Since primitive times roads have cleared the path for human movement and travel (Van der Ree et al. 2015). There are 3.9 million miles of public roads in the United States (US DOT, 2017) and due to various ecological effects associated with increased urbanization, many road agencies now list “environmental sustainability” as one of their goals (Van der Ree et al. 2011). As a result, road ecology research has increased to inform road project planning and implementation (Coffin et al. 2007, Van der Ree et al. 2011, Van der Ree et al. 2015).

The ecological effects that roads cause on wildlife can be categorized as either direct or indirect, with direct impacts directly influencing a species (e.g., mortality, habitat fragmentation), while indirect impacts include behavioral changes due to increased contact with humans (Bennett 1991, Coffin et al. 2007). However, there are many examples of positive ecological effects (Morelli et al. 2014, Rotholz and Mandelik 2013) with road/roadsides contributing to optimal foraging areas (Forman and Alexander 1998, Lambertucci et al. 2009, Rydell 1992, Tirpak et al. 2010) as well as travel corridors (Brown et al. 2006). Ecological effects may vary based upon a given road effect zone, which is the area in which important ecological effects are proportioned outward from a road (e.g. traffic noise) (Bennett 1991, Forman and Deblinger 2001). Gauging how a species utilizes roads can aid researchers in understanding species-specific questions pertaining to movements and space-use in urban environments (Martin et al. 2022, Robb et al. 2022, Wattles et al. 2018).

Wild turkeys (*Meleagris gallopavo silvestris*) (hereafter turkey) are a large-bodied and culturally significant galliform (Kennamer et al. 1992, Bauman et al. 1990). Once extirpated from most of its range, it has made a dynamic recovery, and restoration efforts are known as one of the greatest conservation success stories (Kennamer et al. 1992, Mitchell et al. 2011). Turkeys are a highly sought after game species, trailing only white-tailed deer in harvest statistics in the U.S. (citation). This species is also the only galliform to deal with the threat of harvest during its breeding season (citation). While turkeys can be considered habitat generalists, they do have some fascinating requirements at different phenological phases of their annual cycle. For instance, turkey nest success is strongly correlated with the presence of understory cover and forms of visual obstruction (Lehman et al. 2008). They tend to avoid selecting nesting locations characterized by edges due to an increased density of nest predators (Thogmartin 1999). Turkeys are also linked to early successional habitat during brood rearing (Chamberlain et al. 2020, Nelson et al. 2022) and this preference is shared by other galliform species (Dessecker and McAuley 2001, Gates et al. 2017). A diverse understory layer of forbs and native grasses attracts nutrient rich invertebrate prey which is an essential dietary component for growing poults (Nelson et al. 2022).

Turkeys in Maine persist at their northern range limit, which makes them vulnerable to greater energetic demands associated with bioclimatic events outside of their core niche (Gonnerman et al. 2022). Despite this Maine has a stable population and the state wildlife agency faces the challenge of managing a highly sought after species that often persists at the human-wildlife interface (Gonnerman 2019, [unpublished dissertation]). With a stable wildlife population in urban areas comes risk of collision, and while there were 17 reported turkey-vehicle collisions between 2017-2021 (Maine DOT, 2021), we believe that this number may be underreported. Understanding the ecological reasoning for turkey road-use could help better inform mitigation efforts for both road and state wildlife management agencies.

\*Address Knowledge Gap

\*Introduce Study Goals and Objectives

While many studies have examined spatiotemporal movements and habitat selection of turkeys, there are few that focus solely on the variability of road selection. To address this gap, we examined turkey selection of roads following 3 objectives. These were (1) characterize selection of roads during different phenological stages, (2) examine selection of roads at different times of day, and (3) describe selection of roads based upon differing land cover types in the state. We thus took a holistic approach to gauging context-dependent selection of roads by turkeys in Maine.

**Methods**

**Study Area**

Our study area consisted of four counties in Maine, USA, where telemetry data was collected: Penobscot, Piscataquis, Somerset, and Hancock. Maine’s statewide population density was 44.2 persons per square mile (Census.gov, Maine 2020) and varied considerably at the county scale, with the lowest overall density occurring in Piscataquis and greatest in Hancock. Mean annual temperature and precipitation in our study area were 44.65 ℉ and 50.75” (National Centers for Environmental Information, Apr 2022- Mar 2023). A greater proportion of developed areas existed in the center of our study area with industrial forest located primarily in the east. More developed cover existed in Penobscot and Hancock counties than in the northern and western areas. All land cover characteristics were available to turkeys but varied in their relative abundance.

**Data Collection**

**Turkey Capture and Processing**

We captured turkeys at bait sites across 3 winters (12/01/2018 -03/31/2020) using both rocket (Grubb, 1988) and drop (Glazener et al. 1964) nets. After initial capture, we marked a random sample of hens with 90-g litetrack Lotek GPS transmitters (Lotek Wireless, Newmarket, Ontario, CA). We used a backpack style harness to fit transmitters to hens which did not exceed 4% of the overall body mass of the bird.

**Transmitter Configuration**

  GPS transmitters were programmed to collect locations at hourly intervals during daylight hours from 11/01 through 07/31, as well as a single roost location each night at either 12:00 AM or 1:00 AM (Cohen et al. 2018). Every week, data was downloaded externally using a handheld telemetry yagi and a Lotek GPS downloading device (Lotek Wireless, Newmarket, Ontario, CA). All animal handling procedures were approved by the University of Maine’s Animal Care Committee (IACUC Protocol # A2017\_11\_03).

**Analysis**

**Defining Seasons**

We assessed context-dependent selection of roads based upon season, time-of-day, and land cover type. First, we censored all birds that died within two weeks to account for capture related mortality. To avoid pseudoreplication associated with fine scale telemetry data of closely traveling individuals, we used GPS data from one hen per flock in our sample. We generated 95% utilization distributions describing annual and seasonal home ranges by creating dynamic Brownian bridge movement models (hereafter dBBMMs) (Kranstauber et al. 2012).  We classified movement periods into 5 seasons (winter, spring dispersal, pre-nesting, summer, and fall) based on a visual assessment of Brownian motion variance estimates (σ 2m(Kranstauber et al. 2012), which describes irregularity of a movement path between subsequent locations within a dBBMM (Byrne et al. 2014). To do so, we first created a dBBMM using the full movement track of an individual within a year. We then created individual specific plots of σ 2m over time, identified when trends in σ 2m noticeably shifted, and matched the resulting movement periods with the appropriate ecological season (e.g., wintering behavior, spring seasonal movements, etc.). We then created individual-specific utilization distributions for each marked hen in each season. We matched each GPS location to a season in our analysis to gauge for selection of areas near roads.

**Time of Day**

For our time of day covariates, we used the ‘suncalc’ package (Thieurmel B. and Elmarhraoui A. 2022) in program R (R Core 2023) to calculate the time from each GPS timestamp to sunrise and sunset. We classified timesteps into 3 bins according to time of day (morning, midday, and afternoon) allowing us to account for phenological changes in daylight hours. Any fix that was generated less than 3 hours was considered in the “morning”, and any that was generated less than 3 hours from sunset was considered “afternoon.” If a GPS timestamp fell in between, it was considered “Midday.”

**Land Cover Quantification**

  To measure the distance from each GPS location, we exported a spatial dataset to ArcGIS Pro and generated a Euclidean distance analysis. We measured each used and available step as a gps point measurement to the nearest road with data provided by Maine’s Department of Transportation (Maine Department of Transportation Public Roads Shapefile, MaineDOT Public Roads).  Using seasonal home ranges, we quantified land cover classifications using the 2019 National Land Cover Database (National Land Cover Database (NLCD) 2019 Products) to evaluate hen-specific selection of areas near roads using point statistics in ArcGIS Pro. We constrained our rasters to the 95% quantile in the GIS and then estimated individual selection percentages of “forest”, “agriculture” and “developed” land cover classifications as they were dominant within our study area.

**Step-Selection Functions**

We used step-selection functions (Duschesne et al. 2015, Thurjfell et al. 2014)  (hereafter SSFs) to determine the impact of proximity to roads on the movements of turkeys in various landscapes. Inferences from SSFs are similar to standard RSFs, but instead pair each used location with a set of associated random locations conditional on animal movement (Fortin et al. 2005). We used SSFs as they account for biased sampling by including random intercept terms for individuals (Gillies et al. 2006, Muff et al. 2020).

We created an interaction between season, time of day, and land cover type generating separate models for each. Further, we Z-standardized covariate values to allow for more direct comparison of beta coefficients across models and compared our outputs a standard deviation over from the mean.

We assessed 3rd order selection by turkeys within their home range (Johnson, 1980) using the amt package (Signer et al. 2019) to create used and available steps. We followed a used/available framework (Manly et al. 2002) and for every used location, we generated 10 step-specific available locations at which to compare strength of selection. Thus, we created a model structure where for each used step, we assessed values of 10 random steps available to each individual on the landscape.