Impact of Human Activity Levels on Coyote Temporal Behaviors on Presque Isle State Park



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Humans and wildlife must adapt to coexist in increasingly overlapping environments. Coyotes (*Canis latrans*) are one species that share various types of spaces with humans, such as natural recreation areas, and are already known to spatially distance themselves from humans. However, fewer studies have been conducted to determine if coyotes change what time of the day they are most active to avoid negative human interactions. This study examined Presque Isle State Park in Pennsylvania, an area used by both humans and coyotes, to assess if coyotes change when they are active based on different levels of human activity. Between 30 October 2022 and 3 February 2023, two Cuddeback trail cameras were placed at three locations with high, medium, and low human activity. Photos were analyzed for when coyotes were active and what behaviors they were exhibiting. A total of 229 photos were cataloged with 37 individual detections of coyotes. Of the coyote detections, 35 of them were at night. The results support that the coyotes of Presque Isle State Park were nocturnal, especially in areas with high human activity. These results can be used to inform future management plans for coyotes on Presque Isle and educate the public on the wildlife they may interact with while visiting.

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Introduction

Wildlife and human habitats are overlapping, as human development has continued to expand and fragment natural areas where wildlife resides (Bekoff & Gese, 2003; Grinder & Krausman, 2001; Kays et al., 2017; Kendrot, 1998; Larson et al., 2020; Mastro, 2011; McClennen, 2001; Murray & St. Clair, 2015; Riley et al., 2003; Wallace 2013; Way et al., 2004). Wildlife can now be seen more often in human-dominated environments because of this (Bekoff & Gese, 2003; Grinder & Krausman, 2001; Kays et al, 2017; Larson et al., 2020; Mastro, 2011; McClennen, 2001; Riley et al., 2003; Wallace 2013; Way et al., 2004). Some species, like coyotes (*Canis latrans*), have even been spotted in urban areas with large human populations (Grinder & Krausman, 2001; Murray & St. Clair, 2015; Patten et al., 2019; Riley et al., 2003). This increase in overlapping territory means that humans and wildlife have to learn to coexist, especially in natural recreation areas, such as national and state parks (Kays et al., 2017; Larson, 2020; Reed & Merenlender, 2011; Wallace, 2013). Both positive and negative human-wildlife interactions can happen, but human activity, including persecution of certain species, can affect the ecosystem in major ways; for example, if two species have a direct relationship, human-caused behavior changes in one species will affect the other (Kitchen et al., 2000; König et al., 2020; Nyhus, 2016; Paterson et al., 1999; Patten et al., 2019). Wildlife and nature is something to be protected, and because of that humans have to realize that their presence, activities, and infrastructure do affect wildlife in several ways (Gaynor et al., 2018; Grinder & Krausman, 2001; Kendrot, 1998; Kitchen et al., 2000; Larson et al., 2020; McClennen et al., 2001; Murray & St. Clair, 2015; Patten et al., 2019; Riley et al., 2003; Wallace, 2013; Way et al., 2004). In order to avoid conflicts and preserve wildlife and their ecosystems, humans have to understand exactly how they affect wildlife (König et al., 2020; Mastro, 2011; McClennen et al., 2001; Nyhus, 2016; Way et al., 2004).

One animal of interest is the coyote, a predator in ecosystems throughout the United States (Bekoff & Gese, 2003). While they are distributed across the United States, their presence in the eastern states is relatively new; coyotes have spread to these areas in the past 100 years (Bekoff & Gese, 2003; Mastro, 2011). Specifically in Pennsylvania, coyotes were first documented in the region in the 1930s and 1940s (Mastro, 2011). Coyotes live in a variety of habitats, including areas that overlap with human development, such as urban, suburban, and

natural recreation areas (Bekoff & Gese, 2003). Coyotes have evolved to be active at dawn and dusk - their eyes, for example, function best during the day and crepuscular hours - but the increase in overlapping territory with humans has led to coyotes becoming more nocturnal to avoid interactions with humans (Bekoff & Gese, 2003; Kitchen et al., 2000). Their home territory can vary as well, depending on food distribution, the social organization of the pack, and the season; however in resident coyotes, there is a strong loyalty to their specific home territory that can last for generations (Bekoff & Gese, 2003). The species is also an opportunistic feeder and will eat what is available to them, such as fruit, insects, birds, and white tailed deer (Bekoff & Gese, 2003). As for social organization, the coyote usually has a group containing a breeding male and female, associate members of the pack, and any young from the breeding pair. However, it is not unusual for coyotes to be alone and travel around without a home territory; these coyotes are referred to as transient individuals (Bekoff & Gese, 2003).

Already, several studies have demonstrated that both human activity and development affect coyote mannerisms in a multitude of situations (Gaynor et al., 2018; Grinder & Krausman, 2001; Kendrot, 1998; Kitchen et al., 2000; McClennen et al., 2001; Murray & St. Clair, 2015; Paterson et al., 1999; Patten et al., 2019; Riley et al., 2003; Schell et al., 2018; Schultz & Young, 2018; Way et al., 2004). Captive coyotes, in enclosures and with constant exposure to humans, are wary of human presence (Schell et al., 2018, Schultz & Young, 2018). Even with time, while coyotes may view humans as less of a threat, they remain vigilant when people are nearby and stick to the parts of their enclosures where they can observe humans clearly (Schell et al., 2018, Schultz & Young, 2018). In the wild, these vigilant behaviors increase and become avoidant (Gaynor et al., 2018; Grinder & Krausman, 2001; Kendrot, 1998; Kitchen et al., 2000; McClennen et al., 2001; Murray & St. Clair, 2015; Paterson et al., 1999; Patten et al., 2019; Riley et al., 2003; Way et al., 2004). Furthermore, human development by itself can lead to shifts in coyote behaviors (Kendrot, 1998; McClennen et al., 2001; Riley et al., 2003; Way et al., 2004). Coyotes prefer natural areas with the least amount of human development, such as forests and other undisturbed environments (Grinder & Krausman, 2001; Kendrot, 1998; Riley et al., 2003). If coyotes have to travel through or forage in areas with more humans, they will often become more nocturnal to avoid interaction (Grinder & Krausman, 2001; Kendrot, 1998; McClennen et al., 2011; Murray & St. Clair, 2015; Paterson et al., 1999; Riley et al., 2003; Way et al., 2004).

Even in most natural areas, coyotes can't avoid humans entirely, as people visit these places for recreational purposes (Gaynor et al., 2018; Kays et al., 2017; Kitchen et al., 2000; Larson et al., 2020; Patten et al., 2019; Reed & Merenlender, 2011; Wallace, 2013). Some studies have demonstrated that in these natural areas where coyotes reside, including parks and protected areas, humans have little to no impact on coyote behaviors; in fact, they will use the same trails that humans do (Larson et al., 2020; Kays et al., 2017; Wallace, 2013). On one occasion, coyotes used such trails during the day; however, the trail used by coyotes in this situation was closed to human visitors at the time (Larson et al., 2020). Once it was reopened, coyotes still used the trail, but did so during the night instead (Larson et al., 2020). The idea that coyotes will use human trails, but nocturnally is further supported by other studies (Gaynor et al., 2018; Kays et al., 2017; Kitchen et al., 2000; Larson et al., 2020; Reed & Merenlender, 2011; Wallace, 2013). The majority of results point to the conclusion that no matter where coyotes reside in their natural habitat, they will temporally shift their behaviors if there is human activity (Gaynor et al., 2018; Kays et al., 2017; Kitchen et al., 2000; Larson et al., 2020; Reed & Merenlender, 2011; Wallace, 2013). It should also be noted that it doesn't matter what activity humans are doing in protected areas and parks; any activity, from hunting to hiking, has been shown to influence coyotes to shift to nocturnality (Gaynor et al., 2018; Kays et al., 2017; Kitchen et al., 2000; Reed & Merenlender, 2011; Wallace, 2013). Coyotes altering their behaviors has the potential to affect species they have direct relationships with, such as the gray fox (*Urocyon cinereoargenteus*) (Patten et al., 2019). In a study in California, because of human activity, coyotes became more nocturnal, which increased the overlap time between gray foxes and coyotes; this increased the risk of gray foxes being preyed on by coyotes (Patten et al., 2019).

These previous studies had four main ways of getting information on coyotes and their behaviors: collecting and analyzing scat, using trail cameras, tracking coyotes through radio and/or satellite collars, and through in-situ observation (Duafala, 2012; Grinder & Krausman, 2001; Kays et al., 2017; Kendrot, 1998; Kitchen et al., 2000; Larson et al., 2020; McClennen et al., 2011; Murray & St. Clair, 2015; Paterson et al., 1999; Patten et al., 2019; Reed & Merenlender, 2011; Riley et al., 2003; Wallace, 2013; Ward et al., 2018; Way et al., 2004). Radio and satellite collars, especially those with mortality sensors, were the most used form of tracking coyotes (Grinder & Krausman, 2001; Kendrot, 1998; Kitchen et al., 2000; McClennen et al.,

2011; Murray & St. Clair, 2015; Paterson et al., 1999; Riley et al., 2003; Wallace, 2013; Ward et al., 2018; Way et al., 2004). In these studies, the collars tracked the movements of coyotes and allowed researchers to see when coyotes were in a certain area (Grinder & Krausman, 2001; Kendrot, 1998; Kitchen et al., 2000; McClennen et al., 2011; Murray & St. Clair, 2015; Paterson et al., 1999; Riley et al., 2003; Wallace, 2013; Ward et al., 2018; Way et al., 2004). General observation and trail cameras were also frequent tools, although observations were mainly used to observe when and where humans were on hiking trails (Kays et al., 2017; Larson et al., 2020; Paterson et al., 1999; Patten et al., 2019; Reed & Merenlender, 2011; Schell et al., 2018; Schultz & Young, 2018; Wallace, 2013). Cameras, especially those with infrared, were helpful in getting information on both coyotes and humans in the study location, which included hiking trails and the surrounding area (Kays et al., 2017; Larson et al., 2020; Patten et al., 2019; Wallace, 2013). Scat collection and analysis was also useful in identifying if coyotes were in the vicinity and what was in their diet, however it wasn't a technique used in studying the temporal behavior of coyotes (Duafala, 2012; Reed & Merenlender, 2011; Ward et al., 2018).

Based on prior research and the fact that coyotes are relatively new in the eastern United States, there is a need for more information about coyotes in this region, especially where their natural territories overlap with human activity (Bekoff & Gese, 2003; Mastro, 2011). In these areas of overlap, shifts in coyote behavior may come from human activity (Patten et al., 2019). The main potential effect of changes in temporal behavior is an increased risk of predation on prey species from coyotes, and thus a change in prey populations (Patten et al., 2019). The possibility that dynamics between species and within the ecosystem could change, in addition to interactions with humans, demonstrates a need to understand how humans affect coyote behaviors (Mastro, 2011). Researching coyote temporal behavior has the potential to help people in natural protected areas in the eastern states to understand coyotes and assist with their future management to promote coexistence (König et al., 2020; Mastro, 2011; Nyhus, 2016).

Presque Isle State Park (PISP) is a popular day-time state park that has beaches and swimming on Lake Erie, hosts events such as marathons, and most significantly, has several trails that people use to bike and hike ("Best Trails in Presque," n.d.; Pennsylvania Department of Conservation and Natural Resources, n.d.; "Hiking trails near Presque," n.d.). In addition to having high human activity, PISP also has an ecological reservation and has a natural area called

Gull Point (Pennsylvania Department of Conservation and Natural Resources, 2021). Presque Isle State Park is also known for its wetland areas and ponds throughout the center of the isle (Pennsylvania Department of Conservation and Natural Resources, 2021). This park has documentation of coyotes starting from 2011, confirmed by the Tom Ridge Environmental Center, by trail cameras on the Isle, virtual programs about them hosted by a Presque Isle State Park naturalist, and current PISP employees (The Natural History Museum at the Tom Ridge Environmental Center, 2009; personal connection, October, 2022; Presque Isle State Park, PA, 2012; Presque Isle State Park, PA, 2013; Presque Isle State Park, PA, 2021; Pennsylvania Department for Conservation and Natural Resources, 2020).

With that and its popularity, it is a good place to start gathering information on if and how coyotes in this region follow the pattern of shifting their behavior to become more nocturnal due to humans. By using trail cameras and observation, two forms of data collection used by previous researchers and are available to me, and by connecting to experts in the park, I will determine how human activity on the trails of Presque Isle State Park affects coyote temporal behavior. The results will be valuable for wildlife managers as well as park visitors. It will also lead to further research on human-coyote interactions in the park and the ecological impact of the coyotes' shift in temporal behavior.

Process and Approach

Study Sites

To test the hypothesis that human activity affects the coyotes in PISP by making them more active nocturnally than during their usual day, dawn, and dusk hours, I looked for three study sites on PISP with high, medium, and low levels of human activity. I started by collecting data about hiking trails, as coyotes have been known to utilize them; based on that, along with the fact that a previous study on PISP collected coyote scat on trails, they would be good locations to place cameras (Bekoff & Gese, 2003; Duafala, 2012; Kays et al., 2017; Larson et al., 2020). I first determined which trails had the most human activity around them via trail popularity and proximity to human infrastructure. I created a list of all the trails from the park website (Pennsylvania Department of Conservation and Natural Resources, n.d.). Then I visited the AllTrails website to see which of these were the most popular from their star ratings ("Best Trails in Presque," n.d.). The higher the star rating, the more popular the hiking trail was considered. As popularity can be an indicator of how many people will visit a certain trail, I made a list of the trails from most to least popular. I also used the Hiking Project website to look at trails and their ratings ("Hiking trails near Presque," n.d.). I then utilized the PISP trail map to see the locations of these trails and considered the trails' location in relation to things such as beaches and shelters, as those areas are where humans are most likely to be on the isle (Pennsylvania Department of Conservation and Natural Resources, 2021). I sorted trails based on this information - their popularity rankings from websites, if they were in areas with high human activity, if they were on the ecological reserve portion of the isle - and made preliminary assumptions about which trails would be good candidates for my three different study sites. It is also important to note that these trails and areas would only be used by humans during the day, as PISP is closed to visitors at dusk and no camping is allowed in the park.

After this research, I went out onto the trails to see which were most suitable for study. I looked for three different sites with low, medium, and high levels of human activity. Besides looking at signs of human presence - well-worn trails, proximity to amenities, and more - the locations needed to have objects to secure the trail cameras to, such as trees. I recorded potential locations' GPS coordinates in a notebook. In addition to surveying trails on the isle, I connected with environmental educators from PISP and talked to them about where coyotes have been

known to be in the park. From this and assessing which areas are most suitable for camera placement, I chose three sites (Figure 1).

Figure 1



Figure 1: The three study sites - Old Gas Well Trail, Intersection of Marsh and Ridge Trails, and Off Dead Pond Trail - are marked by yellow stars. Two Cuddeback cameras were placed at each site, and data was collected from 30 October 2022 to 3 February 2023 at Presque Isle State Park, Pennsylvania under permit number 2022-91.

The site I chose to represent high human activity was the Old Gas Well Trail (OGW). While the site itself was on a trail that was forested, it was in close proximity to Beach 8, a shelter, a playground, roads, and other human infrastructure. Additionally, this trail was rated four out of five stars. Based on all of this, and that there were good trees to place the cameras on, I chose the Old Gas Well Trail for high human activity.

The intersection of the Marsh and Ridge Trails (IMR) was the site of medium human activity. This area was also forested, but had less undergrowth. Neither of these two trails were rated, however Marsh comes off of the Sidewalk Trail which had four out of five stars, and the trails were maintained with an obvious path. Considering all of this, it was chosen as the site of medium human activity.

An area off of Dead Pond Trail (ODP) was chosen as the site of low human activity. While still close to the trail, the actual site was not visible from the trail and vice versa. The site, like the others, was forested, but closer to wetlands and featured recent beaver activity and various animal tracks. Furthermore, it was on the ecological reservation portion of PISP. Because of this activity and the area being farther away from humans, it was chosen as the site with low human activity.

Trail Cameras

At each site, I set up two Cuddeback G-Series cameras. These cameras were black flash instead of white flash, as that does not deter animals as much at night like white flash, since black flash is undetectable by animals (personal connection, September, 2022; Sparks, 2022). At the two sites on trails - IMR and OGW - one camera was placed facing the trail while another was facing away from it. This allowed for a wider point of view of the area and larger chances of detecting coyotes. Two cameras were also set up in the low human activity site, with no trails and no human development. This space acted as a control for natural coyote behavior in the park, in comparison to the two sites with more human activity. All cameras were placed at around two feet above the ground, as coyotes stand around two feet in height (personal connection, September, 2022).

Each camera was first set up to have the correct date and time. Then each was tested for battery levels and the success of the SD card and image taking. In the commands, aspect was tuned to full, zone to centered, IR to close, image size to 5 MP, lapse size to 5 MP, and DST to auto. In the settings, the advanced mode was turned on, with day delay at 30 seconds taking a burst of three photos. Video and lapse were off. Night delay was 30 seconds taking a burst of three photos. Black IR was turned on with video and lapse off. Each camera was armed before being attached to the trees at the study sites along with a lock and cable.

Data Collection

To retrieve the photos off of the cameras, every two weeks the SD cards in the cameras were changed out and the batteries of the cameras were checked. The photos were stored on an external hard drive. After I saved the photos, I cleared the media from the SD cards so they could be used again. Batteries were replaced as needed. Cameras were rotated around the sites to increase the chance of capturing coyotes on camera. Cameras were deployed on October 30th,

2022 and collected data until February 3rd, 2023. The cameras were brought back in from the trails on the last day of collection as well.

Supplemental Data

As I only collected data for a short amount of time, I asked Presque Isle State Park employees if they had camera trap data of coyotes that I could use to supplement my own. They did, although their data collection methods were different from my own. In years past they used to take still photos, however because of how blurry they were, the park switched to taking 20 to 30 second videos instead (personal connection, October, 2022). PISP also used cameras such as SpyPoint, Exodus, and Cabela instead of Cuddeback (personal connection, October, 2022). Furthermore, these cameras were kept out all year and have moved around the Isle at various points in time (personal connection, October, 2022). The photos that PISP gave me for this study extend from 2011 to 2022, with 9 different locations (personal connection, October, 2022). The majority of data collected has been during the fall and winter months, which overlap with my timeframe.

Data Analysis

I analyzed the collected media for appearances of coyotes. An individual detection was recognized as a 30 minute delay between detections (personal connection, September, 2022; Kelly & Holub, 2008). If there were other individuals in the photo, they were counted as separate individual detection. Time, as well as behavior, the date, and the location of the media, with any additional notes, were documented in a spreadsheet. Time was split into four categories based on another study: dawn, day, dusk, and night (Paterson et al., 1999). I entered this information after checking when dawn and dusk were for that day, as those times changed throughout the fall and winter. Dawn and dusk were considered an hour before sunrise and an hour after sunset respectively, based on definitions of dawn and dusk and another study ("Glossary - Dawn," 2004; "Glossary - Dusk," 2004; Way et al., 2004). There were three categories of behavior classification based on other studies: active - in the area, active - passing through, and inactive/at rest (McClennen et al., 2001; Paterson et al., 1999; Riley et al., 2003). In the spreadsheet, for these two categories, I created a picklist to choose an option. This made it easier to tally up when coyotes appeared and their behaviors during that time. Time of appearance was compared between site locations at the end of the study. This was done by

sorting each piece of media by where the detection was and when the detection was from the four time categories. For example, one category would be the Old Gas Well Trail at dawn. Each of these categories was counted up to compare the total numbers and determine coyote temporal behavior on PISP.

The photos and videos from PISP personnel followed a similar process of categorization. The only difference were the sites and determining whether they were areas of high, medium, or low human activity. There were 9 different sites identified in the data from PISP, and they were sorted into the different levels of human activity the same way my chosen three trails were: looking at popularity of trails, the proximity of amenities in the area, and looking for signs of human presence in the photos themselves as well. Two of these sites were in areas of high human activity, 5 in medium human activity, and 2 in low human activity. Once each of the 9 sites were labeled as high, medium, or low human activity, they were sorted the same way as my own data.

Results

For my own data, cameras were deployed on October 30th, 2022 and collected data until February 3rd, 2023. The exception for this is one of the IMR cameras, which went up November 6th, 2022 due to issues with the camera lock during the previous visit. During the study period, there were 201 detections of animals. Detections included white tailed deer (*Odocoileus virginianus*) (*n* = 122), gray squirrels (*Sciurus carolinensis*) (*n* = 43), wild turkeys (*Meleagris gallopavo*) (*n* = 11), coyotes (*n* = 9), raccoons (*Procyon lotor*) (*n* = 8), Virginia opossum (*Didelphis virginiana*) (*n* = 1) and woodchucks (*Marmota monax*) (*n* = 1). Six detections had species that could not be identified. For my study areas, the majority of detections were at the IMR site at 46.3 percent (*n* = 93), then the OGW site with 41.3 percent of detections (*n* = 83), and 12.4 percent were at ODP (*n* = 25). In terms of when animals were detected, 45 percent were during the day (*n* = 90), 42 percent at night (*n* = 85), 7 percent at dawn (*n* = 14), and 6 percent at dusk (*n* = 12).

In addition to my own 9 coyote detections, I received supplemental data from PISP of 28 individual coyote detections, leading to a total of 37 individual coyote detections. Of these detections, 94.6% (*n* = 35) were at night. Of the non-night detections, one was from my data at dusk at a low human activity area while the other was from PISP during the day in a medium human activity area (Table 1 and Table 2). Additionally, medium human activity locations had the most coyote detections, with 51% (*n* = 19) of the detections (Table 1 and Table 2).

Table 1. *Canis latrans* Detections by Site and Time of Day

Time of Day[1]	Low	Medium	High
Dawn	-	-	-
Day	-	-	-
Dusk	1	-	-
Night	5	3	-

Table 1. Results of *Canis latrans* detections using camera traps by the amount of human activity at each site - Low correlates to the ODP site, Medium to the IMR site, and High to the OGW site - and time of day. Data was collected from 30 October 2022 to 3 February 2023 at Presque Isle State Park, Pennsylvania under permit number 2022-91.

[1] Time of Day was split up into four categories. Dawn was defined as an hour before sunrise and dusk was an hour after sunset. Night was between dusk and dawn, and day was between dawn and dusk.

From the data I collected, there were 9 individual detections of coyotes - three at IMR and six at ODP - mostly at night (Table 1). The site off of Dead Pond Trail also had one detection at dusk (Table 1).

Table 2. *Canis latrans* Detections by Site and Time of Day From PISP

Time of Day[1]	Low	Medium	High
Dawn	-	-	-
Day	-	1	-
Dusk	-	-	-
Night	7	15	5

Table 2. Results of *Canis latrans* detections from Presque Isle State Park categorized by the time of day in the detection as well as the amount of human activity at the various camera sites (Low, Medium, and High). This data was collected by the employees of PISP and was used to supplement my own data. This data set ranges from May 2011 to December 2022 on Presque Isle State Park, Pennsylvania.

[1] Time of Day was split up into four categories. Dawn was defined as an hour before sunrise and dusk was an hour after sunset. Night was between dusk and dawn, and day was between dawn and dusk.

From the data I acquired from Presque Isle State Park, there were 28 individual detections of coyotes, again mostly at night ($n = 27$). One photo from an area of medium human

activity had a coyote during the day. There were 15 more detections in areas of medium human activity, 5 in high human activity areas, and 7 at low human activity areas, all at night.

Discussion

From the data I collected, there were 37 individual detections of coyotes. Thirty five of these detections were at night, and 12 of them were at locations with low human activity, 18 at medium areas, and 5 at high level sites. The other 2 detections were during the day at a medium activity level site and at dusk in a low activity area. The data supports that the coyotes of PISP prefer to be active nocturnally, regardless of how much human presence is nearby.

The findings of my research share similarities to other studies. Gaynor et al. (2018) looked at the influence of human activity on temporal behaviors around the world for multiple species, including coyotes. That study concluded that despite the type of human activity, coyotes changed their behavior to be nocturnal (Gaynor et al., 2018). Another study from Kays et al. (2017) investigated several species in eastern North America and showed that coyotes were active at night, regardless of nearby human activity and infrastructure. Studies from Wallace (2013) and Larson (2020) looked at coyotes in natural recreation areas surrounded by urban and suburban environments, in Ohio and California respectively. Both of these studies found coyotes to be active at night in those environments, especially with human presence (Larson et al., 2020; Wallace, 2013). One study, Way et al. (2004), did find coyotes to be active during the day and that if they were, they stayed close to their dens where there were young coyotes. My detection of a coyote at dusk in an area of low human activity can be explained by that finding from Way et al. (2004) (Figure 2). While I did not confirm any dens or rendezvous sites on my cameras, the location of the camera from Figure 2 was ODP; that site was close to where a PISP trail camera was in the spring of 2022, where it caught coyote young on video (personal connection, October, 2022). As resident coyotes are known to be loyal to their home territories and don't roam far from their dens when there are young coyotes, the findings of Way et al. (2004) help explain the dusk detection at ODP (Bekoff & Gese, 2003).

Figure 2



Figure 2: Coyote caught on camera at ODP, a site of low human activity, at dusk. Photo taken under permit number 2022-91.

In addition to the temporal behaviors that coyotes exhibited, the results showed that 51% of all coyote detections were in areas of medium human activity. These locations were hiking trails and services roads, or what Way et al. (2004) would refer to as "linear paths." That study highlights a common behavior of wild canines, including coyotes, to use "linear paths (Way et al., 2004)." This behavior can be seen in other coyote studies, in addition to their nocturnal behavior, by detections on trails (Kays et al., 2007; Larson et al., 2020; Wallace, 2013). The research done by Duafala (2012) should also be acknowledged. While that study focused on the diets and movement of coyotes, it is the only study about coyotes on PISP, and specifically used trails as sites to collect scat. Based on that, coyotes in PISP are following another common trend from other coyote studies. However, since previous research notes that coyotes are changing

behaviors to avoid humans, the higher detections in medium human activity sites in comparison to low human activity areas is interesting.

There are a couple of possible explanations for this, besides the "linear paths." These medium level sites were also fluctuating in human activity at the time of the study. PISP is best known for its beaches and hiking in the spring and summer. As the study was conducted in the fall and winter months, when it is less popular, there were less humans as well (personal connection, October, 2022). The decrease of human activity may have encouraged coyotes to visit these medium activity locations more. Additionally, during the fall and winter months, coyotes are known to use the ice on Lake Erie to travel further off the isle (Duafala, 2012). While this may not have impacted the detections in medium areas, it could be responsible for a lack of more detections in low activity sites; coyotes could be moving out of low activity areas due to less possible human interactions and thus more space to move around. The lack of detections in low activity areas could also be because of the habitat. For example, ODP was very close to a pond and wetland area, which isn't the most ideal for coyotes in spite of their adaptability (Bekoff & Gese, 2003; personal connection, September, 2022). The fact that PISP is also a day park has to be acknowledged; the lack of human presence and activity during the night-time hours may have also allowed for coyotes to venture into areas that were deemed to have higher levels of human activity during the day, such as the iced over beaches and water.

The other detection that was not at night needs to be addressed (Figure 3). The explanation above about trails, seasonal changes in human activity in PISP, and habitat suitability all help explain why a coyote would be spotted in a medium human activity area in the daytime. Additionally, Larson (2020) did note that on a closed hiking trail in a natural recreation area, where humans were not present for some time, that coyotes were detected during the day; when the trail reopened though, coyotes returned to being nocturnal. While the trail of this site was not closed, the photo was taken in November, when human activity in PISP began to decline (personal connection, October 2022). This provides a possible explanation for this detection.

Figure 3



Figure 3: Coyote caught on photo in the daytime in 2012 in a medium human activity location. Photo from Presque Isle State Park trail cameras.

In conclusion, the majority of coyotes detected on PISP during this study were nocturnal, possibly due to human activity; the findings of previous studies support this outcome. The two detections that were not at night have similarities to studies as well that help to explain those outcomes.

From here, future research can expand on other coyote behaviors and wildlife in general. As humans are affecting normal coyote behavior, research needs to be done to see what the effects of those changes are. Despite coyotes being known for their adaptability, there could still be changes brought on by human influence that could affect them negatively that were not seen in this study (Bekoff & Gese, 2003). For example, there is little data about the differences between the nocturnal coyotes on PISP in comparison to coyotes with normal active times, especially in terms of their relationship with other species and within their ecosystem, and if

those differences have negative impacts. Already, studies show that changes in coyote temporal behavior can affect predator-prey dynamics and other relationships that coyotes have in an ecosystem (Mastro, 2011; Patten et al., 2019). The specifics of what this looks like on PISP isn't clear. In addition to more research being done on PISP, studying coyotes in a different state park could be done in the future. As PISP is a day-time park, it would be interesting to see the temporal behaviors of coyotes in a state park where there is human night-time activity, such as camping. Another question that could be further researched is why coyotes are choosing to live in environments that overlap with humans. For example, PISP is close to Erie, Pennsylvania. Other studies have also been done in natural areas close to towns and cities (Wallace, 2013; Larson et al., 2020). This also goes with the question of why coyotes are often seen using human "linear paths (Way et al., 2004)." Shortly, researching why coyotes avoid human interaction, but still inhabit the same spaces as humans and use human infrastructure could give insight to coyote behavior and the impact humans have on them.

Any future research can address such questions, in addition to using methods beyond the limits of my study. For example, time was my biggest limiting factor, although that is not the case with PISP data. Longer time frames of research will allow for more data to be collected and give a stronger understanding of coyote behaviors. Another limitation was that to study PISP coyotes, I had to use camera traps, which rely on chance for coyotes to cross the camera's path and for the photos to be clear. Furthermore, as they can not move around with coyotes, the information researchers could conclude from camera trap photos does not give a complete picture of coyote behavior. More study sites and thus more cameras would give more information if this study was conducted again. Another option for future researchers is to use radio or GPS collars to track coyote movements, or the newer technology of these collars with cameras on them (Bump et al., 2023). GPS collars have been used previously by Duafala (2012) on PISP coyotes, but utilizing them again in the future would take funding and coordination with organizations such as the Pennsylvania Game Commission. However, tracking the movements of coyotes and when they are moving would give more information on their spatial and temporal behaviors, in addition to camera trap data. These methods would give a fuller picture of coyote behavior on PISP, in addition to seeing how the greater environment is impacted by their behaviors (Kays et al., 2007; Larson et al., 2020; Patten et al., 2019).

The results and conclusions drawn from this study further supports what is already known about coyotes and gives insight into the specific population in PISP. This knowledge has been spread to the public via educational webinars and social media platforms before this research (Presque Isle State Park, PA, 2012; Presque Isle State Park, PA, 2013; Presque Isle State Park, PA, 2021; Pennsylvania Department for Conservation and Natural Resources, 2020). The continuation, updating, and spreading of this knowledge is important not only for park personnel to accurately manage coyotes, but to continue to educate the public and minimize fear of PISP coyotes, as that knowledge can help to reduce the chance of negative human-coyote interactions.

Studies like this one do bring awareness to the impact of human presence on wildlife behavior in natural areas. These places, whether they be local parks or a national forest, are not only for human recreation; they are homes for coyotes and other wildlife, all of which are important to maintain a healthy ecosystem. Acknowledging the influence that human activity can have on wildlife is important, especially if it is negative, which is also why understanding the behavior of coyotes and wildlife in these natural recreation areas is so important. Taking that relationship into account will allow for the creation of management plans that facilitate coexistence between humans and the natural world. This is especially so as the evidence that coyotes adapt to humans is clear, however humans adapting to wildlife in general is not as obvious or prevalent. While coyotes are able to adapt, the impact of those adaptive changes on the rest of their ecosystem is not fully recognized. Therefore, figuring out how to address human behavior and possibly working to change it to aid in preventing harmful interactions is even more important in order to meet the goal of coexistence.

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