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Understanding how large ungulates respond to temporal risk is of great importance for hunters and land managers across the world. This study aimed to assess how daily changes of temporal risk affected habitat selection of a large ungulate in a hunted population in Mississippi, USA. We make recommendations to minimize the effect that hunters have on large ungulates by adjusting temporal hunting effort.

RH: Henderson *et al*. • Temporal change of habitat use with risk

Temporal effects of relative hunter activity on adult male white-tailed deer habitat use

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**Abstract**

***Context.*** Predation risk, whether from large carnivores or humans, is a primary driver of movement and habitat selection for ungulates. Throughout much of the geographical range of white-tailed deer, predation risk during autumn and winter is driven by hunters; however, information is lacking in how deer respond to hunting pressure during a long hunting season.

***Aims.*** We aimed to determine how differences in daily temporal exposure to hunting risk affected habitat selection of adult male white-tailed deer.

***Methods*.** We deployed GPS collars on 42 adult male white-tailed deer during the 2017-18 and 2018-19 firearm hunting seasons in Mississippi, USA. GPS collars provided fine-scale spatial and temporal information regarding habitat use of our study area.

***Key results.*** We showed a mismatch between what hunters and deer selected; landscape characteristics selected most by hunters were least selected by deer during the day; which we believe has never been documented. Fine-scale temporal analysis showed that deer selected for some areas (food plots) as much as 5-fold during the night when no hunting risk was present than versus during the day when risk was present.

***Conclusions.*** Habitat selection by deer varies depending on the amount of risk that is present. Even in a high risk heavily hunted area, adult male white-tailed deer can recognize external cues on the landscape, and shift habitat selection both spatially and temporally to favor areas that present less risk.

***Implications.*** This study, to our knowledge, provides the first evidence that white-tailed deer actively selected for habitat characteristics that hunters were not utilising. To minimise the effectiveness of risk-avoidance behaviors used by deer, we suggest hunters moderate temporal hunting effort across time to decrease the risk to which deer are exposed ; thus, minimising the response by deer.

**Keywords**: habitat selection, hunting, Odocoileus virginianus, resource selection function, risk, risk avoidance, temporal, white-tailed deer

**Introduction**

The risk allocation hypothesis predicts how animals assess and respond to levels of risk (Lima and Bednekoff 1999). This hypothesis suggests risk is a main driver of habitat selection and has been shown in previous literature (Hochman and Kotler 2006; Crowder and Cooper 2014; Keuling and Massei 2021). In order to access resources, organisms will accept some amount of risk; however, eventually that risk becomes too great and an organism will choose to select a different area. The effect of risk on movement and habitat selection has been demonstrated across taxa, including rodents, amphibians, ungulates, and passerines (Brown 1999; Altendorf *et al.* 2001; Roberts and Liebgold 2008; Tvardikova and Fuchs 2012).

Risk interacts with forage availability creating a trade-off where deer must decide, how much risk will they accept to forage in a high-quality area. Optimal foraging theory (Charnov 1976) suggests organisms weigh the cost versus benefit of using specific habitat types (Brown *et al.* 1992; Brown *et al.* 1999; Fahrig 2007). This has been shown in brown bears (*Ursus arctos*), which alter movements to use more dense cover during hunting season, and elk (*Cervus canadensis*) which avoid open foraging areas when wolves (*Canis lupus*) are present (Creel *et al.* 2005; Ordiz *et al.* 2012). However, ungulates, such as white-tailed deer, may accept greater risk to access specific recources (Lima and Bednekoff 1999). However, at some risk threshold, organisms will avoid certain areas (Lima and Bednekoff 1999; Verdolin 2006).

Past studies have shown that large ungulates use different habitat during high risk periods (Creel *et al.* 2005; Drimaj *et al.* 2021), particularly when that risk is from human hunters (Lone *et al.* 2015; Ranglack *et al.* 2017). However, the knowledge of risk effects on white-tailed deer (hereafter deer) is largely restricted to difference at a broad spatial scale (Karns and Lancia 2012; Little *et al.* 2016; Henderson *et al.* 2020) and not differences in habitat use. Our objective was to determine the changes in habitat use of adult male deer during a 3-month hunting season. We hypothesised deer would respond to risk by altering habitat selection to use areas of lower risk (Creel and Winnie 2005; Ordiz *et al.* 2012; Tvardikova and Fuchs 2012), though this response could be altered by a preference for high-quality foraging habitat (Crowder and Cooper 2014; Kohler and McPeek 2016). We predicted deer would exhibit strong selection towards habitat types with more vegetative cover during times with more hunting risk to reduce their chances of being harvested. We further predicted deer selection for foraging areas, such as food plots, would be consistently strong and positive but reduced in selection strength during high-risk periods, consistent with a trade-off between forage accessibility and exposure to risk.

**Material and methods**

*Study area*

We conducted our study on approximately 20,000 ha in Madison and Yazoo counties in west-central Mississippi, USA (Figure 1). Land cover in our study site was characterised as forest or agriculture, with the forest cover being the most abundant. The largest forest cover type was bottomland hardwoods consisting of approximately 7,500 ha (38%) of the study area and almost entirely along the Big Black River, which floods these bottomland hardwoods annually. The river bottom consisted of hard mast producing trees such as water (*Quercus nigra*) and cherrybark oak (*Quercus pagoda*), and other species important to deer, such as American persimmon (*Diospyros virginiana*). Understory in the hardwood bottom was characterised by species tolerant of inundation, such as dwarf palmetto (*Sabal minor*) and rivercane (*Arundinaria gigantean*). Evergreen areas in our study area were commercial loblolly pine (*Pinus taeda*) plantations and made up approximately 3,000 ha (15%) of the study area. Upland deciduous forest consisted of hardwoods such as white ash (*Fraxinus americana*) and American elm (*Ulmus americana*) and compromised approximately 3,400 ha (17%) of the study area. Understory species in upland portions of the study area included American beautyberry (*Callicarpa americana*), *Rubus* spp., and various herbaceous species. Commercial agriculture was common and comprised approximately 6,000 ha (30%) of the study area. Agricultural crops commonly grown in the study area included soybeans, cotton, and corn.

Average land-holding size was 286.1 ha (SD = 343.9, range = 0.8 – 1357.7). These land-holdings included single families to hunting clubs with 20 or more members. Thirteen of approximately sixty landowners were enrolled in the state Deer Management Assistance Program (DMAP), which allows intensive deer management by providing landowners with doe and buck management tags (Edwards *et al.* 2013). Some landowners decided to opt out of the study, but generally held smaller acreages on the outskirts of the study area.

Anthropogenic nutrient supplementation was common across the study area. Supplemental feeding was conducted on about half the properties in the study area, with corn, rice bran, and protein pellets common. Supplemental agronomic plantings (i.e., “food plots”) consisted of deervetch (*Aeschynomene americana*) during summer, while winter food plots consisted of several types of clover (*Trifolium* *spp*.) and cereal grains (*Avena sativa*). The average food plot size was 1.09 ha (SD = 2.87, range = 0.06 – 21.96). Summer food plot forages lasted until first frost; thus they provided beneficial forage well into the timeframe of our study. They also provided tall vegetation for risk avoidance once the vegetation had senesced. The firearm hunting seasons were 3 months long and runs from November 9th to January 31st. Peak breeding occured from December 29th to January 4th (MDWFP 2020). Landowners were informed of the study through public meetings and phone calls.

*Deer Capture*

We used dart rifles (Pneu-Dart, Inc., Williamsport, PA) and drop nets to capture adult male deer (≥ 2 years of age) from 30 September 2016 to 31 January 2017. We also captured deer during July – September of 2017 and 2018. We anesthetised deer using a mixture of butorphanol, azaperone, and medetomidine (BAM; Zoohpam, Windsor, Colorado; Mich et al. 2008). We set dosages at 2.7 cc of BAM for every deer, with additional BAM administered when necessary. We attached GPS collars (Lotek Wireless, Inc., Newmarket, Ontario, Canada) and uniquely marked deer with orange plastic and metal ear tags (Allflex USA Inc.). We programmed collars to take location estimates at 15-minute intervals during the 2017-2018 and 2018-2019 Mississippi hunting seasons. While anesthetised, we also estimated age (Severinghaus 1949) and injected 3 cc of Nuflor (Merk Animal Health, AN Boxmeer, Netherlands) per 45 kg of body mass to inhibit capture-related respiratory infection. We reversed anesthesia using 0.5 cc of naltrexone and atipamezole at twice the total amount of BAM.

*Hunter effort collection*

Hunters self-collected temporally and spatially-specific hunting effort data from 9 November to 31 January using either of two methods. Hunters recorded their name, the location of the hunt (stand name and GPS coordinates), and the hunt beginning and ending times in a booklet. In other words, hunters only record the time they were sitting in a deer stand waiting while hunting. Alternatively, they recorded the same information using a smartphone app created by the Mississippi State University Extension Service, called MSUES Deer Hunt. Hunters participating in data collection were largely from continuous acreage, providing a large area of consistent data. Both datasets of hunters were thoroughly inspected to make sure abnormal or incorrect data was removed. Based on conversations with landholders and hunters in the study area, we believe that most hunting events were recorded; however, we cannot be certain of how many events are missing.

We tallied the total amount of hunting hours that occurred each day on the study area. To determine how deer responded to different levels of temporal risk, we separated days into three risk categories using 1/3rd quantiles based on the distribution of daily hunting hours: low risk days (<41 hunting hours), moderate-risk days (41-85 hunting hours), and high-risk days (>85 hunting hours). Deer locations were then given a risk level determined by the day the location estimate was taken. Landowners strictly controlled access by hunters, and most agreed not to harvest collared deer during the study period; however, there was no rule against harvesting a collared deer. Multiple collared deer were harvested, thus animals were exposed to direct and indirect risk.

*Data characteristics*

We created aggregate land cover classification rasters using the U.S. National Land Cover Database 2016 (NLCD; Jin *et al*. 2013) and the United States Department of Agriculture (USDA) National Agricultural Statistics Service CropScape Data Layer (CropScape). CropScape delineates temporally and spatially explicit agricultural areas for each year, while the NLCD is not updated annually. Farmers harvested crops prior to data collection, thus agricultural fields were barren. These barren fields provided no cover, but potentially some forage value from naturally occurring plant germination, so we classified them collectively as agricultural fields or “crops”. We combined land cover classifications from the NLCD with CropScape crop classifications to produce a single land cover raster for each year of the study. The “woody wetlands” classification in the NLCD is synonymous with bottomland hardwoods within our study area; thus for simplicity we called this classification “bottomland.” Within our study area shrubland, herbaceous, pasture, and woody wetlands contained similar vegetative structure (ground to waist high) and species (small herbaceous and shrubby species) so we combined them into “herbaceous.” The “mixed forest” classification in the NLCD was present in less than 2%, so we combined it with “evergreen”. We removed several land classifications that should contain little value to deer or were present in small quantities (i.e. developed land, open water, barren land). Even though these other land cover classifications were excluded from the model, an effect was still estimated as proportional cover is relative to what is not included in the model, thus by not including these land cover classifications an effect is estimated (i.e. if selection decreases for all variables in the models, something left out of the models must increase in selection). Finally, we digitized food plot boundaries and supplemental feeder locations in ArcMap v. 10.5 (ESRI, Environmental Systems Research Institute: Redlands, California, U.S.). Further descriptions of variables can be found in Table 1.

We pooled data from both years of hunting seasons and excluded unreliable deer GPS locations with a horizontal dilution of precision (HDOP, a measure of accuracy) >10 (Rempel and Rodgers 1997). We paired each used location with 5 randomly selected available locations, for a 1:5 sampling ratio and conducted a resource selection analysis (Manly *et al*. 2002). We created 95% home ranges based on standard kernel density estimation (Calenge 2015, v.3.5.3. R Core Team 2020). We limited available locations to each deer’s home range (Seaman and Powell 1996). This provides an accurate representation of available locations by constraining availability to areas used by individual deer during the sampling interval. To describe the land cover classifications that were present around each used and available point, we created a 100 m buffer, similar to past research (Street *et al.* 2016). We chose a 100-m buffer to more accurately describe what was available. The NLCD rasters that we used to define land cover classifications were a 30-m by 30-m raster. To accurately capture land cover change near location estimates, we believe our buffer needed to be at least double or more than the raster size. Our GPS collars also had an approximate error of 7 – 12 meters according to the manufacturer. Thus, we believed a 100-m buffer would be a sufficient size to accurately capture changes in land cover. We put our 100-m buffer around each used and available location to describe proportional cover by habitat types and resources around each location. We calculated proportional cover in 100-m buffers by the five land cover variables in the aggregate rasters and summer and winter food plots. We also determined whether a feeder was within a given buffer (i.e. presence/absence of feeder). After calculating proportional cover, we classified each deer location estimate into the three risk groups (low, moderate, and high). To further differentiate temporal variation in risk response, we also grouped deer location estimates into day and night, where daytime (including dawn) was 6 a.m. to 5:59 p.m. and nighttime (including dusk) was 6 p.m. to 5:59 a.m.

*Statistical analysis*

*Deer resource selection function*

We fitted mixed-effects resource selection functions (RSFs) using generalized linear mixed-effects logistic regression via the lme4 package in Program R (Bates *et al*. 2007), including individual animal-year as a random intercept, to assess how different risk levels affected habitat selection during the 2017/18 and 2018/19 firearm hunting seasons. Because annual sample and effect sizes may vary among individuals, we used a random intercept to control for this variation (Gillies *et al.* 2006). Resource selection functions are a form of habitat suitability index and estimate habitat selection using binary (used vs. available) location data (Manly *et al.* 2002). We modeled the probability of selecting used and available points in each risk level. We separately also modeled during selection during day and night (i.e., five models in total). This multi-model approach was necessary because used locations have discrete timestamps, but available locations are equally available at all times and thus have no discrete timestamp; as such, temporal variables cannot be used as predictors in RSFs. In each model we used the same eight predictors: the function of proportional coverage for each land classification (crops, deciduous, evergreen, herbaceous, bottomlands), proportional cover by summer and winter food plots, and binary presence of feeders within the 100 m buffer (Table 1).

*Hunter resource selection function*

We estimated RSFs for hunters using the glm function in Program R to assess resource selection of hunters within our study area. We combined all hunting effort data into one large dataset to describe hunter selection over the entire study area. We defined use and availability to match our deer RSFs and again used a buffer of 100 m. Hunter access was constrained to specific properties, so we restricted their available points to respective property boundaries. We paired five available points to each known hunter location and calculated the same eight predictors and estimated the three risk models as used in the deer RSFs.

*Comparing hunter vs. deer selection across diel*

To visualize differences between deer resource selection across temporal periods, and hunter resource selection during active hunting periods (i.e. daytime), we solved each RSF for every [*x*,*y*]-location in our landscape. This produced 3 distinct predicted space use rasters. To facilitate comparison of predicted space use by deer and hunters, we performed a linear stretch on each raster such that , where *xi,new* was the newly stretched value of the *i*-th pixel, and **x** is the vector of all *xi* in the original raster. This compressed the values of each raster such that with the most strongly selected locations exhibiting *xi,new* approaching 1. Then, we calculated a simple metric of raster similarity *S* as reported by Paolini *et al*. (2018) between the deer daytime raster and the hunter raster, and between the deer nighttime raster and the hunter raster, such that values of 0 indicate perfect dissimilarity and 1 perfect similarity between rasters.

**Results**

*Deer resource selection*

Collars on 42 bucks generated 432,877 used locations (SD = 4,623, range = 1,261- 16,127) with an average HDOP of 3.2 during the 2017/18 and 2018/19 firearm hunting seasons. We paired these location estimates with 2,164,385 available locations. All land covers other than summer food plots and feeders showed a decrease in selection strength by deer from low-risk days to high-risk days (Figure 2). Summer and winter food plots were the most highly selected landscape characteristics, even during high risk periods. Cropland cover classification was the only variable that shifted from a positive selection to a negative selection with increasing risk. Evergreen and herbaceous land cover showed the most dramatic shifts in positive selection, declining by 75% and 74%, respectively. All regression coefficients were significant at p-value < 0.001. In light of all predictors being statistically significant, we focused interpretation on effect size and direction.

Winter food plots showed a six-fold increase in selection from day to night (Figure 3). Deciduous, evergreen, and bottomland classifications were more selected for, 5%, 17%, and 4% respectively, during the day, while all other variables were more selected for during the night.

*Hunter resource selection*

Hunters harvested eight collared deer and poachers killed two deer on participating properties. Harvest of uncollared deer was extensive according to DMAP data. Hunters recorded 7,723 hunting events during the 2017/18 and 2018/19 modern firearm seasons. We paired these location estimates with 38,615 available locations across 79 properties. Hunter selection across different risk levels varied slightly, averaging 14% difference between low and high risk, for natural land cover characteristics (Figure 4), indicating a consistent choice in where they hunted. Summer and winter food plots were the most highly selected land cover variables, with selection coefficients more than double those of natural land cover classifications and feeders. Crop land cover was the only classification to exhibit negative selection; all other variables were positively selected with little variation associated with relative risk. All regression coefficients were significant at p-value < 0.001.

*Differences in realized space use*

Finally, we plotted the linearly stretched solutions of each of our three RSFs across our landscape to visualize differences in realized space use between hunters and deer at different times of day. We observed notable visual differences between deer space use at different times of day, and between hunter space use and deer space use during the day (Figure 5). This indicates that deer use their landscape in a similar fashion to hunters during the night when they are freed from hunting risk; however, during the day, deer modify their space use to avoid hunters. This is reinforced by raster similarity indices *S* = 0.55 and 0.86 during the day and night, respectively, i.e, predicted space use by deer during the day is 55% similar to hunter space use but 86% similar during the night.

**Discussion**

Previous studies of elk (*Cervus canadensis*; Creel *et al*. 2005), white-tailed deer (Marantz *et al.* 2016), brown bears (Ordiz *et al.* 2012), wild hogs (Drimaj *et al.* 2021; Keuling and Massei 2021), and multiple passerine species (Tvardikova and Fuchs 2012) have shown organisms are able to recognise and alter habitat selection based on risk. Few studies, however, have looked at how deer respond to long-term temporal hunting risk over several months and to our knowledge no studies have compared hunter habitat selection with white-tailed deer spatial and temporal behavior. Our results support previous research and our hypothesis that deer altered selection temporally in response to increased risk levels. Over a three-month hunting season, deer altered their behavior more during high-risk times relative to low-risk times. There appeared to be a trade-off with forage accessibility and exposure to risk, where deer were willing to accept greater risk to access high quality forage, but predominately allocated foraging efforts when risk was lowest at night.

As risk increases, cervids may shift from selecting open habitats, to more forested land cover (Lone *et al.* 2015; Padié *et al.* 2015; Simoneaux *et al.* 2016), as open habitats increase exposure (Creel and Winnie 2005; Gehr *et al.* 2020). This supports our findings that natural land cover containing more forested cover or refuge were most selected for by deer during high-risk times. This was not surprising, as understory of these selected areas generally provided greater horizontal and vertical screening cover to provide refuge (Henderson *et al.* 2020). By selecting for refugia, organisms can be less vigilant (Hochman and Kotler 2006; Jayakody *et al.* 2008), which can have positive effects on nutritional uptake (Brown 1999). This is important, because while selecting for cover, organisms must also consider simultaneously selecting forage to meet nutritional needs (Lima and Bednekoff 1999; Meiners and Obermaier 2004; Street *et al.* 2013).

Food plots provide high quality forage (Keegan *et al.* 1989; Hehman and Fullbright 1997; Edwards *et al.* 2004), while simultaneously being the most hunted areas in our landscape and increasing hunter success (Johnson and Dancak 1993). In contrast to our prediction, other land cover classifications greatly decreased in selection strength as risk increased, but food plots remained highly selected. This is counter to past research, but patches of nutritious and abundant forage may be used even in the face of greater risk (Lima and Dill 1990). Even though these areas posed the greatest risk, deer still selected these areas, suggesting deer were willing to accept reduced security for access to nutritious forage (Lima and Dill 1990; Verdolin 2006; Beauchamp and Ruxton 2011).

The substantial amount of hunter risk we report associated with food plots and the subsequent deer use of food plots during these high-risk times may also be a function of a mismatch at a temporal scale (Visscher *et al.* 2017). Previous studies have shown deer movement and habitat selection are different at night than during the day, likely because of hunting risk (Little *et al.* 2016; Simoneaux *et al.* 2016). With the lack of legal hunting, human predation risk should approach zero, increasing diurnal use of high quality foraging areas (Godvick *et al.* 2009), which was theorized in the risk allocation hypothesis (Lima and Bednekoff 1999). The fivefold increase in selection of winter food plots during night compared to day is supported by Lima and Bednekoff (1999), who stated that an organism should allocate most feeding to low-risk situations and feeding bouts should be more intense during low-risk periods. Deer foraged in food plots when risk was absent at night (Lima and Bednekoff 1999; Visscher *et al.* 2017), allowing them to optimize and allocate more energy to anti-predator behavior during high-risk times during the day.

Unlike other studies that directly controlled hunting effort to create low- and high-risk areas (Little *et al.* 2014), we did not control access by hunters. This allowed hunters to select when and where they hunted, naturally creating days with different risk levels. We needed to allow normal temporal risk patterns to occur across normal gradients to truly model deer response via selection to risk (Creel and Winnie 2005). We believe this study design allowed us to evaluate how deer responded to a more typical setting of an uncontrolled population of hunters and deer and detect fine-scale temporal periods of risk.

While other studies have shown how deer responded to hunting risk (Karns and Lancia 2012; Marantz *et al.* 2016; Simoneaux *et al.* 2016), no other study has compared the habitat selection of hunters to the habitat selection of deer. Using this unique approach, we showed a temporal and spatial mismatch between habitat selection of hunters and deer, adding support to previous research that indicates ungulates avoid hunters (Jayakody *et al.* 2008; Benhaiem *et al.* 2008). Mismatch of selection likely creates a trade-off where organisms select for less optimal habitat in order to provide protection (Brown 1999; Crowder and Cooper 2014; Grüner *et al.* 2020). Our results support previous results that cover is selected for at a greater rate than areas without cover when risk is high (Creel *et al.* 2005; Drimaj *et al.* 2021) and that habitat shift from risk can be a form of cover-seeking behavior (Creel and Winnie 2005).

Another interesting indirect effect of predation risk is that organisms may be forced to select for areas not normally selected (Lendrum *et al.* 2012; Benson *et al.* 2016). For example, mountain lions (*Puma concolor*) should not select to be near urban development, but appear drawn by increased access to prey species (Benson *et al.* 2016). Likewise, mule deer are negatively impacted by gas development, but sometimes select these areas during migration (Lendrum *et al.* 2012). Within our models, we excluded variables that where present in small amounts (developed land, open water, barren land), which has been done in similar research (Street *et al.* 2016). Even though these land cover classifications were excluded from the model, we ultimately still estimated an effect by virtue of them being removed from the model. Since the relative selection strength dropped for all variables with increasing risk, the relative selection strength of excluded variables must have increased. These excluded variables contained little to no cover or foraging value so their apparent increased selection suggests that deer avoided risk by using areas of limited value. The possible consequences of such selection decisions is unclear and should be focused on in future research.

*Wildlife management implications*

On a broad scale, our results show that prey species will alter use based on the general habitat that predators are drawn to. This should be especially true for ambush predators that sit and wait for prey to walk near them, such as hunters. As prey species begin to associate specific landscape features with ambush predators, they begin to alter use or behavior while in these areas, regardless of the presence of a threat. For example, a prey species may become more vigilant using areas that ambush predators frequent or reduce use of these areas. Our results support this response.

On a smaller scale, our research provides insights for managers and hunters on how a large ungulate responds to hunting risk. By identifying temporal patterns of white-tailed deer habitat selection in response to increase hunting pressure, we showed that white-tailed deer shifted habitat use most dramatically during high-risk days. We recommend altering the extreme variation in relative hunting risk by shifting hunter density on the landscape. We know that deer responded less on low-risk days, thus by lowering the amount of risk that is present on high-risk days, deer may minimise the extent of their behavioral alteration. Minimising the behavioral alteration to temporal risk can decrease the spatial mismatch between deer and hunters.

**Data availability statement**

Data from this manuscript is not currently available.

**Conflicts of interest**

The authors declare no conflicts of interest.

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Figure 1. Study area site (approximately 20,000 ha) where we attached GPS collars to adult male white-tailed deer in Mississippi, USA.

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Figure 2. Selection of land cover classifications (with 95% confidence intervals) by adult, male white-tailed deer at three relative risk levels (low, lowest third; moderate, middle third, and; high, upper third) during the 2017/18 and 2018/19 modern firearm hunting seasons in Mississippi, USA. All regression coefficients were significant at p-value < 0.001.

Chart, bar chart

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Figure 3. Selection of land cover classifications (with 95% confidence intervals) by adult, male white-tailed deer during day and night during the 2017/18 and 2018/19 modern firearm hunting seasons in Mississippi, USA. All regression coefficients were significant at p-value < 0.001.

Chart, bar chart

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Figure 4. Selection of land cover classifications (with 95% confidence intervals) by hunters at three relative risk levels (low, lowest third; moderate, middle third, and; high, upper third) during the 2017/18 and 2018/19 modern firearm hunting seasons in Mississippi, USA. All regression coefficients were significant at p-value < 0.001.

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Figure 5. Predicted space use by deer during day and night, and by hunters during active hunting periods. Values are linearly stretched to fall between 0 and 1, with values approaching 1 indicating higher relative probability of space use.

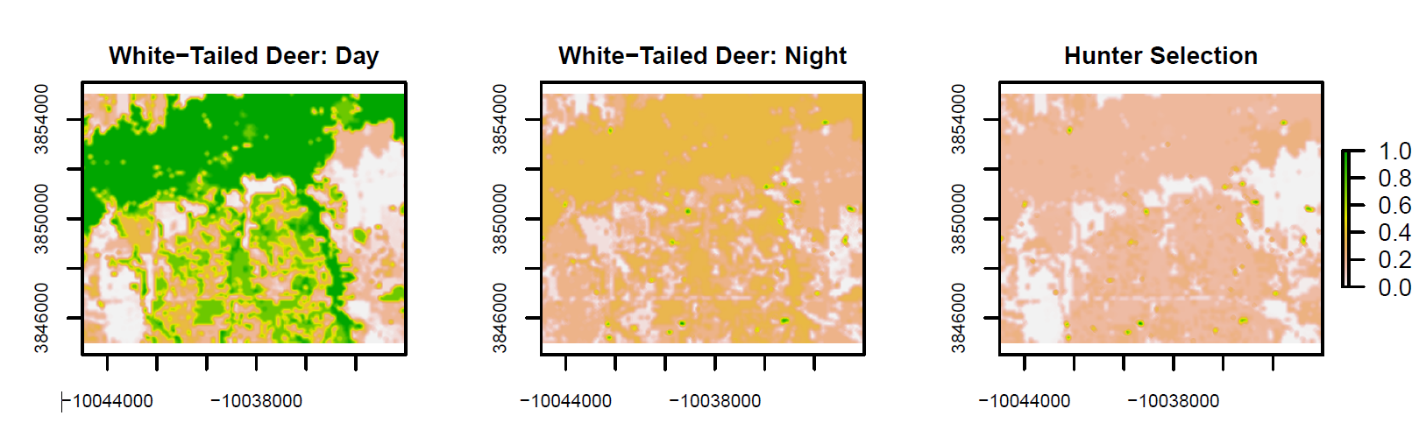


Table 1. Variables used in resource selection functions to estimate habitat selection of adult male white-tailed deer and hunters in Yazoo and Madison Counties, MS, USA.

|  |  |  |
| --- | --- | --- |
| Variable | Description | Source |
| Crop | Aggregate of corn, cotton, and soybean agricultural crops. | USDA CropScape 2017/18 |
| Deciduous | More than 75% of the tree species shed foliage simultaneously in response to seasonal change. | NLCD 2016 |
| Evergreen | More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage. | NLCD 2016 |
| Herbaceous | Areas dominated by gramanoid or herbaceous vegetation, generally greater than 80% of total vegetation. | NLCD 2016 |
| Bottomland | Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water. | NLCD 2016 |
| Summer Food Plots | Summer food plots containing summer forages | Provided by landowners |
| Winter Food Plots | Winter food plots containing winter forages | Provided by landowners |
| Feeders within 100m buffer | Feeder present within 100m of a deer location. | Provided by landowners |