IMPACT OF HUMAN ACTIVITY ON LARGE MAMMAL SPATIAL ECOLOGY IN HOMER, ALASKA

by

Adrienne Calistri-Yeh

A practicum submitted in partial fulfillment of the requirements
for the degree of Master of Science
University of Michigan, School for Environment and Sustainability
April 2024

Practicum Advisor: Dr. Neil Carter
Client Collaborator: Elizabeth Trowbridge

Table of Contents

Abstract

Protected areas are an important strategy to preserve wildlife habitat but can have varying levels of human management and recreation. This can impact animals, with wildlife within protected areas tending to avoid areas with high human presence. Therefore, protected areas that limit human activity may be more effective for wildlife conservation. This study aimed to analyze the impact of human activity on the spatial ecology of moose (*Alces alces*), coyote (*Canis latrans*), black bear (*Ursus americanus*), and Canadian lynx (*Lynx canadensis*), to determine if protected areas limiting people are beneficial for wildlife. Inspiration Ridge Preserve (IRP) and Wynn Nature Center (Wynn) are two wildlife preserves managed by the Center for Alaskan Coastal Studies in Homer, Alaska, with different access policies: IRP limits visitation to 30 people on the preserve per day, while Wynn is open to the public for hiking and recreation. Camera trap data was used to assess human and wildlife presence across the preserves. IRP had lower human impact and greater wildlife presence of all four species compared to Wynn. Wildlife also showed increased temporal avoidance of peak human activity at IRP compared to Wynn, which may indicate a lower level of habituation that could help decrease human-wildlife conflict. These results suggest that the 30-person policy at IRP may be beneficial for wildlife; decreased human impact was correlated with increased wildlife presence and potentially lower habituation to people. This policy can serve as a template for protected areas to reduce anthropogenic impact and most effectively support threatened wildlife populations.

Introduction

Human disruptions to natural habitat, including habitat loss, destruction, fragmentation, and degradation of quality, are a leading threat to biodiversity and the survival of wildlife species worldwide (Hanski, 2011). Animals utilize habitat for the resources they need to survive, reproduce, and persist; increasing land development and resource extraction force species into lower quality habitats that are less able to meet these needs, contributing to rapid population declines (Krausman, 1999; Scanes, 2018). Between 2001 and 2017, the contiguous United States lost over 24 million acres of natural land to human development (Theobald et al., 2019).

Protected areas are a key strategy to combat habitat loss and promote wildlife conservation (Mulongoy and Chape, 2004). Protected areas prevent habitat from being developed and are associated with increased species richness, diversity, and abundance for both total and threatened wildlife species (Chen et al., 2022; Evans et al., 2006; da Silva et al., 2018). However, human impacts still play a role in protected areas through varying levels of recreation and management (Geldmann et al., 2019; Mulongoy and Chape, 2004). This affects animals that utilize the habitat, with wildlife in protected areas tending to avoid building infrastructure, roads, property edges closer to external human settlements, and areas with the highest human presence (Baker and Leberg, 2018; Blom et al., 2004; Nickel et al., 2020). Human recreation (e.g. hiking, biking) in protected areas often overlaps spatially with high quality wildlife habitat, leading some species to modify their temporal activity to avoid times when human presence is highest (Lewis et al., 2021; Nickel et al., 2020). In some protected areas, intensity of recreation was negatively associated with wildlife habitat use, abundance, and native species richness (Procko et al., 2022; Reed and Merenlender, 2008).

To maintain the role of protected areas in promoting human recreation without compromising their purpose to conserve wildlife and biodiversity, some protected areas have introduced limits on human activity. The majority of implemented policies utilize the concept of a recreation carrying capacity based on vegetation and soil disturbances as a result of trampling (Monz et al., 2009; Sayan and Atik, 2011). Considerations for wildlife have also been made, with studies identifying thresholds for the distance of human encounter that negatively impacts animals, in order to inform recreation policies (Dertien et al., 2021; Malo et al., 2011). Fewer papers assessed quantitative thresholds for number of people (Dertien et al., 2021), although one study in Glacier Bay National Park, Alaska, found an approximate lower limit of 40 visitors per week that drastically reduced wildlife presence in remote backcountry areas (Sytsma et al., 2022). However, there is a lack of research assessing how wildlife is affected by actively implemented policies that limit the number of visitors per day in protected areas.

Research Objectives

The primary objective of this project is to determine if a policy limiting the number of people in a protected area has benefits to wildlife. Secondary objectives include assessing how the level of human presence affects spatial behavior and ecology of animals, as well as indirect impacts of human activity on wildlife.

Study Sites

Inspiration Ridge Preserve (IRP) and Wynn Nature Center (Wynn) are two properties in Homer, Alaska stewarded by the Center for Alaskan Coastal Studies (CACS) (Figure 1). Both sites are managed as wildlife preserves, protecting habitat from development and forming migration corridors for a variety of mammals, birds, and other taxa. While IRP and Wynn both welcome people to explore and connect with nature on the preserves, IRP has an additional protective policy limiting the number of visitors to 30 people per day. The policy is intended to minimize negative impacts on wildlife, but there has not been any research assessing if it meets this goal. This practicum project aims to provide data comparing wildlife distributions at IRP and Wynn to determine if the 30 person policy is beneficial.

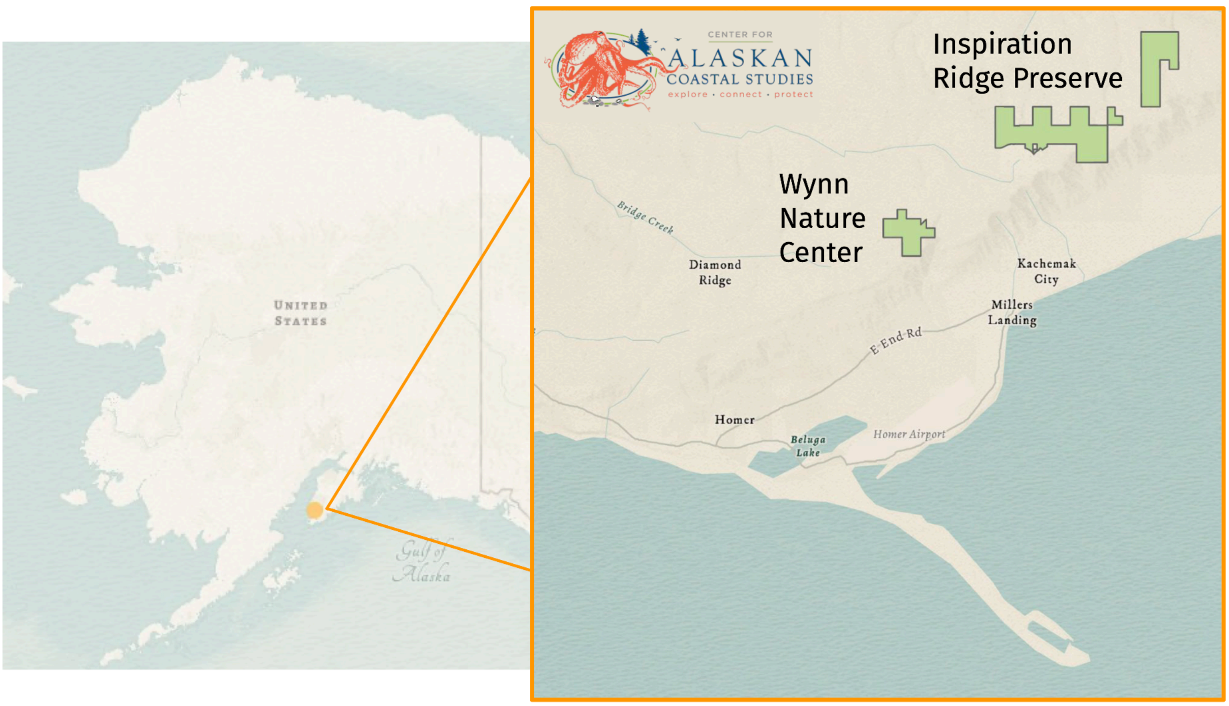


Figure 1: Map of study sites in Homer, Alaska: Inspiration Ridge Preserve (IRP) and Wynn Nature Center (Wynn).

IRP was founded by Nina Faust and Edgar Bailey in the 1990s and pieced together over decades as land parcels went up for sale. Now totaling 693 acres, the property spans critical wildlife habitat in the Fritz Creek watershed and protects the upper part of the ridge overlooking Homer. Wynn, located just 3 miles down Skyline Drive, consists of 140 acres on a former homestead that was donated to CACS by the Carl E. Wynn Foundation in 1990. Wynn is open to the public and features recreational infrastructure including a visitor center, boardwalk, and viewing platforms, with the majority of the property remaining undeveloped wildlife habitat.

Much of the land in Homer was settled by homesteaders throughout the 1900s, including several of the parcels that now make up IRP and Wynn. Prior to the homesteading period, these lands were stewarded for thousands of years by the Dena'ina Athabascan and Alutiiq/Sugpiaq people (Field and Walker, 2003). It is not possible to fully discuss the relationship between people and wildlife in Homer (Dena'ina: *Tuggeght*) without acknowledging and honoring the indigenous knowledge and presence that shaped this area in the past, present, and future. A large portion of the ecological information shared on tours of IRP and Wynn comes from traditional ecological knowledge passed down over generations of knowing the land. Athabascan cultures value respect and relationships with the environment and animals (Jones, 2009), which help to inform and inspire the protection of biodiversity in an increasingly developed world.

Study Species

The species of interest in this study were moose (*Alces alces;* Dena'ina: *dnigi*), coyote (*Canis latrans;* Dena'ina translation unknown), black bear (*Ursus americanus;* Dena'ina: *elt'eshi*), and Canadian lynx (*Lynx canadensis;* Dena'ina: *kazhna*) (Figure 2; Dena'ina translations from Kari, 1974). Large mammals were selected for this study due to their significance as the main top-down regulators in the Homer ecosystem, as well as their greater spatial needs making them more vulnerable to habitat loss (Fuller et al., 2016). Moose tend to be relatively tolerant of passive human presence or stimuli, while black bears and coyotes are moderately sensitive, and lynx species are most sensitive (Lewis et al., 2021; Silverberg et al., 2003).

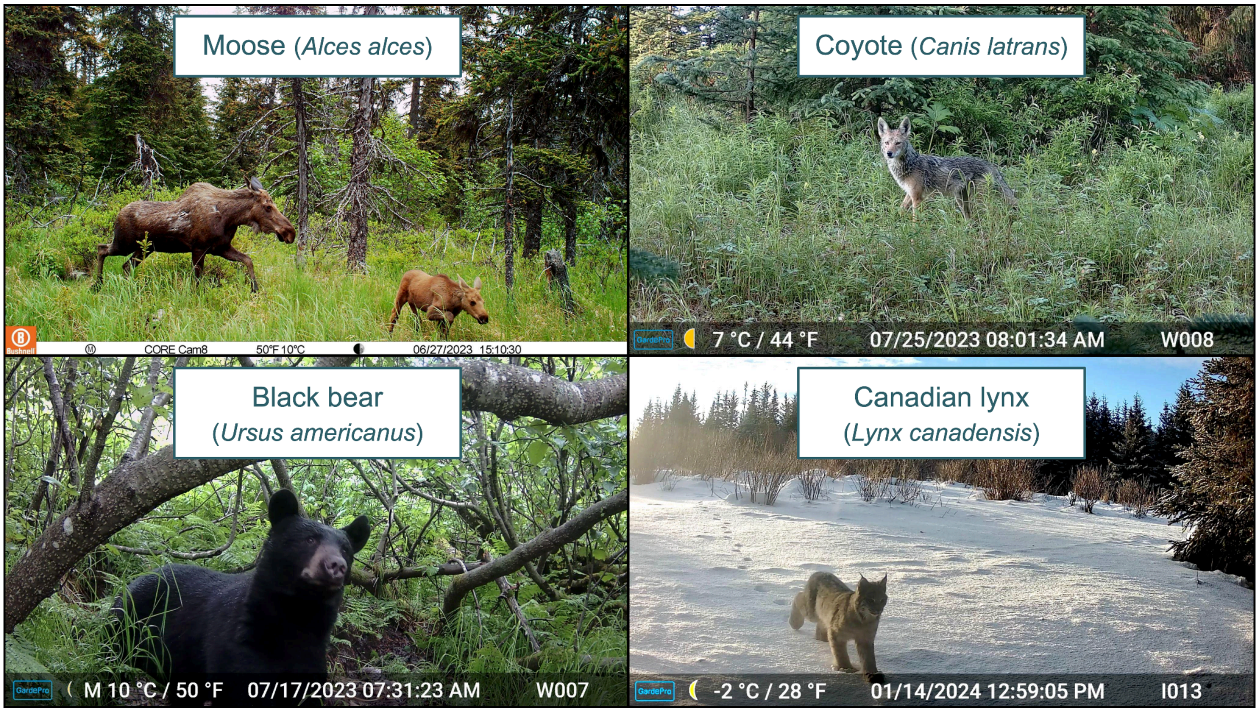


Figure 2: Species of interest: moose (*Alces alces*), coyote (*Canis latrans*), black bear (*Ursus americanus*), and Canadian lynx (*Lynx canadensis*).

Moose, coyote, black bear, and Canadian lynx all have natural home range sizes larger than the area of the study sites, with multiple individuals exhibiting overlapping territories (Andelt and Gipson, 1979; Hundertmark, 2007; Koehler and Pierce, 2003; Vashon et al., 2010). Therefore, it was not possible to distinguish or compare between individual animals for this study, and there were definitely repeats of the same individuals recorded. However, it is still valuable to see which locations animals prefer, even if they are not all unique individuals.

Methodology

Camera Trap Data

Large mammal distributions were assessed using camera trap data following the CACS Trail Camera Monitoring Protocol (Stein, 2023). Human and wildlife occurrences were recorded at 27 camera traps between May 2023 and February 2024 (Table 1). Of the total number of cameras, 17 were deployed at IRP and 10 at Wynn. Start and end dates refer to the temporal span of data used from each camera for analysis, with some cameras having additional gaps due to missing data or camera malfunction (see Figure 3 for survey effort visualization by camera).

Table 1: Camera names, locations, and dates of operation/data used.

Camera ID	Name	Latitude	Longitude	Start Date	End Date
IRP 1	Glacier View Trail	59.69899	-151.41329	5/1/23	1/23/24
IRP g1	Goose Pond	59.70100685	-151.40725625	5/1/23	1/23/24
IRP g2	Greenhouse/Lynx	59.70188121	-151.4107345	5/1/23	1/31/24
IRP g3	Cottonwood	59.70385067	-151.44062679	5/1/23	10/19/23
IRP 6	Gozzie Loop	59.70054635	-151.4050192	5/1/23	1/23/24
IRP 7	Knoll	59.69856	-151.40628	6/6/23	12/6/23
IRP 8	Bog	59.70202	-151.40514	6/6/23	1/23/24
IRP 9	Warbler's Way	59.70360	-151.41499	6/6/23	1/24/24
IRP 10	Nina's Arc Junction	59.70341	-151.42686	6/6/23	2/13/24
IRP 11	Property Boundary	59.70365	-151.41881	6/6/23	1/24/24
IRP 12	Chipper's Corner	59.7071756	-151.4212889	6/6/23	1/24/24

IRP 14	Tunturpak Trail	59.70418	-151.39677	6/7/23	1/24/24
IRP 15	Nina’s Arc	59.70726	-151.42909	6/6/23	1/23/24
IRP 16	Black Bear Ramble	59.70184	-151.4198	6/6/23	1/24/24
IRP 17	Moose Pond	59.70071	-151.42237	6/6/23	1/24/24
IRP 18	Chocolate Cabin	59.69952	-151.43053	6/6/23	2/13/24
IRP 19	Owl Loop	59.70639	-151.41213	6/7/23	2/13/24
Wynn 1	Lynx Link	59.68253765	-151.4712664	5/1/23	1/18/24
Wynn 3	Moose Meander	59.68387331	-151.4787168	5/1/23	12/12/23
Wynn 4	Bog	59.68602581	-151.4819454	5/1/23	12/12/23
Wynn 5	UM Bog	59.68692	-151.47896	6/5/23	1/17/24
Wynn 6	Fireweed Loop	59.68442	-151.48392	6/15/23	1/18/24
Wynn 7	Moose Carcass	59.6834707	-151.4857018	6/13/23	12/12/23
Wynn 8	Powerline	59.68332	-151.48250	6/5/23	1/31/24
Wynn 9	UM Moose Meander	59.67988	-151.47929	6/5/23	1/21/24
Wynn 10	Cottonwood	59.67953	-151.47413	6/7/23	2/11/24
Wynn 11	NorthWynn	59.68198	-151.47358	6/5/23	2/11/24

Note: Wynn cameras 1-4 were renumbered in this report to match the CACS 2024 Google Drive numbering. In datasets used for analysis (uploaded to Basecamp), the numbering followed: Wynn 1 Bog, Wynn 2 Moose Meander, Wynn 3 Lynx Link.

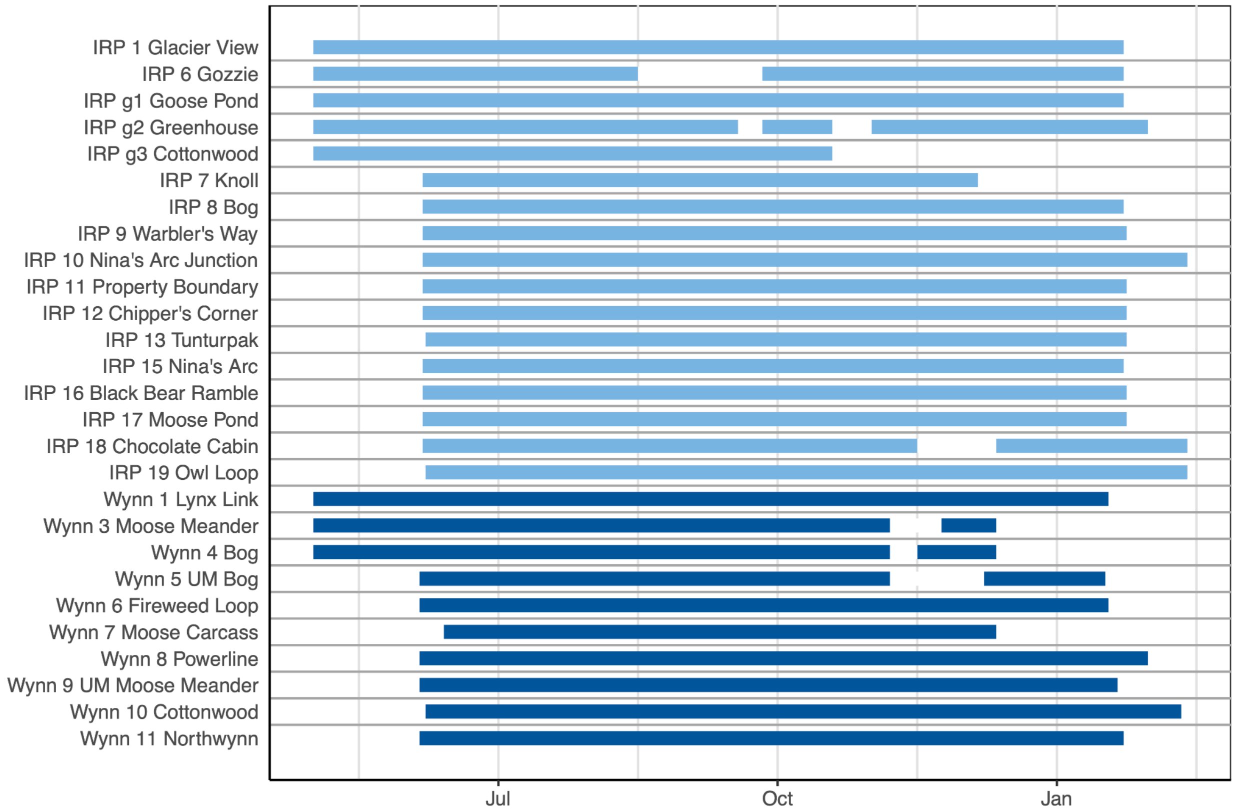


Figure 3: Dates of operation and data gaps for each camera.

In June 2023, 20 new cameras (IRP camera IDs 7-19; Wynn camera IDs 5-11) were implemented for this study to supplement CACS' existing trail cameras. New camera locations were selected loosely following a grid network, with considerations made for existing camera locations, signs of wildlife activity (e.g. scat, tracks), tree availability to mount equipment, and suggestions from local informants. Site selection was largely constrained to established hiking trails or connecting game trails due to dense vegetation making remote sections of the preserves inaccessible. All new cameras were originally Bushnell Core DS-4k models borrowed from the University of Michigan Conservation and Coexistence Lab, replaced in the same locations during the week of July 7, 2023 with GardePro A3S cameras donated by Nina Faust.

Cameras were checked at variable intervals, ranging from weekly to monthly depending on staff availability. Image files were uploaded to a database on Google Drive, as well as stored on an external CACS hard drive. For each photo and/or video containing an animal, data were recorded including date, time, species, number of individuals, and camera ID (providing location data). Some cameras experienced many false triggers (images were captured not containing any animal due to motion activation from wind, leaves, etc.), making manual processing of the folders difficult and time consuming. An AI-based photo filtering approach was trialed for some folders and successfully extracted images containing animals, eliminating the majority of false triggers (see Appendix A for suggested protocol).

Spatial analysis was conducted in ArcGIS Pro to calculate the distance from each camera to the nearest road, trail, building, water source, and preserve boundary (see Appendix B for full table of data). The dominant land cover type was also determined at each camera location using data from Kenai Peninsula Borough (Figures 4 and 5). For each species, standardized occurrence counts (per 30 days) were modeled in R, using a generalized linear model with a Poisson distribution to determine which variables were associated with species distributions (Beirne, 2022). For comparing overall occurrences between IRP and Wynn, a generalized linear model with a Poisson distribution was used following the formula “species_cam ~ Site”. In this model, species_cam represents the daily number of occurrences for a given species totaled across all cameras for the site (IRP or Wynn), divided by the camera density of the site. This method allowed for comparison between the sites while accounting for trapping effort as well as area. For this project, only the main section of IRP containing trails (Figure 4) was used for area measurements (464 acres/1.88 km^2), excluding the northeast portion of the preserve.

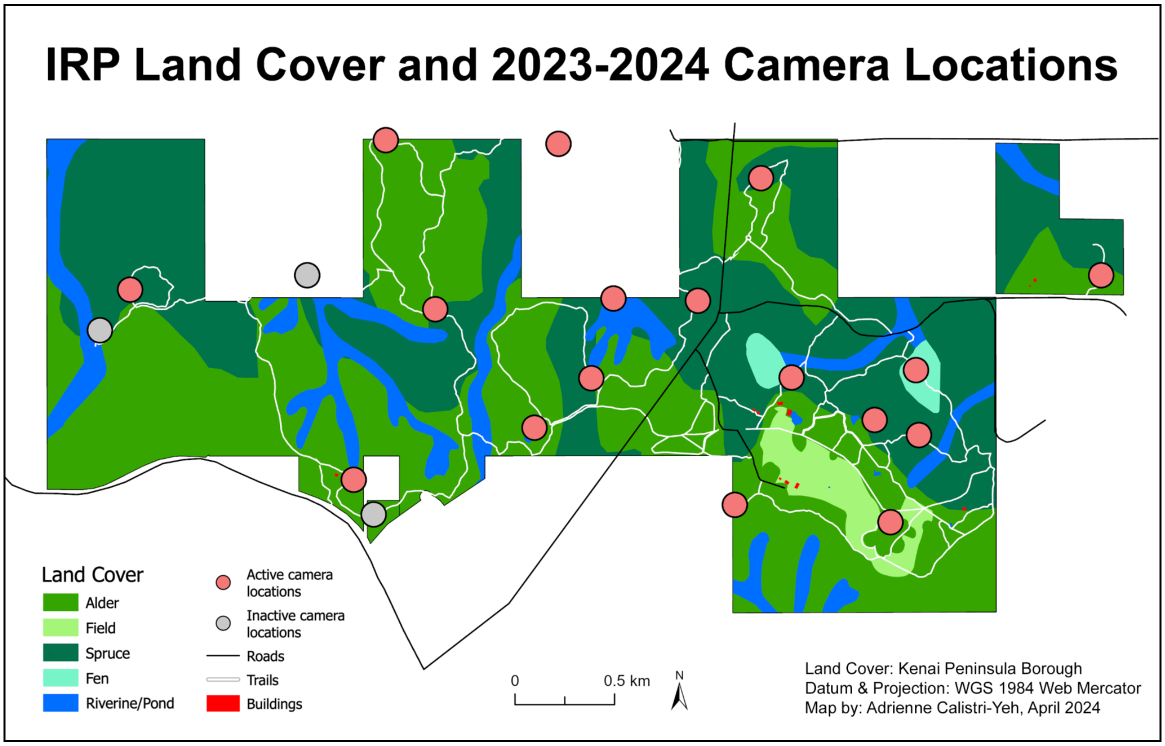


Figure 4: Site map and camera locations at Inspiration Ridge Preserve.

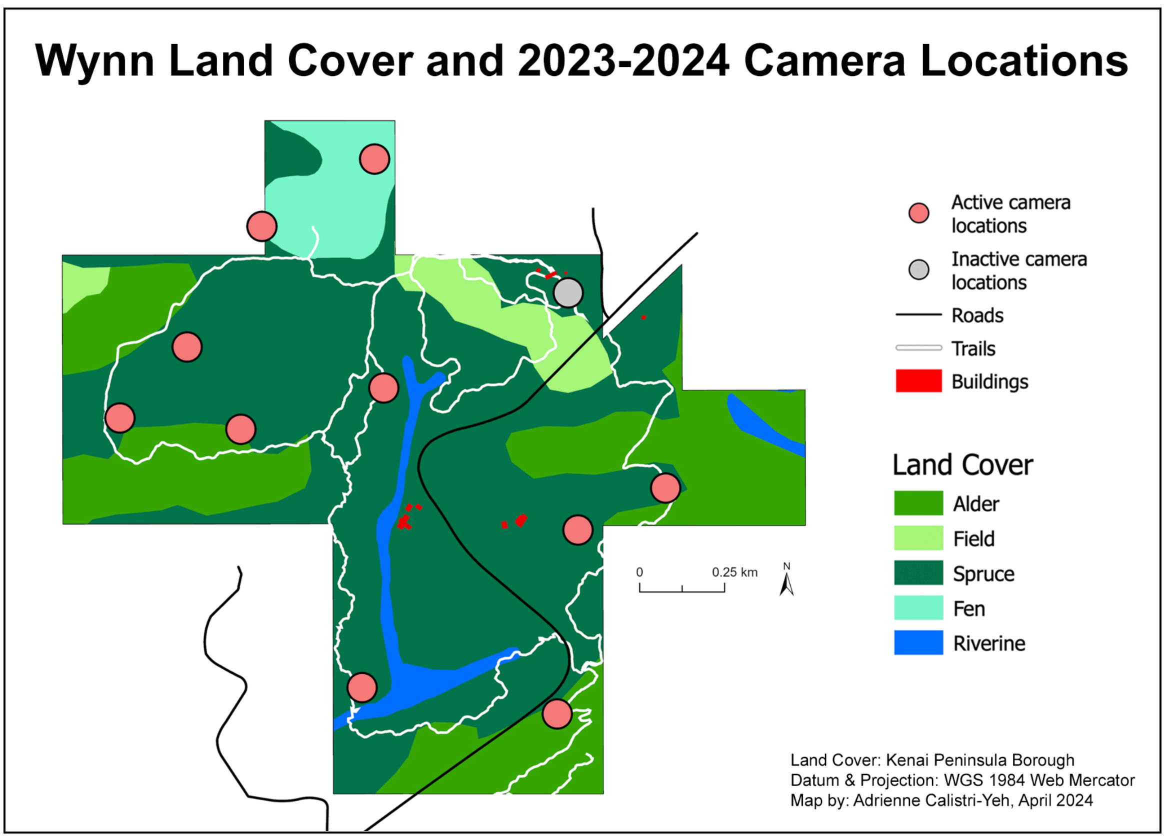


Figure 5: Site map and camera locations at Wynn Nature Center.

Soundscape Recordings

Soundscape recordings were taken using Song Meter SM4 acoustic recorders between June 29, 2023 and July 14, 2023, following the protocol outlined in the 2018 SEAS Capstone Report (Blongewicz et al., 2019). Recorders were set to record for five minutes every hour and remained at each location for 72 hours. Locations were selected from existing camera trap locations at IRP and Wynn based on recommendations from CACS staff, considering human trail usage and proximity to roads (Figures 6 and 7). Within each site, the five locations were randomly assigned to a 3-day date range for data collection to take place.

Figure 6: Map of camera locations used for soundscape recordings at Wynn and IRP.

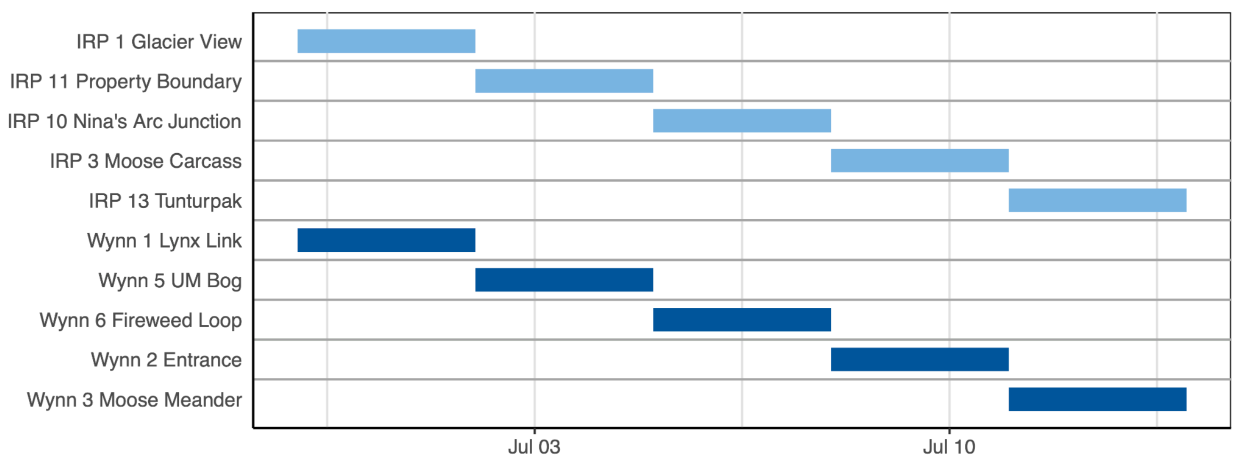


Figure 7: Dates of operation for soundscape recordings at each location.

Due to the vast quantity of data collected (3600 minutes of audio recording), a Python script was created to automatically process each recording and calculate the duration of anthropogenic noise detected (see Appendix C for code). This method provides an approximation that is significantly less accurate than processing recordings manually, but it is useful for large datasets and can be modified to select other frequencies of interest (e.g. birdsong).

Additional Data

Human impact was also assessed using the CACS official visitation records of total people per day during the summer season, as well as building/infrastructure footprints. Building footprints were mapped in ArcGIS Pro using manual polygon creation based on satellite world imagery.

Informal interviews were conducted throughout the summer with CACS staff, Homer residents, visitors to IRP and Wynn, tourists, and professionals working in the field of wildlife tourism. These interviews were opportunistic and did not follow a set script, but rather were intended to gain a more complete understanding of the relationship between humans and wildlife in Alaska, to provide additional context for this report. The notes from each interview were condensed and grouped with similar findings, forming a section of anecdotal evidence that provides supplemental qualitative findings for this study.

Results and Discussion

Human Impact at IRP and Wynn

Visitation Results

Human impact was analyzed between IRP and Wynn to determine the significance of IRP's 30-person policy. For example, if there were fewer than 30 visitors per day at Wynn, comparing the two sites would not reveal any insights to the policy's effect. Human occurrences were mapped at each camera trap location between May 2023 and February 2024 (Figure 8). However, not all cameras were located facing public trails to capture where people were hiking (3 of 10 cameras at Wynn and 11 of 17 cameras at IRP were on-trail, see Figure 8a), so the camera trap comparison does not fully represent the differences in human impact between the sites. An additional trail usage metric was included in Figure 8 to account for this. Approximate trail usage was extrapolated from cameras that were on-trail as well as known tour routes.

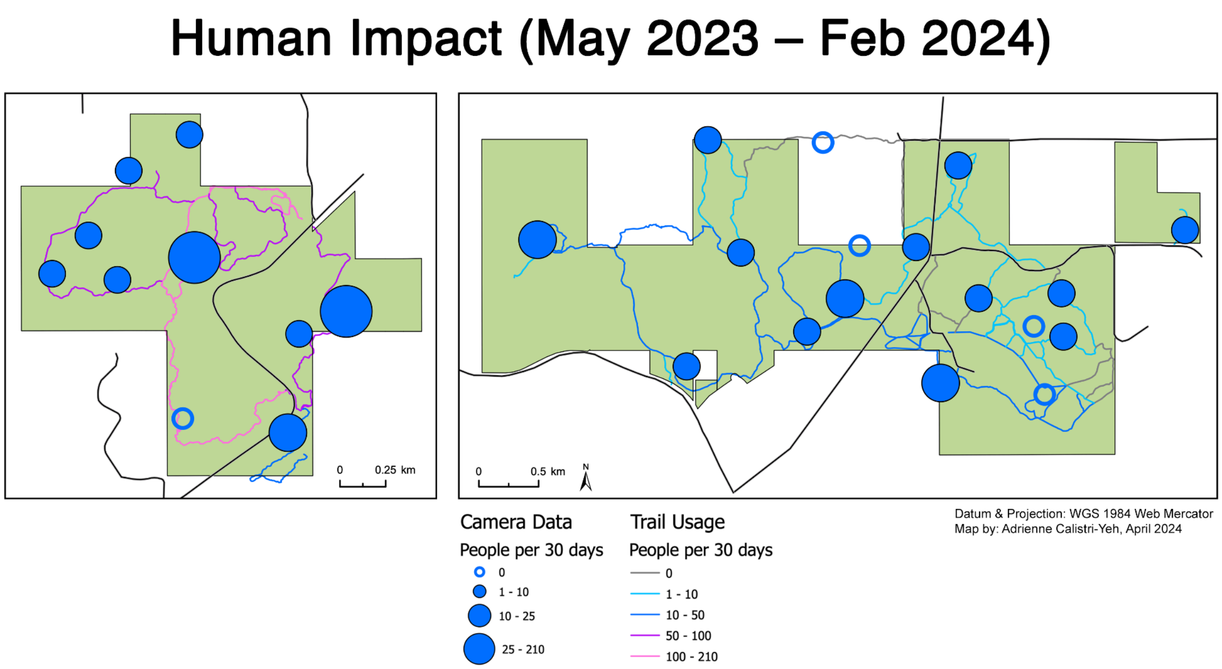


Figure 8: Human camera trap occurrences and trail usage at Wynn and IRP between May 2023 and February 2024.

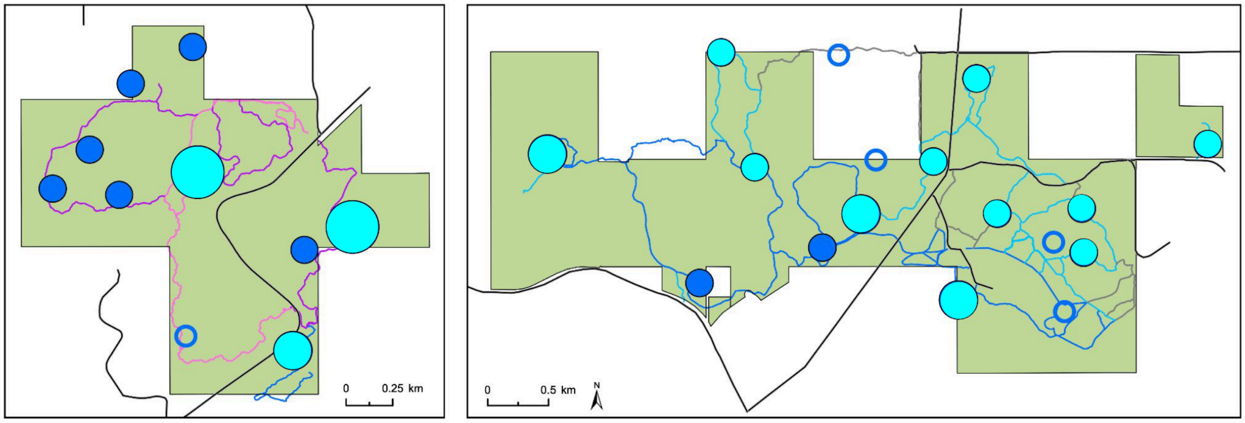


Figure 8a: Subset of camera trap locations (highlighted in turquoise) from Figure 8 that were located on hiking trails.

The trail usage comparison reveals higher human impact at Wynn, with 15-210 people per month compared to 0-25 people per month at IRP. These ranges were calculated by averaging over the course of the study period (May to February), including months in the fall and winter when tourism is much lower overall, so monthly visitation significantly exceeded these ranges for both sites during the summer season. From the CACS official visitation records, Wynn had a total of 3026 reported visitors from June 12 to September 4, 2023, compared to only 220 at IRP.

Based on daily visitation records, Wynn had much higher numbers of people per day, with consistently more than 30 people per day (Figure 9). Visitation records are only kept during the summer season, so camera trap occurrences were compared with the reported number of people to determine if they also capture this difference between Wynn and IRP (Figure 9). Wynn camera trap occurrences were lower than the reported visitation due to only three cameras on-trail, but generally follow the same trends. The primary exception is the drop in camera occurrences between July 5 and July 11, which coincided with a likely gap in data from the Moose Meander camera (Wynn 3). For IRP, the camera occurrences overestimated visitation due to common hiking routes passing by multiple cameras, resulting in people being counted more than once. A notable example of this is June 28, where 9 members of the board of directors were hiking on the property and passed by several cameras, significantly inflating the total number for that day.

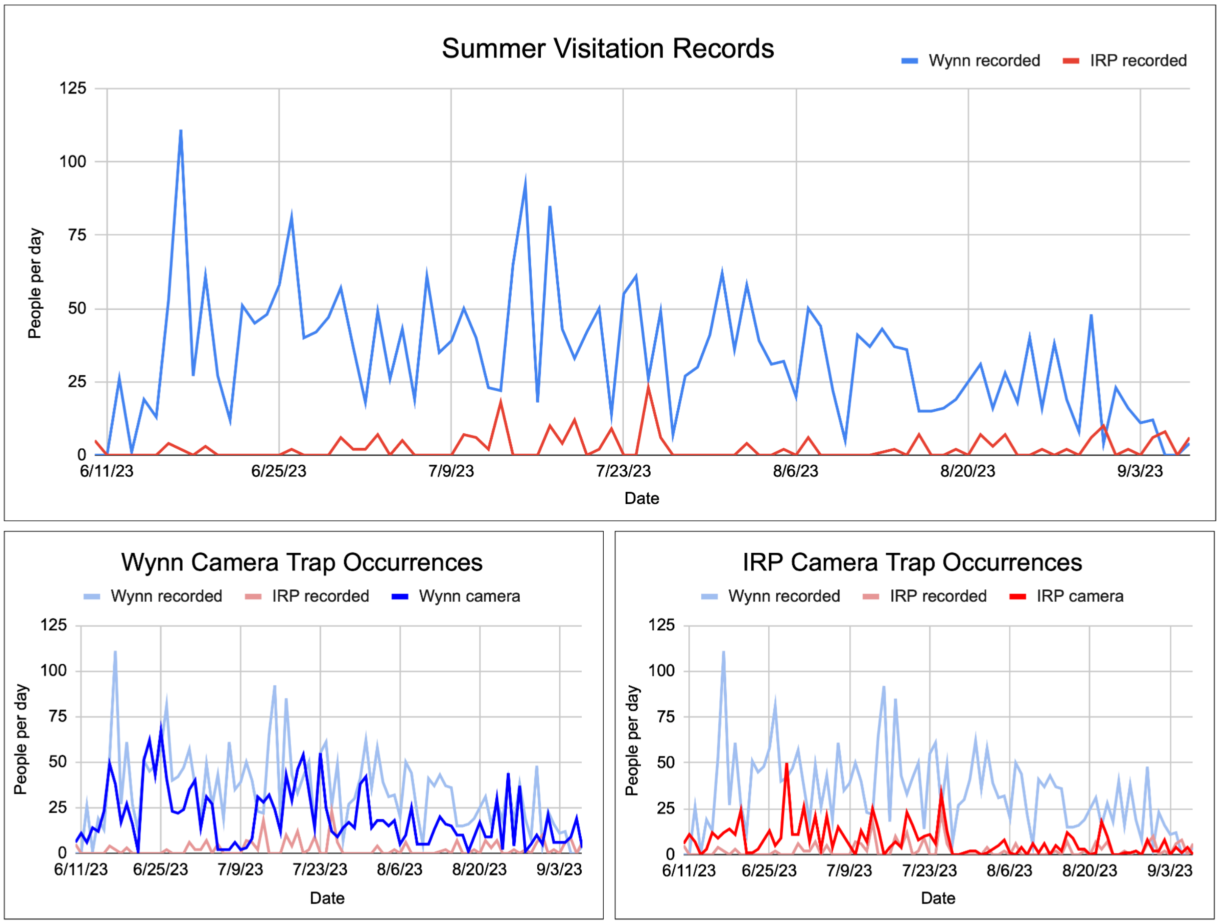


Figure 9: CACS visitation records compared with human camera trap occurrences during the summer season.

Overall, the camera trap occurrences did reflect patterns in visitation and the higher numbers at Wynn than IRP during the summer season. Therefore, despite discrepancies in the on-trail camera percentages, camera trap data was used to compare human impact over the full study period (May through February). In this analysis, Wynn had significantly more people per day (normalized by camera density) than IRP ($p = 0.000375$).

Soundscape Results

Soundscape recorders were used to assess anthropogenic noise pollution across IRP and Wynn, as an indirect form of human impact. Selections extracted from soundscape recordings represented low frequency vehicle or equipment noise, rather than human voices. Comparing the average amount of anthropogenic noise detected per 5-minute recording, Wynn had significantly longer anthropogenic noise duration ($p = 0.0273$). Surprisingly, there was a significant positive relationship between noise duration and distance to road ($p < 0.005$), indicating that there was more anthropogenic noise further from the roads. This is counter to the expected relationship because road noise would intuitively be picked up more at locations closer to roads. However, airplanes represent an important form of transportation in Alaska, and the Homer Airport and Beluga Lake seaplane base are both located within a 20 minute drive of Wynn and IRP.

One of the most common flights is the Anchorage to Homer route (ANC-HOM), which has 5-9 roundtrip flights per day. This flight path passes directly over a portion of IRP and in close proximity to Wynn (Figure 10), meaning that it could provide a significant source of anthropogenic noise to the preserves. When the distance to the ANC-HOM flight path was included in the soundscape model, it has a negative relationship with noise duration ($p = 0.0674$), indicating more anthropogenic noise closer to the flight path. Although this does not fully account for the unexpected positive relationship between noise duration and distance to road, it is important to note the relatively small sample size of sites tested, as well as the numerous other flights that may pass over other parts of the preserves every day. Overall, these results suggest that plane noise has a greater impact than road noise at IRP and Wynn, with Wynn having more anthropogenic noise pollution than IRP as a whole.

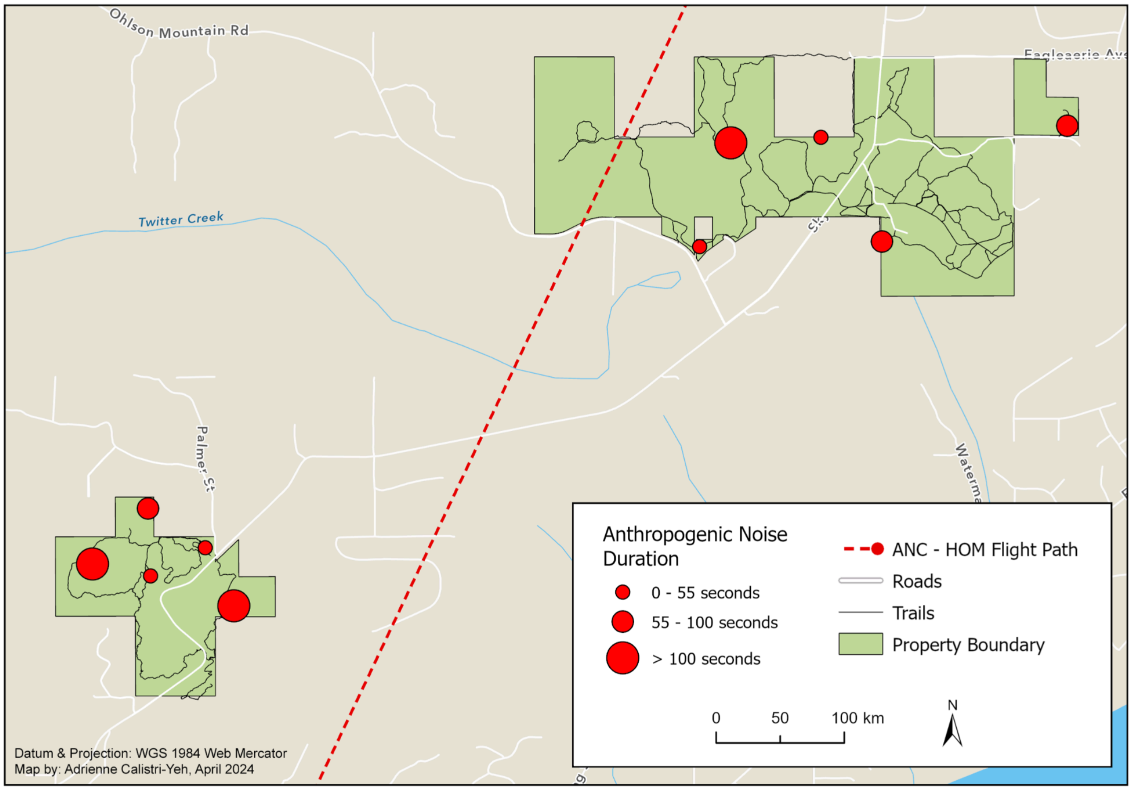


Figure 10: Summer 2023 soundscape results.

Building Footprint

The total building footprint at Wynn was 944.5 m^2, making up 0.16% of the property area. At IRP, the building footprint was 874.5 m^2, making up 0.03% of the property area. Both the overall footprint and percentage of the total preserve occupied by buildings were higher at Wynn, reflecting its greater needs for recreational infrastructure.

Building footprint and anthropogenic noise are both indirect sources of human impact that are unrelated to IRP's 30-person policy. However, they could still be associated with differences in wildlife distribution that are observed between the two sites, and therefore are valuable to consider in the overall assessment of the policy.

Wildlife Activity at IRP and Wynn

Overview of Wildlife Activity

A total of 6131 images were captured across all camera traps between May 1, 2023 and February 13, 2024 (Figure 11). The study species made up 39.4% of the images, with humans making up an additional 31.7%. These percentages refer to the total number of times a camera was set off, not accounting for the number of individuals in each image or consecutive images that were taken of the same individual(s). Of the species not included in analysis (shown in grey in Figure 11), snowshoe hare was the most prevalent, with multiple cameras seemingly located near hare homes. The “other mammal” category included brown bear, domestic cat, porcupine, and wolf, and the “bird” category included grey jay, grouse, magpie, raven, robin, and sandhill crane.

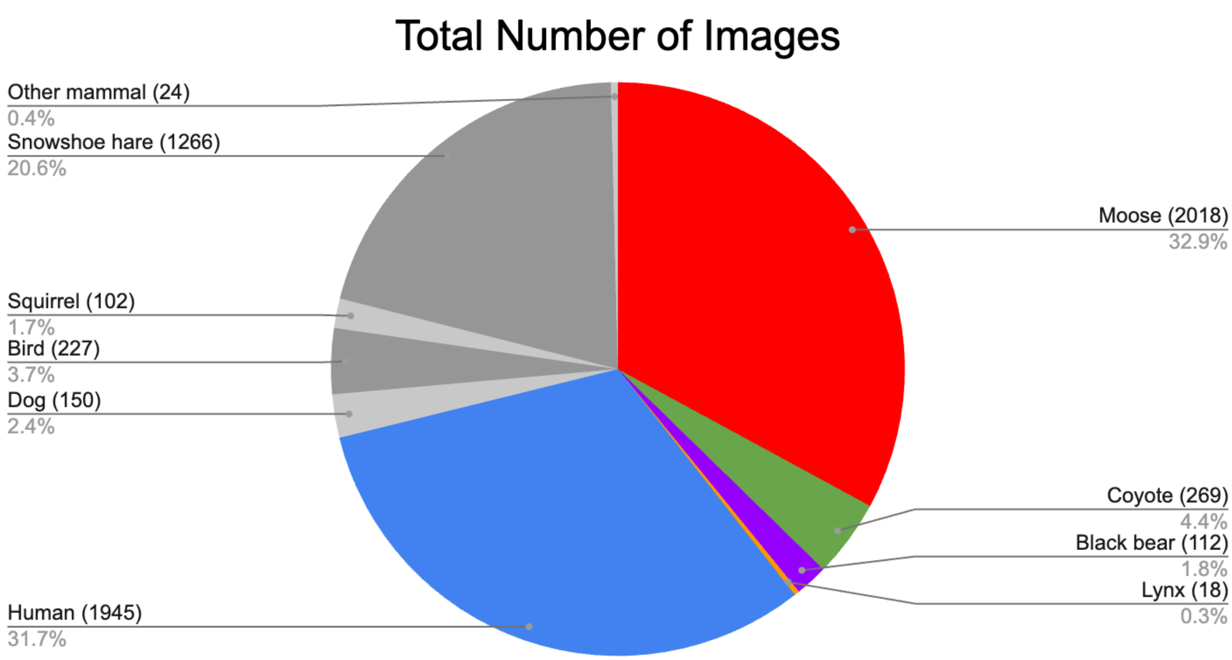


Figure 11: Species distribution of images captured across all camera traps from May 2023 to February 2024.

The total number of individuals for each site across the study period are displayed in Table 2. Moose were the most common large mammal species captured by the camera traps at both sites, followed by coyote, black bear, and lynx. There were more of all four animal species at IRP, along with fewer people.

Table 2: Total number of each species recorded on camera traps between IRP and Wynn.

Species	**IRP Total**	**Wynn Total**
Moose	836	596
Coyote	129	94
Black bear	44	31
Lynx	16	1
Human	790	2219

In order to statistically compare between the two sites, the daily occurrences of each species of interest were normalized by camera density. There were more moose, coyote, black bear, and lynx on average at IRP, while Wynn had more human occurrences (Figure 12). The sample sizes of total occurrences for bear and lynx were quite small (Table 2), so these differences were not significant ($p = 0.32$ for bear, $p = 0.4$ for lynx). The difference for coyote was marginally non-significant ($p = 0.0527$), and moose and human showed significant differences between IRP and Wynn ($p < 0.005$ for both). With a larger, long-term dataset, it is likely that this analysis would yield significant differences for more of the species.

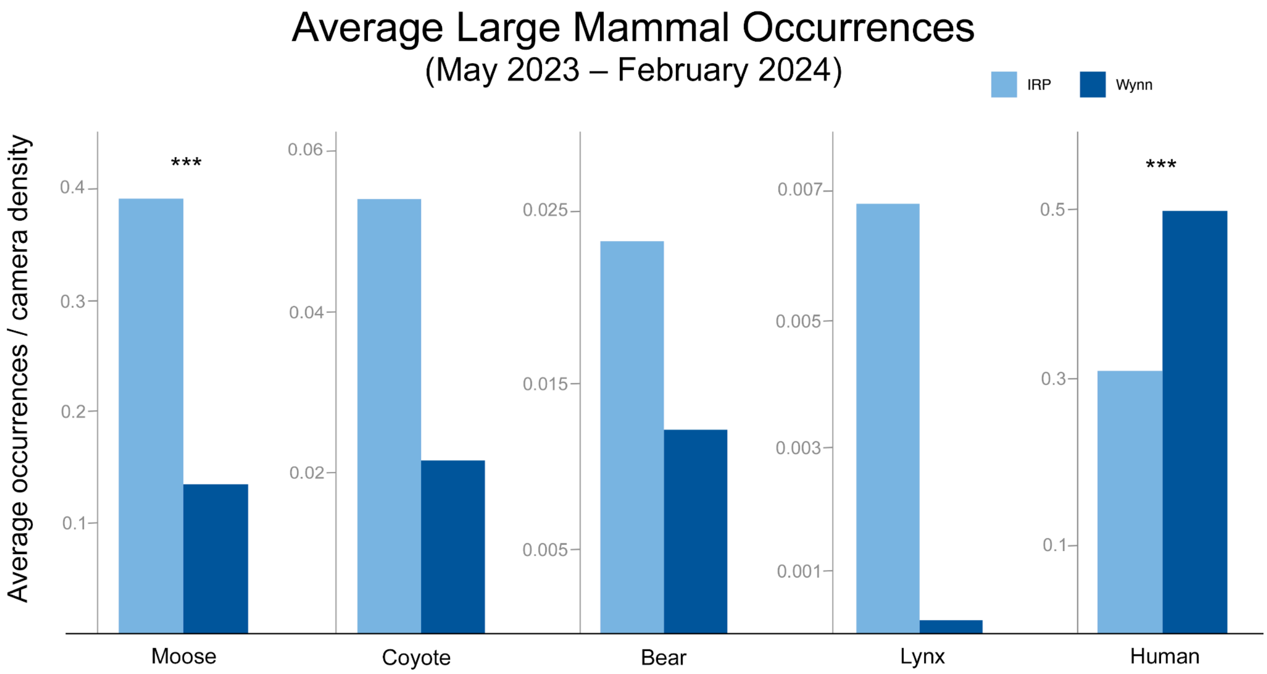


Figure 12: Average large mammal occurrences (normalized by camera density) per day between IRP and Wynn (*** indicates statistical significance with $p < 0.005$).

Modeling Species Distributions

Forest plots were used to display the coefficients for each variable used in the generalized linear model for species distribution (Figures 13 and 14). These models were used to determine if any environmental or human-related variables were associated with locations preferred with each species, across both IRP and Wynn. Lynx were not included in this analysis because the sample size was too small, and distance to building was removed because it correlated with distance to road and did not show a significant relationship with any of the species distributions.

There was substantial variation between species and variables, and the majority of predictors were not significantly associated with animal distribution, however some interesting trends can still be observed. Coyote and bear both tended to occur in locations further from water sources ($p = 0.004$ for coyote), closer to trails, and further from roads. Coyote and moose were more common further inside the property boundaries (p = 0.025 for moose). In other study systems, human-related pressures within protected areas (distance to infrastructure, trails, roads, and boundaries) also yielded varying effects among mammals, with some species using trails and roads as movement corridors, and most large mammals tending to avoid tourism infrastructure and preserve edges (Baker and Leberg, 2018; da Silva et al., 2018; Nickel et al., 2020).

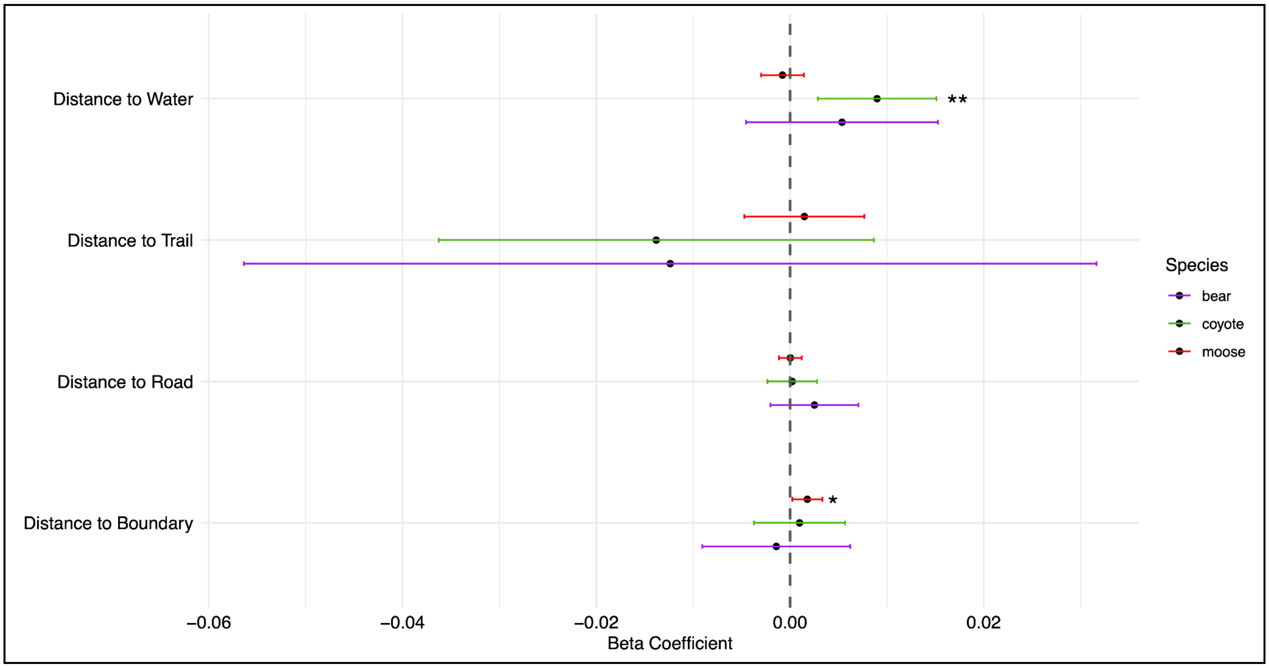


Figure 13: Forest plots showing means and confidence intervals of coefficients for continuous predictors of bear, coyote, and moose distribution (** indicates statistical significance with $p < 0.01$, * indicates statistical significance with $p < 0.05$).

For the categorical variables (Figure 14), medium and low trail use were compared against camera locations with high human trail use. Coyote and moose tended to prefer locations with low human trail use (p = 0.054 for moose), aligning with previous results for large mammals (Zhou et al., 2013), but surprisingly bears did not. Land cover was compared against alder; both moose and coyote tended to prefer alder to spruce, while bears did not. All three species utilized fen more than alder (p = 0.001 for moose), demonstrating that this is an important habitat to protect. IRP and Wynn both feature relatively large fens, so it is great that these ecosystems are being preserved.

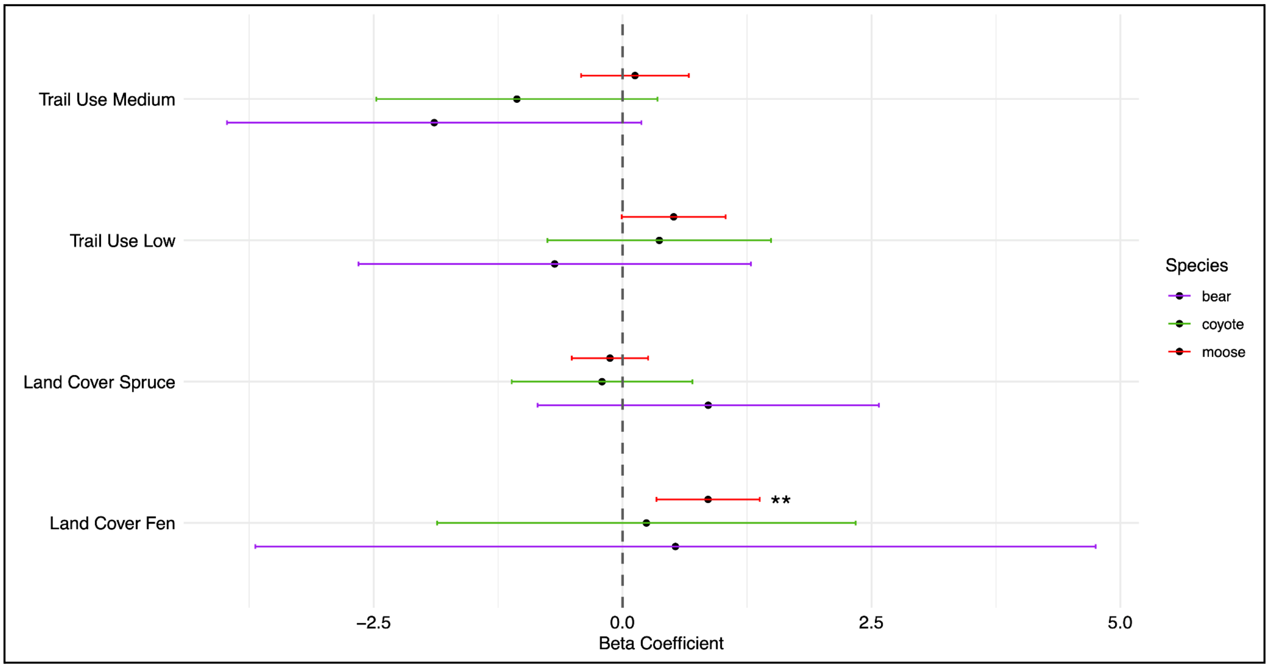


Figure 14: Forest plots showing means and confidence intervals of coefficients for categorical predictors of bear, coyote, and moose distribution (** indicates statistical significance with $p < 0.01$).

Mapping Species Distributions

To form a more complete picture of the spatial behavior of each species, the distributions were mapped across the camera locations over the duration of the study (Figures 15-18). These maps show variability between cameras that was not fully captured by the models. For example, Goose Pond (IRP g1) and Gozzie Loop (IRP 6) are in close proximity and had similar values for the variables included in the model, but differed in occurrences per 30 days for all four species.

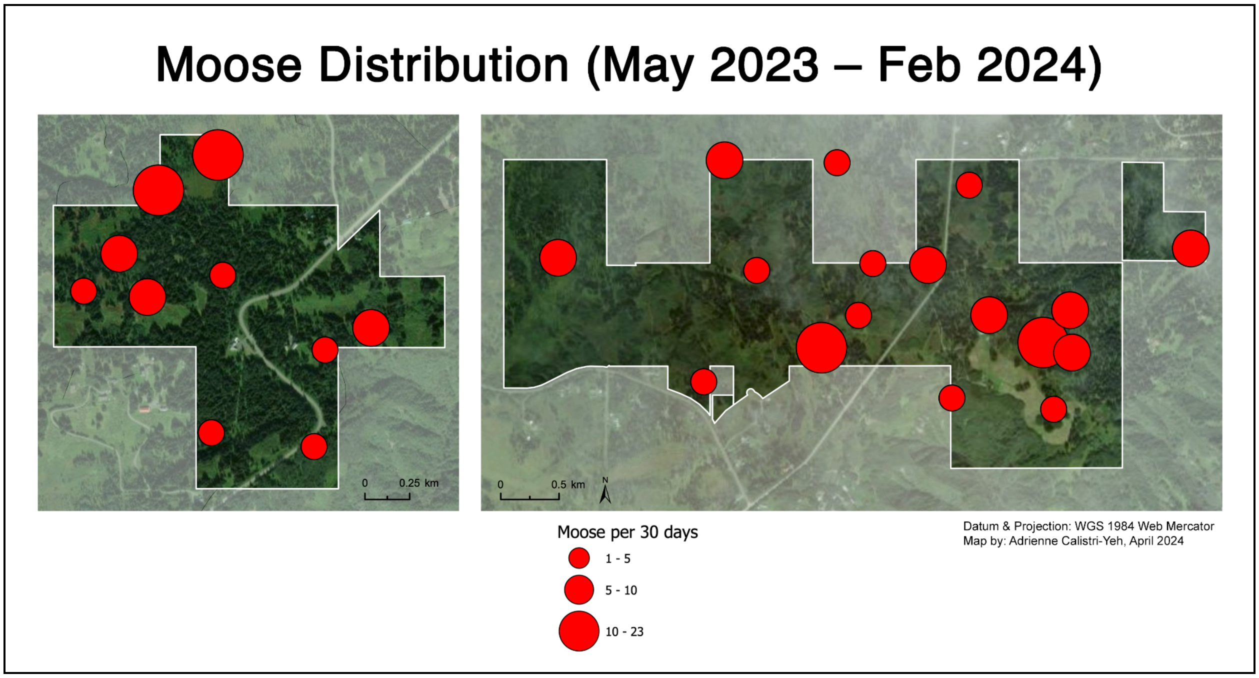


Figure 15: Moose distribution at Wynn and IRP between May 2023 and February 2024.

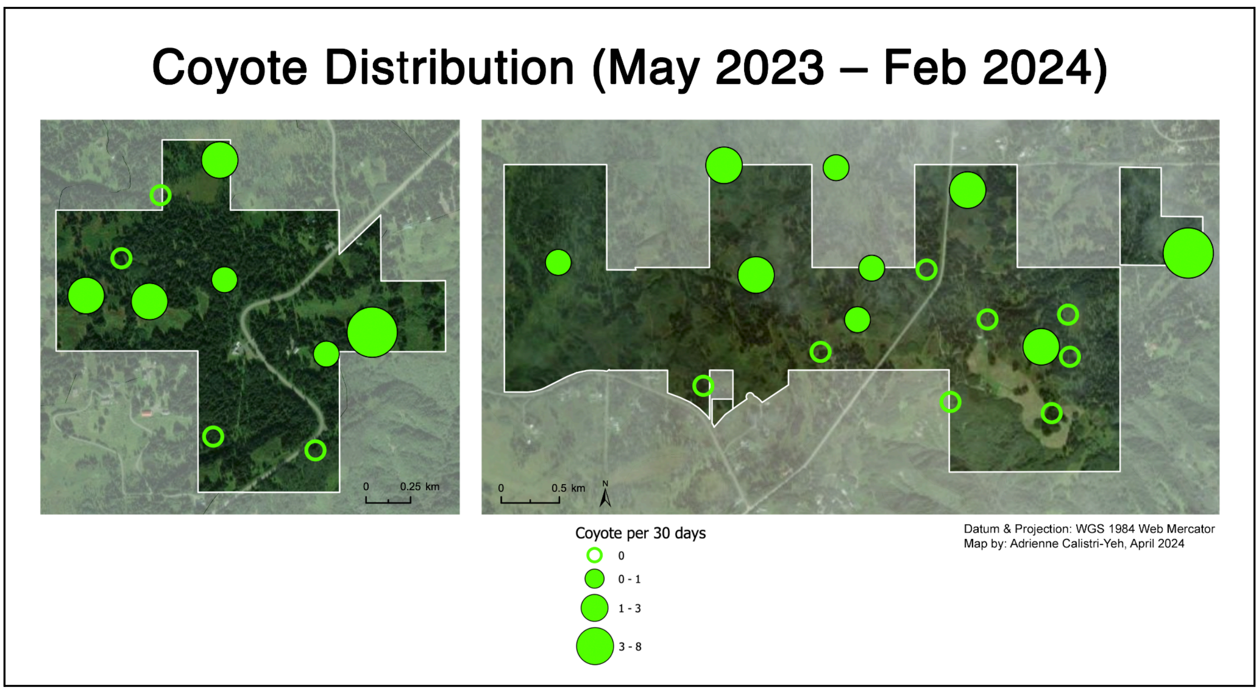


Figure 16: Coyote distribution at Wynn and IRP between May 2023 and February 2024.

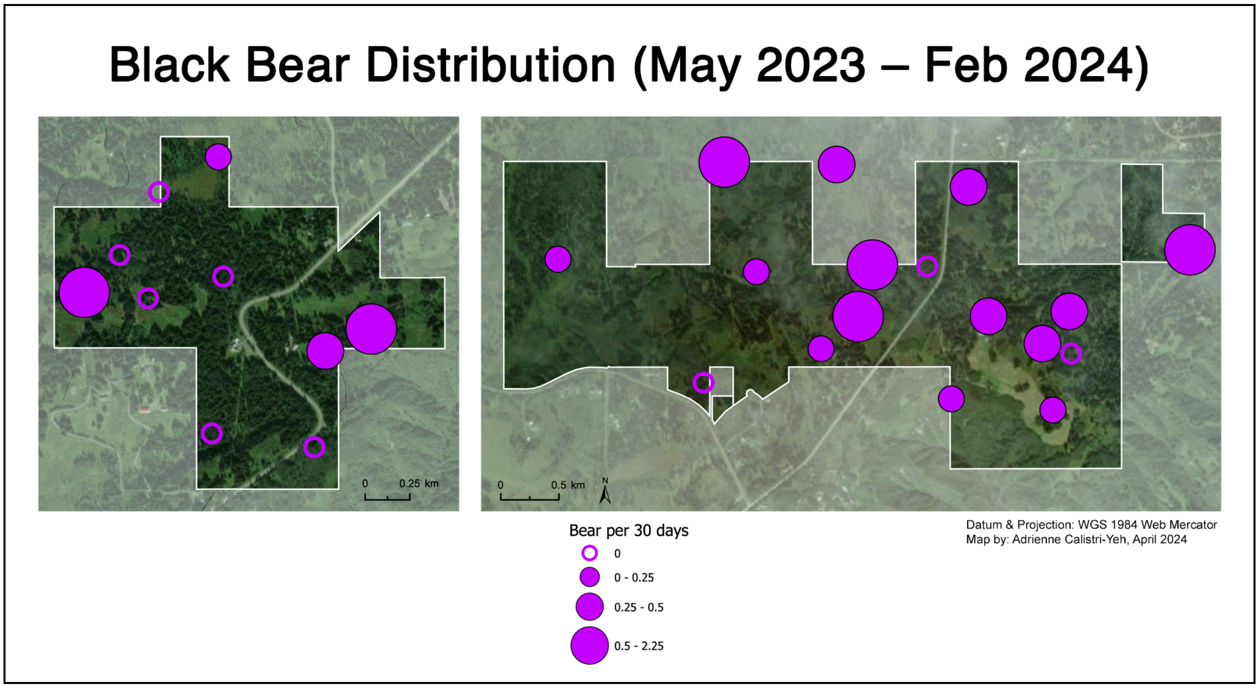


Figure 17: Black bear distribution at Wynn and IRP between May 2023 and February 2024.

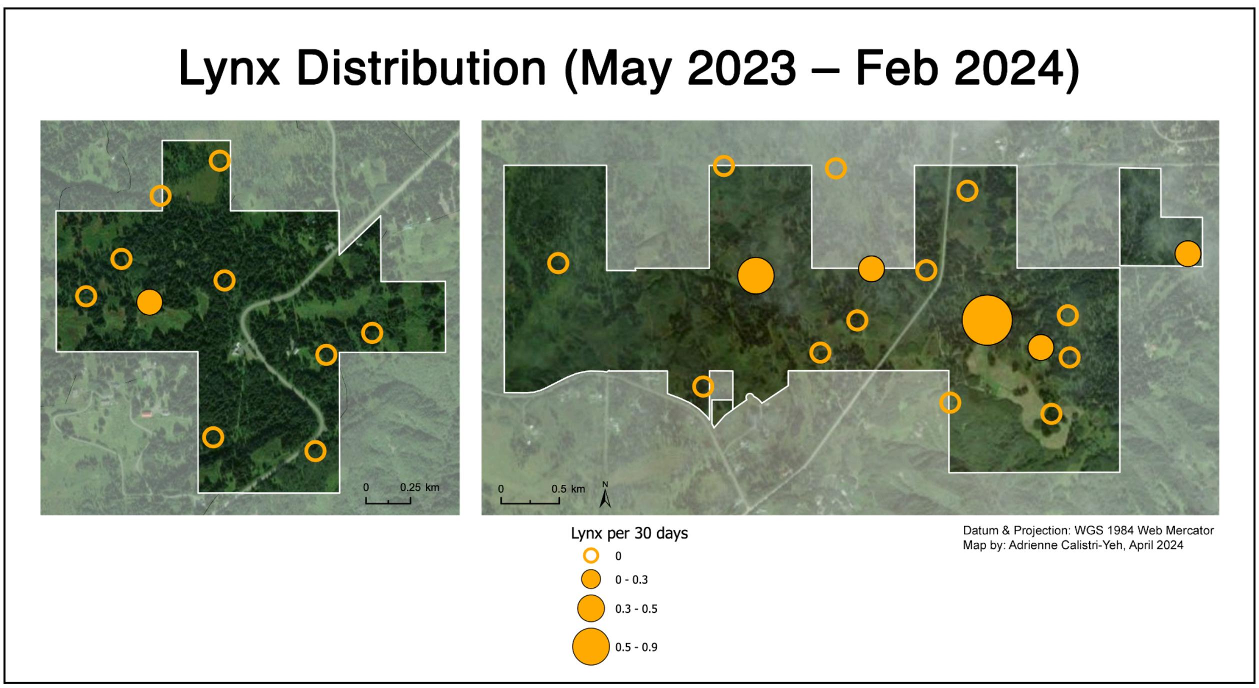


Figure 18: Lynx distribution at Wynn and IRP between May 2023 and February 2024.

Another example of distribution variability is seen in the black bear map (Figure 17). The Lynx Link camera (Wynn 1) had a high number of bear occurrences (including one instance of a sow with three cubs), but they were almost exclusively from the spring, before the summer tourist season started. During the summer, this camera had the second highest number of human occurrences, and almost no bears. The model indicated that bears tended to prefer locations with high human trail use (Figure 14) but was not able to capture the fact that this overlap occurred at different points in time. The Moose Carcass camera (Wynn 7) also had a high number of bear occurrences, but this is due to the fact that the camera was functionally baited with the moose carcass; the majority of bear videos showed the bear actively eating or dragging the carcass.

Seasonal Trends

To compare seasonal differences in large mammal occurrences, the total number of each species across both sites was graphed per day (Figure 19). There were not any obvious differences in seasonality patterns between IRP and Wynn, so all occurrences were combined for a larger sample size. The distribution of activity for each season was also compared with the trapping effort (number of cameras and days active per season) (Figure 20). There was clear species variation in the seasonal activity: humans and moose were much more active during the summer, coyotes were more active in fall and summer, bears were more active in spring and summer, and lynx were almost exclusively active during the winter.

However, with the exception of coyotes, these patterns did not seem to correlate with the timing of human occurrences overall (i.e. there was not any evident spike in animal activity immediately before or after the summer tourist season where human occurrences were higher) (Figure 19).

There was evidence of this at individual camera locations that experienced the highest human activity (bears at Wynn 1 Lynx Link, moose and bears at IRP 1 Glacier View; see StoryMap for graphs of daily occurrences per camera), but this pattern did not extend to IRP and Wynn overall for moose, black bear, or lynx. This suggests that there may be a threshold of human activity where animals will avoid certain locations (Gunderson et al., 2020), but the overall seasonal use of the preserves is likely driven more by natural seasonal behaviors, rather than human presence.

For coyotes, it did appear that activity increased in late summer as human occurrences decreased. Coyotes in urban areas have been found to prefer natural land cover over residential areas during the "dispersal" season (September to December), which could explain the increase in coyote occurrences in a protected area during the fall (Thompson et al., 2021). However, since coyotes are also known to avoid high human presence (Grubbs and Krausman, 2009), it is likely a combination of factors that contributed to increased coyote occurrences at the end of the summer.

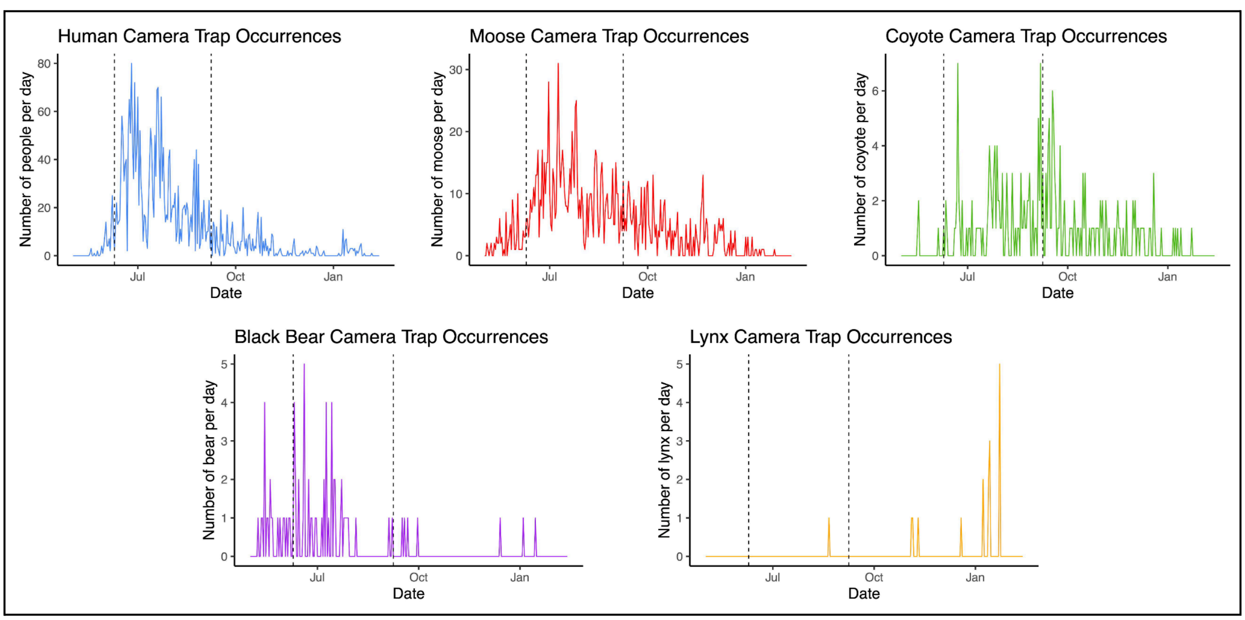


Figure 19: Graphs of occurrences per day for each species (IRP and Wynn). The dashed lines indicate the start and end dates for the CACS 2023 summer season.

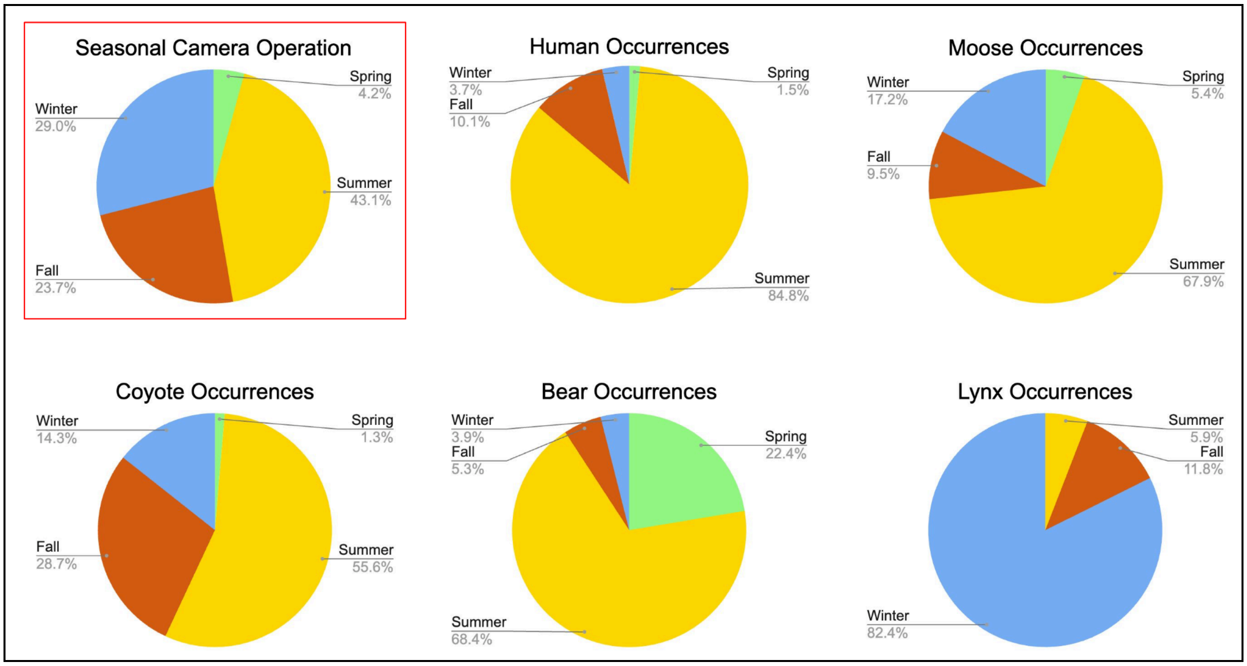


Figure 20: Distribution of occurrences per season, compared to the trapping effort per season (IRP and Wynn).

Temporal Trends

Temporal analysis was also conducted over a smaller timescale using the 24 hour day (Figure 21). As expected, human activity peaked during the day in the late morning and afternoon. It also appears that animal activity decreased during this period, peaking in the early morning and late evening. This aligns with previous results that large mammals adjust temporal behavior to avoid times of peak human activity (Ayres et al., 1986; Nickel et al., 2020). However, bear, coyote, and moose are naturally more active at dawn and dusk (Andelt and Gipson, 1979; Ayres et al., 1986; Belovsky, 1981), so comparing between IRP and Wynn could potentially reveal patterns that are more associated with human activity since Wynn had greater human presence. When the time budget graphs were split into IRP (Figure 22) and Wynn (Figure 23), the sample size for bear was not large enough to see any meaningful trends, so it was removed.

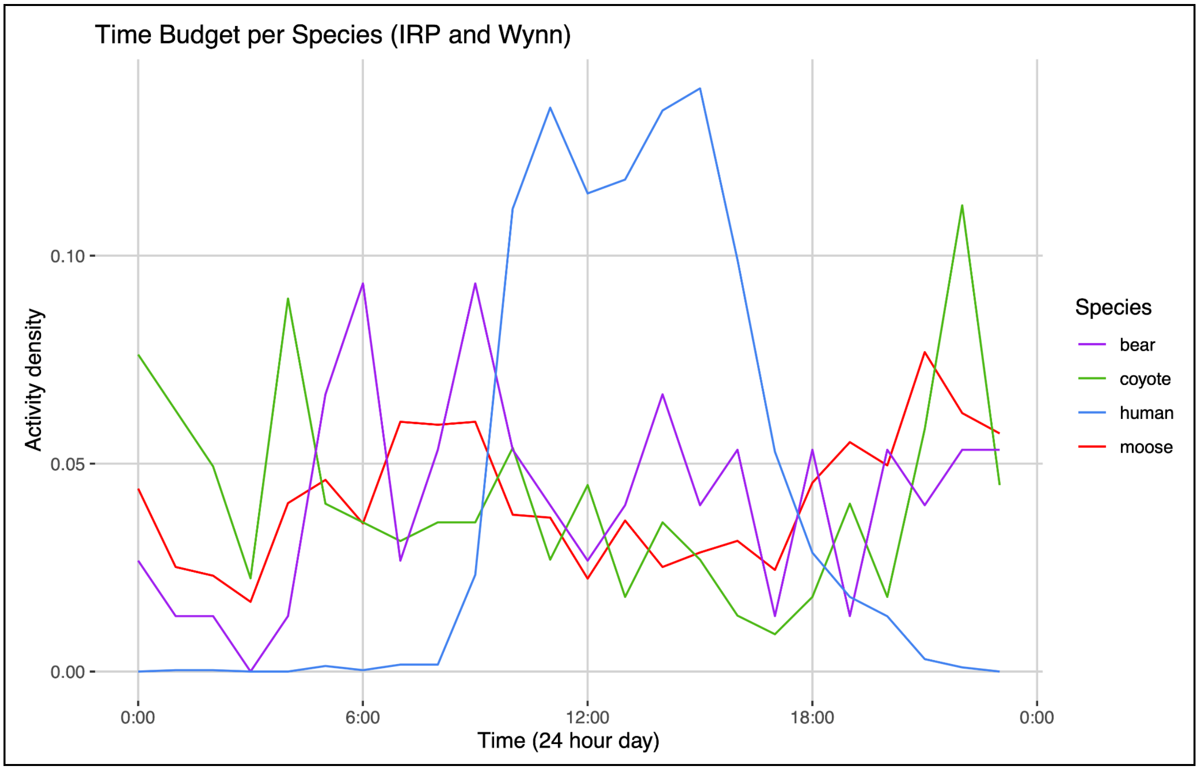


Figure 21: Time budget of each species over the 24 hour day (IRP and Wynn).

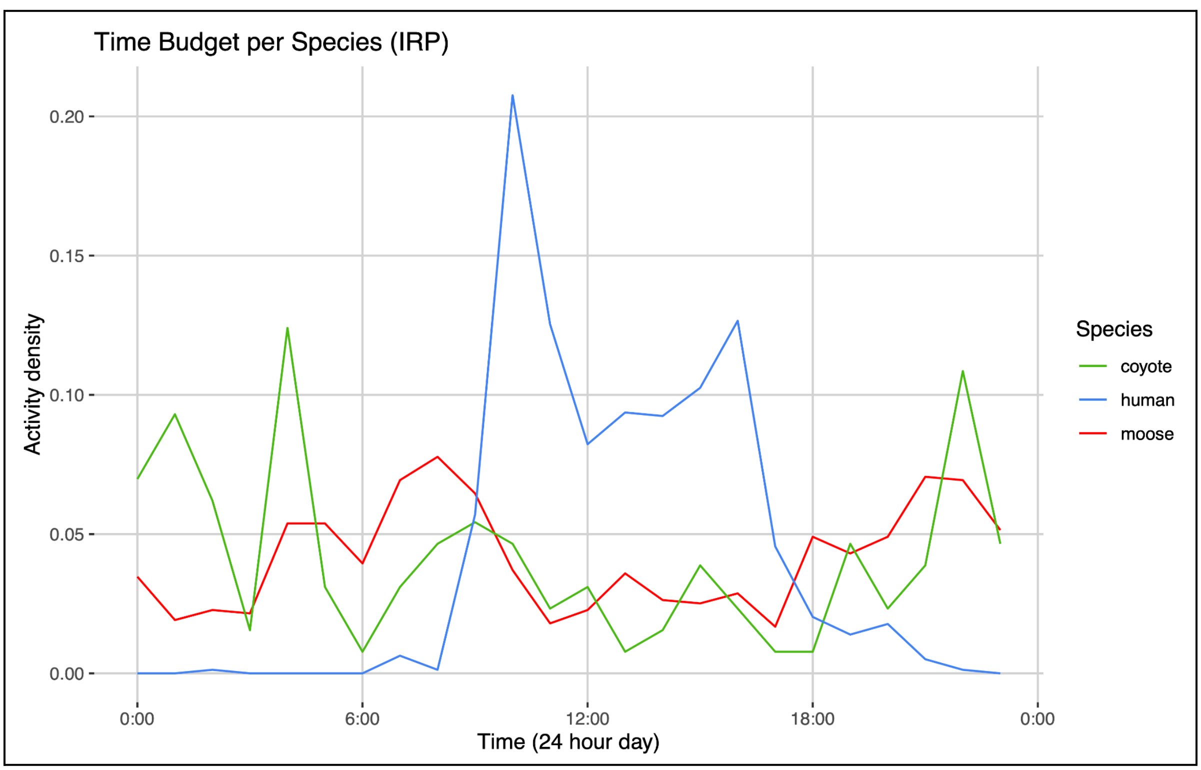


Figure 22: Time budget of coyote, moose, and human over the 24 hour day at IRP.

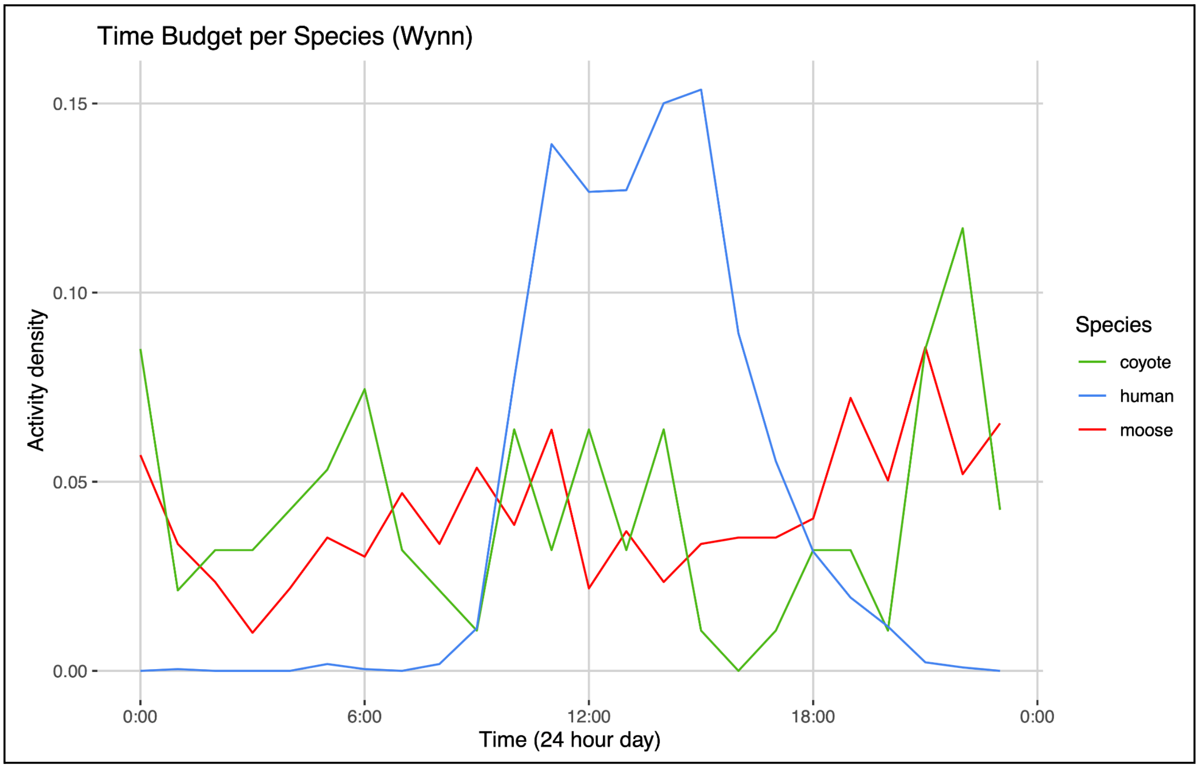


Figure 23: Time budget of coyote, moose, and human over the 24 hour day at Wynn.

The time budget at IRP shows the same trend with animal activity decreasing during peak human activity, but the pattern is less visible with Wynn. This suggests stronger temporal avoidance of people from wildlife at IRP than Wynn, in contrast with previous research that found increased temporal avoidance at sites with higher human disturbance (Soccorsi and LaPoint, 2023). One possible interpretation is that animals at Wynn are more accustomed to being in proximity with people, while animals at IRP are more sensitive to human presence and therefore more temporally avoidant of people. This would be beneficial to wildlife at IRP because animals that are less habituated to people are less likely to engage in interactions that could lead to harmful human-wildlife conflict (Honda et al., 2019).

Stories from the Field: Interviews and Anecdotes

Recognizing the value and importance of qualitative methods in ecological research, the following section documents some of the insights I gained into human-wildlife relationships through conversations and informal interviews conducted during my time in Alaska.

Land Development in Homer

Development of land in Homer has been increasing since the 1990s, when a lot of the original homestead lots were becoming available on the market. Many of these properties were sold to developers and subdivided into smaller plots for housing construction. In fact, a large portion of the parcels that were ultimately purchased to form IRP would have otherwise been subdivided and developed into homes, with one of the properties having a preliminary plan for 20-30 houses on it. IRP founders Nina Faust and Edgar Bailey had to compete with developers for most of the land, but local realtors liked their vision for the preserve and would often call them first when a property was about to be listed.

More recently, Homer residents have noticed that housing developments are being built on habitat where moose and other wildlife had previously lived, and this has come with an increase in human-moose conflict. One development in particular was constructed near a disc golf course, and the moose started having aggressive interactions with disc golf players where there had not been conflict before the habitat was developed. Large mammal sightings in town have also decreased over recent years, coinciding with an increase in both local population and summer tourism. These trends emphasize the importance of preemptively protecting wildlife habitat in Homer as well as other rapidly developing areas.

Unintended Ecosystem Effects

Probably the most widely publicized example of human-wildlife interaction in Homer involved Jean Keene, also known as the "Eagle Lady." Keene began feeding bald eagles on the Homer Spit in the late 1970s and continued every winter until 2009. This resulted in a significant increase in the local eagle population, with eagles migrating to Homer from all over the region. Locals state that this had visibly negative effects on the ecosystem, with the overabundance of eagles hunting nearly all of the cranes, loons, and waterfowl.

Another consequence of humans living in close proximity to wildlife is the interaction between domestic and wild animals. While I was in Homer, I noticed a lot of black domestic rabbits loose around town. I learned that this was the result of pet rabbits that had been released (or escaped) and multiplied substantially, and they are likely having an effect on the local ecosystem. Lynx populations are known to be linked with snowshoe hare populations as their primary prey (Stenseth, 1997), so introducing a non-native rabbit species could alter the lynx, hare, and/or vegetation patterns, as well as create further cascading effects.

Navigating Shared Habitats

With more overlap between habitats used by people and wildlife, there can be shifts in natural behavior on both sides that help facilitate coexistence. Animals commonly adjust spatiotemporal behavior to avoid coming into contact with people, but this can be difficult to identify without a comparison point of their previous behavior patterns. The Covid-19 pandemic provided a natural experiment in the spring and summer of 2020, with previously consistent human activities coming to a stop. CACS operates a field station at Peterson Bay, on the opposite side of

Kachemak Bay from Homer. Usually, staff members begin arriving in the spring to prepare for the summer season, but this did not happen in 2020 due to the pandemic. Staff reported that when they arrived later in the summer, there were significantly more black bears around the field station than normal; they had taken advantage of the lack of human activity to establish on the site during the spring. With the return to the regular schedule in 2021, there have not been as many bears at Peterson Bay.

Temporal avoidance has also been observed by residents living on IRP property, supporting this study's findings that animals at IRP exhibited temporal avoidance of people. An outbreak of spruce bark beetles caused many trees to die and fall over, making navigation of the habitat difficult. Because of this, the established human trails provide the path of least resistance for animals moving through the preserve. It is clear that wildlife use the trails by the numerous signs of tracks and scat located along the paths. However, residents noted that wildlife primarily use the trails in the morning and evening when people are not hiking on them, choosing to stay in denser habitat during the day.

Shifts in human behavior can also benefit wildlife and promote coexistence. IRP co-founder Nina Faust mows the meadow on the east side of IRP every summer to maintain staging habitat for sandhill cranes as they prepare for migration. This gives the cranes a space to congregate away from the human and vehicle disturbances in other parts of town, helping to decrease injury and death caused by power lines and car accidents. Towards the end of the summer, there are commonly 100+ cranes that are able to leave for migration safely at IRP, as a result of Nina's dedication and management. On a smaller scale, some residents in downtown Homer are also trying to facilitate coexistence. There are frequent reports of nuisance moose in Homer destroying people's gardens due to decreasing availability of natural habitat and food sources. I met one local who specifically plants native tree species in her yard for the moose to eat, to counteract the decline of their food sources. She said that it has fed several moose every year, and she thinks that if more people in town planted trees, there would not be as many problems with moose eating people's gardens.

Habituation to Passive Human Presence

Chinitna Bay in Lake Clark National Park is one of the best places to observe coastal brown bears in their natural habitat. I took a boat tour to one of the viewing sites at Chinitna Bay and was able to talk with the tour guides about human-bear interactions. They said that the bears at that location are very calm and accustomed to humans, so they do not react to the tours. The viewing areas are contained and visitors are required to stay with the group and remain quiet, so the bears have learned that humans do not pose a threat. My experience with the tour reflected this; the bears definitely knew we were there but did not appear to pay us much attention. However, the guides said that the other side of Chinitna Bay is not part of the protected national park, and there is a bear hunt allowed there every other year. The bears on that side of the bay immediately run away if there are any people around, since their interactions with humans are much more negative.

I also had the opportunity to speak with a native resident of Utqiagvik, the northernmost town in the United States, where polar bear sightings are common. He runs tours past the city limits to the northernmost point, passing through polar bear habitat. He told me about another polar bear hotspot in Canada where they corral the bears with snowmobiles to bring them closer to photographers, and they can tell by the bears' expressions that they are stressed and trying to get away from the people. In Utqiagvik, bear movements are not restricted or disturbed, so the animals are much more relaxed. Without the negative association to human presence, a lot of the bears will come right up to the truck; one time he saw eleven polar bears in one day.

While lack of fear towards humans can indicate less stress in animals, this habituation can also be harmful, especially if it alters animal behavior in non-protected environments. An employee with Alaska Department of Fish and Game told me that no large mammal species do well with rehabilitation from a young age because they grow accustomed to human presence and this causes problems once they are released back to the wild. All moose cases he was aware of did not survive long enough after release to be reincorporated into the population, due to accidents with vehicles or lack of ability to find food or avoid predators. Bear cubs that were rehabilitated in captivity would become comfortable around people and then approach humans after being released, leading to increased human-bear conflict.

Alaskan Wildlife Tourism

Almost all of the tourists that I talked to were visiting Alaska, at least in part, to see wildlife. One family with four kids hiking at Wynn asked me if I had seen any wildlife that day, and when I responded that there had been a moose around, they asked which direction so they could try to see it. One of the kids told me, "I want to see a moose in real life!" I gave them a brief safety reminder but told them where it had been (unfortunately I did not see them again, so I am unsure if they were successful).

Driving down the Homer Spit, there are a large number of businesses offering luxury bear viewing tours or marine wildlife excursions, and it is clear that wildlife tourism is a huge industry and a critical component of the local economy. This is true throughout Alaska and many other parts of the world, and it emphasizes the need to balance human and wildlife considerations when designing policies and management plans for protected areas. People come to these places for the experience of a wildlife preserve; in many cases this is what keeps small communities alive, so it would not work if every protected area completely prevented access by people. Instead, solutions like IRP's 30 person policy try to meet both needs by limiting entrance but still allowing some visitation in a controlled way.

Conclusions and Future Recommendations

Overall, IRP had lower human impact than Wynn, both by number of visitors (measured by daily camera trap occurrences, average trail usage, and reported summer visitation) as well as indirect human effects. Impacts of anthropogenic noise and building infrastructure, both of which are independent of IRP's 30 person policy, were greater at Wynn than IRP. This could contribute to the differences in wildlife distributions that were observed, as both factors have been shown to be negatively associated with wildlife habitat use (Baker and Leberg, 2018; da Silva et al., 2018; Kunc and Schmidt, 2019; Nickel et al., 2020). The size difference between IRP and Wynn also likely plays a role, with animals typically preferring larger protected areas (da Silva et al., 2018).

There were more occurrences of moose, coyote, black bear, and Canadian lynx at IRP compared to Wynn. The environmental and human-related factors associated with spatial distribution differed by species, although the models were not able to fully capture the complex spatial behavior that was observed. Seasonal wildlife use of the preserves did not seem to be largely affected by human tourism patterns, but seasonal avoidance of specific locations with high human traffic was observed. Temporal avoidance of human activity was greater at IRP than Wynn, which could indicate that wildlife at IRP are more sensitive to human presence.

Overall, the 30 person policy at IRP appears to be beneficial to wildlife. There were fewer people accessing the habitat, which was correlated with more wildlife occurrences. Wildlife at IRP may also be less habituated to people, which would be beneficial in reducing human-wildlife conflict (Honda et al., 2019). This does not discount the environmental, ecological, and cultural benefits of Wynn, which also provides protected habitat that was utilized by all four large mammal species, and further facilitates connection and relationships between people and nature for visitors, educators, and members of the community.

Future Monitoring Recommendations

If possible, camera trap monitoring at IRP and Wynn should continue with minimal gaps to build a multi-year dataset for future analysis. If cameras are moved between locations, the dates and coordinates for each location should be clearly documented so they can be taken into account during analysis. For locations that commonly experience a large number of false triggers (e.g. IRP g2 Greenhouse), AI software can be used to filter out false triggers (see Appendix A). There are also programs that automatically classify and log camera trap images, which could be worth looking into in the future depending on the availability and reliability of the software, as well as CACS' staff capacity for manually classifying images. If additional soundscape monitoring is conducted, using an automated analysis program (see Appendix C) could make processing large datasets much more feasible.

Specific Camera Recommendations

As expected, some cameras captured significantly more wildlife than others (in terms of both species diversity and abundance). Keeping in mind that it is still valuable to know where species are *not* using habitat, the following camera locations were most successful for wildlife captures:

- Overall species diversity and abundance: IRP 13 Tunturpak Trail, Wynn 1 Lynx Link, IRP 10 Nina's Arc Junction, IRP g1 Goose Pond, IRP 11 Property Boundary
- Moose abundance: Wynn 4 Bog, IRP g1 Goose Pond, IRP 17 Moose Pond, Wynn 5 UM Bog

- Coyote abundance: IRP 13 Tunturpak Trail, Wynn 1 Lynx Link, IRP g1 Goose Pond
- Black bear abundance: Wynn 1 Lynx Link, IRP 16 Black Bear Ramble, Wynn 7 Moose Carcass
- Lynx abundance: IRP g2 Greenhouse, IRP 10 Nina's Arc Junction
- Human abundance: Wynn 3 Moose Meander, Wynn 1 Lynx Link, IRP 1 Glacier View
- Non-target species
    - Snowshoe hare: Wynn 11 NorthWynn, Wynn 8 Powerline, IRP 15 Nina's Arc
    - Squirrel: Wynn 11 NorthWynn, IRP 6 Gozzie
    - Brown bear: IRP 10 Nina's Arc Junction (2 instances)
    - Wolf: IRP 15 Nina's Arc (1 instance with 7 individuals)
    - Porcupine: IRP 13 Tunturpak Trail (3 instances)

Camera locations that could potentially be changed or removed:

- IRP 6 Gozzie: This camera only captured moose and people (for large mammal species) during this study. It does not appear to provide many additional insights beyond what is already covered by the nearby Goose Pond and Fen cameras.
- IRP 7 Knoll: This general location could be good to continue monitoring because Nina has observed a lot of wildlife in this area. However, the specific location of the Knoll camera does not seem to be very successful. I would recommend moving it to another area of the knoll to see if more animals are observed.
- IRP 9 Warbler's Way, IRP 18 Chocolate Cabin, and Wynn 10 Cottonwood: These locations could be interesting to keep to provide data near roads and buildings. However, these cameras only captured moose images (for large mammal species).

- Wynn 3 Moose Meander: I would recommend moving this camera lower on the tree or angling it down more. I noticed that a lot of the time the field of view of this camera is too high to capture animals that are shorter than a moose or person, so it is possible that smaller species are being missed.
- Wynn 6 Fireweed Loop: This camera only captured moose during this study (for large mammal species). It does not appear to provide many additional insights beyond what is already covered by the nearby Powerline and Moose Carcass cameras.
- Wynn 9 UM Moose Meander: I would recommend keeping a camera in the southern part of Wynn, however this particular location did not appear to be very successful or provide additional insights beyond what is already covered by Wynn 3 Moose Meander.

The total and daily large mammal counts for each camera are displayed in the accompanying StoryMap. Based on CACS' current and future monitoring priorities, this information can be used to determine which cameras will be most useful for long-term monitoring.

Acknowledgements

I would like to thank Neil Carter and everyone in the Conservation and Coexistence Lab for providing support and feedback on this project, specifically Fang Chen, Jason Hagani, Kirby Mills, Carly Thompson, Anna Yu, and Amy Zuckerwise. Thanks so much to Nina Faust and my partners at CACS for helping to develop this project and assisting with fieldwork and logistics: Beth Trowbridge, Henry Reiske, Maya Nabipoor, Katie Gavenus, Sarahlily Stein, and the CACS interns. And a big thank you to Julia Slater, Moe Dailey, Emilia Shokoohi, and Grant Sprague for all their help over the summer.

References

Andelt, W.F. & Gipson, P.S. (1979). Home range, activity, and daily movement of coyotes. *The Journal of Wildlife Management, 43*(4), 944-951. https://doi.org/10.2307/3808278

Ayres, L.A., Chow, L.S., & Graber, D.M. (1986). Black bear activity patterns and human induced modifications in Sequoia National Park. *Bears: Their Biology and Management, 6*, 151-154. https://doi.org/10.2307/3872819

Baker, A.D. & Leberg, P.L. (2018). Impacts of human activity on carnivores in protected areas. *PLoS One, 13*(4), e0195436. https://doi.org/10.1371/journal.pone.0195436

Beirne, C. (2022). *An introduction to camera trap data management and analysis in R.* Wildlife Coexistence Lab, University of British Columbia. https://bookdown.org/c_w_beirne/wildCo-Data-Analysis/

Belovsky, G.E. (1981). Optimal activity times and habitat choice of moose. *Oecologia, 48*, 22-30. https://doi.org/10.1007/BF00346984

Blom, A., Zalinge, R.V., Mbea, E., Heitkönig, I.M.A, & Prins, H.H.T. (2004). Human impact on wildlife populations within a protected Central African forest. *African Journal of Ecology, 42*(1), 23-31. https://doi.org/10.1111/j.0141-6707.2004.00441.x

Blongewicz, K., Cortés, L., Finch, E., Joyal, L., Leisman, D., & McLaughlin, E. (2019). *Inspiration Ridge Preserve protocols for ecological inventories and management*. University of Michigan School for Environment and Sustainability.

Chen, C., et al. (2022). Global camera trap synthesis highlights the importance of protected areas in maintaining mammal diversity. *Conservation Letters*, *15*(2), e12865. https://doi.org/10.1111/conl.12865

da Silva, M.X., Paviolo, A., Tambosi, L.R., & Pardini, R. (2018). Effectiveness of Protected Areas for biodiversity conservation: Mammal occupancy patterns in the Iguaçu National Park, Brazil. *Journal for Nature Conservation, 41*, 51-62. https://doi.org/10.1016/j.jnc.2017.11.001.

Dertien, J.S., Larson, C.L., & Reed, S.E. (2021). Recreation effects on wildlife: a review of potential quantitative thresholds. *Nature Conservation, 44*, 51-68. https://doi.org/10.3897/natureconservation.44.63270

Evans, K.L., Rodrigues, A.S.L., Chown, S.L., & Gatson, K.J. (2006). Protected areas and regional avian species richness in South Africa. *Biology Letters, 2*(2). https://doi.org/10.1098/rsbl.2005.0435

Field, C. & Walker, C. (2003). *A site profile of the Kachemak Bay Research Reserve: a unit of the National Estuarine Research Reserve System.* Kachemak Bay Research Reserve. https://coast.noaa.gov/data/docs/nerrs/Reserves_KBA_SiteProfile.pdf

Fuller, A., Mitchell, D., Maloney, S.K., & Hetem, R.S. (2016). Towards a mechanistic understanding of the responses of large terrestrial mammals to heat and aridity associated with climate change. *Climate Change Response, 3*(10). https://doi.org/10.1186/s40665-016-0024-1

Geldmann, J., Manica, A., Burgess, N.D., Coad, L., & Balmford, A. (2019). A global-level assessment of the effectiveness of protected areas at resisting anthropogenic pressures. *Proceedings of the National Academy of Sciences*, *116*(46), 23209–23215. https://doi.org/10.1073/pnas.1908221116

Grubbs, S.E. & Krausman, P.R. (2009). Use of urban landscapes by coyotes. *The Southwestern Naturalist, 54*(1), 1-12. https://doi.org/10.1894/MLK-05.1

Gundersen, V., Myrvold, K.M, Rauset, G.R., Selvaag, S.K., & Strand, O. (2020). Spatiotemporal tourism pattern in a large reindeer (*Rangifer tarandus tarandus*) range as an important factor in disturbance research and management. *Journal of Sustainable Tourism, 29*(1), 21-39. https://doi.org/10.1080/09669582.2020.1804394

Hanski, I. (2011). Habitat loss, the dynamics of biodiversity, and a perspective on conservation. *AMBIO, 40*, 248–255. https://doi.org/10.1007/s13280-011-0147-3

Honda, T., Yamabata, N., Iijima, H., & Uchida, K. (2019). Sensitization to human decreases human-wildlife conflict: empirical and simulation study. *European Journal of Wildlife Research, 65*(71). https://doi.org/10.1007/s10344-019-1309-z

Hundertmark, K.J. (2007). Home range, dispersal and migration. In A.W. Franzmann, C.C. Schwartz, & R.E. McCabe (Eds.), *Ecology and management of the North American moose* (2nd ed., pp. 303-336). University Press of Colorado.

Jones, E. (2009). *The Athabascan peoples and their cultures.* Smithsonian Arctic Studies Center in Alaska. https://learninglab.si.edu/collections/the-athabascan-peoples-and-their-cultures/ymRj9afV0WUrRCA2

Kari, J. (1974). *Kenai Tanaina noun dictionary*. https://www.tebughnafoundation.com/wp-content/uploads/2023/07/kari-1974-kenai_tanaina_noun_dictionary.pdf

Koehler, G.M. & Pierce, D.J. (2003). Black bear home-range sizes in Washington: Climatic, vegetative, and social influences. *Journal of Mammalogy, 84*(1), 81-91. https://doi.org/10.1644/1545-1542(2003)084%3C0081:BBHRSI%3E2.0.CO;2

Krausman, P. R. (1999). Some basic principles of habitat use. Grazing behavior of livestock and wildlife, 70, 85-90.

Kunc, H.P. & Schmidt, R. (2019). The effects of anthropogenic noise on animals: a meta-analysis. *Biology Letters, 15*(11). https://doi.org/10.1098/rsbl.2019.0649

Lewis, J.S., Spaulding, S., Swanson, H., Keeley, W., Gramza, A.R., VandeWoude, S., & Crooks, K.R. (2021). Human activity influences wildlife populations and activity patterns: implications for spatial and temporal refuges. *Ecosphere, 12*(5), e03487. https://doi.org/10.1002/ecs2.3487

Malo, J.E., Acebes, P., & Traba, J. (2011). Measuring ungulate tolerance to human with flight distance: a reliable visitor management tool? *Biodiversity and Conservation, 20*, 3477-3488. https://doi.org/10.1007/s10531-011-0136-7

Monz, C.A., Cole, D.N., Leung, Y., & Marion, J.L. (2009). Sustaining visitor use in protected areas: Future opportunities in recreation ecology research based on the USA experience. *Environmental Management, 45*, 551-562. https://doi.org/10.1007/s00267-009-9406-5

Mulongoy, K.J. & Chape, S. (2004). *Protected areas and biodiversity: An overview of key issues.* UNEP World Conservation Monitoring Centre. https://portals.iucn.org/library/sites/library/files/documents/2004-011.pdf

Nickel, B.A., Suraci, J.P., Allen, M.L., & Wilmers, C.C. (2020). Human presence and human footprint have non-equivalent effects on wildlife spatiotemporal habitat use. *Biological Conservation, 241*, 108383. https://doi.org/10.1016/j.biocon.2019.108383

Procko, M., Naidoo, R., LeMay, V., & Burton, A.C. (2022). Human impacts on mammals in and around a protected area before, during, and after COVID-19 lockdowns. *Conservation Science and Practice, 4*(7), e12743. https://doi.org/10.1111/csp2.12743

Reed, S.E. & Merenlender, A.M. (2008). Quiet, nonconsumptive recreation reduces protected area effectiveness. *Conservation Letters, 1*(3), 146-154. https://doi.org/10.1111/j.1755-263X.2008.00019.x

Sayan, M.S. & Atik, M. (2011). *Ekoloji, 20*(78), 66-74. doi:10.5053/ekoloji.2011.7811

Scanes, C.G. (2018). Human activity and habitat loss: destruction, fragmentation, and degradation. In C.G. Scanes, & S.R. Toukhsati (Eds.), *Animals and Human Society* (pp. 451-482). Academic Press.

Silverberg, J.K., Pekins, P.J., & Robertson, R.A. (2003). Moose responses to wildlife viewing and traffic stimuli. *Alces: A Journal Devoted to the Biology and Management of Moose, 39*, 153-160. https://www.alcesjournal.org/index.php/alces/article/view/473

Soccorsi, A.E. & LaPoint, S.D. (2023). Assessing spatiotemporal patterns of mesocarnivores along an urban-to-rural gradient. *The Journal of Wildlife Management, 87*(7). https://doi.org/10.1002/jwmg.22474

Stein, S. (2023). *Protocol for trail camera monitoring*. Center for Alaskan Coastal Studies.

Stenseth, N.C., Falck, W., Bjørnstad, O.N., & Krebs, C.J. (1997). Population regulation in snowshoe hare and Canadian lynx: Asymmetric food web configurations between hare and lynx. *Proceedings of the National Academy of Sciences, 94*(10), 5147-5152. https://doi.org/10.1073/pnas.94.10.5147

Sytsma, M.L.T, Lewis, T., Gardner, B., & Prugh, L.R. (2022). Low levels of outdoor recreation alter wildlife behavior. *People and Nature, 4*(6), 1547-1559. https://doi.org/10.1002/pan3.10402

Theobald, D.M., Leinwand, I., Anderson, J.J., Landau, V., & Dickson, B.G. (2019). *Loss and fragmentation of natural lands in the conterminous U.S. from 2001 to 2017.* Conservation Science Partners.
https://www.csp-inc.org/public/CSP%20Disappearing%20US%20Exec%20Summary%20011819.pdf

Thompson, C.A., Malcolm, J.R., & Patterson, B.R. (2021). Individual and temporal variation in use of residential areas by urban coyotes. *Frontiers in Ecology and Evolution, 9*. https://doi.org/10.3389/fevo.2021.687504

Vashon, J.H., Meehan, A.L., Jakubas, W.J., Organ, J.F., Vashon, A.D., Mclaughlin, C.R., Matula Jr., G.J., & Crowley, S.M. (2010). Spatial ecology of a Canada lynx population in northern Maine. *The Journal of Wildlife Management, 72*(7), 1479-1487. https://doi.org/10.2193/2007-462

Zhou, Y., Buesching, C.D., Newman, C., Kaneko, Y., Xie, Z., & Macdonald, D.W. (2013). Balancing the benefits of ecotourism and development: The effects of visitor trail-use on mammals in a protected area in rapidly developing China. *Biological Conservation, 165*, 18-24. https://doi.org/10.1016/j.biocon.2013.05.007

Appendices

A. Protocol for Using AI for Photo Filtering

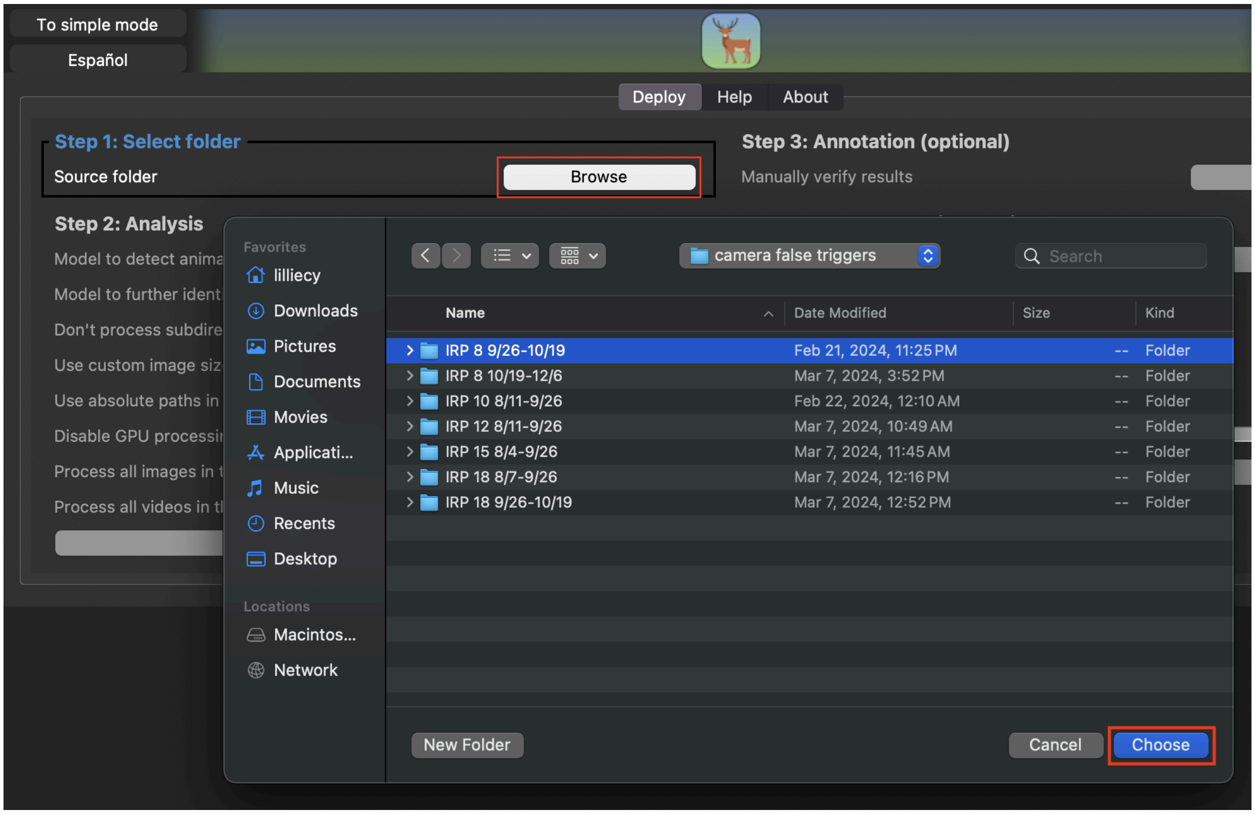
EcoAssist is one of several free, open-source applications available for automatically filtering camera trap data. It uses AI to identify animals or people in a photo or video, and can process an input folder to produce a list of files that contain animals/humans to be further analyzed. In the 2023-2024 large mammal study, this software was used successfully to extract animal/human images from folders containing many false triggers. Based on spot check verification, the following settings have a low likelihood of missing animal/human occurrences, and remove the vast majority of false triggers. This protocol is only recommended for folders that contain more than ~50% false triggers.

Please note that this method is not perfect and there may be other applications (or future updates to this software) that would have a smoother process, especially for post-processing videos. However, in my experience, this was significantly faster and easier than manually going through false-trigger-heavy folders. It takes some time to run the program, but I was able to do other work or process other folders while it was scanning the photos/videos.

Instructions for Use:

A. Installation
    a. Follow installation instructions for either Windows or Mac.
B. Step 1: Select folder
    a. Click the button in the top left corner of the window to enter *Advanced mode*.

b. Click *Browse* to select the source folder. Navigate to a local folder (located on your computer, not Google Drive) containing images to be processed, and select the folder (not individual images). Click *Choose*. Note: folders can contain both images and videos.



C. Step 2: Analysis

a. Use the following settings in the *Step 2: Analysis* window:

i. Next to “Model to detect animals, vehicles, and persons”, select “MegaDetector 5a”

ii. Next to “Model to further identify animals”, select “None”

iii. Check the box for “Process all images in the folder specified”

iv. Check the box for “Process all videos in the folder specified”

v. Check the box for “Don’t process every frame”

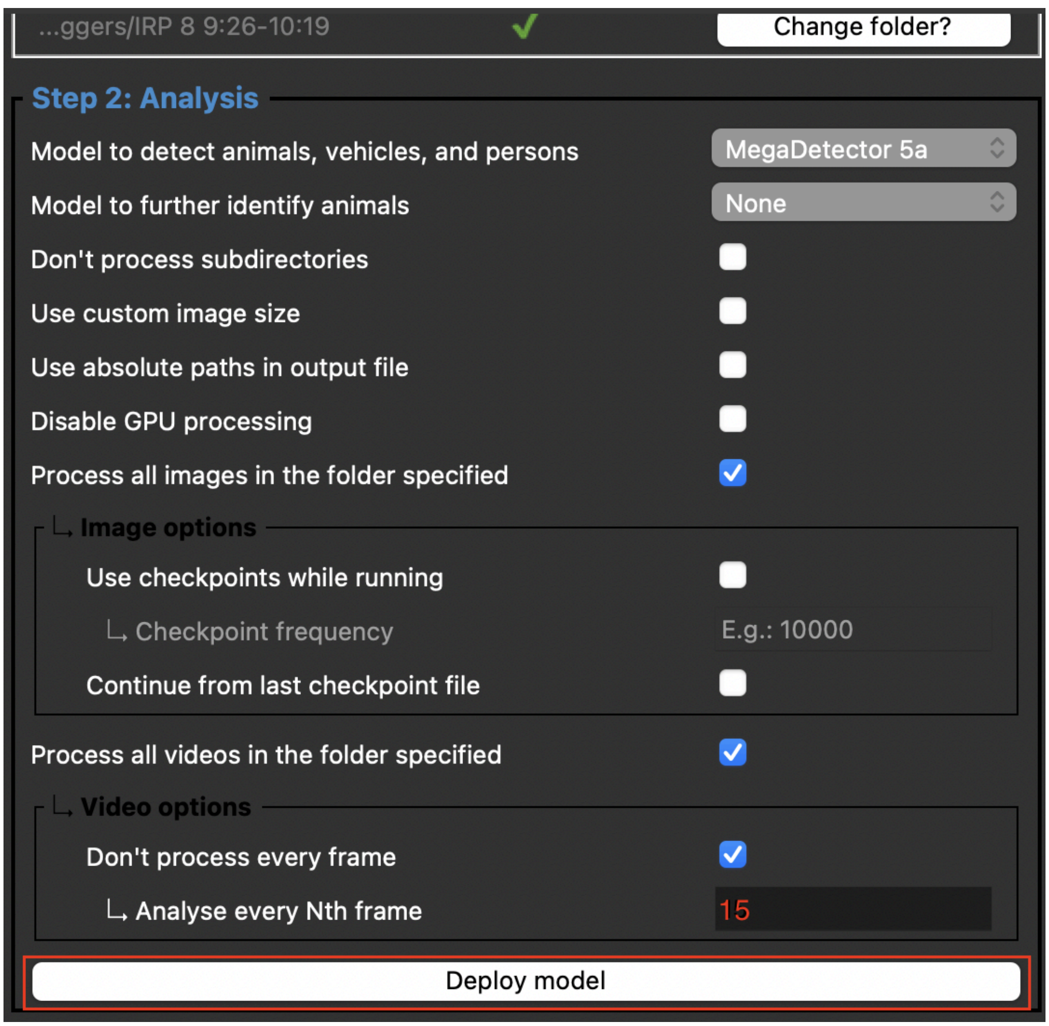
vi. In the box next to "Analyse every Nth frame", enter "15"

1. This speeds up the processing time significantly. At the time of this report, the CACS cameras are set to record at 30 frames per second, so processing every 15th frame results in 2 frames being analyzed per second, rather than 30.

vii. All other boxes should remain unchecked.

b. Click *Deploy model*. You may need to scroll down for this button to be visible.

c. Once you complete this process for the first folder, the program should save your settings and autofill them in the future.



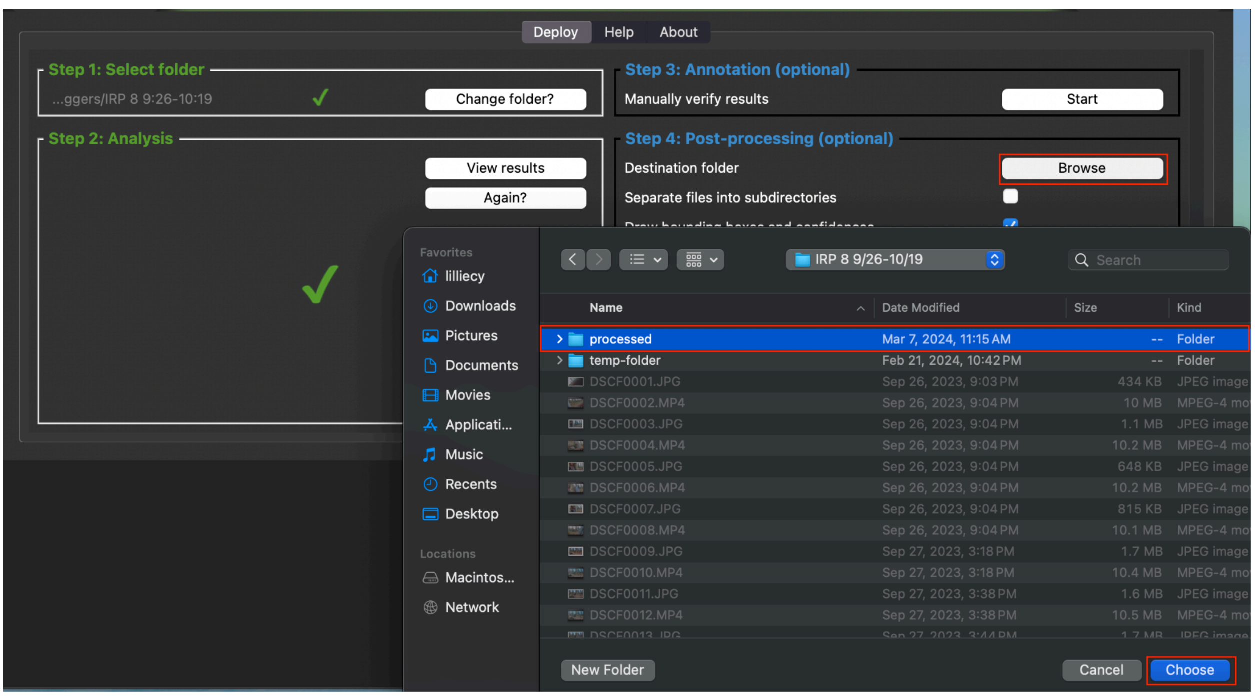
d. Wait for the *Analysis progress* window to reach 100% for localizing animals in both images and videos. This may take some time depending on the number of files in the folder. Ignore any warnings as long as the analysis window shows a green check.

D. Skip <u>Step 3: Annotation</u>

E. <u>Step 4: Post-processing</u>

a. Click *Browse* to select the folder for the exported files.

b. Create a new folder titled "processed" (or similar) inside the source folder containing the original images that were processed. Click *Choose*.



c. Use the following settings in the *Step 4: Post-processing* window:

i. Check the box for "Draw bounding boxes and confidences"

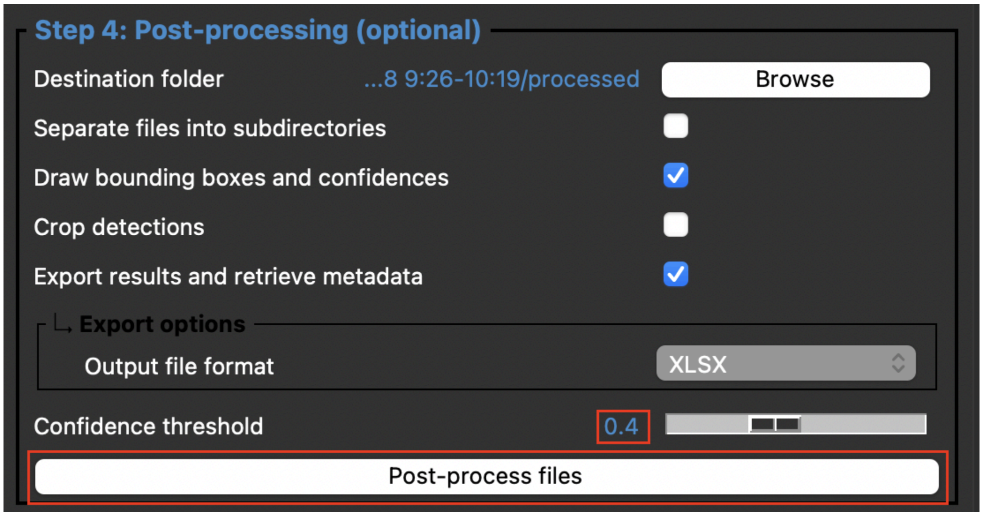
ii. Check the box for "Export results and retrieve metadata"

iii. Next to "Output file format", select "XLSX"

iv. Next to "Confidence threshold", move the bar to "0.4"

1. A 0.4 threshold was found to meet the balance of limiting the number of false triggers that pass through, while preventing animal/human images from being missed.

v. All other boxes should remain unchecked.

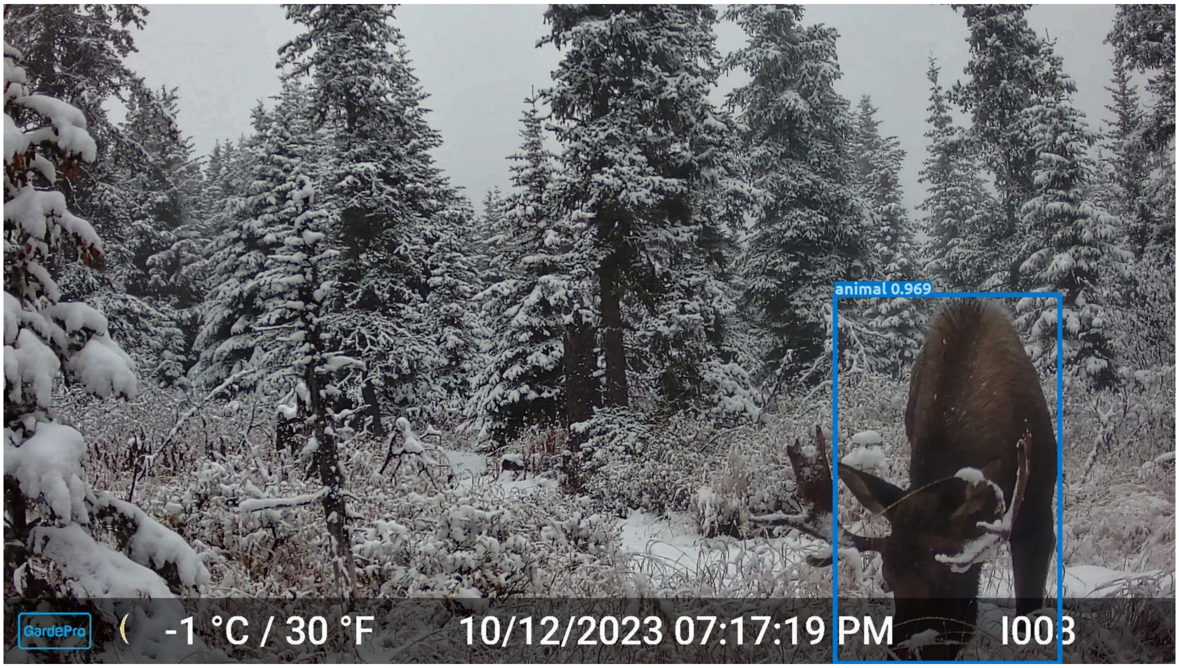


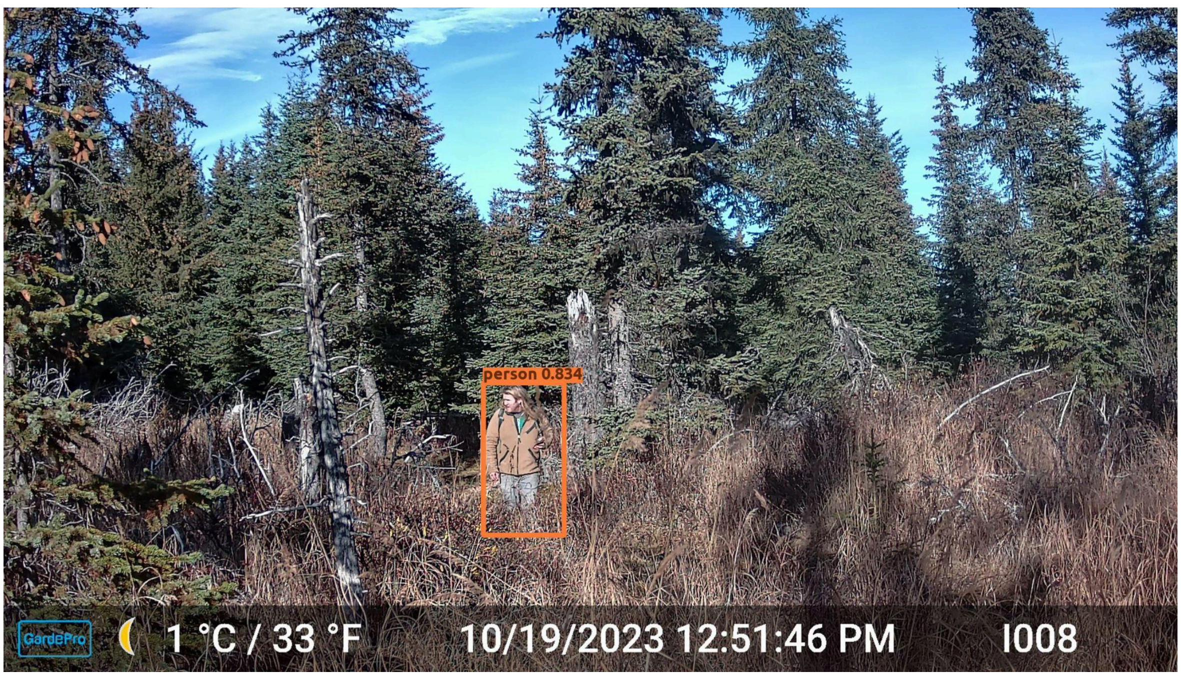
d. Click *Post-process files*.

i. Click *OK* on the popup that visualization is not supported for videos.

ii. This step fills the "processed" folder with copies of the images that the program selected, with a bounding box drawn around the area of the image that was identified as an animal/human.

iii. The number next to "animal" or "person" on the bounding box represents the confidence that it was correctly identified. By setting the confidence threshold to 0.4, any selections that had less than 0.4 confidence were not included in the export folder. The threshold can be adjusted if it seems like animal selections are falling within a higher or lower confidence.





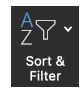
e. At the time of this report, EcoAssist is unfortunately not able to extract and copy the selected videos with bounding boxes. However, it provides the file names of the selected videos in an output Excel spreadsheet, located in the same "processed" folder.

F. Excel spreadsheet

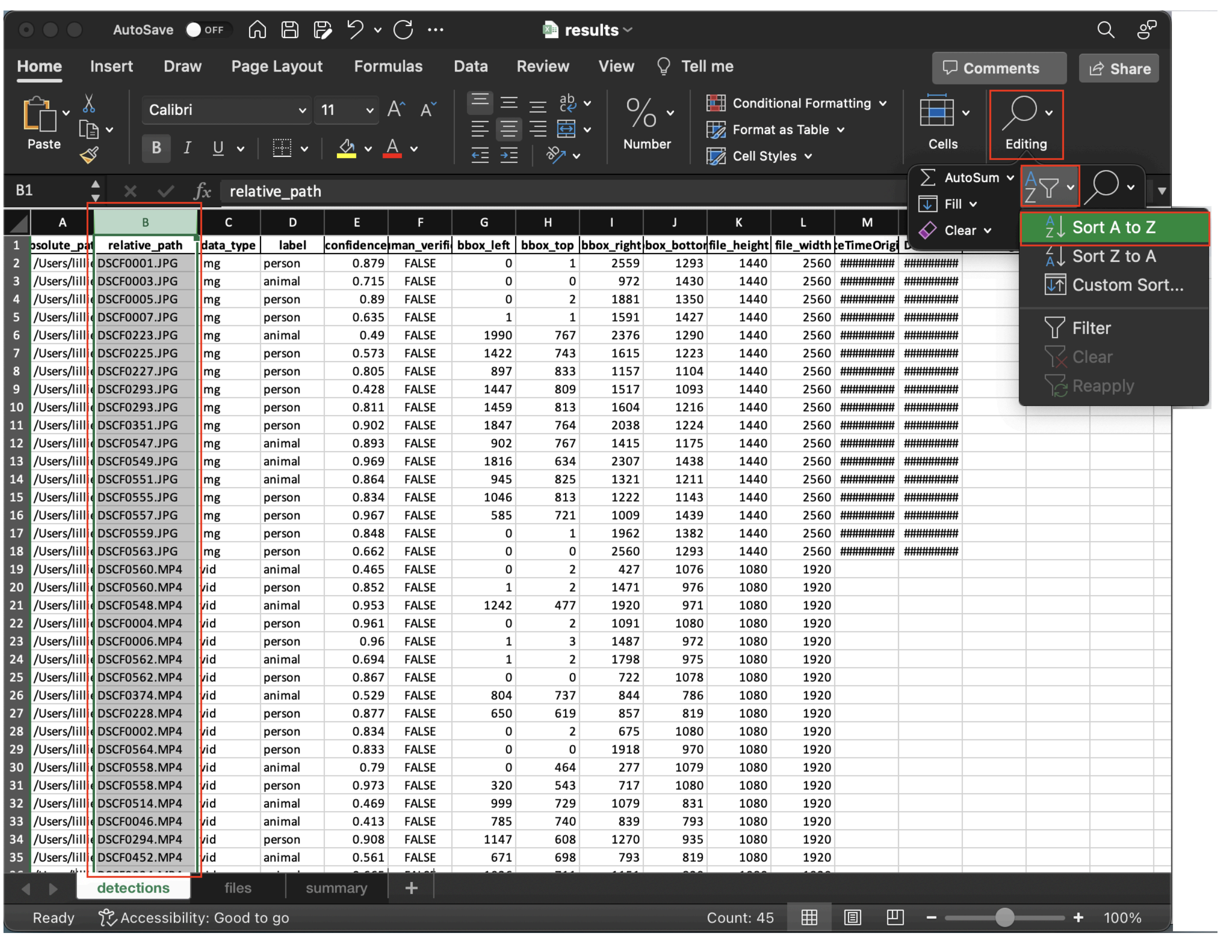
a. The simplest workflow is to use the output spreadsheet to identify and copy the selected videos into the “processed” folder, then go through and log the contents of the “processed” folder according to the usual Camera Trap Protocol.

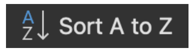
b. Open the “results” spreadsheet located in the “processed” folder.

c. Expand column B: *relative_path* so you can see the full length of each entry. These are the file names of the selected photos and videos.

d. Highlight column B: *relative_path* and click *Sort & Filter* 

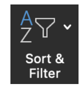
in the upper right corner of the Home menu bar. The *Sort & Filter* option is located within the *Editing* menu if your screen is not fully expanded.



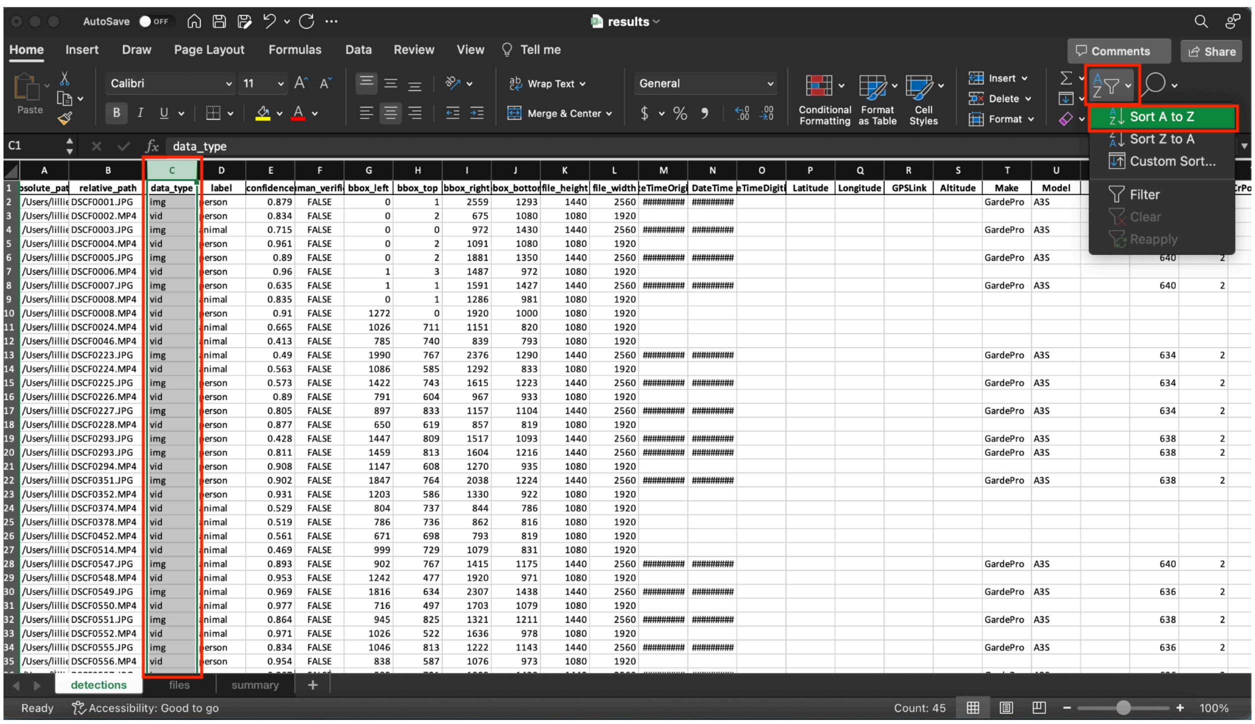
e. Select *Sort A to Z* 

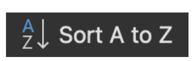
and keep the option selected to "Expand the selection". Click *Sort.*

i. This sorts the data by filename, but images and videos are still mixed together.

f. Highlight column C: *data_type* and click *Sort & Filter* 

in the upper right corner of the Home menu bar.



g. Select *Sort A to Z* 

and keep the option selected to "Expand the selection". Click *Sort.*

i. This sorts the alphabetized files into images and videos.

h. Scroll down to the beginning of the "vid" selection in column C. Using the filenames in column B, locate all the video files from the spreadsheet in the original un-processed folder and copy them into the "processed" folder.

15	/Users/lillie	DSCF0555.JPG	img	person	0.834	FALSE	1046	813	1222	1143	1440	2560
16	/Users/lillie	DSCF0557.JPG	img	person	0.967	FALSE	585	721	1009	1439	1440	2560
17	/Users/lillie	DSCF0559.JPG	img	person	0.848	FALSE	0	1	1962	1382	1440	2560
18	/Users/lillie	DSCF0563.JPG	img	person	0.662	FALSE	0	0	2560	1293	1440	2560
19	/Users/lilli	DSCF0002.MP4	vid	person	0.834	FALSE	0	2	675	1080	1080	1920
20	/Users/lilli	DSCF0004.MP4	vid	person	0.961	FALSE	0	2	1091	1080	1080	1920
21	/Users/lilli	DSCF0006.MP4	vid	person	0.96	FALSE	1	3	1487	972	1080	1920
22	/Users/lilli	DSCF0008.MP4	vid	animal	0.835	FALSE	0	1	1286	981	1080	1920
23	/Users/lilli	DSCF0008.MP4	vid	person	0.91	FALSE	1272	0	1920	1000	1080	1920
24	/Users/lilli	DSCF0024.MP4	vid	animal	0.665	FALSE	1026	711	1151	820	1080	1920
25	/Users/lilli	DSCF0046.MP4	vid	animal	0.413	FALSE	785	740	839	793	1080	1920
26	/Users/lilli	DSCF0224.MP4	vid	animal	0.563	FALSE	1086	585	1292	833	1080	1920
27	/Users/lilli	DSCF0226.MP4	vid	person	0.89	FALSE	791	604	967	933	1080	1920
28	/Users/lilli	DSCF0228.MP4	vid	person	0.877	FALSE	650	619	857	819	1080	1920
29	/Users/lilli	DSCF0294.MP4	vid	person	0.908	FALSE	1147	608	1270	935	1080	1920
30	/Users/lilli	DSCF0352.MP4	vid	person	0.931	FALSE	1203	586	1330	922	1080	1920
31	/Users/lilli	DSCF0374.MP4	vid	animal	0.529	FALSE	804	737	844	786	1080	1920
32	/Users/lilli	DSCF0378.MP4	vid	animal	0.519	FALSE	786	736	862	816	1080	1920
33	/Users/lilli	DSCF0452.MP4	vid	animal	0.561	FALSE	671	698	793	819	1080	1920
34	/Users/lilli	DSCF0514.MP4	vid	animal	0.469	FALSE	999	729	1079	831	1080	1920
35	/Users/lilli	DSCF0548.MP4	vid	animal	0.953	FALSE	1242	477	1920	971	1080	1920
36	/Users/lilli	DSCF0550.MP4	vid	animal	0.977	FALSE	716	497	1703	1079	1080	1920
37	/Users/lilli	DSCF0552.MP4	vid	animal	0.971	FALSE	1026	522	1636	978	1080	1920
38	/Users/lilli	DSCF0556.MP4	vid	person	0.954	FALSE	838	587	1076	973	1080	1920
39	/Users/lilli	DSCF0558.MP4	vid	animal	0.79	FALSE	0	464	277	1079	1080	1920
40	/Users/lilli	DSCF0558.MP4	vid	person	0.973	FALSE	320	543	717	1080	1080	1920
41	/Users/lilli	DSCF0560.MP4	vid	animal	0.465	FALSE	0	2	427	1076	1080	1920
42	/Users/lilli	DSCF0560.MP4	vid	person	0.852	FALSE	1	2	1471	976	1080	1920
43	/Users/lilli	DSCF0562.MP4	vid	animal	0.694	FALSE	1	2	1798	975	1080	1920
44	/Users/lilli	DSCF0562.MP4	vid	person	0.867	FALSE	0	0	722	1078	1080	1920
45	/Users/lilli	DSCF0564.MP4	vid	person	0.833	FALSE	0	0	1918	970	1080	1920

i. Now, the "processed" folder should contain all the photos and videos that were selected by the program. Log the contents of the "processed" folder as normal, according to the CACS Camera Trap Protocol.

Appendix B: Environmental and Wildlife Data for Camera Locations

Camera	Name	Latitude	Longitude	Site	Type	DistRoad	DistTrail	DistWater	DistBuilding	DistBoundary	LandCover	TrailUse
IRP 1	Glacier View Trail	59.69899	-151.41329	IRP	Existing	91.491021	5.11019	95.78172	129.761752	5.279698	Alder	High
IRP g1	Goose Pond	59.70100685	-151.4072563	IRP	Existing	212.232053	60.800931	39.124402	210.867443	309.440861	Spruce	Low
IRP g2	Greenhouse/Lynx	59.70188121	-151.4107345	IRP	Existing	183.580435	3.971435	24.666058	64.376087	235.004525	Spruce	Low
IRP g3	Cottonwood Cam	59.70385067	-151.4406268	IRP	Existing	448.672822	0.546448	107.95841	518.274157	190.059195	Spruce	Medium
IRP 6	Gozzie Loop	59.70054635	-151.4050192	IRP	Existing	193.807008	6.46554	54.451155	214.128145	196.886571	Spruce	Medium
IRP 7	Knoll	59.69856	-151.40628	IRP	New	283.666965	25.200735	80.435864	184.915049	229.272679	Alder	Low
IRP 8	Bog	59.70202	-151.40514	IRP	New	101.964708	3.966099	55.533997	320.288668	184.993335	Fen	Medium
IRP 9	Warbler’s Way	59.7036	-151.41499	IRP	New	57.578634	4.555441	104.576323	306.689014	47.116669	Spruce	Medium
IRP 10	Nina's Arc Junction	59.70341	-151.42686	IRP	New	576.470184	1.939557	49.788484	439.545071	185.061244	Spruce	Medium
IRP 11	Property Boundary	59.70365	-151.41881	IRP	New	244.543981	76.276668	0	451.850888	2.585622	Spruce	Low
IRP 12	Chipper’s Corner	59.7071756	-151.4212889	IRP	New	286.439083	19.166689	58.364303	197.581809	-94.610641	Spruce	Low
IRP 13	Tunturpak Trail	59.70418	-151.39677	IRP	New	61.946949	0.730267	78.124319	164.374962	49.164367	Alder	Low
IRP 15	Nina's Arc	59.70726	-151.42909	IRP	New	723.888456	0.520784	192.035158	153.248227	2.469615	Alder	Medium
IRP 16	Black Bear Ramble	59.70184	-151.4198	IRP	New	169.98733	0.224336	0	309.219922	197.079573	Spruce	High
IRP 17	Moose Pond	59.70071	-151.42237	IRP	New	211.98444	31.12438	21.237606	177.150783	71.461133	Alder	Low
IRP 18	Chocolate Cabin	59.69952	-151.43053	IRP	New	100.412649	13.985416	19.356151	41.140228	24.490087	Alder	Medium
IRP 19	Owl Loop	59.70639	-151.41213	IRP	New	77.812435	4.67371	291.807616	161.287711	99.486931	Spruce	Medium
W 1	Lynx Link	59.68253765	-151.4712664	Wynn	Existing	237.038291	4.33326	121.984512	209.771721	55.488782	Spruce	High
W 3	Moose Meander	59.68387331	-151.4787168	Wynn	Existing	105.189655	8.411166	34.100567	174.971548	198.280805	Spruce	High
W 4	Bog	59.68602581	-151.4819454	Wynn	Existing	204.24426	47.796675	6.690923	171.731689	-4.655457	Fen	Low
W 5	UM Bog	59.68692	-151.47896	Wynn	New	233.256112	136.439378	188.059149	217.566544	30.293738	Fen	Low
W 6	Fireweed Loop	59.68442	-151.48392	Wynn	New	335.297438	41.89027	179.933111	286.266705	136.40238	Spruce	Low
W 7	Moose Carcass	59.6834707	-151.4857018	Wynn	New	282.731159	21.599391	296.310499	209.580653	85.258845	Spruce	Medium
W 8	Powerline	59.68332	-151.4825	Wynn	New	203.991356	33.164482	240.40087	167.964386	140.396008	Spruce	Medium
W 9	UM Moose Meander	59.67988	-151.47929	Wynn	New	173.297093	11.801006	25.414467	140.372478	43.296615	Spruce	Medium
W 10	Cottonwood	59.67953	-151.47413	Wynn	New	26.677904	15.292069	100.742901	260.330582	68.587715	Alder	High
W 11	NorthWynn	59.68198	-151.47358	Wynn	New	134.027625	38.358458	147.884699	77.209033	37.135647	Spruce	Low

Camera	Start	End	DaysTotal	DaysMissing	DaysDeployed	People	Moose	Coyote	Bear	Lynx	People30	Moose30	Coyote30	Bear30	Lynx30
IRP 1	2023-05-01	2024-01-23	268	0	268	220	41	0	2	0	24.62687	4.58955	0	0.22388	0
IRP g1	2023-05-01	2024-01-23	268	0	268	1	122	20	4	2	0.11194	13.65672	2.23881	0.44776	0.22388
IRP g2	2023-05-01	2024-01-31	276	23	253	15	78	0	3	7	1.77866	9.24901	0	0.35573	0.83004
IRP g3	2023-05-01	2023-10-19	172	0	172	70	47	4	1	0	12.20930	8.19767	0.69767	0.17442	0
IRP 6	2023-05-01	2024-01-23	268	42	226	40	70	0	0	0	5.30973	9.29204	0	0	0
IRP 7	2023-06-06	2023-12-06	184	0	184	1	13	0	1	0	0.16304	2.11957	0	0.16304	0
IRP 8	2023-06-06	2024-01-23	232	0	232	77	74	0	2	0	9.95690	9.56897	0	0.25862	0
IRP 9	2023-06-06	2024-01-24	233	0	233	75	45	0	0	0	9.65665	5.79399	0	0	0
IRP 10	2023-06-06	2024-02-13	253	0	253	66	18	16	2	3	7.82609	2.13439	1.89723	0.23715	0.35573
IRP 11	2023-06-06	2024-01-24	233	0	233	0	20	1	5	2	0.00000	2.57511	0.12876	0.64378	0.25751
IRP 12	2023-06-06	2024-01-24	233	0	233	1	8	1	3	0	0.12876	1.03004	0.12876	0.38627	0
IRP 13	2023-06-07	2024-01-24	232	0	232	10	74	59	5	2	1.29310	9.56897	7.62931	0.64655	0.25862
IRP 15	2023-06-06	2024-01-23	232	0	232	64	39	8	5	0	8.27586	5.04310	1.03448	0.64655	0
IRP 16	2023-06-06	2024-01-24	233	0	233	94	32	6	8	0	12.10300	4.12017	0.77253	1.03004	0
IRP 17	2023-06-06	2024-01-24	233	0	233	3	118	0	1	0	0.38627	15.19313	0	0.12876	0
IRP 18	2023-06-06	2024-02-13	253	27	226	33	23	0	0	0	4.38053	3.05310	0	0	0
IRP 19	2023-06-07	2024-02-13	252	0	252	34	14	14	3	0	4.04762	1.66667	1.66667	0.35714	0
W 1	2023-05-01	2024-01-18	263	0	263	578	52	40	19	0	65.93156	5.93156	4.56274	2.16730	0
W 3	2023-05-01	2023-12-12	226	18	208	1451	33	2	0	0	209.27885	4.75962	0.28846	0	0
W 4	2023-05-01	2023-12-12	226	10	216	14	165	0	0	0	1.94444	22.91667	0	0	0
W 5	2023-06-05	2024-01-17	227	32	195	4	112	14	1	0	0.61538	17.23077	2.15385	0.15385	0
W 6	2023-06-15	2024-01-18	218	0	218	3	68	0	0	0	0.41284	9.35780	0	0	0
W 7	2023-06-13	2023-12-12	183	0	183	3	14	15	7	0	0.49180	2.29508	2.45902	1.14754	0
W 8	2023-06-05	2024-01-31	241	0	241	35	78	16	0	1	4.35685	9.70954	1.99170	0	0.12448
W 9	2023-06-05	2024-01-21	231	0	231	2	32	0	0	0	0.25974	4.15584	0	0	0
W 10	2023-06-07	2024-02-11	250	0	250	119	22	0	0	0	14.28000	2.64000	0	0	0
W 11	2023-06-05	2024-02-11	252	0	252	10	20	7	4	0	1.19048	2.38095	0.83333	0.47619	0

Appendix C: Code for Soundscape Analysis in Python

This script uses Python to automate the loading, processing, and analysis of soundscape recordings. I am using these recordings to estimate the level of road noise at different locations across IRP and Wynn. Recorders were placed at 10 locations with known coordinate values and recorded a 5-minute file every hour for 3 days (per location). This resulted in over 3600 minutes of geotagged audio recordings to be analyzed. I used Python to make a loop to load each of the 732 audio files. Then I adapted code from an audio processing example that was included with the documentation for scikit-maad, an open-source Python package for processing soundscape recordings (https://scikit-maad.github.io/_auto_examples/2_advanced/plot_unsupervised_sound_classification.html#sphx-glr-auto-examples-2-advanced-plot-unsupervised-sound-classification-py).

This function automatically selects regions of interest that are within the desired frequency and time parameters, which I adjusted to fit my analysis for road noise. The regions of interest are saved in a dataframe including the start and end time, so I wrote the last part of my code to loop through the rows of the dataframe and calculate the total amount of time for the selected regions of interest. This gives me the total duration of road noise for each recording, which I can use to compare between locations.

In [2]:

```
#Imports
import matplotlib.pyplot as plt
import pandas as pd
import os
import numpy as np
from maad import sound, features, rois
from maad.util import power2dB, plot2d, format_features, overlay_rois


#create dictionary to store file names and total road noise time
recs=dict()

#count total number of files
number_files=0
for file in os.listdir():
    if file.endswith(".wav"): # find all .wav files
        number_files=number_files+1


#Loop through every audio file in folder
filenum=0

for file in os.listdir():
    if file.endswith(".wav"): # find all .wav files
        fname=os.path.join(file)

        #audio analysis code based on example from scikit-maad.github.io link shown in description above

        #Load and view data

        s, fs = sound.load(fname)
        #print('Loaded file:',fname)
        s_filt = sound.select_bandwidth(s, fs, fcut=(100,3000), forder=3, ftype='bandpass')
        #used a bandpass filter with 100 Hz as the lower limit to remove some background noise but keep road noise
        #upper limit as 3000 Hz because this was higher than the road noise

        db_max=70  # used to define the range of the spectrogram
        Sxx, tn, fn, ext = sound.spectrogram(s_filt, fs, nperseg=1024, noverlap=512)
        Sxx_db = power2dB(Sxx, db_range=db_max) + db_max
        #plot2d(Sxx_db, **{'extent':ext}) #plot base spectrogram


        #Find regions of interest (ROIs)

        Sxx_db_rmbg, _, _ = sound.remove_background(Sxx_db)
        Sxx_db_smooth = sound.smooth(Sxx_db_rmbg, std=1.2)
        im_mask = rois.create_mask(im=Sxx_db_smooth, mode_bin ='relative', bin_std=2, bin_per=0.25)
        im_rois, df_rois = rois.select_rois(im_mask, min_roi=1000, max_roi=None)
        #min and max roi define minimum and the maximum area (in pixels) possible for an ROI
        #trial and error to choose min as 1000 so it's only selecting the longer pieces of road noise


        #Format ROIs and visualize the bounding box on the audio spectrogram.

        df_rois = format_features(df_rois, tn, fn)
        #ax0, fig0 = overlay_rois(Sxx_db, df_rois, **{'vmin':0, 'vmax':60, 'extent':ext})



        #view table of data for ROIs
        #print(df_rois)


        #Calculate total time of road noise and save to dictionary
        time=0
```

```
        for row in range(len(df_rois)): #iterate through each row of ROIS dataframe
            t=df_rois.iloc[row,-1]-df_rois.iloc[row,-3] #max_t - min_t

            #if fname[0:8]=='S4A02006' and df_rois.iloc[row,-3]>=180 or fname[0:8]=='S4A07721' and df_rois.iloc[row,-1]<=160:
            #used for comparing the test clips where S4A02006 starts 3 minutes after S4A07721

            time=time+t

        recs[fname]=time
        filenum=filenum+1
        print('Data saved for file:',fname,'(',filenum,'/',number_files,')')


datasave = pd.DataFrame(data=recs, index=[0])
datasave = (datasave.T)
datasave.to_csv("datasave.csv")
#I used filenames "wynnsave" and "irpsave" (shown in the next code block) in place of "datasave" used here for an example.
#The audio files of interest were located within the working directory at the time, so for "wynnsave", the only files in the
#folder were the recordings from Wynn
```

In [4]:

```
#Format and compile data into full csv
wynn = pd.read_csv('wynnsave.csv')
irp = pd.read_csv('irpsave.csv')
wynn.columns=['Filename','NoiseDuration']
irp.columns=['Filename','NoiseDuration']
wynn['Site']='Wynn'
irp['Site']='IRP'
bothsites=pd.concat([wynn, irp], axis=0, ignore_index=True)
bothsites['Date']=0
bothsites['Hour']=0

for index, row in bothsites.iterrows():
    file=bothsites.iloc[index,0]
    date=file[9:17]
    bothsites.iloc[index,3]=date[0:4]+'-'+date[4:6]+'-'+date[6:8]
    hr=int(file[18:24])
    bothsites.iloc[index,4]=round(hr/10000)

print(bothsites)
bothsites.to_csv("soundscapedata.csv")
```

```
                         Filename  NoiseDuration  Site        Date  Hour
0    S4A07721_20230630_120000.wav     192.021333  Wynn  2023-06-30    12
1    S4A07721_20230630_020000.wav      62.997333  Wynn  2023-06-30     2
2    S4A07721_20230713_120000.wav      84.181333  Wynn  2023-07-13    12
3    S4A07721_20230713_020000.wav       0.000000  Wynn  2023-07-13     2
4    S4A07721_20230708_090000.wav      84.586667  Wynn  2023-07-08     9
..                            ...            ...   ...         ...   ...
727  S4A02006_20230711_050000.wav      12.202667   IRP  2023-07-11     5
728  S4A02006_20230702_160000.wav      44.181333   IRP  2023-07-02    16
729  S4A02006_20230712_190000.wav     119.850667   IRP  2023-07-12    19
730  S4A02006_20230712_090000.wav      12.288000   IRP  2023-07-12     9
731  S4A02006_20230630_200000.wav      60.970667   IRP  2023-06-30    20

[732 rows x 5 columns]
```