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Explaining Hunting Participation in Ohio: A Story of Changing Land Use and New Technology

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RH: Socio-cultural Effects on Hunting Participation

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Abstract

Long-term per-capita participation in hunting is declining in the United States, although trends vary by region and type of hunting activity. Numerous studies have identified diverse factors affecting individuals' likelihood of participating in hunting, but relatively few have examined factors influencing involvement at a broader scale. Landscape and cultural changes associated with urbanization coupled with the distractions of entertainment technologies have been implicated as factors negatively influencing hunting participation at the broad, socio-cultural scale. By examining factors related to Ohio hunting license and deer permit sales at the county-level (2007), we found that access to huntable lands, agriculture-forest matrix characteristics, proliferation of entertainment technologies, rurality, and racial/ethnic demographics were associated with participation rates. Although exurbanization drives parcelization and land use change, some regions are not yet saturated with technological infrastructure (e.g., southeastern Ohio) or have unique population demographics (e.g., Amish) that are likely to deter future declines in hunting participation.

Keywords: deer hunting, hunter recruitment and retention, hunting participation, urbanization, technology

Introduction

The number of Americans participating in hunting, trapping, and fishing has fallen over the past several decades (Cordell et al., 1999; US Fish and Wildlife Service, 2013). The decline is even more precipitous when participation is measured on a per capita basis. Some scholars view this trend as part of a broader shift away from "nature-based" forms of recreation (Pergams & Zaradic, 2008), but participation rates in various non-consumptive types of outdoor recreation (e.g., camping, bird watching, hiking) actually increased or remained stable over the same time period (Cordell, Betz, & Green, 2008; Siikamäki, 2009). The reasons for such divergent trends are numerous and complex.

Larson, Stedman, Decker, Siemer, and Baumer (2014) contextualized the available literature by nesting all factors that potentially affect hunting participation within a multi-level framework, from factors influencing individual decision making to broad institutional forces such as policies and regulations that operate at state and/or national levels. Numerous studies have sought to explain an individual's probability of hunting with variables operating at individual and family levels (e.g., Enck, Swift, & Decker, 1993; Floyd & Lee, 2002; Heberlein & Thomson, 1996; Zinn, Manfredo, & Barro, 2002). Sex (male, female), whether one's father was a hunter, and whether one grew up in a rural setting are consistently found to be important predictors of individual-level hunting participation (Duda, Bissell, & Young, 1995; Hendee, 1969; Miller & Hay, 1981; Stedman & Heberlein, 2001).

More recently, several studies have considered factors related to hunting participation at a societal scale using aggregate data at the county, state, and national levels (Heberlein, Madison,

Ericsson, & Wollscheid, 2002; Larson et al., 2014; Pergams & Zaradic, 2008; Poudyal, Cho, & Hodges, 2008; Robison & Ridenour, 2012). With influences not necessarily confined to either end of the individual−society continuum, a host of other factors that potentially influence hunting participation become relevant, such as per capita income (Miller & Hay, 1981), ethnicity (Floyd & Lee, 2002), age (Heberlein et al., 2002), education (Poudyal et al., 2008), residential stability (Wright, Rodgers, & Backman, 2001), public land availability (Miller & Vaske, 2003), land access policies of private landowners (Responsive Management & National Shooting Sports Foundation, 2010), satisfaction with existing hunting regulations and bag limits (Enck et al., 1993), human population density (Lindberg, 2010), prevalence of electronic media and technology (Robison & Ridenour, 2012), race (Heberlein & Thomson, 1996), land use/habitat composition (Heberlein et al., 2002), and motivations for hunting (Enck et al., 1993).

Many of these factors may be considered components of urbanization and exurbanization, which are broad social forces that generally deter hunting (Charbonneau & Lyons, 1980; Larson et al., 2014; Poudyal et al., 2008). Yet, classifying an individual or society as "rural" or "urban" based on relatively coarse criteria (e.g., zip code or proportion of county classified as rural as derived from government census data) does not convey the actual mechanisms behind declining participation trends (Heberlein et al., 2002). Parcel size is a potentially suitable alternative for replacing coarse, and oftentimes dichotomous, rural/urban classifications, and the rural-urban continuum codes (RUCC) provide a more nuanced description of a county's population size and distribution relative to nearby urban centers (Economic Research Service, 2013). Prior research indicates that smaller parcel sizes are associated with limited hunting opportunities due to size constraints (Harden, Woolf, & Roseberry, 2005; Lovely, McShea, Lafon, & Carr, 2013; Storm,

Nielsen, Schauber, & Woolf, 2007). Specifically, we propose that parcelization limits hunting opportunities by: (a) reducing areas that can be safely hunted (i.e., increased structure/residence density), (b) requiring additional effort for access (i.e., increased number of landowners a hunter must obtain permission from to hunt), and (c) increasing the probability of contact or conflict with other hunters (Heberlein, 2002). Other research indicates that population density, which is positively correlated with increased parcelization and human development gradients, has a negative association with hunting participation (Lindberg, 2010).

Changing patterns in landscape connectivity, land use, and shifting human population demographics are not the only consequences of an urbanizing landscape. Life in urbanized modern society can hinder nature-based forms of recreation (Hendee, 1969) by increasing travel times to places with hunting opportunities (Miller & Hay, 1981; Poudyal et al., 2008). In addition, urbanism may precipitate both subtle transformations of cultural values (Heberlein & Ericsson, 2005; Stedman & Heberlein, 2001) and shifts in leisure settings that more closely resemble work environments (i.e., indoors; Kraus, 2008; O'Dell & Taylor, 1996). New entertainment technologies (e.g., broadband internet, video games, mobile "smartphones") have captivated Americans who spend increasing amounts of leisure time in front of a screen—a phenomenon some have dubbed "videophilia" (Pergams & Zaradic, 2008; Robison & Ridenour, 2012). This term is somewhat problematic in that it implies individuals are consciously seeking out and selecting media experiences, thereby choosing not to engage in other forms of recreation. Yet, this phenomenon need not operate at a conscious level; rather, the availability of convenient and diverse entertainment technologies may lead individuals to habitually engage in new media without much thought or deliberative choice. Indeed, research indicates that television can be

addictive, an idea supported by the fact that people in industrialized nations spend more time watching television than any other activity, except work and sleep (Kubey & Csikszentmihalyi, 2002). Obviously, an individual's use of or addiction to entertainment technology cannot occur without the availability of media for consumption. Consequently, distributional (i.e., availability) or general use metrics provide a means for evaluating technological impacts at the socio-cultural level.

Couple the increasing convenience and hedonistic qualities of new entertainment technologies with the numerous constraints to consumptive forms of outdoor recreation (e.g., increased travel time from cities to rural landscapes, increasingly restricted access to private hunting lands, crowded conditions on public hunting lands; Heberlein, 2002; Miller & Hay, 1981; Responsive Management & National Shooting Sports Foundation, 2010) and the trend away from consumptive recreation is not surprising (Pergams & Zaradic, 2008). Children are not exempt from these broad scale transformations (Hofferth & Sandberg, 2001; Lowell, 2008). Numerous studies suggest that precipitous declines in outdoor activity are closely tied to multimedia's increasingly pervasive influence (e.g., Carpenter, 2012; Wells & Lekies, 2006).

The purpose of our study is to model relationships between various social and land use characteristics and hunting participation in Ohio based on per capita resident hunting license sales and per capita white-tailed deer (*Odocoileus virginianus*) permit sales at the county-level. Examining sales of general hunting licenses (required to hunt waterfowl, small game, or big game) and white-tailed deer hunting permits (Ohio's only big game species) allows comparison between activities with slightly different participation trajectories. Despite the nationwide drop in hunting participation overall, the number of big game hunters has remained relatively stable,

whereas small game and waterfowl hunting have sharply declined (US Fish and Wildlife Service, 2011; Vrtiska, Gammonley, Naylor, & Raedeke, 2013). Our analysis differs from many previous studies because it does not focus explicitly on trends (i.e., time-series analyses such as the US Fish and Wildlife Service surveys) or focus on individual-level participation. Rather, we examine the socio-cultural environment for hunting participation (Larson et al., 2014; Figure 1). Our study explicitly explores the mechanistic relationships of parcelization and proliferation of entertainment technologies (PETs) with per capita hunting participation at the county level. Importantly, our study does not attempt to assess where hunters are hunting; rather, we use per capita license/permit sales to understand how broad socio-cultural and environmental factors impact hunting participation. Although these data do not allow us to assess the impact of these factors on individual behavior, we assume that these factors impact individuals whether they are aware of the impact or not. Table 1 summarizes the factors explored in this study, and we hypothesized positive relationships between hunting participation and rurality, forested land cover, public land ownership, mean parcel size, and demographic characteristics of the human population (proportion Amish, proportion Caucasian, median age). We hypothesized negative relationships between hunting participation and internet availability, human population density, per capita income, and several measures of agricultural land use and farming intensity.

Figure 1 about here

Methods

We collected 2007 hunting license and deer permit sales information from the Ohio Division of Wildlife to derive the dependent variables. We generated per capita general hunting license and deer permit measures for each county by dividing resident sales data by county

population estimates (US Census Bureau, 2010). Deer permits are not county-specific and may be used statewide, thus, these data generally reflect where a hunter lives, rather than where he or she hunted. We used data from 2007 because it was the last year that records separated resident and non-resident license and permit purchases, and 2007 coincided with the USDA Agricultural Census (2007), which provided county-level data on many social factors used in our analyses. In addition, online purchases (untraceable to county of origin) were still relatively uncommon. We identified and compiled data from various sources that served as our independent social, geographic, and ecological variables (Table 1), and we calculated bivariate correlations between our dependent measures (per capita hunting license and deer permit sales) and each independent variable.

Table 1 about here

Including most of these variables was intuitive, as they relate directly to key factors examined in past studies of hunting participation, but perhaps a few are not as obvious. To test PETs' relationship to hunting participation in 2007, we used the variable "% of farms with broadband internet." Some measures of entertainment technologies (e.g., "percent households with television") already achieved market saturation by 2007 and left little inter-county variance to evaluate hypotheses. Other measures were not yet commonplace or widely utilized in 2007 (e.g., "smartphones"). Furthermore, broadband internet simultaneously opened up numerous entertainment options including on-demand television show and movie viewing, interactive video gaming, social media, and searching the internet. In contrast, a television set or a video gaming console provided a much narrower range of entertainment options, and as such, we deemed broadband internet to be the best single proxy for PETs in 2007. Variables pertinent to

more recent technological phenomena (i.e., "smartphones") were not included in our formal analyses, but are discussed later in this paper. We included two variables – "mean government subsidy per farm" and "gross sales per farm" – to measure agricultural intensity (USDA Agricultural Census, 2007). The RUCC variable, which accounts for a county's human population and their proximity to metro areas, ranges from a scale of 1 (highly urban) to 9 (highly rural; Economic Research Service, 2013).

To address multicollinearity among independent variables, we eliminated the variable "% farmlands" based on threshold VIF>10 (Hair, Black, Babin, & Anderson, 2009). Further analysis revealed non-linear relationships between some of the explanatory variables and the response measures. Variables "proportion of county public land open to hunting" and "proportion of population Amish" had left-truncated distributions due to numerous counties having a value of 0, and log transformation significantly improved normality. We log-transformed "mean gross sales" to improve fit for the deer permit analysis. "Per capita income" was log-transformed for inclusion in both sets of analyses. Lastly, we included a squared term to account for non-linearity in the relationships between independent variables "population density" and "mean parcel size" and each dependent factor. We used stepwise regression to identify a parsimonious model that best explained each sales measure in separate analyses. Using adjusted R^2 and AIC scores, we compared each possible stepwise derivative (R Core Team, 2013). We included 13 and 14 ("antlerless bag limit" in deer permit model only) variables in each global model, respectively.

We evaluated spatial autocorrelation using significance testing of Moran's-*I* for model residuals of the license/permit sales models within distance classes with $\geq$30 pairs of points (R

Core Team, 2013). The initial lag distance interval (45.7 km) was set above the maximum nearest neighbor distance (max = 40.8 km) between county centroids with subsequent distance classes every 45.7 km. For each distance class, we used 999 random permutations to determine the probability (given a null expectation of $I = 0$) of observing a value of Moran's-*I* exceeding the observed value. We detected no spatial autocorrelation in the general hunting license model, but did detect positive spatial autocorrelation within a single distance class for the deer permit sales model (for lag distance = 411.5 km, $I = .44$, $p = .016$)—sample size ($n = 27$) in that distance class was lower than our minimum sample size for significance testing. This result was not impactful enough to prompt accounting for spatial autocorrelation in the deer permit sales model (positive spatial autocorrelation present at small lag distances would have been).

Results

Bivariate Analyses: Factors Associated with Per Capita Hunting License and Deer Permit Sales

All explanatory variables were correlated ($p < .05$; "mean government subsidy" and "% croplands" to per capita hunting license sales $-.05 < p < .10$) with each response measure (i.e., per capita hunting license sales and per capita deer permit sales; Table 2) except for "median age of Ohio resident." All three variables that assessed agricultural intensity (i.e., "% croplands," "mean government subsidy," "mean gross sales") were negatively correlated with both per capita participation measures. The strength of these relationships was stronger with per capita deer permit sales than with hunting licenses.

Table 2 about here

Of all bivariate relationships examined, per capita general hunting license sales and per capita deer permit sales were most strongly correlated with "percent of farms with broadband internet." In both cases, the relationship was negative where increased internet access was associated with decreased participation rates (Figure 2a). "Per capita income" was strongly related to both response variables; counties with higher average income levels were likely to have lower per capita participation rates (Figure 2b). Likewise, increased human densities had a strong negative relationship with participation (Figure 2c), and more rural counties (RUCC) were associated with increased participation rates. "Mean parcel size" – a factor that decreases with growing exurbanization and human development (Figure 2d; Theobald, Miller, & Hobbs, 1997) – was positively correlated with per capita sales. "Percent county forested" and "proportion of county public land open to hunting" were positively correlated with greater hunting license and deer permit sales. In addition, both hunting license and deer permit sales were positively associated with larger Amish and Caucasian (non-Latino/Hispanic) populations. To evaluate the relationship of white-tailed deer harvest opportunity, we correlated "antlerless bag limit" with the deer permit response variable; not surprisingly, bag limit, set for each county by the Ohio Division of Wildlife, had a strong positive relationship with per capita deer permit sales.

Figure 2 about here

Multivariate Analyses: Per Capita Hunting License Sales and Deer Permit Sales Model

Six variables ("% of farms with broadband internet," "mean parcel size," "% croplands," "proportion of population Amish," "proportion of population Caucasian," and RUCC) explained 81% of variance in per capita hunting license sales, and six variables (five of the same and "% forested" less "proportion of population Caucasian") explained 86% of variance in per capita

deer permit sales (Table 3). "Percent of farms with broadband internet" was negatively correlated with per capita license ($\beta = -.054$, $p < .001$, partial-$R^2 = .159$) and permit sales ($\beta = -.100$, $p < .001$, partial-$R^2 = .233$), and "proportion of population Amish" was positively related to both dependent variables ($\beta = .012$, $p = .013$, partial-$R^2 = .075$ and $\beta = .026$, $p < .001$, partial-$R^2 = .134$, respectively). Proportion of a county's land area in croplands was negatively associated with per capita hunting license ($\beta = -.0002$, $p < .001$, partial-$R^2 = .237$) and deer permit sales ($\beta = -.0006$, $p < .001$, partial-$R^2 = .453$). Percent of county land area in forests was important only in the per capita deer permit sales model ($\beta = .0002$, $p = .014$, partial-$R^2 = .073$). The quadratic relationship between "mean parcel size" and the response variables indicated that parcel size was positively related with hunting license and deer permit sales up to a point, then exhibited a negative relationship with all other variables being equal. We detected a positive relationship between "proportion of population Caucasian" and per capita hunting license sales ($\beta = .050$, $p = .020$, partial-$R^2 = .065$). Rurality, as accounted for by the RUCC factor, was positively associated with increased participation rates ($\beta = .003$, $p < .001$, partial-$R^2 = .183$ and $\beta = .004$, $p < .001$, partial-$R^2 = .162$, respectively). With the effects of all other factors accounted for, the other independent factors did not have a significant relationship with either dependent variable.

Table 3 about here

We conducted post-hoc analyses to evaluate for collinearity of "percent of farms with broadband internet" in masking the potential effect of "per capita income" and "human population density." In separate tests, we replaced "percent of farms with broadband internet" with "per capita income" (and with "human population density") in the parsimonious model for

each response variable. Overall variation explained decreased with the "per capita income" substitution (hunting license model – adjusted R^2 = .720; deer permit model – adjusted R^2 = .798) and the "human population density" substitution (hunting license model – adjusted R^2 = .782; deer permit model – adjusted R^2 = .842). In addition, we substituted "human population density" for "mean parcel size", and overall variance explained decreased for both analyses of per capita hunting participation (hunting license model – adjusted R^2 = .758; deer permit model – adjusted R^2 = .813).

Discussion

Per capita general hunting license and deer permit sales were correlated with nearly the same suite of county-level factors. We propose that each member of our candidate variable set can be viewed as an environmental factor that raises or lowers participation barriers within a socio-cultural context. We use the term "environmental" broadly to capture characteristics of habitat (i.e., the physical environment surrounding hunters and the species they hunt) and the socio-cultural environment of humans (i.e., urbanized society with elevated access to entertainment technologies). Although prior studies implicate diverse and complicated factors directly influencing choice of participation at the individual-level, our study suggests a different (albeit overlapping) set of factors that operate at broader socio-cultural scales, and which may affect an individual's choice without their conscious awareness. Our findings suggest that those socio-cultural factors could play a substantial role in recruitment and retention of participants in consumptive outdoor activities, which is a general conclusion supported by others (Arlinghaus, Tillner, & Bork, 2015; Robison & Ridenour, 2012).

Given the different habitat requirements between white-tailed deer and other hunted species (i.e., small game, waterfowl, upland birds), and consequently, their availability to be pursued by hunters, it is not surprising that "percent county forested" was associated with deer permit, but not general hunting license sales. Presence of forest in an agriculturally-dominated state such as Ohio is necessary to support medium to high densities of white-tailed deer (Roseberry & Woolf, 1998). In fact, comparing partial-R^2 values suggests that the negative effect of "% cropland" was one of the strongest influences on deer hunting participation, whereas its effect was considerably less in the general hunting license model. Upland game populations of pheasant (*Phasianus colchicus*), waterfowl hunting opportunities, and other small game populations that thrive within intensively-farmed lands provide alternative quarry for sportsmen (*sic*.) living in regions devoid of appreciable woodlots, and help compensate for lower densities of game such as white-tailed deer and Eastern wild turkey (*Meleagris gallopavo silvestris*). The re-enrollment of Conservation Reserve Program contracts and maintaining other remnant habitats (e.g., wetlands) is potentially critical for continued hunting opportunities within Ohio's counties northwest of the glaciated front (Young & Osborn, 1990). Although there were model differences among important habitat variables, it is not surprising that the two models were otherwise similar—consider that four-fifths of Ohio's small game hunters also pursued white-tailed deer (unpublished data, Ohio Division of Wildlife). Also, considerable waterfowl hunting occurs in harvested agricultural fields with residual waste grain; even duck and goose hunters are not inextricably linked to other habitat types (e.g., availability of water bodies) not explicitly considered in our analysis. That "antlerless bag limit" did not explain additional variance in the per capita deer permit sales model was surprising, but few Ohio hunters (23.4%; unpublished

data 2011−12, Ohio Division of Wildlife) harvested one or more antlerless deer, making this variable's exclusion more understandable.

Amish populations constituted a considerable proportion of some Ohio counties and were associated with higher rates of participation in both multivariate analyses. Amish are one of the fastest growing religious or ethnic minorities in the United States (McConnell & Hurst, 2006). Possessing beliefs and values resistant to modernization (Denlinger, 1993), participation rates are likely to remain stable or possibly increase where Amish are a substantial portion of the population. Consistent with our analysis of 2007 data, 25% of Amish persons cited hunting as being in their top three leisure activities (Hurst & McConnell, 2010), a rate far exceeding that of any other American religious, ethnic, or cultural group of which we are aware. That "proportion of population Caucasian" (i.e., race) was positively related to per capita hunting license sales was not surprising (Floyd & Lee, 2002; Heberlein & Thomson, 1996) as a bivariate relationship, but certainly interesting within the multivariate model. Within Ohio's top 15 most densely populated counties, race (M = .853, SD = .096 in densely populated counties, and M = .955, SD = .028 in sparsely populated counties) explained considerable variance, whereas other model variables (except parcelization) were more suited for explaining variance in less developed landscapes. Demographers project declining population proportions of Caucasians in coming years, and this ongoing trend bodes ominously for continued declines in hunting participation, particularly within urbanized settings (Floyd & Lee, 2002).

Individual-level hunting and fishing participation studies (Duda et al., 1995; Lindberg, 2010; Miller & Hay, 1981) consistently identified age as an important predictor; our study examined aggregate dependent variables and not individual persons' participation. "Median age

of Ohio resident" was not related in either bivariate or multivariate analyses, and lack of sufficient inter-county variation in median age likely caused this result. Our finding is supported by other socio-cultural evaluations of participation (Heberlein et al., 2002).

Our data illustrate why dichotomous urban versus rural classifications are insufficient to explain mechanistic processes. Specifically, the continuous measure of "human population density" was not an important predictor when the more relevant process of hunter access, as measured by parcelization, was included in the model. Opportunity is not necessarily limited by the number of people living in an area, but rather, whether individual tracts of land in one's immediate area are suitably large to be hunted. For clarity, our results suggest that human population density does not directly affect whether people choose to hunt, although this conclusion is tenuous as evidenced by the significance of the RUCC variable. This result suggests that a county's human density is only important within the context of its proximity to urban centers. Also, perhaps these data (i.e., RUCC) are an indirect means for accounting for more subtle and underlying rural values that are harder to account for at this scale of analysis. Despite post-hoc analyses involving "human population density" and controlling for urbanization/rurality with a multitude of different measures (see Table 3, footnote c), the relationship of PETs to per capita hunting participation in Ohio remained (Figure 3).

Figure 3 about here

We hypothesized that "mean parcel size" would be linear and positively related to our participation proxies, but Lovely et al. (2013) lend possible insight into our models' improved fit of "mean parcel size" as a non-linear effect on per capita participation. Conversion of rural areas to exurbia creates prime deer habitat (increased edge habitat and micro-refugia), and deer

densities are curvilinear to "mean parcel size" with the densest populations occurring at intermediate levels of parcelization between high intensity development and rural agricultural- or forest-dominated landscapes (Lovely et al., 2013). This explanation seems likely if deer permit and hunting license sales respond to changes in deer population densities. The presence of public land also impacts access and opportunity for hunting, but it was collinear with other habitat/land use variables (i.e., "% county forested," "mean parcel size"). Although public land was not an important factor in our models, we recognize that it can still play a crucial role in recruitment and retention (e.g., reducing access barriers for individuals living in urban settings).

We hypothesized that higher income likely leads to higher local (i.e., county and township) tax revenue, which may promote development of infrastructure and greater availability of technological conveniences such as broadband internet, but "per capita income" was not significant in either multivariate model even though it showed strong negative correlations with both dependent variables. These results raised our concerns that "per capita income" was masked by collinearity with the broader measure of rural broadband internet access or that rural internet availability was actually a proxy for "per capita income" in Ohio, but post-hoc analyses indicated that neither was an issue. Although the intent of our study was to provide a parsimonious model that explained county-level hunting participation in Ohio, we do not want to dismiss the effects of other variables on the dependent measures. Indeed, although we focus here on proximate explanations for per capita participation, we recognize that a variety of factors (e.g., education, income) likely have strong indirect effects on per capita participation.

A recent study operationalized videophilia (e.g., proportion of households with internet; Robison & Ridenour, 2012) and examined the influence of technological usage on hunting

participation at the individual and state levels. They implicated the use of electronic media as a causal process negatively impacting an individual's likelihood of hunting (Robison & Ridenour, 2012). In our study, we believe that increased availability of technological conveniences likely operates by reallocating how leisure time is spent by both adults and minors within an increasingly modernized society. Research indicates that although leisure time for males has increased in recent decades, there has also been a marked increase in leisure time inequality. Males with less than 12 years of schooling saw significant gains in leisure time (~8 hours, per week), but those with 16 or more years saw a substantial decrease (~6 hours per week; Aguiar & Hurst, 2008). These data hint at a possible mechanism underlying the negative bivariate association between per capita hunting participation and income—that is, education promotes both increased income (via higher paying jobs) and decreased leisure time. Conversely, unemployment can have a positive effect on hunting participation rates, reiterating the important role of leisure time (Responsive Management, 2013).

In contrast to adults, children's non-obligated leisure time is declining (Hofferth & Sandberg, 2000; Louv, 2005). Hofferth and Sandberg (2000) found that leisure time declined by 12% between 1981 and 1997 in a study that used time diaries to examine children's leisure time. They also found the decline in leisure time was largely the result of increased time in child care or school, as well as time spent in personal care. Not only is leisure time shrinking, youth increasingly spend that time engaged in multimedia viewing/listening, video gaming, and social media (as recently as 2009, nearly eight hours daily; Vahlberg, 2010), which apart from the obvious detraction of time from other (outdoor) activities, bodes ominously for future recruitment efforts into outdoor recreation activities (Robison & Ridenour, 2012). In addition,

sustained separation from outdoor entertainment environments can acculturate perceptions that outdoor and wild places are to be feared due to negative risk factors (i.e., injury, strangers, the "unknown;" Lougheed, 2008; Louv, 2005), a phenomenon potentially difficult to overcome as children mature to adulthood.

Perhaps current hunters will utilize "smartphones" to complete any number of tasks related and/or un-related to the immediate activity of hunting while hunting. As the geography of mobile connectivity increases (Oulasvirta, Rattenbury, Ma, & Raita, 2012), technology could prove useful in overcoming some barriers to hunting (e.g., Colorado's online elk hunting university module), but other media and entertainment technologies (e.g., video games, social media) will likely continue to compete for leisure time, particular in younger generations. Anecdotally, we observed that "% of farms with broadband internet" was closely related to the topography of the county. We surmise that topography could be an impediment to constructing infrastructure needed to distribute certain technologies to make it widely available. A post-hoc examination of distribution maps of wireless data networks offered by cellular communications companies suggested that this speculation is not far-fetched. That another medium – portable information and communication technology (Oulasvirta et al., 2012) – generally follows the same spatial distribution suggests that southeastern Ohio's relief may alleviate, or at least delay, technology's widespread negative influence on hunting participation.

Our study has several limitations that can hopefully provide guidance for future explorations of socio-cultural level factors related to hunting participation. First, there are several county-level factors that could not be explored in this analysis (e.g., wildlife value orientations, landowner willingness to grant hunting permission) that may have explained

additional model variance or pinpointed causal processes. We acknowledge that examining *where hunters hunt* would likely yield different results than we presented here. Inevitably, certain influential variables would overlap with our analysis, and a few variables may even be more important in the context of where a hunter hunts versus where he or she lives (e.g., percent county forested). It is important that our study only be interpreted as addressing the landscape and socio-cultural environment in which hunters *live*. The same statements can be made for examinations of hunting participation at different spatial scales (e.g., census tract vs. county vs. state vs. national levels). Another limitation is the scope of analysis; expanding analyses to a broader suite of similar Midwestern states and/or other regions would provide insightful comparisons. In states where white-tailed deer are not the primary sought-after species, variables affecting general hunting and deer hunting may be different (e.g., in North Dakota where pheasants are the most popular game species). A final limitation is that causal relationships cannot be reliably deduced with cross-sectional data. Until experimental evidence is presented that implicates the effects of PETs (and other variables) on declining hunting participation, researchers should approach correlative evidence with some caution.

Conclusion

The potential effects of reduced recreational hunting license sales are obvious and profound. It seems likely that with human populations becoming increasingly concentrated in urban and suburban population centers, changing rural cultural values, PETs, and land use conversion will only accelerate; thus, further contractions in hunting participation are probable. Collateral impacts could shrink already-tightened state and federal natural resource agency budgets. Unless disengaged hunters switch to other forms of outdoor recreation that fund

conservation at comparable levels to those of consumptive users, permanent losses of capital for wildlife conservation could dramatically limit future conservation efforts (Vrtiska et al., 2013). Also, because hunters are the primary tool whereby agencies manage some game populations (e.g., those prone to causing conflict and damage), effective and efficient management may be jeopardized (Brown, Decker, Siemer, & Enck, 2000). Participation in deer hunting also likely impacts white-tailed deer harvest density, and subsequently, the state's ability to regulate populations through the traditional mechanism of hunter harvest. As of yet, the rugged topography and forest cover of Ohio's southeastern counties still resists widespread land use conversion and development, and the region still lacks infrastructure to provide ubiquitous access to certain technological conveniences. Future monitoring of trends within Ohio's hunting participation strongholds (e.g., some southeastern Ohio counties and Amish communities) will be telling – whether or not the deep cultural and rural values that characterize the citizens of these communities will resist ever-increasing pressures deleterious to consumptive outdoor recreation activities.

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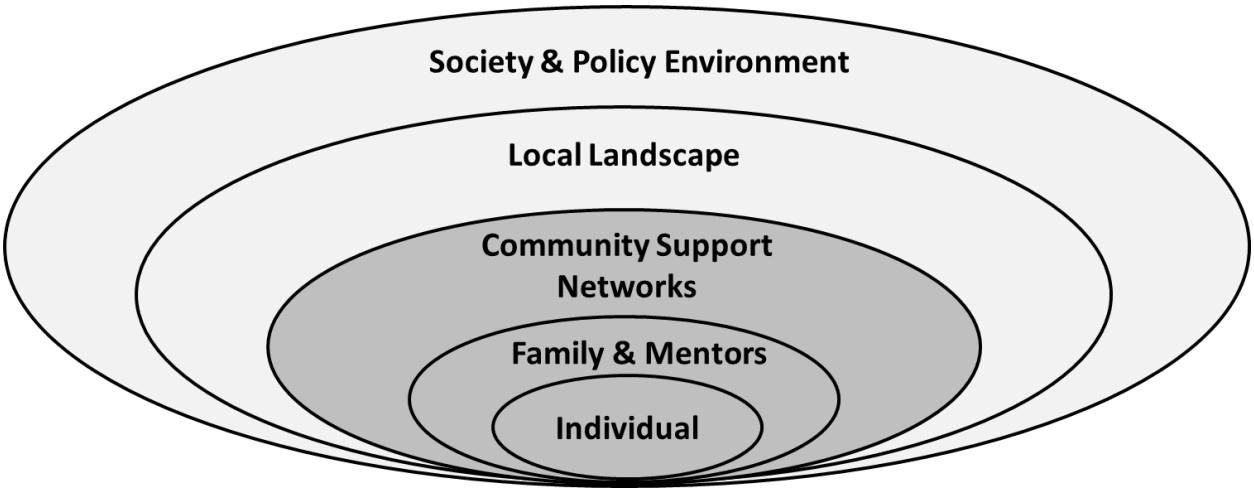

Figure 1. Levels of social structure that combine to influence hunting participation. Increasing oval size represents the scale of each level's influence from micro to macro. The lightly-shaded ovals are the scales at which our study focuses. Diagram adapted from social-ecological models of individual behavior (Bronfenbrenner, 1979; Larson et al., 2014; Moskell & Allred, 2013; Sallis, Owen, & Fisher, 2008).

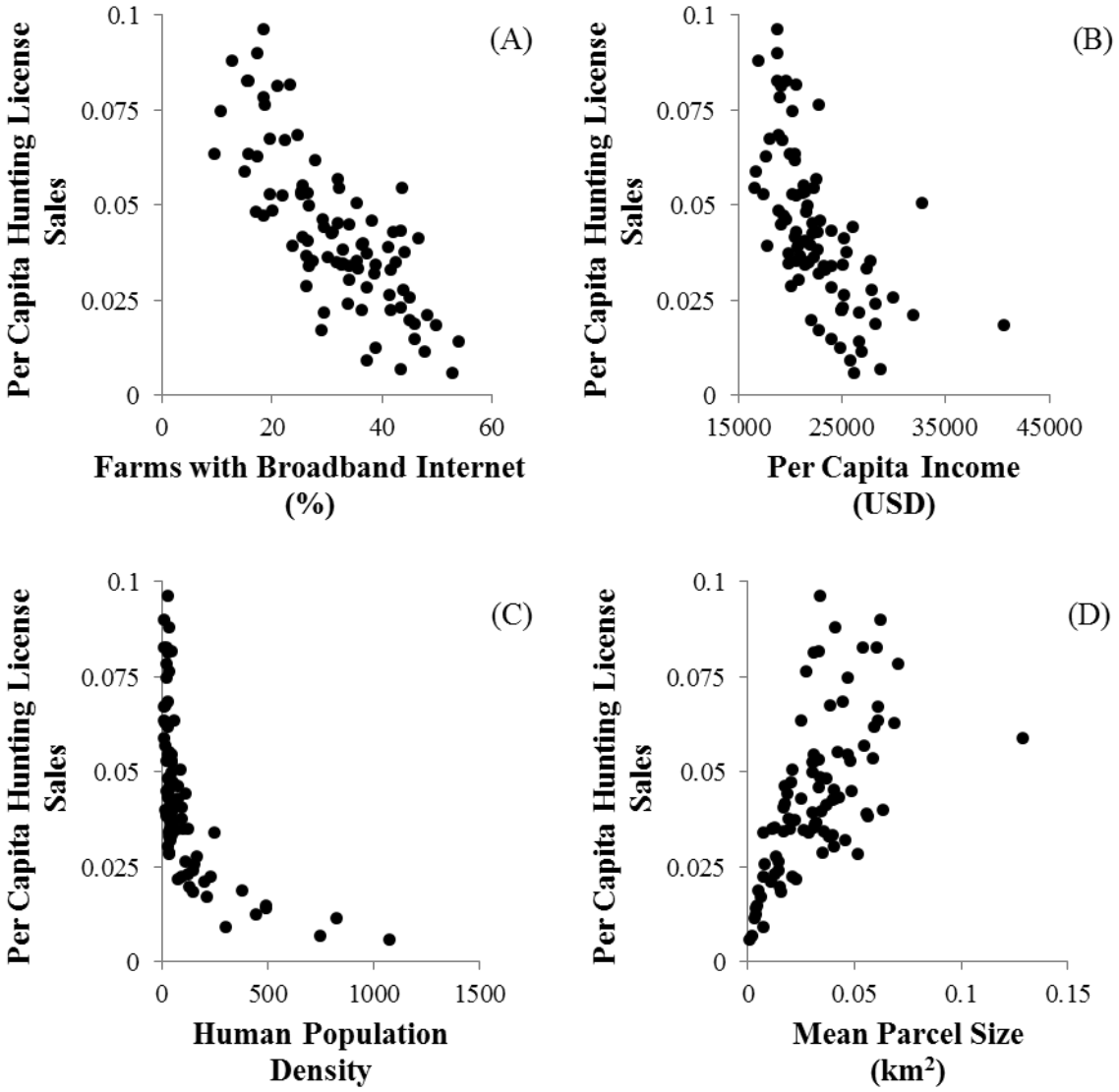

Figure 2. Scatterplots showing strong bivariate relationships between by-county ($N = 88$) per capita hunting license sales and independent variables. Note that plots were generated from un-transformed data.

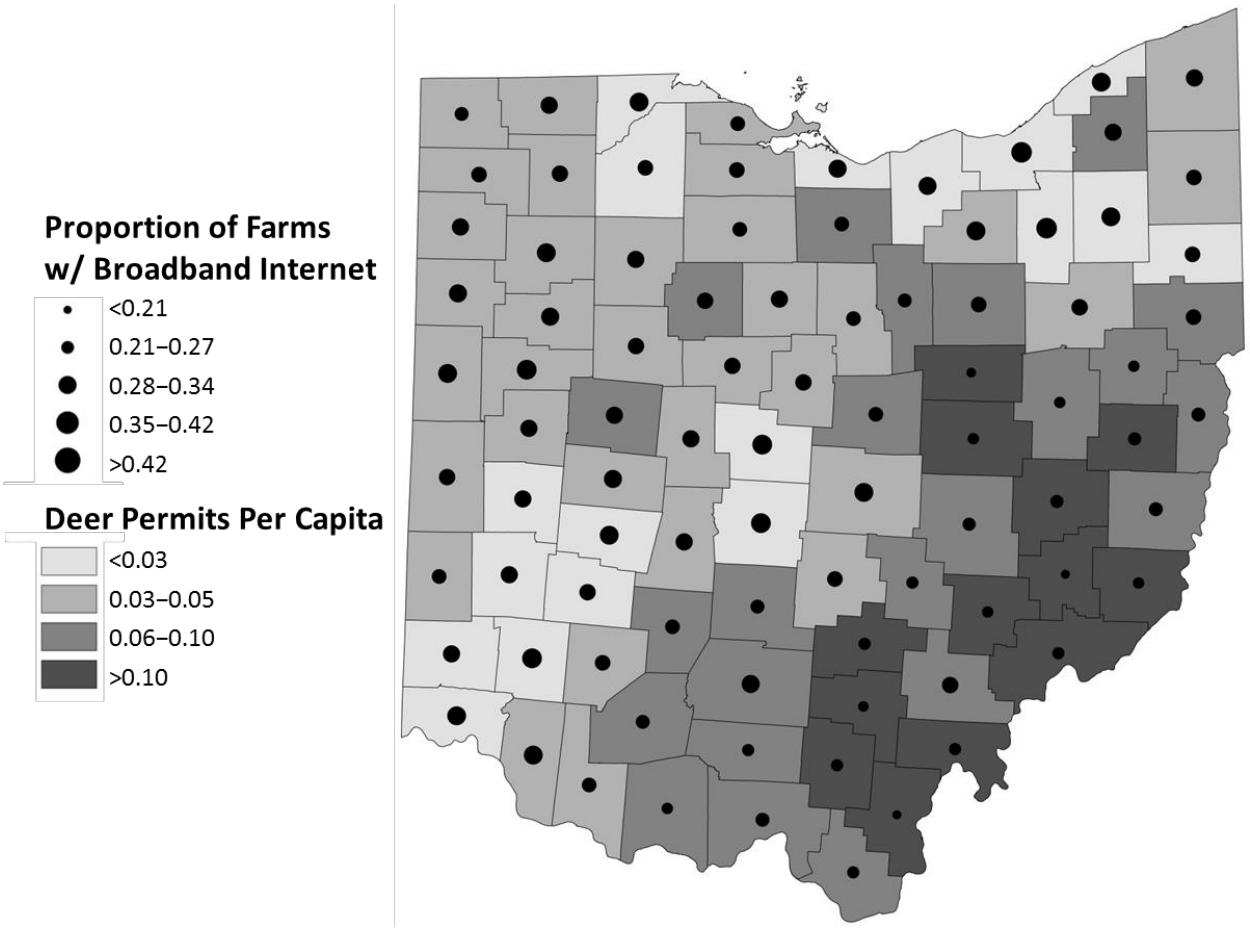

Figure 3. Per capita deer permit sales and the proportion of farms with broadband internet exhibit regional distribution patterns. Southeastern counties tended to have greater deer permits per capita, and northeastern and western counties tended to have the largest proportion of farms utilizing broadband internet.

Table 1. Data summarization of county-level independent factors included in analysis of hunting participation in Ohio.

Independent Variable	Median	Mean	Min-max	Std. dv.	Hypothesized effect
% of farms with Broadband Internet [a]	32.1	31.6	9.6−53.9	10.5	−
Median age of Ohio resident [b]	39.8	39.7	26.4−46.5	2.9	+
Population density /km^2 [b]	46.3	111.1	12.4−1076	178.6	−
Mean parcel size (km^2) [c]	.032	.032	.001−.129	.021	+
Proportion of county public land open to hunting [d]	.021*	.045*	<.001−.281*	.058*	+
% forested [e]	27.0	30.9	2.9−79.4	23.7	+
% croplands [a]	36.3	41.7	.4−91.5	27.1	−
Mean govt subsidy /farm (USD) [a]	5,215*	5,509*	1,144-11,922*	2,359*	−
Mean gross sales /farm (USD) [a]	78,340	89,716	7,016−411,051	70,998	−
Proportion of population Amish [f]	.009*	.027*	<.001−.422*	.068*	+
Antlerless bag limit [d]	2	2.360	1−3	.610	+
Per capita income (USD) [g]	21,799	22,624	16,642−40,682	3,918	−
% farmlands [a]	50.1	53.6	1.0-99.0	25.5	−
Proportion of population Caucasian [b]	.957	.937	.674−.990	.061	+
Rural-urban continuum code [h]	4.0	3.7	1.0-8.0	2.13	+

* Value drawn from subset of counties with value > 0.
[a] Data source: USDA Ag Census (2007).
[b] Data source: US Census (2010).
[c] Data source: individual county tax and auditor records.
[d] Data source: Ohio Division of Wildlife; 2007−08 regulations.
[e] Data source: NLCD 2006 (Fry et al., 2011).
[f] Data sources: Donnermeyer, Anderson, & Cooksey (2013), Donnermeyer & Luthy (2013).
[g] Data source: US Census (2013); 5-year average American Community Survey 2007−2013.
[h] Data source: Economic Research Service (2013).

Table 2. Bivariate correlations between each county-level independent variable and per capita Ohio resident hunting license and deer permit sales, 2007. Values are Pearson's product-moment correlations (r) for all variables except 'population density' and 'mean parcel size' (for these, reported value equals square.root(multiple-r^2) for bivariate regression of linear and quadratic term).

Independent Variable	Per Capita Hunting Licenses	Per Capita Deer Permits
% of farms with Broadband Internet	−.779*	−.801*
Median age of Ohio resident	.150	.167
Population density /km^2	−.678*	−.578*
Mean parcel size (km^2)	.692*	.616*
Log(Proportion of county public land open to hunting)	.527*	.631*
% forested	.284*	.345*
% croplands	−.168**	−.379*
Mean government subsidy /farm	−.204**	−.345*
Mean gross sales /farm	−.294*	−.600*
Log(Proportion of population Amish)	.422*	.431*
Antlerless bag limit	NA	.580*
Log(Per capita income)	−.654*	−.653*
% farmlands [a]	.013	−.194**
Proportion of population Caucasian	.575*	.477*
Rural-urban continuum code	.639*	.558*

* $p < .05$.
** $p < .10$.
[a] Deleted based on VIF>5 (collinear with variable '% croplands').

Table 3. Stepwise regression models explaining per capita Ohio resident hunting license and deer permit sales, 2007.

Dependent variable				Overall model		
Predictor variables	β	*t*-value	Partial-R^2	R^2	Adj. R^2	*F*-value
Per capita hunting license sales*				.827	.812	54.82
% of farms with Broadband Internet*	−.054	−3.893	.159			
Mean parcel size* [a]	.832	5.068	.243			
Proportion of population Caucasian*	.050	2.366	.065			
% croplands*	−.0002	−4.986	.237			
Proportion of population Amish (log)*	.012	2.538	.075			
Rural-urban continuum code*	.003	4.239	.183			
Per capita deer permit sales*				.874	.863	79.16
% of farms with Broadband Internet*	−.100	−4.926	.233			
Mean parcel size* [b]	1.560	6.690	.359			
% forested*	.0002	2.515	.073			
% croplands*	−.0006	−8.132	.453			
Proportion of population Amish (log)*	.026	3.517	.134			
Rural-urban continuum code*	.004	3.927	.162			

* $p < .05$

[a] Quadratic term for mean parcel size (β = −6.290, t = −4.633, partial R^2 = .212)

[b] Quadratic term for mean parcel size (β = −10.79, t = −5.536, partial R^2 = .277)

[c] To address reviewer concerns, we examined additional variables in the multivariate analyses but found none to be important. Each variable was correlated (Pearson's correlation coefficient) with hunting license and deer permit sales, respectively: proportion of population >65 years old – r = .316*, .319*; proportion of population >18 years old – r = −.058, .038; US highway/interstate road density – r = −.568*, −.535*; proportion of population with ≥1 year post-high school education – r = −.494*, −.506*; mean distance from residence to centroid of county hunted – r = −.684*, −.683*; proportion of county's population classified as rural – r = .734*, .697*; number of farms per county – r = $.117^{NS}$, $.005^{NS}$. These data were derived from the following sources: Ohio Division of Wildlife; USDA

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Ag Census (2007); US Census (2010); US Census (2013); TIGER shapefile (2013).