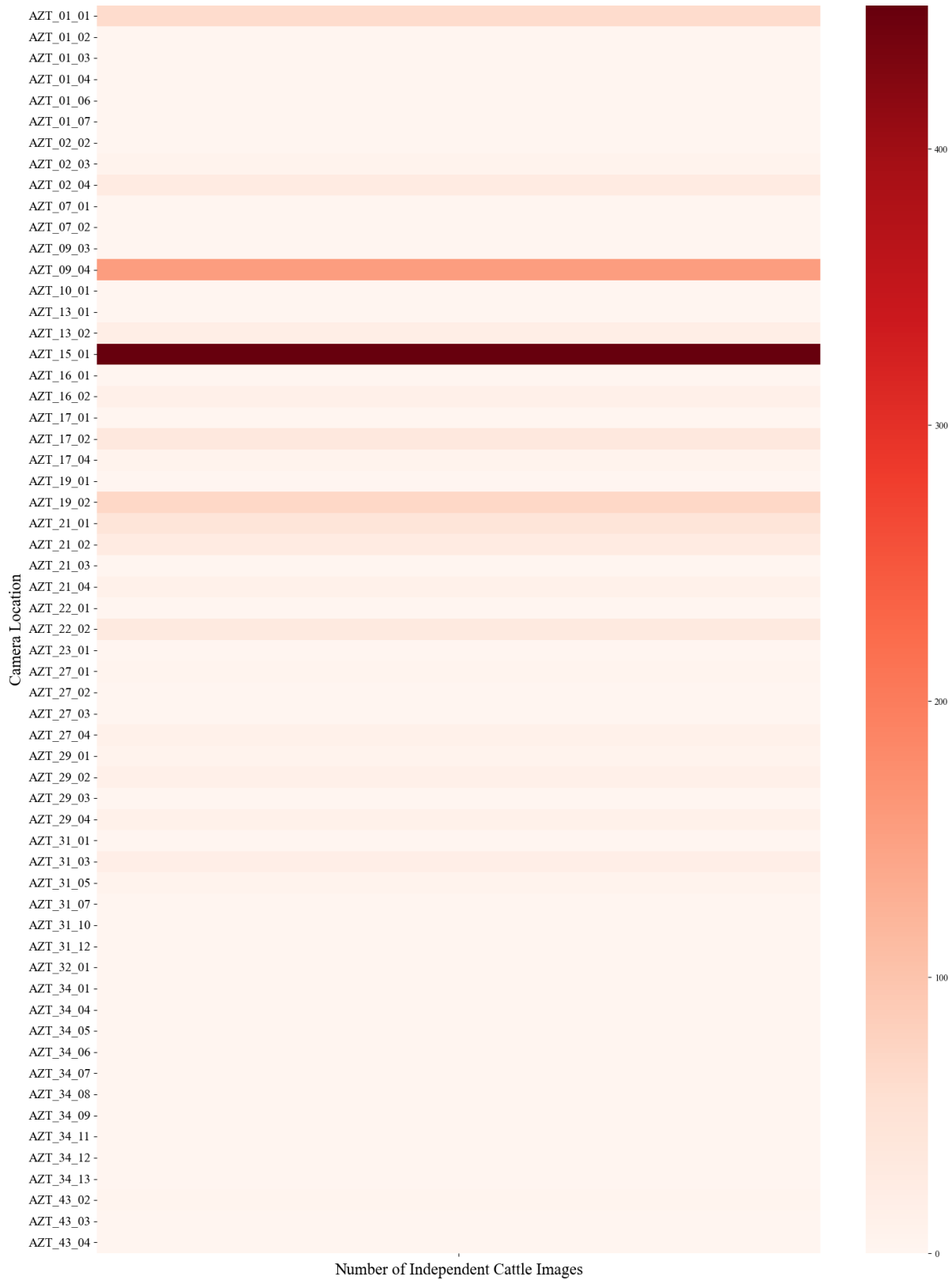
### 3.2.3 Cattle Activity

The presence of cattle on or near natural trails can affect both the experience of human users and the surrounding ecosystem. Cattle may damage the trail, surrounding vegetation, and leave manure, which can be unpleasant for visitors (Fleischner, 1994). They can also transmit diseases such as *E. coli* to humans (*Hazards & Considerations – Explore the Arizona Trail*, n.d.), especially around the scarce water sources. In some cases, particularly when humans are in close proximity to cattle, injuries can occur due to aggressive behavior (Fraser-Williams et al., 2016). While such incidents are relatively rare, it is still important to be aware of the presence of cattle in order to prepare for emergencies and consider appropriate actions, such as notifying visitors. This is especially important for those traveling with pets, as they need to ensure the safety of both their animals and themselves.

The heatmap in Figure 20 shows where cattle were detected by camera traps on the AZNST. Darker red areas indicate higher numbers of detections. One site, AZT\_15\_01, stands out with by far the greatest number of cattle images, suggesting it lies within or near a heavily grazed area. Other sites, such as AZT\_09\_04 and AZT\_13\_02, also recorded notable cattle activity, though at lower levels. By contrast, many cameras, especially those in higher-numbered passages like AZT\_34 and AZT\_43, recorded few or no cattle, reflecting either locations outside grazing zones or areas less accessible to livestock. These patterns provide useful insight into where cattle overlap with recreational use and wildlife habitats, helping inform decisions on trail management, habitat protection, and land-use practices.



**Figure 20:** *The Heatmap of the Frequency of Cattle across AZNST per Camera Trap*





**Picture 7:** *Picture of a cow, Saddle Mountain, Passage 22, Arizona Trail, 2018*



Table 5 highlights clear differences in how people, dogs, and cattle use different sections of the Arizona Trail. AZT\_34\_04 emerged as the busiest site, with 2,468 hikers, 1,005 bikers, and an impressive 296 dog detections, making it the most heavily used location overall. Cattle presence was generally low across most sites, but AZT\_15\_01 stood out with 452 detections, suggesting heavy grazing in that area. AZT\_13\_01 also saw high use, with over 1,000 hikers, more than 1,800 bikers, and the highest number of horseback riders (34), reflecting a mix of recreational activities. In contrast, sites like AZT\_34\_07 and AZT\_31\_04 showed very little activity of any kind.



**Table 5: Variation in Human and Domestic Animal Activity across Camera Sites on the AZNST**

Camera Number	Hiker	Biker	Horseback Rider	Cattle	Dog
AZT_01_01	616	59	10	63	34
AZT_01_02	1110	0	1	0	19
AZT_01_03	1364	0	2	0	36
AZT_01_04	1281	0	2	0	46
AZT_01_06	468	0	1	0	17
AZT_01_07	713	0	2	0	6
AZT_02_02	421	87	11	0	22
AZT_02_03	103	0	1	6	22
AZT_02_04	868	120	10	27	141
AZT_07_01	200	57	0	0	22
AZT_07_02	524	295	8	0	30
AZT_09_03	359	0	6	0	4
AZT_09_04	485	225	0	155	15
AZT_10_01	1137	1775	0	0	197
AZT_13_01	1001	1808	34	0	34
AZT_13_02	50	10	1	21	4
AZT_15_01	420	126	9	452	13
AZT_16_01	498	200	27	0	29
AZT_16_02	399	105	8	13	10
AZT_16_03	4	0	0	10	0
AZT_16_04	3	1	0	0	0
AZT_17_01	235	163	19	0	6
AZT_17_02	494	576	28	34	14
AZT_17_04	252	142	4	6	9
AZT_19_01	821	1	4	1	52
AZT_19_02	338	1	12	69	38
AZT_21_01	100	4	6	44	7
AZT_21_02	513	31	43	28	27
AZT_21_03	211	33	4	0	10
AZT_21_04	346	21	29	12	41
AZT_22_01	144	2	4	0	5
AZT_22_02	458	12	48	31	25
AZT_23_01	19	3	5	0	0
AZT_27_01	142	21	1	4	26
AZT_27_02	89	23	0	0	24
AZT_27_03	565	68	5	0	97
AZT_27_04	228	3	3	12	43
AZT_29_01	9	1	0	6	4
AZT_29_02	297	47	6	13	19



AZT_29_03	315	50	4	1	17
AZT_29_04	311	44	8	12	22
AZT_31_01	168	330	0	0	60
AZT_31_03	259	119	0	18	60
AZT_31_04	2	2	0	0	0
AZT_31_05	110	168	3	6	26
AZT_31_07	244	44	2	0	67
AZT_31_08	32	13	1	0	7
AZT_31_09	38	56	4	0	14
AZT_31_10	109	184	9	0	41
AZT_31_12	328	86	2	0	91
AZT_31_13	104	163	6	22	30
AZT_32_01	46	63	0	0	21
AZT_34_01	1498	1105	26	0	242
AZT_34_03	12	4	2	0	1
AZT_34_04	2468	1005	20	0	296
AZT_34_05	712	455	5	0	106
AZT_34_06	679	620	3	0	137
AZT_34_07	10	2	0	0	3
AZT_34_08	169	59	2	0	47
AZT_34_09	48	12	1	1	21
AZT_34_10	4	1	0	1	3
AZT_34_11	1238	1702	17	1	192
AZT_34_12	448	294	8	0	80
AZT_34_13	128	12	1	1	4
AZT_43_02	157	9	0	4	2
AZT_43_03	194	9	0	0	5
AZT_43_04	109	20	0	1	4

### 3.2.4 Impacts of COVID-19

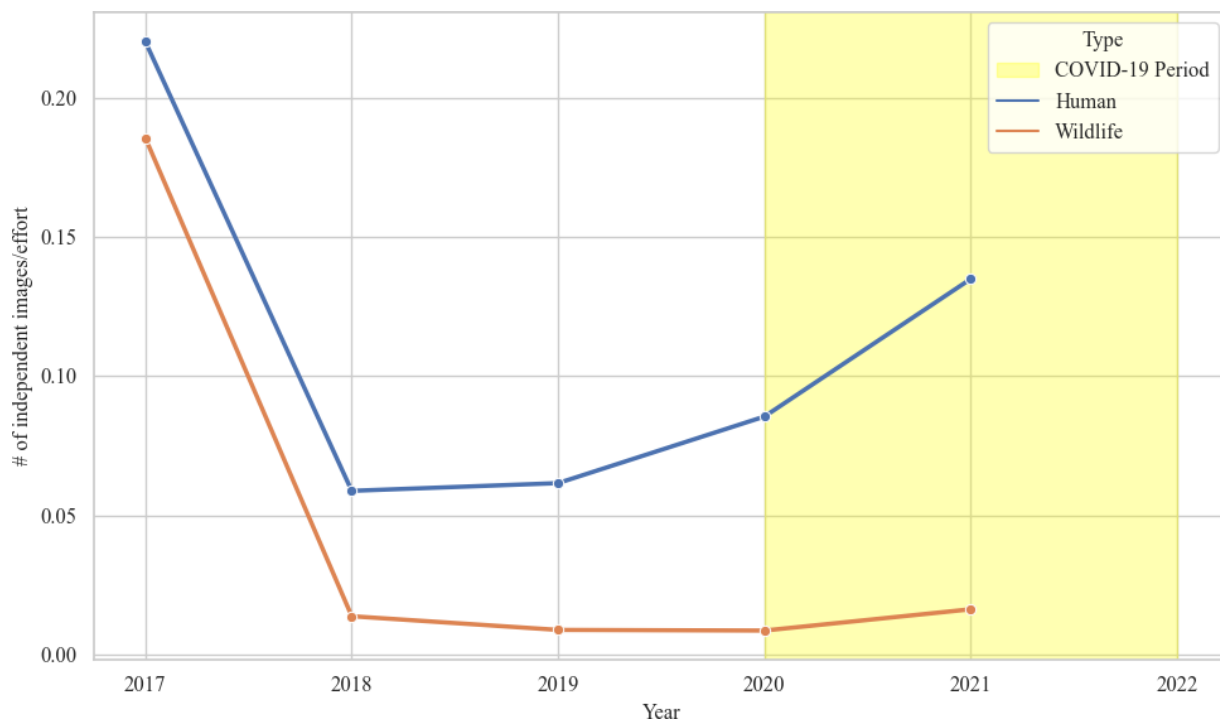
One of the most significant global events in recent years has been the COVID-19 pandemic. Given the extensive debate surrounding the pandemic’s impact on both wildlife presence and human use of outdoor spaces, it is valuable to examine patterns of wildlife and human activity along the AZNST during this period. The COVID-19 period is highlighted in yellow in Figure 20, spanning from 2020 to 2022. It is important to note, however, that the data presented are based solely on observations from camera traps, and variations in camera trap activity and placement may have influenced the number of detections. Pandemic-related restrictions led to less frequent maintenance and a reduced number of active cameras, which likely contributed to the lower number of recorded observations during this time. Specifically, in



2022 and 2023, active cameras were limited to Passage 1, with some devices malfunctioning in 2022.

To account for these limitations, Figure 21 presents the data as the number of independent images divided by the number of active cameras, providing a standardized measure of camera effort and offering a more realistic depiction of activity levels. According to the figure, human activity reached its peak in 2021. Wildlife activity showed a gradual increase from 2018 to 2020, then an increase from 2020 to 2021. Overall, in comparison to human activity, the presence of wildlife demonstrated relatively minor fluctuations throughout the observed period. In 2017, 2022, and 2023, a limited number of cameras were in the field, which makes the interpretation for 2023 difficult. As the number of locations was low in 2022 and 2023, we excluded them from this figure because it is not useful to see the impact of COVID-19 on species in these two years.

**Figure 21:** Comparison of Human and Wildlife Presence During and Outside the COVID-19 Pandemic across AZNST (COVID-19 Period is Highlighted in Yellow)





**Picture 8:** *Picture of a Puma, Huachuca Mountains, Passage 1, Arizona Trail, 2022*



**Picture 9:** *Picture of three juvenile Bobcats, Las Cienegas, Passage 7, Arizona Trail, 2019*



## 4. Suggestions and Implications

A great deal of effort has gone into managing the AZNST, with the dedication of staff and volunteers making it possible for visitors to enjoy the incredible natural landscapes. People using the trail, such as bird watchers, are often seeking out wildlife as part of their trail experience. People with pets, on the other hand, may also be trying to avoid conflict with certain species. Thus, understanding the wildlife communities along the trail can be beneficial for trail management and trail users. Ongoing monitoring and adjustments remain essential to ensure these lands continue to serve both as public spaces and as havens where wildlife can thrive.

### 4.1 Regular Monitoring

Regular evaluation of the trail ecosystems, through methods such as camera traps, acoustic monitoring, visitor feedback, remote sensing, or other techniques, can all help guide effective management. Based on our results, camera traps worked very well in documenting different human activities and species monitoring. It is crucial to set the cameras in the field simultaneously, which makes the analysis more accurate. Additionally, having cameras in places with different environmental factors, such as elevation, vegetation, and ruggedness, would provide valuable results.

Once areas for improvement or challenges are identified, a clear implementation plan should outline the resources needed. As actions are put into place, they should be adjusted based on visitor feedback and observed impacts on wildlife and vegetation. Continuous monitoring will be key to ensuring that desired outcomes are met, and documenting trends or emerging patterns will help track progress. The monitoring needs to focus on both wildlife and human aspects of the trail.

### 4.2 Balancing Visitation

Based on the data from this report, visitation tends to be lower in the summer and winter months. Adding shaded rest areas or water access points could make summer visits more comfortable, while seasonal events might encourage more use during less busy times (Parkami et al., 2026). Such strategies not only promote the therapeutic benefits of outdoor recreation but also help distribute visitor use more evenly across time. The local communities living near the passages represent an important audience, as they can enjoy the scenic beauty of the AZNST with the added benefits of proximity and cost-efficiency. Additionally, while certain months may be less appealing to some visitors due to the temperature (either cold or hot), they may still attract domestic or international visitors from regions with different climates.

It is equally important to understand the visitor experience in terms of crowding. For example, how many group encounters are typical in a single day? If numbers exceed acceptable levels, management actions will be needed. This will ensure that the current visitors are enjoying their time on the AZNST enough to revisit the same area.



It is essential to define acceptable levels of visitor impact on the trail system and surrounding areas. Continuous monitoring will help determine whether visitor numbers can be increased in certain places or should be limited to protect sensitive resources, and whether prohibitive measures or law enforcement are necessary to be put in place.

### **4.3 Wildlife Signage for Visitors**

Because several sensitive species inhabit the area, educational signage on trails where wildlife behavior has been detected could help foster greater awareness and balance between recreation and conservation. Similarly, since some trails that prohibit pets have still recorded dog activity, clearer communication about restrictions and the reasons behind them will be essential. However, this information can also be provided on other platforms, such as social media posts or different websites, where the trails or passages are promoted. This report also provided information on the various species that inhabit different parts of the trail, which can be incorporated into signage or other interpretive materials to inform visitors about the species they may encounter along the trail, both in terms of being prepared and also to enjoy and know what they see in the landscape. They can also learn what to expect if they encounter species such as pumas or bears, including how to behave respectfully toward the animal and how to safely manage the encounter. Not feeding wild animals and keeping a distance from them, and how to protect your personal food and belongings in the presence of certain species are examples of such educational messages. This information also needs to be tailored to the different types of recreational use on the trails. For instance, the guidance and considerations relevant to bikers may differ significantly from those for horseback riders or hikers.

### **4.4 Gateway Communities**

Gateway communities play a crucial role in supporting trail use (Bowker et al., 2007), not only by providing services to visitors but also as a source of potential visitors themselves. Combined with the seasonal effect, our work's results show that the gateway community population had a minor but significant positive impact on the number of hikers on the trail in the Fall (Parkami et al., 2026). Understanding their interactions with tourists can help reduce conflict and enhance the overall visitor experience. Based on their distance from the passages, the gateway community might also play a key role in the survival of wild species in their area. Some species may venture into nearby towns in search of food (Bateman & Fleming, 2012). It is important for the community to know what behaviors to expect and how to manage encounters in ways that are safe for both people and wildlife, while also preventing changes to the animals' natural behavior.

### **4.5 Future Studies**

The current project highlighted small- to large-sized mammals. However, many other species also inhabit the AZNST, including birds, amphibians, reptiles, and plants, which can be included in future research. There are many non-invasive monitoring techniques, like camera traps, that can detect species without disturbing trail users.



The impact of human presence on different species can reveal both positive and negative effects, including the potential introduction of invasive species. Such species may be introduced in various ways, such as through horse and cattle waste or from pets along the trail. Regular monitoring and research will therefore be essential to maintaining the natural balance of the area.

Future research could also examine the impacts of other types of recreation, such as horseback riding on trail vegetation, or the extent to which dogs disturb wildlife, including both predators and prey species like birds and mammals. While this report focused on three primary human activities (hikers, mountain bikers, and horseback riders), studying additional recreational activities would further expand our understanding. For future studies, it would be more helpful to do more consistent and standardized sampling, an increased number of passages, and a more balanced reach between gateway cameras and more remote sections.

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