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Investigating the Social Habitat of Deer Hunters in Michigan

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Table of Contents

Acknowledgements

Abstract

State wildlife management agencies are funded primarily by revenue from hunting and angling license sales as well as federal excise taxes on equipment. These agencies are also responsible for managing wildlife populations and providing recreational resources to the public. Declines in hunting participation across much of the United States throughout the last two decades have prompted researchers and wildlife professionals to search for explanations and solutions that will ensure a level of funding for state agencies that allows continued management of wildlife within biological and social carrying capacities, engagement in conservation initiatives, and development of recreational opportunities. Most of the current body of research on hunting participation focuses on social-psychological and individual socio-demographic explanations for why people hunt or not, but a new framework, a *social habitat of hunting* theory, encourages scholars and practitioners to consider the broader social and community contexts within which individuals are situated.

This thesis empirically tests the social habitat theory, investigating how socio-demographic, economic, ecological, and policy variables impact deer hunting in Michigan. The analysis is based on a regression model that investigates individual and community-level variables to analyze the entire population of Michigan in the year 2010 based on population data from the U.S. Census Bureau and hunting license sales data from the Michigan Department of Natural Resources. At the individual level, the odds of males purchasing a hunting license was 10 times greater than females, but this varies by age. Community-level factors are also important, however, and appear to have a much greater impact on deer hunting than individual demographic variables. County hunting participation rates are influenced by aggregate measures of education, ethnicity, rurality, and land use characteristics. The results show that a socio-ecological framework may be a useful way to describe the community context that helps shape an individual's decision to hunt or not, and aid decision-making strategies by policymakers and wildlife managers in recruitment and retention efforts.

1. Introduction

Hunting participation rates and hunting license sales across much of the United States have been declining for the last several years (Bissell et al. 1998, Enck et al. 2000, Jacobson and Decker 2006, Larson et al. 2014, Karns et al. 2015). Although the numbers of hunting licenses sold in a particular year varies, (U.S. Fish and Wildlife Service 2012), per capita participation rates have steadily declined in most states (Adams et al. 1997). State wildlife management agencies are dependent on revenue from hunting license sales to help provide a plethora of resources to the public. State agencies are responsible for ensuring healthy wildlife populations, stewardship of natural resources, maintaining healthy ecosystems, providing recreational opportunities, and engaging the public in outreach and educational efforts. When consumptive activities and corresponding funding decline, agencies' ability to perform these tasks becomes less certain. In light of decreasing resources and increasing issues associated with overabundant wildlife populations, the adaptive capacity and effectiveness of state-led hunting efforts is under question (Riley et al. 2003). Wildlife professionals are ultimately responsible for setting policies that keep wildlife populations at ideal levels, and their ability to do so depends in large part on a funding model established at the turn of the 20th century, under a specific social context, to rely on the participation of hunters and anglers (Patterson et al. 2003). Hunters are the primary mechanism for controlling white-tailed deer populations (Brown et al. 2000), and overabundance leads to forest and crop damage and deer-vehicle collisions.

State agencies have implemented several strategies to address the problems associated with declining participation. The most common efforts have been to attempt to increase hunting participation through recruitment and retention programs. Recruitment and retention programs are designed to help usher youth into the hunting population by providing hunting camps, mentoring programs, and hunter education courses with the hope that they will be retained as hunters into adulthood, continually supporting the agency through license and equipment purchases. However, these strategies have not always been effective at increasing participation, and uncertainty still exists about the best way to approach hunter recruitment and retention (Beucler and Servheen 2008, Ryan and Shaw 2011, Larson et al. 2014).

Human dimensions research points to several social-psychological and demographic factors that influence individual hunting participation, but these approaches neglect to account for the indirect influences of socio-cultural, ecological, and policy contexts on individual behavior. The inability of state-led efforts to boost hunting participation may be due in part to inadequate theoretical frameworks for guiding research and designing targeted programs that move beyond assessment of individual hunters and their immediate support structures to account for influences at broader scales that act on behavior in indirect ways. Larson et al. (2014) suggest that a comprehensive framework is needed to integrate knowledge of social-psychological and demographic influences on hunting with influences at broader scales. This hierarchical approach represents a "social habitat" for hunting, or an understanding of how social, cultural, ecological, and broader policy contexts collectively constitute a hunter's environment. I hypothesize that a social-ecological model that explains how community level factors shape the social context within which people decide to hunt or not can help agencies better understand hunting participation trends. My research asks, *how important is the community context in relation to individual factors that influence deer hunting participation, and what factors shape that context?*

This thesis addresses the question by using statistical analysis to investigate individual and county-level deer hunting license sales records from 2010 in Michigan, and corresponding socio-demographic, economic, ecological, and policy variables. This approach can highlight how individual and community factors influence the decision to hunt or not, and also provides the first empirical test of the social habitat theory by situating individual hunters within a socio-ecological framework. From this analysis we can investigate the importance of community context, giving wildlife professionals and managers a better understanding of how various social settings relate to hunting participation. This can lead to better recruitment and retention strategies, as the specific "habitat" of a hunter is seen as a dynamic set of circumstances and community characteristics that influence individuals in direct and indirect ways. A social habitat framework can help predict those influences and measure how they change over time, setting the stage for a greater range of policy options that may be more successful at engaging people in hunting, conservation, and wildlife-related recreation.

1.1 Background

To understand the current issues surrounding hunting participation, it is worth examining the roots of the political system of governance within which wildlife management takes place in the United States. Formal state wildlife management agencies were organized in the early 20th century as part of a deliberate conservation strategy to stop the dramatic decline of wildlife populations seen throughout the 19th century as a result of over-hunting and habitat loss (Sporting Conservation Council, 2008). Several principles emerged from this conservationist movement, known collectively as the North American Model of Wildlife Conservation (Prukop and Regan 2005). The "Public Trust Doctrine" is arguably the most foundational of these tenets to the structure of wildlife management agencies today, defining wildlife as a public resource and assigning all citizens to the role of "stakeholder" (Smith 2011, Organ et al. 2014).

State agencies were structured to be dependent on funds generated from hunting and angling license sales. The Pittman-Robertson Act of 1937 placed a federal excise tax on firearms and other hunting equipment that generated funds for state wildlife management agencies. These funding mechanisms secured a relationship between consumptive activities and wildlife management that characterized conservation throughout the 20th century, successfully rescuing many species from the brink of extinction (Duda and Jones 2008). The structure and function of state agencies reflected the socio-political context of the early 20th century, which was dominated by a rural, agrarian landscape (Patterson et al. 2003). Consumptive activities (e.g. hunting, angling, and trapping) were the primary ways for agencies to protect wildlife populations, and those activities in turn were the primary ways stakeholders engaged with wildlife. This system regulated harvest of game and prevented further exploitation of wildlife species. However, this piecewise mechanistic approach tended to favor game species popular with hunters, and led to policies of predator eradication that removed natural checks on recovering ungulate populations. As a result, white-tailed deer (*Odocoileus virginianus*) and other game species flourished to the point of overabundance in many areas (Rooney and Waller 2003).

Throughout the 20th century, many rapid changes were occurring in the United States. Post-World War II modernization in the U.S. was accompanied by broad shifts in

societal attitudes, beliefs, and norms. Increased economic security, urbanization, and affluence changed the ways in which people viewed their relationship to nature (Inglehart and Baker 2000). Values that were previously oriented toward wildlife as a natural resource to be used for human benefit gradually shifted toward preservation and ethical and humane treatment of wildlife (Manfredo et al. 2003). Accompanying social and environmental movements emphasizing ecological integrity and appreciation for nature further influenced attitudes and norms of younger generations, reducing the acceptability of hunting and other consumptive activities while increasing the diversity of stakeholders to which state agencies are accountable under the Public Trust Doctrine (Jacobson and Decker 2008).

The North American Model defines all citizens as stakeholders, and the burgeoning diversity of values, attitudes, and beliefs about our relationship to nature led to a greatly expanded set of mandates for state agencies to consider (Chase et al. 2000, Chase et al. 2004, Jacobson and Decker 2008). Animal welfare organizations, environmental groups, and conservation organizations have criticized the traditional relationship between hunters and wildlife managers. They contend that the dependence on funds generated by hunters and anglers through license sales constitutes a form of "agency capture", whereby a regulatory agency is controlled by the industry it is supposed to regulate, making decisions that benefit the industry instead of acting in the public interest (Organ and Fritzell 2000). Growing numbers of non-consumptive stakeholder groups have voiced concerns that the decisions made by state agencies primarily favor game species and the needs of hunters over other users (Jacobson and Decker 2008).

Wildlife managers have pushed for greater flexibility in adapting to the needs of stakeholders. However, bureaucratic institutions can be slow to change, even in the face of societal pressure, and state wildlife management agencies are no exception (Loker et al. 1998). Instead of changing the funding mechanisms making agencies less reliant on hunting license sales and – at least hypothetically – more responsive to non-consumptive stakeholders, the response by many state agencies to hunting declines has been to focus intensively on recruitment and retention programs in an effort to boost hunting participation rates (Gude et al. 2012). Enck et al. (2000) define recruitment as first-time hunting license buyers or graduates from hunter education courses, and retention is the continued participation in hunting over time. Boosting recruitment and

retention ensures continued support for state agencies, both financially and through the consistent management of wildlife populations within biological and social carrying capacities (Brown et al. 2000).

Recent research into declining hunting participation rates has shown that generational transitions will continue to drive down numbers of hunters in the future (Winkler and Henderson 2015). Members of the "Baby Boomer" generation that have hunted at high rates throughout their lives are beginning to age out of hunting, and younger generations that have not participated at equally high rates are unable to replace them (Winkler and Warnke 2012). Moreover, younger generations are more demographically diverse, urbanized, and face greater demands on their time from technology (Barton 2012). Therefore, understanding the social dynamics of hunting participation may help wildlife professionals anticipate further changes in the hunting population and open up a greater range of options tailored toward demographics and geographies that hold greater potential to support conservation and management goals through participation in outdoor recreation. Bridging knowledge and support of conservation through the activities of hunters and other types of outdoor recreation is important for state agencies whose natural resource and wildlife management goals need to exhibit resilience and the adaptive capacity to respond to trends in hunting and angling populations. My analysis provides a potential framework for increasing understanding of different types of stakeholders and their socio-cultural environment. A social habitat approach can give wildlife managers and researchers a way to incorporate socio-ecological considerations into decision-making frameworks, potentially opening new pathways to increasingly adaptive and sustainable natural resource governance models.

2. Literature Review

2.1 Social-Psychological Models

Research investigating hunter characteristics has identified a range of factors that influence an individual's participation in hunting. Using social-psychological or cognitive development approaches, the motivations, expectations, attitudes, beliefs, and values of individuals have been empirically associated with hunting participation (Fulton et al. 1996, Zinn et al. 1998, Rossi and Armstrong 1999, Hrubes et al. 2001, Daigle et al. 2002, Floyd and Lee 2002, Zinn et al. 2002, Manfredo et al. 2003, Mehmood et al. 2003, Miller and Vaske 2003, Brunke and Hunt 2008), and these social-psychological characteristics have been used to understand why individuals hunt or not (Heberlein et al. 2008). Consistent findings indicate that demographic factors such as age, sex, ethnicity, and place of residence are strongly associated with hunting participation (Bissell et al. 1998, Floyd and Lee 2002, Heberlein et al. 2002). However, less certainty exists regarding the ways in which these factors influence a hunter's behavior.

Many of these studies take a theoretical approach based on the Theory of Reasoned Action (TRA) (Ajzen and Fishbein 1980) or the Theory of Planned Behavior (TPB) (Ajzen 1991, Ajzen and Fishbein 2005) which are close variations that utilize a similar framework. This framework asserts that peoples' beliefs, attitudes, and behavioral intentions are logically consistent when attitudes are directed toward a specific behavior, and that this provides a reasonable prediction of future behavior. In other words, according to these theories, the best predictor of behavior is holding an intention to carry out the behavior.

The pathways that structure one's values, attitudes, beliefs, and behaviors are complex, and the empirical evidence on the utility of such models for consistently predicting behavior is often conflicted. Sheppard et al. (1988) provide a meta-analysis of the Theory of Reasoned Action and found its utility in predicting behavior to be justified, but with several caveats that limit its generality. Rossi and Armstrong (1999) tested the suitability of both TRA and TPB to predict hunting intentions, finding that TPB is better suited for investigating natural resource behaviors, but that the model still explained relatively little of the variance in hunting participation among respondents ($R^2 = 0.38$).

Both theories have been used extensively to investigate participation in a host of outdoor recreational behaviors, including hunting (Hrubes et al. 2001, Daigle et al. 2002).

Researchers have found a range of motivations for participating in hunting, and levels of satisfaction with the hunting experience. Brunke and Hunt (2008) investigated the expectations, satisfaction, and future intentions to continue hunting among Mississippi waterfowl hunters. They found that seeing abundant game influenced hunter expectations, which in turn influenced their future intentions. This indicates that the ability of state agencies to manage wildlife populations may have an impact on retention of hunters. Bissell et al. (1998) found that most active hunters (88%) were satisfied with their recent hunting experiences, and also found that over the preceding decade, the number of hunters whose primary motivation is hunting for meat decreased while those hunting to be close to nature increased. The same study surveyed non-hunters and found that the hunting context influenced opinions, with nearly three quarters of the public approving of hunting for meat, but far lower approval levels for trophy hunting.

State agencies are particularly concerned with the individual indicators of hunting participation and satisfaction derived from social-psychological approaches. Resources have been poured into hunter recruitment and retention programs, hunter education programs, and youth and family initiatives, as well as assessment of those efforts (Larson et al. 2014). Programs are initiated with the goal of improving hunting participation, and agencies rely on information regarding hunter attitudes, values, norms, perceptions, expectations, and satisfaction to design and implement programs. However, assessment of those efforts has shown that an understanding of individual characteristics does not necessarily translate into effective recruitment and retention strategies that transform non-hunters into hunters (Enck et al. 2000, Beucler and Servheen 2008, Byrne 2009, Ryan and Shaw 2011, Gude et al. 2012).

2.2 Individual Characteristics

A person's age has the potential to influence their participation in hunting, (as well as many other recreational pursuits). Age reflects both one's physical abilities and the events and experiences one typically encounters at specific points in the lifecourse. Key events such as going to college, getting married, having kids, and retirement represent pivotal ages in an individual's life, and these changes may determine the types

of leisure activities, hobbies, and interests in which a person is involved. In general, hunters are recruited as young teenagers, participation tends to drop off around age 18 when individuals leave for college, but participation begins to increase again during the late 20's and remain highest among people in their 30's and 40's. Retirement ages are sometimes associated with a slight increase in participation rates, followed by a sharp decline among individuals older than 70, as aging's physical effects begin to restrict the activities one is capable of performing. Though consistent patterns can be found among different ages and their participation trends, age alone is an inadequate predictor of hunting participation. Age can be confounded by cohort effects, or generational influences that affect individuals in different generations in different ways, influencing their actions throughout life regardless of age and contributing to broad demographic and social changes (Winkler and Warnke 2012).

In conjunction with age, a person's sex is an important individual characteristic shown to be associated with hunting participation. Duda et al. (1995) in a three-year study examining national trends in hunting and angling in the United States found that age was the 2nd most important predictor of hunting participation among males, but that gender differences contribute to overall hunting participation trends in unexpected ways. Since 1980, male participation nationally has generally been decreasing, while female participation has been increasing (Bissell et al. 1998). Stedman and Heberlein (2001) provide an in-depth description of socialization patterns for males and females that may contribute to differences in hunting participation through formation of attitudes and gender norms at very young ages. Heberlein et al. (2008) investigated patterns of female hunting participation more directly and found that although female participation is increasing, the effect is mediated by males. This indicates that further declines in male participation may eventually affect female participation. However, this conclusion assumes that female recruitment remains dependent on male influence, which could be alleviated by state-led efforts that appeal to women directly through special programs and educational courses designed specifically for females.

In addition to age and sex, other demographic factors have been found to be associated with hunting participation in the United States. Floyd and Lee (2002) surveyed hunting and fishing license purchasers in Texas and found that when controlling for age, gender, education, income, and place of residence, ethnicity was one of the best predictors of hunting and fishing license purchasers. Those with Hispanic and

African American ethnic backgrounds were far less likely to have purchased a license, while white individuals were overrepresented in the hunting and fishing population. The 2011 Fishing, Hunting, and Wildlife-Associated Recreation survey in Michigan (U.S. Fish and Wildlife Service 2012) showed that individuals with a non-Hispanic white ethnic background comprised 99% of resident hunters. Given that individuals in younger cohorts are increasingly diverse, the ethnic composition of communities may be of increasing importance when investigating the social context for hunting.

A key insight of Heberlein's (2008) study is that the importance of external factors, or community characteristics, is often overlooked in social-psychological inquiries. Moreover, understanding an individual's attitudes, motivations, and beliefs does not always accurately predict behavior (Heberlein 2012). Ajzen and Fishbein (2005) argue that differentiating between *types* of attitudes can resolve some of the discrepancy between attitudes and behavior, but in the context of hunting participation, social-psychological inquires have not resulted in more effective recruitment and retention strategies (Ryan and Shaw 2011). What may be needed is an approach that links individual behavior with their community context, or socio-cultural environment of individual hunters.

2.3 Community Characteristics

Social, cultural, demographic, economic, and ecological factors that comprise a hunter's community can be characterized as "habitat requirements." In much the same way that deer require the right kind of habitat in order to thrive, so do deer hunters (Heberlein et al. 2008, Larson et al. 2014). Moving beyond individual explanations for hunting participation can highlight the indirect ways in which a hunter's surrounding community influences their behavior. Larson et al. (2014) offer a new theoretical framework for analyzing hunter recruitment and retention within this community context known as the *social habitat* (see Figure 1). A social habitat approach situates individuals within complex networks of social, ecological, and policy settings. These settings are comprised of social networks, family relationships, neighborhood characteristics, the physical geography of the surrounding landscape, and overarching networks of laws and policies. Together, these create a social and cultural atmosphere that is unique to each individual. This can be thought of as a "socio-cultural" context, and

determining how one's socio-cultural context influences hunting participation is a primary aim of the social habitat theory.

A strong consensus exists in the literature that rural setting is an important component of a social system that supports hunting (Duda et al. 1995, Stedman and Heberlein 2001, Heberlein et al. 2002, Heberlein et al. 2008, Schorr et al. 2014). Patterson et al. (2003) describe how the rural, agrarian social context of the early 20th century structured our interactions with wildlife. Hunting wildlife became woven into the fabric of rural landscapes and communities, reflecting traditional values, norms, family structures, and gender roles. Hunting was often seen as a "way of life", or a "rite of passage" for young men, who were generally socialized into the hunting population by their father or other male relative (Stedman and Heberlein 2001). However, this process has been changing as society has urbanized. In 1900, roughly 20% of the U.S. population was described as "urban", compared to today where 80% live in urban or metropolitan areas (Auch et al. 2004). Rural areas are still a stronghold of hunting participation, but since a lower proportion of people live in rural areas participation rates have declined. Stedman and Heberlein (2001) point out that although rural residence is an important variable affecting hunting participation, the ways in which rurality interacts with other variables is less well-understood. Further exploring the community context can help operationalize a social habitat approach, and provide insight into hunting participation that goes beyond the rural/urban divide by considering other variables that may constitute "habitat requirements" for hunting participation.

Less research has specifically investigated the role of communities and how they influence hunting behavior. Several researchers have found evidence for family and community settings to be indicative of certain wildlife value orientations (Zinn et al. 2002, Manfredo et al. 2003, Manfredo et al. 2009). Manfredo et al. (2003) describe how value orientations provide an underlying hierarchical structure for attitudes and norms, which have the potential to influence an individual's behavior. The researchers also define an empirical scale for measuring wildlife value orientations. On one side of the scale is a "use" orientation, while at the other end is a "protection" orientation. Individuals classified as having a use orientation typically exhibit traditional, utilitarian, use-based values that support hunting and fishing as mechanisms for management and use of wildlife. Protectionist orientations tend to favor preservation and animal rights perspectives, and hold less positive views of hunting, fishing, and traditional wildlife

management. Utilitarian orientations tend to be characteristic of rural areas, while protectionists tend to be more characteristic of urban environments (Manfredo et al. 2009). Fulton et al. (1996) demonstrated that value orientations can successfully predict hunting participation by measuring the relationships between wildlife value orientations and attitudes.

Inglehart and Baker (2000) emphasize the modernization of societies to explain the shift from traditional values toward modern values that are more reflective of a developed 21st century culture. America in the post-World War II era is characterized by economic security, which leads to greater equality, rising levels of education, and more emphasis on self-expression and other non-survival needs. Consequently, values shift away from traditional and become more fluid, tolerant, and participatory. However, Inglehart and Baker (2000) also found that traditional values leave a persistent cultural imprint that can linger despite the modernization of a society. Manfredo et al. (2003) found in their assessment of six states in the Western U.S. that "traditional" wildlife value orientations were associated with lower levels of income, urbanization, education, and geographic mobility, while greater numbers of "protectionists" had a positive association with those same variables. This underscores the importance of investigating the community context and how social settings influence values, attitudes, and behavior.

In addition to community contextual factors, ecological and policy factors have been found to play a role in influencing individual hunting behavior. Though less empirical evidence has been gathered at this scale in regard to hunting participation, biological and ecological sciences can point to certain habitat requirements for game species, and hunters need healthy game populations in order to hunt. Thus, the ecological and physical characteristics of particular landscapes may interact with communities and individuals, mediating their proximity and access to game, and influencing their decision to hunt or not. In this way, ecological characteristics of place might be considered an important aspect of a hunter's social habitat. Heberlein et al. (2002) investigate macro scale factors associated with hunting participation trends across the United States, Canada, and Europe. They found that while controlling for the effects of rurality, forest cover has a strong positive impact on the number of hunters.

The policy environment set by state and federal agencies provides an overarching context within which hunting takes place. The North American Model sets forth a

specific framework for regulated hunting, implemented by state agencies and dependent on hunters to control game populations. Brown et al. (2000) questioned the future effectiveness of hunting as the primary mechanism for white-tailed deer population control, highlighting several regulatory criteria for white-tailed deer management. Hunting regulations need to take into account declining numbers of hunters on the landscape, increasing land development that may fragment access to deer habitat, deer ranges that include urban and suburban landscapes, and regulations that provide incentives for shooting antlerless deer (Brown et al. 2000). This suggests that an important component of a hunter's social habitat could include amount and type of land access (e.g. federal, state, or private), and policies regulating antlered deer harvest.

2.4 Social-Ecological Models

Researchers have learned a lot about the characteristics that are typically associated with individual hunters from social-psychological approaches, but are only beginning to recognize that the surrounding social environment is also important. The ways in which hunters are socialized can impact recruitment and retention, so state agencies have designed programs to foster those processes (Stedman and Heberlein 2001). However, strategies have not always been effective at recruiting more hunters, increasing participation rates, or retaining hunters over the long-term (Ryan and Shaw 2011).

This raises an important question: If we know a good deal about the attitudes and values of individual hunters, their direct social support networks, and the vast majority of the population supports legal hunting, *why aren't more people hunting?* Part of the reason may be due in part to the fact that hunting is not just an individual decision, but is based on several external factors beyond the hunter and their immediate support networks (Heberlein et al. 2008). It may be that socio-cultural and demographic settings in which hunters live indirectly influence individual behavior in ways that social-psychological approaches alone cannot measure.

A large body of scholarship in environmental sociology, human ecology, systems ecology, and community psychology have investigated the role of context in human-environment interactions. Social-ecological frameworks situate individuals in a nested hierarchical structure of complex interrelationships between individuals, communities,

social structures, and the natural world. These approaches grew out of the "Chicago School" of human ecology in the early 20th century, and have been used in several disciplines to study an array of issues, such as health promotion, violence prevention, epidemiology, child development, and urban planning. Stemming from work in child development, Bronfenbrenner (1979) developed a human-ecological model of development by considering the nested structures influencing the development of children within networks comprised of households, neighborhoods, communities, and macro-level social and environmental influences. Human and social ecology take an interdisciplinary perspective that bridges cultural and institutional contexts with developmental and psychological attributes of individuals to study the interactions between people and social and natural environments.

Environmental sociology grew out of the need to integrate natural biophysical forces into classical sociological theory that had previously viewed human activity as separate from the environment (Dunlap and Catton 1979, Buttel 2002). Environmental sociologists tend to focus on the social, political, and economic forces that structure our interactions with the natural world, and, many would argue, result in environmental damage. Building on these frameworks, community psychological approaches recognize that human behavior is shaped by influences at multiple scales, and Ecological Models of Behavior have been used to identify the ways in which individual characteristics interact with attributes of the surrounding environment (Moskell and Allred 2013).

Thinking of hunting as a complex socio-ecological interaction between humans and the environment lends itself to analysis that situates hunters at the center of a hierarchical structure where they may be influenced by myriad social, cultural, demographic, economic, and ecological traits. A model that accounts for the complex interactions originating at multiple scales within this hierarchical structure might provide a more nuanced understanding of the socio-cultural conditions that are favorable to hunting participation.

2.5 Social Habitat Theory

Building on social-ecological theory, Larson et al. (2014) suggest a new framework for investigating hunter recruitment and retention, a *social habitat* for hunting. This framework situates individuals in a nested hierarchical network of factors

at micro, meso, and macro scales that interact to influence individual behavior, including hunter recruitment and retention.

The social habitat model articulated by Larson et al. (2014) accounts for the importance of social support structures but also the indirect influences of an individual's community, local landscape characteristics, and policy and management frameworks in which the individual is situated. Researchers and practitioners suggest that the social context of hunting may be changing rapidly as further urbanization and demographic transitions in society lead to new social organizations and networks of stakeholders for which state agencies need to account. A social habitat framework can help to identify effects at different scales, allowing for more effective interventions and programmatic efforts by managers. I suggest that organizing social-psychological approaches within a larger socio-ecological context can highlight the various individual, social, community, ecological, and policy components of hunting participation and how they act in concert to influence the individual decision to hunt or not. My research analyzes the community factors that comprise the social habitat for hunting in Michigan in 2010, providing an empirical test of the social habitat theory and setting the stage for further analysis using a social habitat framework.

3. Research Design

3.1 Hunting in Michigan

Hunting in Michigan is an important social, cultural, ecological, and economic activity. Funds generated from hunting license sales help fund the Department of Natural Resources, which manages wildlife populations and provides recreational benefits to all stakeholders. Restricted funds that are allocated to the MDNR for use specifically on fish and wildlife conservation comprise 76% of the DNR's budget (Humphries et al. 2007). One third of these restricted funds are exclusively from hunting and fishing license fees (MDNR 2015). Also included in the restricted funds is revenue from the Federal Aid in Wildlife Restoration Act (Pittman-Robertson Act), which places excise taxes on firearms, ammunition, and other equipment to be distributed to state fish and wildlife programs. In 2011, total hunting expenditures, including license purchases, equipment purchases, and travel costs, by Michigan residents age 16 and over was $2.3 billion (U.S. Fish and Wildlife Service 2012). These funds support local communities through food and lodging, travel expenses, equipment sales, and permits and access fees.

The number of Michigan hunters has generally been declining since the late 1990's, following a pattern similar to national trends (Winkler and Henderson 2015). The number of hunting license purchasers declined by over 100,000 during the first decade of the 21st century, from 838,078 in 2000 to 737,551 in 2010. Figure 2 shows age-specific participation rates among all resident hunting license purchasers between the ages of 12 and 80 in 2000, 2005, and 2010. There is a general pattern of decline for most age groups, as well as the migration of peak participation towards older ages. This corresponds to an aging hunter base (i.e. the Baby Boomers), and indicates continued declines in participation and license sales are likely as these cohorts continue to age (Winkler and Warnke 2012, Winkler and Henderson 2015) . Declining license sales can impact the state's ability to keep wildlife populations within acceptable levels, leading to ecological and social consequences such as over-grazing of native plants (Rawinski 2008) and increased deer-vehicle collisions (Brown et al. 2000). Hunting is also an important cultural activity in rural areas that characterize many parts of Michigan, providing a sustainable source of food, a mechanism of socialization through which

cultural traditions can be passed on, and connection to local landscapes (Stedman and Heberlein 2001, Larson et al. 2014).

Deer hunting is the most popular type of hunting in Michigan, followed by small game (Frawley 2006). Other species of interest include elk, wild turkey, waterfowl, bear, and furbearers. Although a greater number of hunters in Michigan live in the lower peninsula, a higher proportion of hunters characterize the upper peninsula and northern lower peninsula (Frawley 2006, Winkler and Henderson 2015). Most hunters are male, but female participation has been increasing with potential for greater impact on the hunting population in the future (Winkler and Henderson 2015).

The underlying drivers of declines in hunting participation in Michigan and other states are often complex and multi-faceted. Urbanization, competing time demands from work and family, demographic changes, hunting policy changes, land development, and perceptions of sparse game typically earn a portion of the blame (Larson et al. 2014). My analysis explores a way of operationalizing the social habitat concept to investigate Michigan hunters, and help determine which factors play the biggest role in determining hunting participation. My research focuses on the most popular type of hunting in Michigan: deer hunting. In 2009, 725,190 people purchased a deer hunting license (firearm or archery) and harvested roughly 444,000 deer, representing 10.2 million days in the field (Frawley 2010).

Although many people are hunting each year, recent research suggests that demographic changes in the state will continue to contribute to declining participation rates in the future, compounding the potential impacts on the state's ability to meet the demands of stakeholders, implement conservation projects, and adequately manage wildlife populations (Winkler and Henderson 2015). Michigan's hunters and anglers have an important role to play in a state that values nature-based recreation, conservation, and wildlife. There are two central aims of this analysis. First, I seek to explore a potential way of operationalizing the social habitat theory, providing the first empirical test of the social habitat by situating individual hunters within a socio-ecological context. Second, I aim to understand how a hunter's social habitat can affect hunting participation rates and ways in which wildlife professionals can use that information to guide recruitment and retention efforts with a more complete understanding of the stakeholders involved.
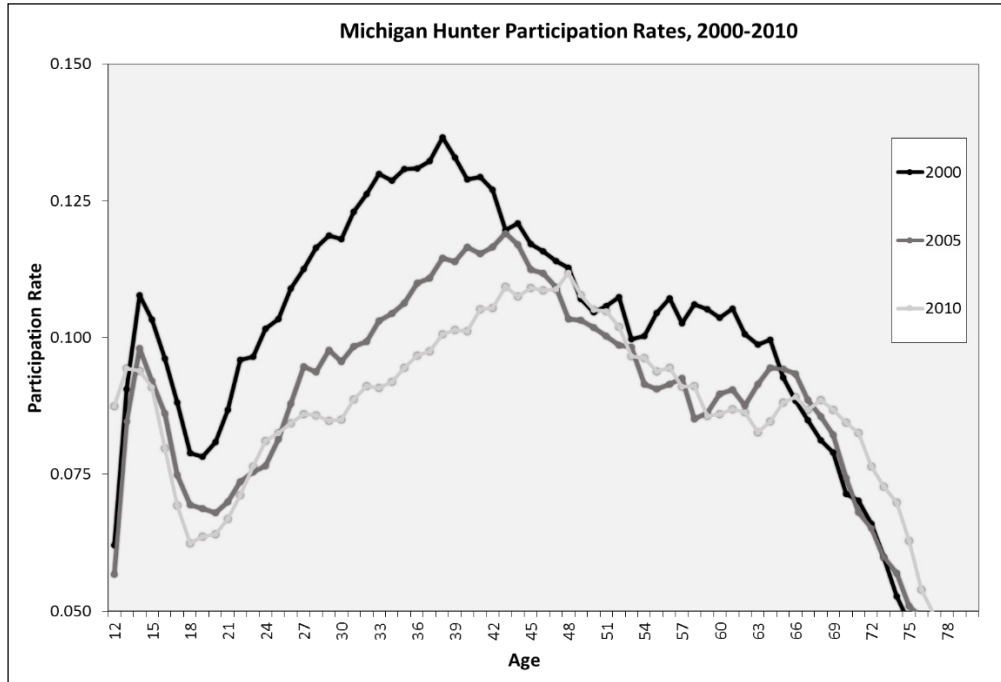
Michigan Hunter Participation Rates, 2000-2010

Figure 1: Hunting participation rates for Michigan residents from 2000-2010. Males and females between ages 12 and 80 who purchased a hunting license of any type. (Winkler and Henderson 2015)

3.2 Analytical Framework

My conceptual framework for exploring the social habitat of Michigan hunters considers variables at the individual and county level that might influence one's decision to hunt or not. Age and sex are important individual attributes that are associated with hunting participation. Males constitute the majority of hunters, and individuals of either sex are more likely to hunt at certain ages. Age, sex, and county of residence are available for individual hunting license purchasers in 2010 from the Michigan Department of Natural Resources database, which I used to comprise the individual level of my social habitat model. However, as the previous section explored, individual factors are not the only determinants of hunting participation. I use county level variables to represent the "socio-ecological landscape" of Michigan communities in which individuals reside. I chose to use measurements at the county level as a proxy for an individual's community, and although I recognize that there is variation within counties that might present a different scale for the "community", such as zip codes and census blocks, counties remain a reasonable approximation of community-level factors that influence

17

individuals and provide a rich source of data. Variation in hunting participation rates between Michigan counties provide a continuous dependent variable which can then be analyzed using regression techniques to determine the strength of relationships between hunting participation rates and social, demographic, economic, and ecological variables at the county level. In other words, individuals living in different counties will likely be exposed to differences in demographic, social, cultural, economic, ecological, and policy environments (collectively, the "socio-cultural context"), and these aggregate characteristics will influence the behavior of county residents. I expect that hunting participation will depend both on individual level variables such as age and sex, as well as the socio-cultural context.

Figure 2 shows the nested structure of this conceptual model, with individuals and associated variables of age and sex situated in the center. Moving out into the larger community includes county hunting participation rates. I hypothesize that several variables at the county level will be associated with hunting participation, such as the percent of county residents with a Bachelor's degree, ethnic composition of the county's population, the amount of migration into the county, population density, proximity to urban centers, and the percent of the population employed in manufacturing or extractive industries.

Expanding the boundaries of our conceptual community framework to include the physical landscape includes ecological variables, such as forests and agricultural land use. Forests and croplands provide habitat for game and access for hunters. Counties vary in the amount of forest cover and agriculture which can then influence perceptions of game abundance or hunting opportunities. Counties also differ in amounts of federal, state, and privately managed land in each county that is available for hunting. Variation in the amounts of accessible land may influence the social habitat by representing a motivating factor when hunting areas are plentiful, or barriers to participation when access to hunting areas is sparse or difficult.

Policies instituted and enforced by the MDNR may also play a part in constructing a social habitat model. Regulations such as antler point restrictions are implemented across groups of counties, providing a regional layer to the model that contains both counties and individuals nested within it. I hypothesize that regions of the state with different antler point regulations will influence hunting participation by

contributing to social and cultural norms. Often actions taken by management agencies are perceived as burdensome, and communities within parts of the state with stricter rules and regulations may have a collective attitude that those policies represent barriers to participation that must be navigated. Deer hunting success rates in differing regions of the state might work in much the same way by contributing to a collective environment that perceives higher success rates as a motivator, while lower success rates are perceived as a barrier. The contexts of communities might be influenced by these macro-scale processes, shaping the social habitat in various ways depending on the overarching frameworks of macro-scale variables.
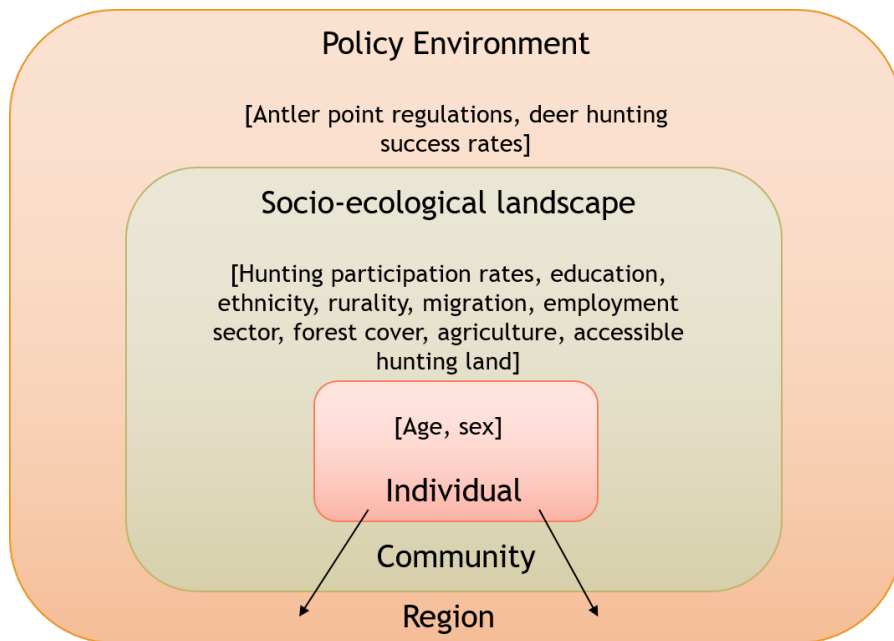

Figure 2: Conceptual multilevel framework of factors influencing hunting participation and comprising the social habitat for hunting. Adapted from Larson et al. (2014) and Moskell and Allred (2013).

Table 1. Variables and data sources

Variable	Source
Age	Michigan Dept. of Natural Resources; United States Census Bureau, SF1 2010
Sex	Michigan Dept. of Natural Resources; United States Census Bureau, SF1 2010
County hunting participation rates	Michigan Dept. of Natural Resources; United States Census Bureau, SF1 2010
Education	U.S Census Bureau, 2006-2010 American Community Survey
Geographic mobility	U.S Census Bureau, 2006-2010 American Community Survey
Seasonal homes	U.S Census Bureau, 2006-2010 American Community Survey
Percent rural population	United States Census Bureau, SF1 2010
Metro/non-metro county	USDA Economic Research Service, 2010 rural-urban continuum codes
Non-Hispanic white ethnicity	United States Census Bureau, SF1 2010
American Indian/Alaska Native ethnicity	United States Census Bureau, SF1 2010
Employed in extractive industry	U.S Census Bureau, 2006-2010 American Community Survey
Manufacturing dependent county	USDA Economic Research Service, 2004 county typology codes
Forest cover	USFS Forest Inventory and Analysis Report, 2010
Agricultural land	USDA Census of Agriculture, 2010
Acres of hunting land per county	Michigan Department of Natural Resources
Antler point regulations	Michigan Department of Natural Resources
2009 hunting success rates	Michigan Department of Natural Resources

3.3 Data and Variables

3.3.1. Individuals

Hunting license sales data for 2010 were obtained from the Michigan Department of Natural Resources (MDNR). The MDNR data is organized by a customer ID number, license type, gender, age, state of residence, and county of residence. Hunting license sales records for license types specified for deer hunting purchased by

individuals between the ages of 12 and 85 were incorporated into a "hunter" dataset. Population data from the United States Census Bureau, Summary File 1, provides a count of Michigan's entire population for 2010 by single year of age, sex, and county of residence. Subtracting the number of hunters in each particular age and sex category from the entire population dataset results in a net dataset comprised only of non-hunters. These two datasets were then merged together with a dichotomous variable generated to indicate hunting status, where 1 = deer hunter, and 0 = non-hunter, that accounts for each individual between the ages of 12 and 85 in the State of Michigan in 2010, and organized according their individual age, sex, county of residence, and hunting status.

3.3.2. Communities

County level measurements were then integrated into the data to investigate community level effects. These factors represent characteristics of the county that affect the people living there and may shape hunting participation rates. County hunting participation rates were generated by dividing the total hunting licenses of any type purchased in each county by the total number of county residents. These rates indicate a measure of local social norms – higher county participation rates indicate an activated social norm that may provide a level of "peer pressure" to hunt, while lower rates may not exhibit the formation of strong community norms supporting hunting participation.

The United States Census Bureau provides a count of the population defined as "rural" and "urban" for each county in 2010. The Census Bureau defines "urban areas" as areas of 50,000 or more people, or "urban clusters" with populations between 2,500 and 50,000. People falling into either of these classifications are considered to be "urban." The remainder of the population is thus defined as "rural." Percentages are obtained by dividing the rural population by the total population for each county. Metro and non-metro counties are included as dummy variables according to the USDA Economic Research Service's rural-urban continuum codes. Together, the rural and metro variables provide a measure of both population density and proximity to urban centers, both important community characteristics measuring different aspects of rurality.

Levels of educational attainment are estimated by the 2006-2010 American Community Survey, reporting the percent of each county's population that has a

Bachelor's degree or higher. Several studies have found hunting participation to be negatively associated with educational attainment, meaning that individuals with more education are less likely to be hunters. Researchers have also found a relationship between wildlife value orientations and education, suggesting that as education increases, protectionist values towards wildlife also increase. These values then form the basis for attitudes and norms that influence hunting behavior. At the county level, the percent of the county with a Bachelor's degree or higher is likely to affect the socio-cultural context of that community in ways that impact hunting participation.

Data on ethnic background were obtained from the United States Census Bureau, 2010 Summary File 1. This includes characteristics of the total population, including population counts by race. Non-Hispanic white ethnic background is one of the most consistent demographic characteristics associated with hunting participation, and as such, characterizing communities as "percentage of the population with a non-Hispanic white ethnic background" constitutes an integral component of hunting's community context. Total population of non-Hispanic white individuals in each county was divided by the total county population to obtain a percent. American Indian and Alaska Native ethnic background was also included as a percent of the population of each county to control for the status of Native American populations hunting on tribal lands operating outside of the MDNR hunting license framework. Tribal deer hunters are not required to purchase licenses from the MDNR, but are counted in the census, and are thus counted in my dataset as "non-hunters." Statistically controlling for this population accounts for their presence in the non-hunting dataset generated from census counts.

The "seasonal housing" variable is a measure of housing characteristics reported in Census 2010 as the number of "seasonal, vacation, or occasional use" housing units in each county divided by the total number of housing units. These units can be characterized by lake cabins, summer time-shares, or urban condos, encompassing a wide range of uses. According to the 2010 census, 5.6% of all housing units in Michigan fall into this category. I expect that seasonal housing could affect the socio-cultural environment of counties by shifting the age structure of the community to older individuals, bringing urban culture into rural areas, subdividing land into smaller parcels, introducing no-trespassing signs to private property, or otherwise alter the socio-cultural environment in ways that make the county as a whole and individuals within in it less likely to participate in hunting.

Migration is a measure of geographic mobility that can potentially influence hunting participation. Migration information is available from the ACS 5-year estimates, provided by the Census Bureau. This is measured as a sum total of all individuals who moved into each county in the previous 12 months divided by the total population to obtain a percentage of the population defined as recent in-migrants. Geographic mobility has been shown to be negatively associated with protectionist value orientations, which may then affect hunting participation (Manfredo et al. 2003). Higher amounts of in-migration indicate greater geographic mobility within that county's population, and higher numbers of new residents may affect the socio-cultural environment of communities in ways that weaken the traditional aspects of hunting culture, such as family and neighborhood relationships that are responsible for recruiting and socializing new hunters.

The dominant employment sectors can influence the social context of communities by attracting people with certain expertise and skills into the same area, influencing the social and institutional culture. The percent of the county population employed in the extractive industry and counties classified as "manufacturing dependent" were economic variables used in this analysis. County measures of employment by industry are available from the ACS 5-year estimates. The "extractive industry" is defined by the Census Bureau as occupations in agriculture, forestry, fishing and hunting, mining, quarrying, and oil and gas extraction. The percent of the population employed in extractive industries was obtained by dividing the population employed by the total population. I used the USDA Economic Research Service's 2004 county typology codes to generate a dummy variable for counties classified as "manufacturing dependent". Manufacturing dependence was determined by counties where 25% or more of annual average earnings were from manufacturing during the preceding three years.

3.3.3. Local Landscape

Acres of forest cover for each county in Michigan were obtained from the United States Forest Service's Forest Inventory and Analysis reports for 2010. For the purposes of this analysis I used the percentage of forest cover by county, rather than acres of forest cover, to account for differences in land area between different counties. Acres of

agricultural land were obtained from the United States Department of Agriculture Census and divided by the total acreage in each county, providing a percentage of agricultural land use. Forest and agricultural land provide a measure of both white-tailed deer habitat and access for hunting. Modified forest and agricultural habitats support denser populations of white-tailed deer (*Odocoileus virginianus*) (Rooney and Waller 2003). Areas that contain a mixture of forests and croplands may support the highest populations of deer if both abundant forage and dense cover are available within a particular range (Lagory 1986).

Management and policy factors were integrated to provide an analysis of macro-scale influences on deer hunting license purchases. Overarching policy frameworks may influence the decision to hunt in indirect ways and have often been overlooked (Larson et al. 2014). Antler point regulations are a categorical variable and refer to restrictions on the deer that a hunter may take based on their license type and the characteristics of the animal's antlers. The categories correspond to regions of the state falling under different regulations based on the number and length of antler points on bucks. These restrictions are implemented and enforced by the MDNR to help achieve balanced ratios of bucks to does and advance young bucks to older age classes before they can be hunted.

APR region 1 is the Upper Peninsula, region 2 corresponds to Leelanau County, region 3 is a group of counties in the northeastern corner of the Lower Peninsula, and region 4 contains the majority of counties in the Lower Peninsula. These data are coded as a series of dummy variables, with the reference category referring to a group of counties in the northwestern Lower Peninsula that did not have antler point regulations in 2010. APR's have been controversial, as they affect the number of legal deer on the landscape that can be hunted, potentially influencing hunter success rates.

Acres of federal, state, and privately managed land open for hunting in each county in 2010 were provided by the MDNR. The total number of acres in each county available for hunting were divided by the total county acres to obtain a percent of land area that is open for hunting. Hunters often perceive that there is less hunting access as previously undeveloped land becomes parceled and developed, leading to shifting distributions of deer within their range. The amounts of land that is "huntable" in each county may influence a hunter's decision to participate if they perceive that there is quality accessible habitat nearby (or lack thereof). Deer hunting success rates in different

parts of the state may contribute to community norms where hunting is perceived as productive or the chance of seeing game is higher, and were provided by the MDNR 2009 Michigan Deer Harvest Survey Report.

3.4 Analysis

Analysis was conducted in a hierarchical fashion by utilizing several statistical models to investigate how individual, community, and regional variables influence hunting participation in Michigan. I am interested primarily in modelling how these variables characterize the community context within which hunting activities take place. Socio-demographic variables at the county level are of particular interest because this allows me to use the county as a proxy for community, and investigate the various factors that comprise the social context of that community.

The first model is a hierarchical intercept-only, or "empty" model, containing only the dependent variable, individual hunting status, with no predictor variables. I use logistic regression without any independent variables to determine whether the constant in the model is statistically significant when accounting for individuals grouped by county of residence. When no predictor variables are included in the analysis, the standard error of the constant is equal to the mean of the response variable. If we find that clustering of individuals based upon their county of residence is statistically significant, it indicates that county-level effects matter.

Model 2 investigates socio-demographic, economic, ecological, and policy variables that comprise the community context at the county level. County-level hunting participation rates are used as a continuous dependent variable and analyzed using traditional OLS regression. This model investigates the hypothesis that community-level factors are associated with hunting participation rates, and determines the direction and strength of those relationships.

Model 3 includes age and sex as predictor variables to investigate the impact that individual factors have on individual hunting participation using traditional logistic regression analysis. Since the relationship between age and hunting is non-linear, I separated the age variable into five categories: 12-16, 17-23, 24-59, 60-69, and 70+. These age categories were then interacted with sex so that gender-specific effects at various ages can be identified.

Model 4 is a hypothetical hierarchical approach that uses multiple units of analysis (individual, county, and region) to analyze hunting participation within a social habitat framework. This model is limited by the fact that only basic data on age and sex are available at the individual level. For this reason, I cannot utilize a statistically valid multilevel model. Instead, I include Model 4 as a talking point for considering how a full social habitat model could be operationalized in future research.

3.5 Limitations

Some limitations to this study should be considered when interpreting the results. Using the county as a proxy for "community" necessarily limits the amount of within-county variation for which the individual model can account. I don't have data regarding family, mentor, neighborhood or other relationships that might characterize a hunter's social support network. Individual level data only report age, sex, county of residence, and hunting status, which limits the amount of variance in hunting participation that can be explained by individual factors.

The richness of data available in census year 2010 enables a thorough cross-sectional analysis of Michigan's entire population, however, a longitudinal study would be ideal to investigate changes in the social habitat of hunting over time and identify specific geographies or demographics where recruitment and retention efforts show the most potential to have the greatest impact. Future studies could incorporate longitudinal and multilevel data to have the greatest impact as a social habitat approach that can help managers and decision-makers implement recruitment and retention programs.

Finally, these data only report the residence associated with hunting license sales, and do not indicate where hunting is taking place. An important aspect of a hunter's social habitat may be where they travel to hunt and characteristics of their trip, such as how far they travel, how long they are gone, who they travel with, whether they hunt on public or private land, and levels of satisfaction. Although these aspects would be interesting to consider, the purpose of this study is to investigate the influence of one's surrounding community on hunting participation, which necessitates knowing something about where an individual lives. In this context, the data associated with an individual hunter's residence is more appropriate and informative than data regarding where that individual actually hunts.

4. Results

4.1 Unconditional Model

Model 1 is an intercept-only model that tests the significance of the dependent variable without any predictor variables, while accounting for the clustering of individuals within counties. The robust standard error is 0.171, and is statistically significant at the p<.001 level. In an unconditional model, the standard error is also the intra-county correlation coefficient which means that 17% of the variance in individual hunting participation can be attributed to differences *between* counties, with the remainder due to differences *within* counties. The unconditional model suggests that individuals clustered within counties are more likely to have similar hunting propensities to others in their county. In other words, hunting participation can be thought of as a cultural or social norm in counties with higher participation rates. This evidence suggests that community level characteristics do impact hunting participation.

Table 2. Intercept-Only Model of Michigan Deer Hunters

Dependent Variable: Individual purchased license in 2010 (0= no, 1=yes)

Constant	*-2.6544****
Standard Error	*0.1705*
P-value	*0.000*
n	*8,253,571*

*p < .05; **p < .01; ***p < .001

4.2 County-level Model

The county-level model investigates the socio-cultural context of Michigan counties using aggregate social, demographic, economic, and ecological variables. These variables are associated with hunting participation rates at the county level, and correlations can be determined with multivariate linear regression. Since the individual model shows that individual characteristics of age and sex work together to influence hunting participation patterns, I ran two separate models at the county level to investigate the hunting participation rates of males and females.

27

Table 3 shows the results of the analysis for males and females, and associated independent variables that influence participation rates. R^2 values are .822 for males and .323 for females, meaning that about 82% and 32% of the variation in county hunting participation rates can be explained by this model. For males, aggregate county measures of education, ethnic background, and forest cover were statistically significant in their association with county hunting participation rates. Education has a negative relationship, indicating that as the proportion of the county's population with a 4 year degree increases, male hunting participation rates decrease. Ethnicity and forest cover are positively associated with county hunting participation rates, meaning that as the proportion of a county's population with a non-Hispanic white ethnic background increases and as the percent of forested area in a county increases, county hunting participation rates increase.

For females, the only significant variable in this model is the proportion of the population employed in extractive industries, which was also positively associated with county hunting participation. The model does not explain as much of the variance in female participation. Males and females participate in hunting for different reasons (Heberlein et al. 2008), and future research should test the underlying assumptions regarding gender differences explicitly. Recent research shows that female hunting participation has the potential for tremendous growth in the future and represents a promising area for state agencies to focus their efforts (Winkler and Henderson 2015).

Beta coefficients allow for direct comparison between independent variables. Ethnicity (0.34) and forest cover (0.34) had the greatest magnitude impact on male hunting participation rates at the county level, with education (-0.26) following behind. The rurality variable, while not statistically significant, shows a beta coefficient of 0.22. Female hunting participation rates were influenced most heavily by forest cover (0.46), followed by employment in extractive industries (0.35), education (-0.26), ethnicity (-.23), and population density (-0.25).

A correlation matrix and variable inflation factor (VIF) tests were used to investigate collinearity between independent variables. I found that variables for forest cover, rurality, seasonal homes, and agriculture were correlated with each other at levels that warrant mentioning. The mean VIF value was 4.15 with no variable exceeding a value of 10, which is generally considered acceptable. However, VIF values for forest

cover (9.73), rurality (8.81), seasonal homes (8.77), and agricultural land use (8.19) suggest that these variables are capturing something about the rural character of particular counties, and may be masking the underlying causal mechanisms.
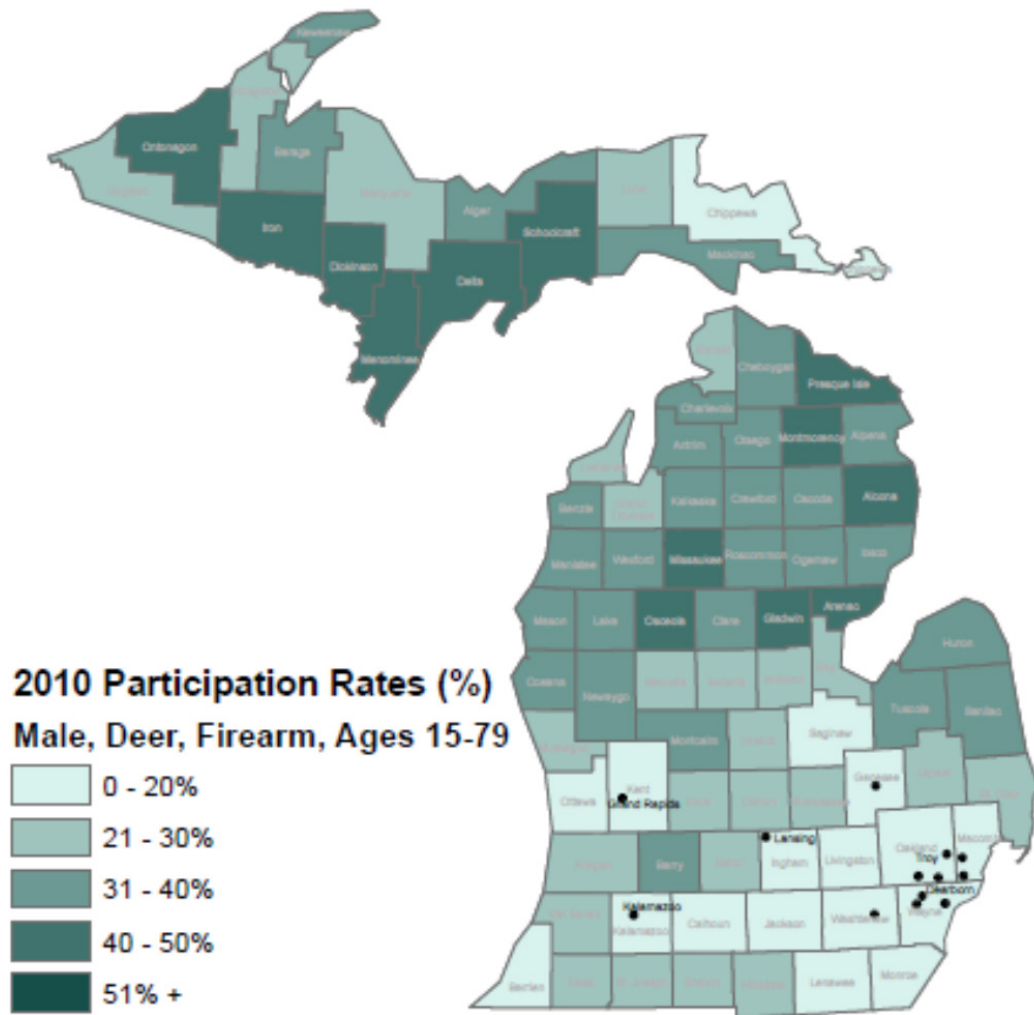
Figure 3: Variation in male firearm deer hunting participation rates of Michigan Counties in 2010. Rates were derived by dividing the total population of male firearm deer hunters between ages 15-79 by the total male population of the county at the same ages. Higher participation rates are observed in the Upper Peninsula and northern Lower Peninsula, with the lowest participation rates in the southern one third of the Lower Peninsula (Winkler and Henderson 2015).

Table 3. County-Level Factors Influencing Hunting Participation Rates

Dependent variable: County hunting participation rate (%)

Independent Variables	Males			Females		
	Coefficient	β	p-value	Coefficient	β	p-value
Education	-0.657**	-0.2600	0.002	-0.2291	-0.2953	0.104
Rural population	0.0830	0.2238	0.110	-0.0323	-0.2494	0.359
Metro/non-metro	-0.0054	-0.0242	0.777	0.0047	0.0607	0.715
In-Migration	-0.1131	-0.0170	0.793	-0.1416	-0.0607	0.630
Ethnicity						
Non-Hispanic White	0.4066***	0.3426	0.000	0.0956	0.2304	0.131
Native American	-0.1020	-0.0294	0.666	0.3041	0.2503	0.063
Employment Sector						
Extractive Industry	0.6837*	0.1566	0.032	0.5422*	0.3551	0.013
Manufacturing	0.0018	0.0089	0.889			
Local Landscape						
Agriculture	-0.0389	-0.0735	0.583	0.0156	0.0842	0.747
Forest Cover	0.1274**	0.3460	0.020	0.0596	0.4632	0.107
Ag x Forest	0.0607	-0.0560	0.610	-0.0536	-0.0607	0.772
Seasonal Homes	-0.0874	-0.1336	0.336	0.0006	0.0025	0.993
Available Land	0.0032	0.0086	0.898	-0.0027	-0.0206	0.875
Success Rate	0.0002	0.0170	0.866	-0.0007	-0.1411	0.472
Constant	-0.1343	---	0.169	-0.0203	---	0.760
n = 83						
R^2 =		0.822			0.323	

*p < .05; **p < .01; ***p < .001

4.3 Individual Model

One assumption that must be met for statistical validity is that independent variables are normally distributed; however, the relationship between age and hunting participation is non-linear, which violates this assumption. To account for this, age categories were established based on empirical studies (see Figure 2) that show individuals are more likely to hunt at certain ages than at others. Most people tend to be recruited into hunting in their youth, but are generally not retained throughout teenage years or early adulthood. Participation tends to be higher throughout middle aged years

and fall off again after retirement. Inflection points on the graph in Figure 2 where participation changes can mirror key events or time periods in a person's life. Individuals in teenage and early adult years are often preoccupied with school, extracurricular activities, applying to colleges, and spending time with friends. They often leave home and live in areas that are unfamiliar and have weaker cultural ties to local landscapes.

Young adulthood is often marked by the beginning of one's career, major life changes such as getting married, building a family, and becoming financially independent. The middle of one's life course is generally more stable, and leisure activities can once again emerge as a priority, and this tends to be when we see hunting participation rates at their peak. This is also when one might be involved with teaching their kids how to hunt.

Often retirement provides an increased opportunity for participation in hunting, but this can be mediated by the physical effects of age, which may restrict mobility. However, state agencies often provide special hunting access permits and programs for older individuals to encourage continued participation. To summarize, age is an interesting variable in that it might be used to understand something about the ways in which individuals allocate their time, often attempting to balance school, work, family, and other leisure activities. A more qualitative analysis might ask individuals directly how these competing demands influence their participation in hunting, but since our data only report an individual's age, sex, and hunting status, we can try to infer these potential relationships from the interaction of age and sex at various age categories.

Table 3 shows the odds ratios for age categories 12-16, 17-23, 24-59, and 60-69, as a series of dummy variables, with the 70+ age category serving as the reference category, since the likelihood of participating in hunting after age 70 decreases markedly. Sex is a dichotomous variable, with males coded as 1 and females as 0. Overall, males were 10 times more likely to have purchased a deer hunting license than females, but this figure masks important interactions between age and sex in different age ranges. Individuals in all age groups had an increased likelihood of participating compared to the 70+ age group. The odds of someone between 12 and 16 buying a hunting license were one and a half times higher than the reference category. Young adults in the 17-23 age category had odds 1.2 times higher, while middle ages were associated with the greatest increase in odds of purchasing a hunting license at 1.8 times greater than the

70+ age category. Individuals between 60 and 69 were also 1.5 times more likely than their older counterparts to purchase a license in 2010.

Interestingly, the relationship between age and hunting becomes less certain when accounting for sex. I added an interaction term to determine if the effect of age on deer hunting license purchasing differs for males and females. Males in the two younger age groups (12-23) were associated with a decreased likelihood of purchasing a deer hunting license, suggesting that young females may be playing an increasingly important role in the hunting population. All age groups and age-sex interaction terms were statistically significant at the $p<.001$ level.

Table 4. Influence of Age and Gender on Individual Hunting License Purchases

Dependent Variable: Individual hunting license purchased in 2010 (0=NO, 1=YES)

Independent Variables	Odds Ratio
Age	
12-16	*1.511****
Male	*0.458****
17-23	*1.150****
Male	*0.691****
24-59	*1.801****
Male	*1.220****
60-69	*1.538****
Male	*1.278****
70+ (Ref.)	---
Sex	*10.41****
n = 8,253,571	
R^2 *= 0.11*	

*p < .05; **p < .01; ***p < .001

4.4 Future Research: Hierarchical Model

In addition to investigating the effects of age and gender on individual hunting participation, I developed a hypothetical multi-level logistic regression model to investigate factors at individual, county, and regional units of analysis that determine the likelihood of an individual having purchased a hunting license in 2010. Because only

very limited variables are available for individuals (age and sex), this model should be used as an exploration of a possible way to operationalize the social habitat approach in future research. The results should not be considered statistically valid, and thus implications based on Model 4 will not be discussed. However, a hierarchical or multi-level approach when analyzed with appropriate data might provide the best approach for the social habitat theory, since the crux of the theory is that influences at various scales (e.g. micro, meso, and macro) might influence a hunter's behavior in indirect ways. Moreover, interactions between influences at different scales of measurement may provide key insights that are overlooked in studies using a single unit of analysis.

Model 4 includes data for the entire population of Michigan in 2010 between the ages of 12 and 85 (no sampling error), while allowing for random effects, or clustering, at the county level. According to Khan (2011), multilevel logistic regression analysis "*allows the simultaneous examination of the effects of group level and individual level variables on individual level outcomes while accounting for the non-independence of observations within groups*" (p. 95-96). In other words, the characteristics of one's community (in this case county) may make them more or less likely to participate in a socio-cultural activity such as hunting, and these characteristics will differ from one community to the next. A main assumption that must be met for statistical validity in a logistic regression model is that observations are independent of one another; however, as the unconditional model suggested, individuals are not scattered randomly on the landscape but are clustered within counties in a statistically significant way.

Since the only individual level data available are age, sex, county of residence, and hunting status, this model determines the log likelihood that an individual in 2010 purchased a hunting license based on their age and sex. The random effects portion of the model determines the influence of county-level factors not captured in the data on individual hunting participation. Odds ratios allow direct comparisons between variables, with odds ratios further from 1 indicating a greater impact, and values closer to 1 indicating a lower impact.

Aggregate variables at the county and regional level were included to represent the broader community contexts within which individuals are situated. However, in order for this model to determine the likelihood of individuals to purchase a hunting license within a multilevel framework, we would need data on each individual's

education, housing, migration, ethnicity, employment, etc. Since these are aggregate measurements and only limited data is available for individuals, Table 5 presents the results of a hypothetical approach for operationalizing the social habitat theory in future research.

Table 5. Hypothetical Multilevel Social Habitat Framework

Dependent Variable: Individual hunting license purchased in 2010 (0=NO, 1=YES)

Independent Variables	Odds Ratio
Individual Factors:	
Age	
12-16 (X Sex)	5.1610 (0.2966) ***
17-23 (X Sex)	2.9705 (0.4145) ***
24-59 (X Sex)	3.1718 (0.6378) ***
60-69 (X Sex)	2.1647 (0.7261) ***
70+ (Ref.)	---
Sex (M=1, F=0)	18.520***
Community Factors:	
Education	0.0902***
Seasonal Homes	0.5819***
In-Migration	0.1933***
Rurality	
% Rural	1.5474***
Metro/Non-metro	0.9344***
Ethnicity	
Non-Hispanic White	11.359***
Native American	0.5224***
Employment Sector	
Extractive Industry	5.0911***
Manufacturing	1.0400***
Local Landscape	
Forest Cover	4.7949***
Agriculture	4.0374***
Ag X Forest	0.4480***
Available Land	0.7258***
Regional Factors:	
Deer Hunt Success	0.9924***
APR 1	1.0211**
APR 2	0.7648***
APR 3	0.9905
APR 4	0.8163***
n = 8,253,571	
R^2 = 0.181	

*$p < .05$; **$p < .01$; ***$p < .001$

5. Discussion

My analysis explores several ways in which the social habitat approach can be operationalized. This socio-ecological approach, as opposed to a social-psychological approach that emphasizes individual motivations, can help us understand how community characteristics can influence cultural norms and behavior at micro, meso, and macro scales. This in turn can help decision makers and practitioners base management decisions on a better understanding of the complexities and nuanced characteristics that comprise a hunter's social context.

Altogether, the results clearly show that community context matters. The unconditional model (Model 1) provides evidence that county-level effects can influence hunting participation, and that considering aggregate measures of socio-demographic, economic, and ecological variables can help us understand something about hunting participation rates. My county-level analysis (Model 2) explains over 80% (R^2 = 0.82) of the variance in county-level hunting participation, indicating that variations in socio-cultural and ecological contexts explain variation in hunting participation.

The results show that counties with lower hunting participation rates were associated with higher educational attainment, greater population density, closer proximity to metro areas, greater ethnic diversity, higher rates of in-migration, greater numbers of seasonal or vacation housing, less employment in extractive and manufacturing sectors, and less land area covered by forests. Collectively, these characteristics evoke an image of a setting that is less conducive to hunting participation, and given the history of development throughout the latter half of the 20th century, it might be fair to assume this setting will be increasingly common in the future. State agencies may not be able to reverse processes such as urbanization or control the economics of rural areas, but knowledge of the ways in which the social habitat is favorable to hunting or not can help tailor recruitment and retention programs in areas where they have the greatest chance of success. In addition, my results indicate that a blanket approach to recruitment and retention programs may not be the most effective approach. Recruitment efforts designed to attract kids, families, young adults, urbanites, or minorities will need to consider the socio-cultural context of different stakeholders' communities. Further research may find differences between county-level characteristics

and species hunted since different species have different habitat requirements; however, approximately 90% of hunters in Michigan in 2010 purchased a deer hunting license (Frawley 2011), and the county-level variables in my analysis explain a high amount of variance in deer hunting participation rates for males.

Given that further changes in society are likely to continue to drive down per capita participation in hunting, greater emphasis may be needed on creating unique and accessible hunting opportunities that engage demographics that have not historically hunted at high rates, such as women and minorities. My individual hunting participation model (Model 3) shows that participation varies by age and sex. Males in 2010 were much more likely than females to participate in deer hunting, but the relationship is not as straightforward as it first appears. When accounting for sex, young cohorts of males had a decreased likelihood of participating in deer hunting, suggesting that young females may be playing an increasingly important role in hunting participation. Research has begun to explore the potential impact that female participation may have in the future (e.g. Winkler & Henderson 2015). State agencies that wish to capitalize on these trends may benefit from increasing the opportunities for females and other "non-traditional" hunters. My data are limited in that the effects of age may also be associated with other phenomena, such as changing time demands, leisure preferences, and increasing technology usage. Moreover, I don't have individual level characteristics such as educational attainment, migration, occupation, or familial relationships available. Further research could explore the relationships between age, hunting participation, and the changing ways in which people interact with their environment to develop an individual level model that explains more variation in hunting participation.

The multilevel modeling approach outlines a possible framework for future research to fully evaluate the social habitat theory. Deliberately designing studies to collect data that allows for a multilevel analysis could create the opportunity to operationalize the social habitat theory. Model 4 shows how this might be accomplished. Organizing individuals into larger nested units, such as families, neighborhoods, communities, zip codes, counties, and regions allows researchers to determine how these contexts together influence behavior. If results show that smaller scales such as neighborhoods and communities are important, it could highlight the need for further examining the role of extended social networks and mentoring programs. If broad macro-scale influences are more important, it would highlight the need for state and

federal agencies to rethink the ways in which management and policy actions can present barriers or create opportunities for participation.

6. Conclusions and Policy Implications

Hunting's future role in society and its relationship to wildlife management and governance of natural resources is not certain. A century of tradition built on a model of wildlife conservation dependent on consumptive activities is slowly being eroded as complex changes in society alter the ways in which people view their relationship to nature. State wildlife management agencies and the governance structures we are familiar with may not be sustainable under the changing social and demographic conditions explored by human dimensions researchers. Institutions dependent on revenue generated from hunting and angling license sales are facing an impending state of upheaval that may fundamentally change how we conduct the business of wildlife management and conservation on public lands. The ability to adapt to these changes may depend on grounding management actions in a complete understanding of the changing social contexts of hunting, angling, and wildlife-related recreation. The key question boils down to one that is simple, yet infinitely complex: *Where do we go from here?*

State agencies have the ability to adapt institutional structures to reflect changing societal conditions. Several states have increased the funding their fish and game departments receive from general funds, tax check-offs, sales taxes, lottery ticket sales, and license plate sales, however these solutions face political barriers to implementation. Increasing knowledge of stakeholder support for and engagement in conservation-oriented goals on public lands through volunteers, NGO's, private landowners, and resource managers can help integrate the various entities that collectively constitute our primary governance structures. Measuring support for various aspects of management and conservation, investigating underlying social processes, and increasing the engagement of citizens in conservation activities beyond hunting and angling may be important tasks for state agencies to consider.

If there is any certainty about the future of hunting, it is that demographic changes in the population, an increasingly urbanized society, and shifting ecological conditions will create a vastly different habitat for both wildlife and hunters in the future. Understanding the social setting of hunters can help managers, wildlife professionals, and scientists address these challenges. Non-traditional recruitment mechanisms and an expanded set of tools, such as the social habitat model, can help to

bridge the gap between hunters and non-hunters by considering broad social-ecological influences on behavior, allowing different stakeholders to share common outdoor experiences, increase hands-on education, and communicate the importance of hunting and wildlife management's role in conservation to diverse communities. Building a stronger and more diverse constituency that retains strong support for traditional uses of wildlife while embracing an expanding set of non-consumptive preferences without alienating stakeholders will be a major challenge, but crucial for state agencies to remain relevant in the 21st century.

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