Understanding Visitors to Wildlife Management Areas in Minnesota.

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CHAPTER 1

Investigating Experience Preferences as Self-Described by Minnesota Wildlife Management Area Users

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DIGEST

Previous research has shown that hunters are motivated to participate in recreational activities in order to achieve a specific set of desired experiences. Using data obtained from a self-administered mail survey conducted in 2016, we examined the different recreational experiences hunters were pursuing. We used k-means cluster analysis to define unique clusters of users who recreated on Minnesota Department of Natural Resources' publically-owned Wildlife Management Area (WMAs) during the fall 2015-2016 hunting season. We identified six clusters based on recreation experience preferences at WMAs. The clusters differed on demographic characteristics, as well as level of satisfaction with various experiences during their hunting trips to WMAs. The cluster of hunters with the highest overall satisfaction for WMAs also had the highest place and emotional attachment to these publically accessible areas. In addition, the cluster that showed the lowest satisfaction with WMA experiences was also the least supportive of management actions. This information will help wildlife managers understand their constituents, manage public lands, and help recruit, retain, and reactivate hunters into the activity.

KEYWORDS: cluster analysis, Minnesota, hunters, Wildlife Management Areas, place attachment, experience preferences

INTRODUCTION

Wildlife management agencies are tasked by the public trust doctrine to protect, control, and conserve wildlife and their habitat for the benefit of the public (Jacobson et al. 2010). Public benefits provided by wildlife-based recreation opportunities include hunting, fishing, and wildlife viewing (Driver 1985). Managers must understand both ecological and anthropogenic interests towards wildlife, and be willing to integrate them in order to achieve socially desirable wildlife benefits (Forstchen and Smith 2014; Organ et al. 2014). Participating in outdoor, wildlife-related activities has been shown to have many economic, environmental, as well as social- and personal- benefits (Schorr et al. 2014; Driver 1985; Hammitt et al. 1990; Decker et al. 1980; Brown et al. 1977; Hendee 1974). Wildlife-based activities provide satisfaction on multiple levels for the individual participant, as being in nature has well-documented short-term and long-term effects on both the psychological and physiological aspects of human life (Wolf et al. 2014; Mayer et al. 2009; Haluza et al. 2014). While demand and interest in some recreational activities has reached all-time highs (e.g., birdwatching; Cordell 2008; Outdoor Foundation 2014), hunter numbers nationally are declining (U.S. Department of the Interior 2012; Vrtiska et al. 2013). Hunters provide the primary capital for wildlife management, and declining hunting license sales will drastically reduce available funding for state wildlife agencies (Schorr et al. 2014). As such, it is important to understand which barriers (e.g., lack of access to land) may be contributing to declines in hunting participation

State-owned lands are crucial for protecting wildlife resources and providing both consumptive and non-consumptive recreational opportunities. Access to publicly-owned land is especially important in the Midwestern and eastern United States, as access to private land declines when lands are parceled, sold, or otherwise fragmented (Larson et al. 2014). It is important to maintain public land for hunters to use, especially when private land is otherwise unavailable. Wildlife management agencies can ensure the public obtains benefits from publicly managed, wildlife-producing lands by better understanding desired outcomes and motivations of hunters (Schroeder et al. 2006; Hayslette et al. 2001; Decker et al. 1980; Hammit et al. 1990). In turn, these agencies can help ensure hunters are recruited, retained, and reactivated for generations to come (Larson et al. 2014).

The Wildlife Management Area (WMA) classification of lands was created by the Minnesota Legislature as part of the Outdoor Recreation Act of 1975. They were established, in part, "to protect those lands and waters that have a high potential for wildlife production, public hunting, trapping, fishing, and other compatible outdoor recreational uses" (http://www.dnr.state.mn.us/wmas/description.html). Currently, the WMA system is comprised of about 1,440 units totaling over 1.3 million acres.

The purpose of our research was to determine if there are distinct segments of hunters who use WMAs, and if so, to better understand how those different segments can be served by management policies and actions. Understanding and describing the heterogeneity of experiences and preferences within the population of WMA users can assist with prioritization of acquisition and improved management. We anticipate that some groups of hunters will show higher levels of satisfaction and place attachment to WMAs when compared to hunters with different experience preferences. Wildlife managers could potentially adapt their management strategies in order to recruit, retain, and reactivate more hunters (Larson et al. 2014). Our research will inform wildlife managers about the constituents who seek to use WMAs for hunting experiences and help continue to improve overall experiences at WMAs.

Importance of public land - Natural resource recreation has long been a popular American pastime, with a notable boom in the 1960s due to a population surge and an increase in disposable income and leisure time (Cordell 2008). Participation in wildlife-based recreation activities, such as hunting, has received particular research attention by state and federal wildlife management agencies (Jacobson et al. 2010; RM NSSF 2010). State agencies are charged with ensuring wildlife is managed for public benefit, which includes providing space for recreation, hunting or otherwise, as an essential part of the public land trust. In general, hunting participation declined across North America from 1980 to 2015 (U.S. Department of the Interior 2012; Vrtiska et al. 2013). This decline is concerning for natural resource managers because a large portion of the funding that goes towards acquisition and maintenance of public lands relies on the economic input of hunting licenses and fees (Heffelfinger et al. 2013). Arnett and Southwick (2015) found that 13.7 million American hunters spend more than $38.3 billion on non-commercial, hunting-related expenses each year. As hunter numbers continue to decline, state agencies will continue to lose a major funding source for wildlife and habitat management.

Substantial research has focused on understanding the drop-off in hunter numbers (Brunke and Hunt 2007; Heberlein and Kuentzel 2002; RM NSSF 2010). Leading theories suggest that constraints, including the lack of access to hunting lands, have significantly affected the decline. Constraints to hunting can be difficult to quantify, but can generally be placed into two categories: personal and perceived situational constraints (Miller and Vaske 2003). Personal constraints are an individual's beliefs about their own participation, and are considered to be outside of the agency's control (Backman and Wright 1993; Wright and Goodale 1991). Personal constraints include confidence in their ability to find a hunting partner, poor health, lack of finances, shifts towards urban lifestyles, and competing interests (Miller and Vaske 2003; Robison and Ridenour 2012). In contrast, perceived situational constraints, such as finding access to private lands for hunting, may or may not be controlled by regulatory agencies (Miller and Vaske 2003). Understanding constraints and where they stem from can help agencies better manage active hunters as well as recruit individuals interested in hunting but not yet actively participating.

Hunters choose public versus private land for many reasons. Of the 12.5 million US hunters who participated in 2006, more than 80% accessed private land, while 39% used public land (Harris 2011; U.S. Department of the Interior 2006). However, only 15% of all hunters relied solely on public land for their hunting access (Harris 2011). The preferences to use private land are varied and may include seeking places with higher quality habitat as well as a reduction in crowding. By understanding the constraints and motivations that move hunters toward private land, managers can attempt to reconcile the difference between private and public land, thereby making public land more enticing. One way to bridge the gap between public and private land hunters is to provide public access to hunting on private land. The Walk-In Access (WIA) Program started in 2011 in Minnesota allows public hunting opportunities on private land. For a small fee ($3.00 USD in 2015), hunters can gain access to lands voluntarily offered by private land owners who are enrolled in this conservation program (http://www.dnr.state.mn.us/walkin/index.html).

Managing lands and experiences to benefit hunters - Human dimensions researchers use different metrics to measure hunter's beliefs and relate that information back to constraints on future participation. Two such metrics include understanding both motivations and satisfactions that stem from specific recreational experiences (Driver 1985; Manfredo and Larson 1993; Manfredo and Driver 2002). The definition of motivation varies across the literature, but for this paper, we consider it to be the psychological outcomes and the perceived, desired consequences of engaging in a particular activity (i.e., one will encounter pleasing conditions or experiences by engaging in that activity, Tarrant et al. 1999). Driver first described the importance of understanding the goods and services produced through wildlife management that may satisfy greater public needs, and substantial research has built upon this theory (Driver 1985). Wildlife and the environments they occupy provide a wide range of products that can be utilized differently, depending on a user's experience goals. These products translate into wildlife opportunities where a specific user has the ability to utilize, appreciate, or benefit from wildlife (Driver 1985). In order to understand which wildlife products should be made available by wildlife managers, it is necessary to understand the users and which experiences they may be seeking. Typologies, groupings of users based on experience preferences, can facilitate experience-based management decisions to provide increased user satisfaction (Manfredo and Larson 1993). A variety of users pursue nature-based recreation, and while the recreational opportunities and experiences they value might be in some conflict, all are dependent upon nature to provide their diverse experiences (Rolston 1981; Schroeder et al. 2006).

In addition to a diversity of recreationists, there is a desire to enjoy multiple experiences and outcomes during a single trip, and it can be difficult to tease apart the fluid nature of these desired experiences (Schroeder et al. 2006; Tarrant et al. 1999). Recreation-experience-preference scales have been used to measure the motivations for seeking specific leisure activities. Through established and consistent measurement of domains and scales in user-feedback surveys, it is possible to measure motivation across a variety of sought after wildlife experiences (Manfredo et al. 1996). These pursued experiences include connection with nature, increased overall attention span, time and space for self-reflectance, and are distributed across personal-, social/cultural-, economic-, and environmental benefits (Manfredo and Driver 2002; Mayer et al. 2009; Haluza et al. 2014). These benefits are collectively studied in experience-based management that focuses on the experience-, setting-, and activity-opportunities provided to users that yield a satisfactory experience (Manfredo et al. 2002). Meaningful and satisfactory trips result in visitor-reported benefits like harvesting game, time spent outdoors, seeing game, strengthening relationships with friends and relatives, improving skills, acknowledging heritage, developing positive memories, and establishing a strong sense of self-confidence (Manfredo and Driver 2002; Mehmood et al. 2003; Larson et al. 2014). Motivations and satisfactions are most productively utilized when studied together to find the best benefits-based management practices for outdoor recreational seekers (Manfredo and Driver 2002; Fisher 1997; Arlinghaus 2006).

Place attachment - The places where people choose to recreate can also help inform managers about users' desired experiences. Place attachment can be broken into two measureable components, functional attachment and emotional attachment (Payton et al. 2005; Anderson and Fulton 2008; Moore and Graefe 1994; Vaske and Kobrin 2001; Williams and Vaske 2003). Functional attachment measures the ability of a place to fit the needs and objectives of a visitor, and how that place compares to other available places. Emotional place attachment incorporates personal bonds to certain places, such as childhood memories (Anderson and Fulton 2008). Understanding the influences of place attachment can help managers predict the likelihood of returning visitors. In addition, managers can attempt to create places and experiences that visitors will feel positively about, encouraging return visits. In part, this means reducing perceived and personal constraints on hunters. Past research findings indicates that crowding, habitat quality, and fear of injury from other hunters are some of the personal and perceived constraints encountered by hunters (Miller and Vaske 2003; RM NSSF 2010). Through knowledgeable management of constraints, managers can improve the perception of visits on public lands and create experiences that will retain hunters or encourage new hunters to join the activity. Positive hunting experiences may influence a hunter to return to a particular area, cementing their attachment to particular space, either functionally or emotionally. Managers should seek to minimize constraints within their power in order to provide the best possible recreation experiences. Previous literature has found that recreation experience preferences will predict place attachment (Anderson and Fulton 2008; Kyle et al. 2004) but more recent literature has also found that place attachment can predict recreation experience preferences (Budruk and Wilhelm-Stanis 2013). Managers should seek to build place attachment among their constituents through a minimization of constraints to produce highly sought-after hunting experiences.

Study Rationale - The purpose of our research is to determine if there are diverse categories or groups of hunters who use WMAs. If so, we seek to understand the following differences across these groups: a) satisfactions with overall hunting experiences on WMAs as well as satisfaction with pursing individual species/seasons, b) experience preferences, c) support of management actions, d) type of hunting land preferred by users, and e) levels of place attachment, both emotional and functional components. Information about the different groups will allow for more specific management strategies and programming to ensure that WMAs provide the best possible experiences for the distinct groups seeking to us them.

METHODS

Research Area and Survey Methods

We designed this project to understand two components of WMA usage – the number of people who use WMAs and the characteristics of those visitors. We counted visitors by intercepting them in the field (technicians recorded license plate IDs) and also provided them an opportunity to participate in mail survey to better understand their characteristics. This paper is focused on better understanding WMA visitor characteristics based on data from the second part of the study.

Our study area included 1,061 WMAs located in 43 counties within the prairie pothole region of western Minnesota. We divided the study area into 2 regions (northwestern and southwestern) based on the number and type of WMAs found in these areas (Figure 1). The northern study area is best characterized by larger counties, and fewer but larger WMAs. Conversely, the southern study area has smaller counties and more, albeit smaller WMAs. Using ArcMap 10.2, we created a sampling grid for each region, with grid size being a function of average county size within each region. Within each of the 21 grid blocks, we randomly selected 1 WMA and the 9 nearest neighbors to create a group of WMAs to sample visitor usage. These exact group sizes were modified in some cases because of access issues and to ensure equal sampling effort. The final sample consisted of 228 WMAs organized into 21 driving routes, which represents 21% of the total WMAs in the study area. The recruitment period ran for 11 weekends, starting with waterfowl opener on September 26, 2015 and ending on December 6, 2015, when hunter numbers had declined precipitously. We ultimately distributed 2,046 intercept recruitment letters encouraging participation in the study. The intercept letter included a short survey to collect contact information that could be returned by mail or completed online. A total of 405 surveys were returned (19.8%), which provided sufficient contact information for 443 individuals who were later be contacted to complete the WMA visitor experience survey. Human subject use for this study was approved by the University of Minnesota Institutional Review Board Human Subjects Code Number 1602E84687.

To provide for a more robust sampling framework, we also mailed 5,000 invitations to individuals at least 18 years old who purchased both a small game license and pheasant stamp in 2015. We chose these license types because publicly accessible pheasant habitat is limited in an otherwise predominantly privately-owned region of Minnesota and we theorized a higher percentage of these individuals may use WMAs. Individuals were mailed a contact letter explaining the study and requesting their participation. To participate in the study, interested individuals returned a business-reply postcard indicating they had visited a WMA and would be willing to participate in the study. In total, 88 were undeliverable and 932 individuals (18.9%) returned postcards indicating they had visited WMAs and would be willing to complete a larger survey about their experiences. This combination sampling strategy provided an initial study sample size of 1,375. Comparisons were made between the two groups of contacts after the surveys were returned to demonstrate that these two sample populations were similar (Table 1).

We contacted the 1,375 individuals by mail using the procedures for mail survey administration (Dillman et al. 2014). We asked individuals to complete a self-administered survey questionnaire that included the following topics on attitudes, beliefs, satisfactions, and support of management actions. For the analysis reported here we only focus on experience preferences, satisfaction of hunting various species/seasons, place attachment, support or opposition of management actions, and land types used by WMA hunters.

Experience preferences (Manfredo et al. 1996) were measured using 24 items, where respondents were asked to indicate on a 7-pt scale from “1 = Extremely Unimportant” to “7 = Extremely Important” various statements related to overall satisfaction for hunting on WMAs during the 2015-2016 hunting season. In addition, we asked study participants about their overall satisfaction with hunting experiences on WMAs, as well as their satisfaction with pursuing individual species and seasons. Response options for these questions ranged from “1 = Extremely Dissatisfied” to “7 = Extremely Satisfied”.

We followed functional and emotional place attachment indices developed by Williams and collaborators (Williams and Roggenbuck 1989; Williams and Vaske 2003; Williams et al. 1992). These measurement items have been thoroughly tested in numerous studies and provide reliable measures of place attachment. We adapted these place attachment items to be specifically about Minnesota WMAs, and respondents rated their agreement to the items on a 7-pt scale ranging from "1 = Extremely Disagree" to "7 = Extremely Agree". We examined levels of support on seven key management actions where responses on a 7-point scale ranged from "1 = Extremely Oppose" to "7 = Extremely Support". We were also interested in knowing which types of land are used most often by WMA users. Respondents were asked to rate on a 4-point scale ranging from "1 = None" to "4 = All" how often they used Wildlife Management Areas, Walk-in Access Areas, Waterfowl Production Areas, Other Public Land, and Private Land.

Data Analysis

We used cluster analysis to separate the population into smaller groups with similar traits, using procedures adopted from previous studies that used Recreational Experience Preference items to define typologies (Manfredo and Larson 1993; Schroeder et al. 2006). Cluster analysis is a broadly used technique to develop empirical groupings of persons, conditions, and events that can be used as categories for subsequent analyses (Punj and Stewart 1983; Romesburg 1984). Following the previous studies, we selected items items with the greatest amount of variance from a series of related items (i.e., experience preferences) in order to detect groups of individuals seeking distinctly different experiences. Six items were chosen for cluster analysis: a) "Being with family", b) "Being on my own", c) "Developing my skills and abilities", d) "Thinking about personal values", e) "Shooting a gun", and f) "Getting food for my family" (Table 2). We used k-means cluster analysis with distances computed using simple Euclidean distance (IBM SPSS Statistics for Windows, version 24). While Manfredo and Larson (1993) suggested increasing the number of clusters over successive analyses until the addition of another cluster produced a group with <3% of the respondents, this rule resulted in a larger number of clusters for our sample population (>10). Instead, we defined 6 clusters, for which the smallest group contained 9% of the respondents (n=74).

To create our place attachment indices, we computed average scores for each respondent for both functional and emotional place attachment. We compared the six clusters to identify differences between groups based on experience preference items, demographic information, satisfaction means, and place attachment scores. Comparisons of groups means were made using ANOVA with a Tukey post hoc test to identify differences among the 6 clusters. Differences in species/seasons pursued by the 6 clusters were identified using chi-square analysis.

RESULTS

Descriptive Results

Of the 1,375 full-length surveys, 11 were undeliverable and 1 was identified as a minor and disqualified from participating. Of the remaining 1,363 viable surveys, 949 surveys were returned for a 70% response rate. Non-response surveys were sent to the 418 non-respondents, of which 4 were undeliverable. Of the 414 viable surveys, 142 were returned for a 34% response rate. The only significant differences in demographic data between the field-intercepted and the postcard-intercepted respondents were education and income (Table 1). The results of our shortened non-response survey demonstrate that those who did not respond to the original mailing had similar trends for most questions, including overall satisfaction with WMAs ($t = -1.376$, p-value = 0.171), likelihood of returning to a WMA ($t = -1.921$, p-value $= 0.056$) and overall demographics. The average survey respondents were middle-aged white males ($\bar{x} = 50.8$ years old; 96.2% white; 95.5% male), who had been hunting an average of 36 years. The overall satisfaction for hunting experiences on WMAs averaged 5.1 on our 7-pt scale. When analyzed in aggregate, our respondents rated all experience preferences as important, on average (mean score > 4.0) except "Getting food for my family" ($\bar{x} = 3.9$; Table 2).

Cluster Descriptions

The k-means cluster analysis resulted in 6 distinct groups. The 6 identified clusters differed on all of the experience preference items (Table 3) but had similar satisfaction levels with hunting of all species except grouse (Table 4). Comparison of the clusters for mean experience preferences and other characteristics helps to understand similarities and differences across the clusters (Tables 3-8).

Cluster 1 (n = 74 hunters) – This group is about the same age ($\bar{x} = 49.3$) as the overall sample group, have been hunting about the same length of time ($\bar{x} = 35.2$) as the entire sample group, and had much less overall satisfaction ($\bar{x} = 4.9$) than sample group. On average, these less-engaged hunters rated 22 out of the 24 experience items lower than did respondents in the other 5 clusters. Their lowest experience preference scores came from "Getting food for my family" ($\bar{x} = 2.0$) and "Getting my own food" ($\bar{x} = 2.3$; Table 3). Their highest experience preference scores came from "Enjoying nature and the outdoors", followed by "Good behavior among other hunters". This group of hunters rated 6 out of 12 individual species/seasons satisfactions lower than the respondents in other clusters (Table 4). Cluster 1 was the most dissatisfied with firearm deer, archery deer, geese, doves, rabbits, and squirrels. They were more favorable towards spring turkey than any other cluster group. This cluster had the lowest average responses for both the emotional and functional components of place attachment, when compared to the other 5 clusters (Tables 5). They also had the lowest support for almost every management action (Table 6). However, they were very likely to use WMAs and least likely to use private land (Table 7). Cluster 1 also hunted deer less often than expected. Respondents indicated they hunted firearm deer at only 68%, muzzleloader deer at 43%, and archery deer at 10% of expected values (Table 8).

<u>Cluster 2 (n = 162 hunters)</u> – This group was slightly older ($\bar{x}$ = 51.8) than the overall sample group, had been hunting for longer ($\bar{x}$ = 37.1) than the overall sample group, and were generally more satisfied ($\bar{x}$ = 5.2) than the overall sample group. Their lowest scores for experience preferences came from "Getting food for my family" ($\bar{x}$=3.8) and "Getting my own food" ($\bar{x}$ = 4.0; Table 3). Highest scores came from "Enjoying nature and the outdoors" ($\bar{x}$ = 6.3), "Hunting provides an enjoyable way to get exercise" ($\bar{x}$ = 5.9), and "I feel better mentally, after I have spent time hunting" ($\bar{x}$ = 5.9). For this group of hunters, only 1 experience preference out of 24 had lower importance than the other clusters, and this fell to "Good behavior among hunters". This group did not have any extremes in terms of satisfaction or dissatisfaction of pursing various species or season (Table 4). They were most satisfied with fall turkey and least satisfied with rabbits. This group has a much higher emotional than functional place attachment ($\bar{x}$ = 4.2 compared to $\bar{x}$ = 3.4, respectively; Table 5). Cluster 2 had low support for most management actions (Table 6) and used private land almost as much as they use WMAs

($\bar{x}$ = 1.9 compared to $\bar{x}$ = 2.5, respectively; Table 7). This group hunted ducks and geese much less frequently than expected, with ducks being pursued by 64% and geese pursued by 58% of expected hunters (Table 8).

Cluster 3 (n = 149 hunters) – Age for this group was less than the overall average ($\bar{x}$ = 48.3), as was time spent hunting ($\bar{x}$ = 33.9). However, overall satisfaction was higher than the other clusters, though not significant ($\bar{x}$ = 5.2). On average, these hunters rated 24 out of 24 experience items higher than respondents in the other 5 clusters (Table 3). Their highest mean score for experience preferences came from "Enjoying nature and the outdoors" ($\bar{x}$ = 6.9) and "Getting away from crowds of people" ($\bar{x}$ = 6.8). Lowest scores came from "Harvesting an animal" ($\bar{x}$ = 5.9) and "Getting my own food" ($\bar{x}$ = 5.9). When compared to other clusters, this group had the lowest hunting satisfactions scores for ducks and pheasant, but the highest satisfaction scores for rabbits (Table 4). This group has the highest place attachment for both emotional and functional components (Table 5). This group is very supportive of all management actions (Table 6) and are among the most frequent users of WMAs ($\bar{x}$ = 2.6; Table 7). This group pursued all species/seasons far more than expected, with firearm deer pursued by an additional 31% of expected hunters and ducks pursued by an additional 29% of expected hunters (Table 8).

Cluster 4 (n= 167 hunters) – This was the youngest group ($\bar{x}$ = 47.9), had been hunting for the least amount of time, ($\bar{x}$ = 33.4) and was slightly below overall satisfaction ($\bar{x}$ = 5.0) compared to the sample group. This group fell into the middle range of feelings of importance for experience preference questions (Table 3). The lowest score came from "Shooting a gun" ($\bar{x}$ = 4.1) and the highest score came from "Enjoying nature and the outdoors" ($\bar{x}$ = 6.6). This group was highly satisfied with many of the species hunted (Table 4). On average, this group of hunters rated 7 out of 12 species/seasons higher than respondents in the other 5 clusters. They were very satisfied with firearm deer, muzzleloader deer, archery deer, duck, geese, pheasant and ducks. This group has a higher emotional component ($\bar{x}$ = 4.4) of place attachment when compared to their functional component ($\bar{x}$ = 3.4), but both means were near the middle of the range of all clusters (Table 5). This group had mixed support for different management actions, and were more likely to support "Conservation grazing", and "Create more WMAs", than any other cluster (Table 6). This group is also highly likely to use WMAs ($\bar{x}$ = 2.6; Table 7). Cluster 4 pursued all species/seasons more often than expected, except for spring and fall turkey and pheasants (Table 8). They pursued archery deer 68% , ducks 21%, and geese 44% more than expected.

<u>Cluster 5 (n = 150 hunters)</u> – This was the oldest group of hunters ($\bar{x}$ = 55.0) who had been hunting for the longest time ($\bar{x}$ = 38.2) and their satisfaction was similar to the overall sample group ($\bar{x}$ = 5.1). This group of hunters believed that "Getting food for my family" ($\bar{x}$ = 2.7) and "Getting my own food" ($\bar{x}$ = 3.5) were less important than other experience preferences, although the overall, most experience preferences were important (Table 3). The most important components for this group included "Enjoying nature and the outdoors" ($\bar{x}$ = 6.7), "Good behavior among other hunters" ($\bar{x}$ = 6.6), "The excitement of hunting" ($\bar{x}$ = 6.5), and "I feel better mentally after I have spent time hunting" ($\bar{x}$ = 6.5). This group was did not differ significantly with their satisfaction of individual species/seasons when compared with other clusters (Table 4). This group has a very high

emotional component of place attachment (x̄ = 4.8), but their functional component still falls below neutral (x̄ = 3.8; Table 5). Cluster 5 is on the high end of support for most management actions (Table 6) and are more likely to use WMAs when compared to other land types (Table 7). This group was observed to pursue all species and seasons with relatively equal observed and expected counts (Table 8).

Cluster 6 (n = 121 hunters) – This group of hunters was slightly younger, (x̄ = 49.4), had been hunting for slightly less (x̄ = 34.2), but had a high overall satisfaction (x̄ = 5.1). On average, these hunters rated 2 of the 24 experience items lower than respondents in the other 5 clusters; these included "Getting food for my family" (x̄ = 1.8) and "Shooting a gun" (x̄ = 2.0; Table 3). This group believes that "Enjoying nature and the outdoors" (x̄ = 6.7), "Good behavior among hunters" (x̄ = 6.4), and "I feel better mentally after I have spent time hunting" (x̄ = 6.3) are all important components to a satisfactory experience. This group was more dissatisfied, on average, with muzzleloader deer, spring turkey, and fall turkey when compared to other clusters, but more satisfied with grouse and squirrels when compared to other clusters (Table 4). Cluster 6 had showed that their emotional component of place attachment was higher when compared to the functional component (x̄ = 4.5 vs. 3.5 respectively), although these were within the ranges of place attachment for the other clusters (Table 5). This cluster is supportive of most management actions (Table 6), and very likely to use WMAs (x̄ = 2.6; Table 7). This group also pursued most species/seasons less often than expected, especially as deer hunters. However, hunters pursued pheasants 6% more than expected (Table 8).

Summary of key differences across the cluster types. - Experience preferences were significantly different across all groups and preferences, demonstrating that these clusters are seeking very different experiences when they are on WMAs (Table 3). Experience preferences that were the most different (as indicated by a high F-value) include the following: “Getting food for my family” ($F = 348.09$) had cluster means ranging from 1.8 to 6.0, “Shooting a gun” ($F = 254.65$) had cluster means ranging from 2.0 to 6.2, “Developing my skills and abilities” ($F = 144.8$) had cluster means ranging from 2.9 to 6.5, “Thinking about personal values” ($F = 129.67$) had cluster means ranging from 3.2 to 6.3, and finally “Getting my own food” ($F = 126.74$) had cluster means ranging from 2.3 to 5.9.

The 6 clusters did not differ on overall satisfaction with experiences on WMAs ($F = 0.419$, $p = 0.836$). For satisfaction levels on individual species/seasons, the six clusters differed only on grouse hunting ($F = 3.153$, $p = 0.010$; Table 4). The clusters also differed on ratings of both functional place attachment ($F = 5.991$, $p<0.001$) and emotional place attachment ($F = 6.872$, $p<0.001$) differed among the 6 groups (Table 5).

The only management actions that did not show a statistical difference among the clusters was “Remove trees to reduce predation on pheasants/small game” ($F = 2.077$, $p = 0.066$) and “Use of prescribed burns during the FALL to promote prairie maintenance/enhancement” ($F = 0.881$, $p = 0.493$; Table 6). Otherwise, all other management actions showed a statistical difference in support from the six clusters. Cluster 1 came out as feeling the least supportive of 5 out of the 7 proposed management actions, while Clusters 3 and 6 were the most supportive of 3 out of 7 proposed management actions, each. Cluster 4 remained fairly neutral and did not swing towards either end of the spectrum in extreme support or opposition for any of the proposed management actions.

There were no statistical differences between the clusters and their preferred land-use type (Table 7). Clusters did differ on their participation in firearm deer, muzzleloader deer, archery deer, spring turkey, duck, and goose hunting ($p < 0.05$; Table 8). However pheasants, the most commonly pursued species, did not show significant difference across the clusters ($p = 0.730$).

DISCUSSION

Experienced-based management research has demonstrated that experiences, settings, and the opportunity for recreational activities are all crucial for a visitor to perceive their visit as satisfactory experiences (Manfredo et al. 2002). Our research shows that users who believe specific experience preferences are important will likely also have high place attachments to these WMAs (Anderson and Fulton 2008; Kyle et al. 2004). Clusters 1 and 2, who ranked most experience preferences as less important than their peers, were also the least attached to these places. In contrast, Clusters 3 and 6 ranked most experience preferences as highly important, felt highly satisfied with their WMA experiences, had moderate to high place attachment, and were among the most likely to use WMAs when compared to other clusters.

Management support was closely linked with place attachment, as Cluster 2 had low place attachment attributes and were less likely to support management actions, whereas Cluster 5 had high place attachment and indicated they support most management actions on WMAs. Previous research on Minnesota hunter's support of management has focused more specifically on regulatory actions (Cornicelli et al. 2011; Schroeder et al. 2016), however, our management questions had less to do with regulation and more to do with site maintenance. Nevertheless, we see that there is a strong tie between how these places serve as important locations for hunters and the resulting support those same hunters have for management.

Given our study focused on WMA users, we expected the different clusters might use WMAs (versus other land types) somewhat equally. Satisfaction of hunting various species is dependent on multiple variables, including harvest and non-harvest components, such as seeing wildlife in the field (Hayslette et al. 2010). The differences in importance of experience preferences demonstrates that diverse hunter needs must be met in order to have desirable WMA experience. Secondly, place attachment differed among the 6 clusters on both the emotional and functional components. Across all clusters, emotional components had a higher importance to WMA users than the functional component of place attachment, an observation that has been seen in previous work (Kyle et al. 2004). Finally, although support for management actions varied across the clusters, there appeared to be general consensus about support for all management actions (all aggregate means >4.0), however, users felt most strongly about creating more WMAs ($\bar{x}$ =6.4).

In order to improve WMA user's experiences in the field, wildlife managers can better understand who is seeking to use these areas, and what actions can be done to improve their experiences. We were able to segment our sample population into distinct 6 groups. By examining demographic information and which species these clusters are most interested in pursuing, wildlife managers can target those users who are having less than desirable experiences. Outreach can be made more effective by finding a target audience and adapting educational materials to their needs and experience preferences. All clusters showed a strong attachment to WMAs, and managers could capitalize on those feelings to promote continued visitation to these areas.

Conclusions and Future Research

Satisfaction with recreational or hunting experiences on public lands can be improved if wildlife managers better understand the heterogeneity of hunters and the experiences they desire. Many of the experiences sought by hunters have more to do with the non-consumptive outcomes (i.e., being on my own, getting away from crowds of people, enjoying nature and the outdoors), which can be enjoyed by non-hunters as well. In an effort to recruit and retain hunters into the future as a means of securing a funding source, wildlife managers should employ all possible avenues for keeping hunters in the field. Encouraging discussions about the use of hunting as a moral act that contributes to conservation funding (e.g., habitat protection, conservation education), population goals, an appreciation for nature, and quality time with family and friends can improve relations between agencies and hunters seeking to recreate within legal limits (Peterson et al. 2010). In general, dialogue between managers and their constituents needs to be transparent and informative. Many hunters participate in non-hunting, non-consumptive natural resources recreation activities, sometimes during the same visits where their main objective is to hunt. Surveys indicate that hunters can gain as much appreciation from seeing game as they do from harvesting an animal (Mehmood et al. 2003; Larson et al. 2014). Managers can capitalize on these non-consumptive activities including seeing game and being with friends and family. Increasing the availability of these non-consumptive, secondary motivations for hunters can help increase participation numbers over time.

Study Limitations

This study was created with two objectives in mind, to understand the number and characteristics of WMA visitors. Our sampling methods were designed to include both objectives, but it placed limitations on the overall project. Because we weren't able to accumulate enough responses from visitors who were intercepted in the field, we were forced to sample an additional population of Minnesota hunters via a postcard solicitation focusing on small game (pheasant) hunters. Although these groups showed very similar demographic characteristics, we acknowledge some differences may exist. Additionally, our study area only encompassed a portion of the state, as an attempt to maximize sampling effort with budget and logistical limitations. As there are over 1,400 WMAs in Minnesota, a census of users would have been impractical. Thus, we may be unable to extend our conclusions to areas outside our sampling framework.

Table 1.1. Demographic similarities between field-intercepted and postcard-recruited populations. Significance threshold for p-values was set at 0.05.

Demographic tested	Field-intercept mean	Postcard-recruited mean	p-value
Average Age[1]	51.5 years	50.46 years	0.289
Age at first hunt[1]	13.7 years	14.4 years	0.146
Income[1]	$72,654	$82,228	0.011
Miles Driven[1]	98 miles	101 miles	0.710
Male[2]	96%	97%	0.336
Took a dependent[2]	45%	46%	0.874
Took a spouse/partner[2]	18%	18%	0.860
Proportion of pheasant hunters[1]	58%	70%	< 0.001
Proportion of duck hunters[1]	37%	29%	0.012
Proportion of firearm deer hunters[1]	38%	22%	< 0.001
Proportion of archery deer hunters[1]	15%	11%	0.09
Proportion of muzzleloader deer hunters[1]	12%	7%	0.016

[1] Students t-test; [2]Chi-square analysis

Table 1.2. Importance of experience outcomes for WMA users in Minnesota, USA. Significance threshold for p-values was set at 0.05.

Experience Preferences	Mean [a]	Variance
Enjoying nature and the outdoors	6.60	0.64
Good behavior among other hunters	6.33	1.09
I feel better mentally, after I have spent time hunting	6.25	1.00
Getting away from crowds of people	6.23	1.14
The excitement of hunting	6.16	0.94
Hunting provides an enjoyable way to get exercise	6.15	1.01
I feel better physically, after I have spent time hunting	6.11	1.12
Access to a lot of different hunting areas	6.01	1.34
Reducing tension and stress	5.93	1.59
The prospect of hunting motivates me to stay physically healthy	5.93	1.32
The challenge of making a successful shot	5.81	1.49
Hunting on WMAs reduces stress in my normal work and home life	5.76	1.71
Being with friends	5.72	1.62
Seeing a lot of wild game	5.69	1.52
Being with family [b]	5.69	2.02
Being on my own [b]	5.21	2.43
Sharing my hunting skills and knowledge	5.19	1.99
Developing my skills and abilities [b]	5.19	2.23
Thinking about personal values [b]	5.18	2.05
Using my hunting equipment (calls, blinds, guns, etc.)	5.09	2.02
Harvesting an animal [c]	4.63	2.68
Shooting a gun [b]	4.43	3.34
Getting my own food [c]	4.11	3.32
Getting food for my family [b]	3.87	3.66

[a] Means based on a scale of "1 = Extremely Unimportant" to "7 = Extremely Important".
[b] Items used in the cluster analysis.
c After ranking our 24 experience preference items by level of variance, we found that several items with the most variance pertained to harvest success. In order to get a more useful cluster analysis, we did not include the last two harvest success items in the cluster analysis.

Table 1.3. Experience Preferences outcomes by WMA User Clusters. Significance threshold for p-values was set at 0.05.

Experience Outcomes	**Means [a]**							
	Cluster 1 n=74	**Cluster 2 n=162**	**Cluster 3 n=149**	**Cluster 4 n=167**	**Cluster 5 n=150**	**Cluster 6 n=121**	***F***	***p***
Enjoying nature and the outdoors	6.2 [b,1]	6.3[1,2]	6.9[4]	6.6[2,3]	6.7[3,4]	6.7[3,4]	13.2	≤0.001
Getting away from crowds of people	5.6[1]	5.9[1,2]	6.8[4]	6.3[3]	6.4[3,4]	6.1[2,3]	19.6	≤0.001
Getting food for my family	2.0[1]	3.8[3]	6.0[5]	5.4[4]	2.7[2]	1.8[1]	348.1	≤0.001
Shooting a gun	2.5[1]	5.0[2]	6.2[3]	4.1[4]	5.3[2]	2.0[5]	254.7	≤0.001
Access to a lot of different hunting areas	5.2[1]	5.8[2]	6.7[3]	5.9[2]	6.3[4]	5.7[2]	27.2	≤0.001
Harvesting an animal	3.2[1]	4.9[2]	5.9[3]	4.7[2]	4.7[2]	3.3[1]	60.5	≤0.001
Being on my own	3.0[1]	5.1[2]	6.4[3]	4.6[4]	5.8[5]	5.4[2,5]	86.8	≤0.001
Being with friends	4.8[1]	5.3[2]	6.4[5]	5.7[3,4]	6.1[4,5]	5.6[2,3]	27.5	≤0.001
Developing my skills and abilities	2.9[1]	4.4[2]	6.5[5]	5.5[4]	5.8[4]	4.9[3]	144.8	≤0.001
Being with family	4.2[1]	4.6[2]	6.6[5]	6.2[4,5]	6.1[4]	5.5[3]	82.0	≤0.001
Good behavior among other hunters	5.7[1]	5.7[1]	6.8[3]	6.5[2]	6.6[2,3]	6.4[2]	30.8	≤0.001
Reducing tension and stress	4.6[1]	5.4[2]	6.7[4]	6.1[3]	6.2[3]	6.0[3]	46.1	≤0.001
Seeing a lot of wild game	5.0[1]	5.5[2,3]	6.4[4]	5.7[2,3]	5.8[3]	5.3[1,2]	20.4	≤0.001
Sharing my hunting skills and knowledge	3.6[1]	4.5[2]	6.2[4]	5.6[3]	5.5[3]	4.8[2]	70.6	≤0.001
Thinking about personal values	3.2[1]	4.1[2]	6.3[5]	5.6[3,4]	5.8[4]	5.2[3]	129.7	≤0.001
Using my hunting equipment (calls, blinds, guns, etc.)	3.6[1]	4.9[3]	6.1[5]	5.1[3]	5.6[4]	4.4[2]	58. 5	≤0.001
Getting my own food	2.3[1]	4.0[3]	5.9[5]	5.0[4]	3.5[2]	2.6[1]	126.7	≤0.001
The excitement of hunting	5.4[1]	5.9[2]	6.7[4]	6.2[3]	6.5[3,4]	5.9[2]	29.5	≤0.001
The challenge of making a successful shot	4.8[1]	5.5[2]	6.6[4]	5.9[3]	6.1[3]	5.3[2]	37.8	≤0.001
Hunting provides an enjoyable way to get exercise	5.4[1]	5.9[2]	6.7[4]	6.2[2,3]	6.3[3]	6.1[2,3]	23.1	≤0.001
Hunting motivates me to stay physically healthy	5.1[1]	5.7[2]	6.6[4]	5.8[2,3]	6.2[3]	5.8[2,3]	24.9	≤0.001
Hunting on WMAs reduces stress in work & home life	4.6[1]	5.4[2]	6.5[4]	5.8[2,3]	6.0[3]	5.9[3]	29.0	≤0.001
I feel better physically, after I have spent time hunting	5.2[1]	5.8[2]	6.7[4]	6.1[2,3]	6.3[3]	6.1[3]	28.4	≤0.001
I feel better mentally, after I have spent time hunting	5.4[1]	5.9[2]	6.7[4]	6.3[3]	6.5[3,4]	6.3[3]	25.3	≤0.001

[a] Means based on a scale of “1 = Extremely Unimportant” to “7 = Extremely Important”

[b] Numbered superscripts indicate group mean difference determined by Tukey post hoc test at p ≤0.05

Table 1.4. Satisfaction of hunting various species/seasons by WMA user clusters. Significance threshold for p-values was set at 0.05.

Species/Season Pursued	N [b]	Aggregate Mean [c]	Means [a] Cluster 1 n=74	Cluster 2 n=162	Cluster 3 n=149	Cluster 4 n=167	Cluster 5 n=150	Cluster 6 n=121	*F*	*p*
Firearm Deer	256	4.55	4.3[e,1]	4.7[1]	4.4[1]	4.7[1]	4.7[1]	4.6[1]	0.24	0.946
Muzzleloader Deer	78	4.01	3.0[1]	3.5[1]	4.4[1]	4.5[1]	4.3[1]	2.0[1]	2.17	0.068
Archery Deer	112	4.90	4.0[1]	4.7[1]	4.9[1]	5.1[1]	4.8[1]	4.8[1]	0.31	0.906
Spring Turkey	86	5.37	6.0[1]	5.6[1]	5.5[1]	5.2[1]	5.8[1]	4.2[1]	1.49	0.202
Fall Turkey	24	5.0	NA [d]	5.5[1]	4.6[1]	5.5[1]	6.0[1]	3.7[1]	0.97	0.450
Duck	297	4.57	4.4[1]	4.6[1]	4.3[1]	4.8[1]	4.6[1]	4.6[1]	0.66	0.651
Geese	199	4.24	3.8[1]	4.0[1]	4.1[1]	4.6[1]	3.8[1]	4.5[1]	1.51	0.189
Grouse	132	4.68	4.7[1]	5.1[1,2]	4.4[1,2]	4.3[1,2]	4.0[1,2]	5.8[2]	3.15	0.010
Pheasant	628	4.76	4.8[1]	4.7[1]	4.6[1]	5.0[1]	4.7[1]	4.8[1]	0.56	0.732
Dove	54	4.37	2.3[1]	4.3[1]	4.7[1]	4.8[1]	3.7[1]	4.5[1]	1.11	0.367
Rabbits	46	4.22	1.0[1]	3.3[1]	5.0[1]	4.3[1]	4.2[1]	4.4[1]	1.34	0.270
Squirrels	41	4.56	2.5[1]	3.7	5.1[1]	4.4[1]	5.0[1]	5.5[1]	1.40	0.248

[a] Means based on a scale of “1 = Extremely Unsatisfied” to “7 = Extremely Satisfied”

[b] Aggregate mean displays the overall mean of the entire sample population (prior to clustering)

[c] Represents the number of respondents who indicated a level of satisfaction on the survey

[d] No participants from Cluster 1 indicated a level of satisfaction with fall turkey

[e] Numbered superscripts indicate group mean difference determined by Tukey post hoc test at $p \leq 0.05$

Table 1.5. Place Attachment by WMA User Groups. Significance threshold for p-values was set at 0.05.

Place Attachment	Aggregate Mean [c]	Means [a] Cluster 1 n=74	Cluster 2 n=162	Cluster 3 n=149	Cluster 4 n=167	Cluster 5 n=150	Cluster 6 n=121	*F*	*p*
Emotional	4.5	4.0[b,1]	4.2[1]	5.0[3]	4.4[1,2]	4.8[2,3]	4.5[1,2,3]	6.87	≤0.001
I feel like WMAs are a part of me. I identify strongly with WMAs. I am very attached to WMAs. (Cronbach's α = 0.93)									
Functional	3.6	3.3[1]	3.4[1,2]	4.1[3]	3.4[1,2]	3.8[2,3]	3.5[1,2]	5.99	≤0.001
WMAs are the best places for what I like to do. No other place can compare to WMAs. I get more satisfaction out of visiting WMAs than from visiting any other place. Doing what I do at WMAs is more important to me than doing it in any other place. I wouldn't substitute any other area for doing the types of things I do at WMAs. (Cronbach's α = 0.92)									

[a] Means based on indices described by Williams and colleagues

[b] Numbered superscripts indicate group mean difference determined by Tukey post hoc test at p ≤0.05

[c] Represents aggregation of place attachment for all survey respondents

Table 1.6. Support or Opposition of Management Actions for WMAs. Significance threshold for p-values was set at 0.05.

Management Actions	Aggregate Mean [b]	Means [a] Cluster 1 n=74	Cluster 2 n=162	Cluster 3 n=149	Cluster 4 n=167	Cluster 5 n=150	Cluster 6 n=121	*F*	*p*
Create more wildlife food plots.	6.09	5.9 [c,1]	6.0[1,2]	6.4[2]	5.9[1]	6.2[1,2]	6.0[1,2]	3.64	0.003
Wetland restoration/recovery effort.	6.11	5.9[1,2]	5.8[1]	6.3[2,3]	6.0[1,2,3]	6.4[3]	6.3[2,3]	4.87	≤0.001
Conservation grazing as a management tool for prairie(grassland)	4.32	4.0[1]	4.1[1,2]	4.7[2]	4.4[1,2]	4.3[1,2]	4.4[1,2]	2.29	0.044
Create more WMAs.	6.38	6.2[1]	6.2[1]	6.6[2]	6.4[1,2]	6.4[1,2]	6.5[1,2]	3.18	0.007
Remove trees to reduce predation on pheasants/small game.	4.48	4.2[1]	4.3[1]	4.6[1]	4.3[1]	4.8[1]	4.8[1]	2.08	0.066
Use of prescribed burns in the SPRING to promote prairie (grassland)	5.41	5.0[1]	5.2[1,2]	5.6[1,2]	5.5[1,2]	5.5[1,2]	5.7[2]	2.68	0.021
Use of prescribed burns in the FALL to promote prairie maintenance/enhancement.	4.16	4.1[1]	3.9[1]	4.2[1]	4.2[1]	4.3[1]	4.4[1]	0.88	0.493

[a] Means based on a scale of "1 = Extremely Oppose" to "7 = Extremely Support"

[b] Aggregate mean displays the overall mean of the entire sample population (prior to clustering)

[c] Numbered superscripts indicate group mean difference determined by Tukey post hoc test at p ≤0.05

Table 1.7. Land Types used by WMA hunters in the 2015 hunting season. Significance threshold for p-values was set at 0.05.

Land Types	Aggregate Mean [b]	Means [a] Cluster 1 n=74	Cluster 2 n=162	Cluster 3 n=149	Cluster 4 n=167	Cluster 5 n=150	Cluster 6 n=121	*F*	*p*
Wildlife Management Area	2.40	2.6 [c,1]	2.5[1]	2.6[1]	2.6[1]	2.5[1]	2.6[1]	0.38	0.864
Walk-in-Access Area	1.41	1.4[1]	1.5[1]	1.4[1]	1.4[1]	1.5[1]	1.5[1]	0.47	0.798
Waterfowl Production Area	1.76	1.9[1]	1.8[1]	2.0[1]	1.9[1]	1.8[1]	1.9[1]	1.63	0.151
Other Public Land	1.41	1.3[1]	1.5[1]	1.5[1]	1.5[1]	1.5[1]	1.4[1]	0.71	0.619
Private Land	1.95	1.9[1]	2.1[1]	2.1[1]	2.1[1]	2.0[1]	2.0[1]	1.16	0.328

[a] Means based on a scale of use ranging from 1 = None to 4 = All

[b] Aggregate mean displays the overall mean of the entire sample population (prior to clustering)

[c] Numbered superscripts indicate group mean difference determined by Tukey post hoc test at $p \leq 0.05$

Table 1.8: Chi-Square analysis of percentage of respondents by species/seasons hunted, based on clustering.

		Cluster 1 n=74		**Cluster 2 n=162**		**Cluster 3 n=149**		**Cluster 4 n=167**		**Cluster 5 n=150**		**Cluster 6 n=121**	
Species/Season Pursued	**p-values**	Obs [a]	*Exp*	Obs	*Exp*	Obs	*Exp*	Obs	*Exp*	Obs	*Exp*	Obs	*Exp*
Firearm Deer	0.012	15	*22*	43	*48*	58	*44*	57	*49*	48	*44*	21	*36*
Muzzleloader Deer	0.007	3	*7*	12	*15*	20	*14*	25	*15*	9	*14*	6	*11*
Archery Deer	0.000	1	*10*	20	*21*	27	*20*	37	*22*	15	*20*	9	*16*
Spring Turkey	0.005	3	*8*	19	*17*	28	*15*	14	*17*	11	*15*	9	*12*
Fall Turkey	0.052	0	*2*	8	*5*	8	*4*	2	*5*	2	*4*	3	*3*
Duck	0.006	20	*25*	36	*56*	66	*51*	69	*57*	56	*51*	35	*41*
Geese	0.001	13	*17*	22	*38*	46	*35*	56	*39*	33	*35*	22	*28*
Grouse	0.507	7	*12*	22	*26*	25	*24*	33	*27*	23	*24*	21	*19*
Pheasant	0.730	60	*54*	117	*119*	110	*109*	108	*122*	114	*110*	94	*89*
Dove	0.394	3	*5*	8	*11*	14	*10*	11	*11*	7	*10*	11	*8*
Rabbits	0.231	1	*4*	7	*9*	11	*8*	13	*9*	5	*8*	8	*7*
Squirrels	0.228	2	*4*	7	*8*	12	*7*	10	*8*	3	*7*	6	*6*

[a] Observed and Expected Values

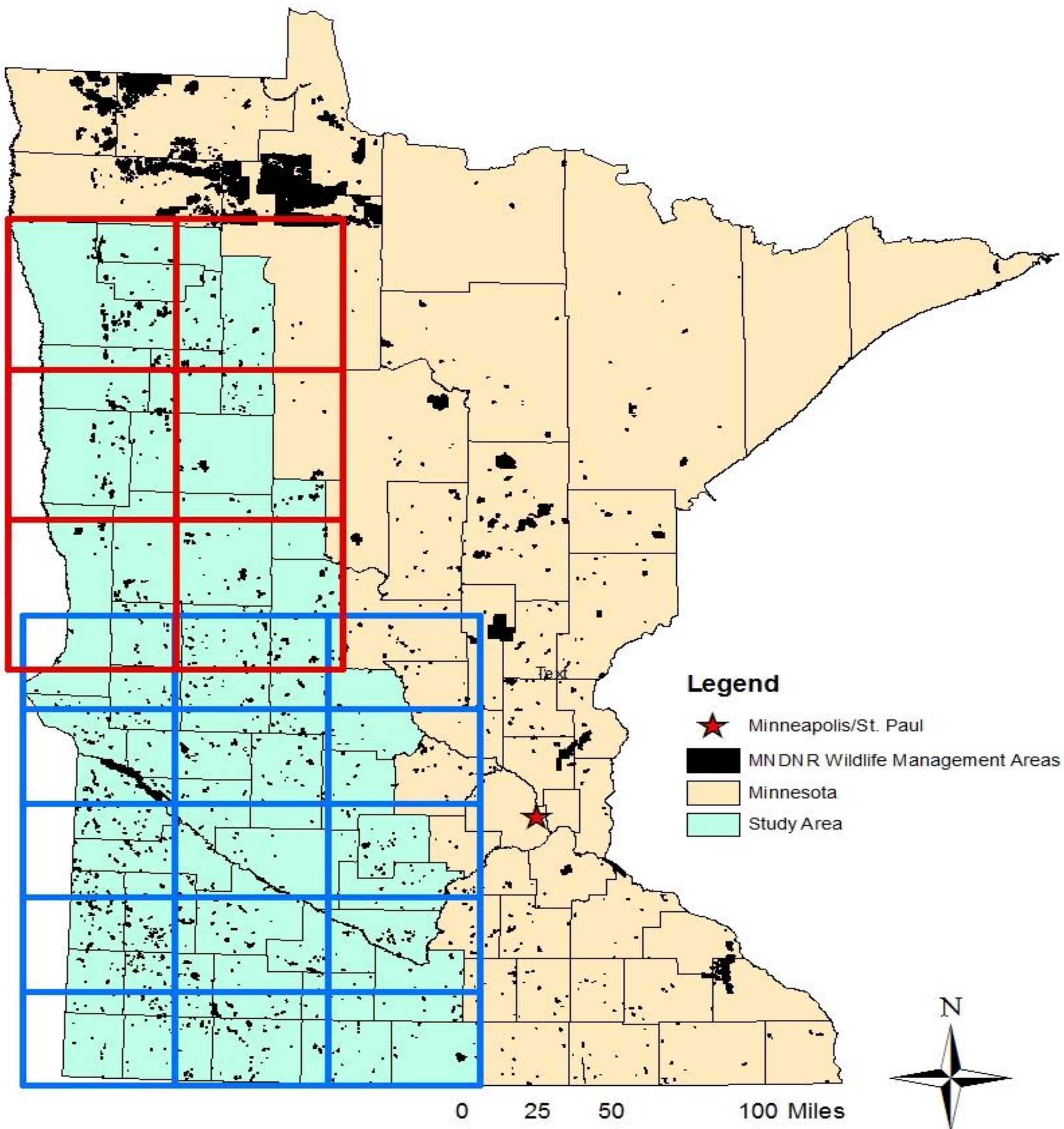

Figure 1. Overlay of northwest and southwest grid blocks on corresponding counties. Note the larger counties in the northwest were sampled with larger, fewer grids, while the smaller counties in the southwest were sampled using a higher number of smaller grids. A layer of WMA sites throughout the state is included.

CHAPTER 2

Estimating visitor use on dispersed, state-owned land in Minnesota

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DIGEST

In Minnesota, the Wildlife Management Area (WMA) system encompasses more than 0.52 million hectares across 1,400 units. In order to better understand their visitors to these areas of high-quality habitat, wildlife managers want to know how many individuals use the WMA system and ultimately, the recreational experiences they are hoping to achieve. From September to December 2015, we counted vehicles using a randomized sample of WMA units in order to estimate total visitation during the fall 2015 hunting season. Our field observations were conducted during single point-in-time driving surveys that occurred over 10 weekends. We used a linear mixed-effects model to estimate visitation based on mean vehicle counts per site (averaged over the hunting season) and WMA site attributes (e.g., unit size, presence of popular game species, and distance to points of interest). We refined our point-estimate using intensive observations conducted on a subsample of study WMAs and self-reported hunting trip data from a companion study of WMA users. We determined the average probability of intercepting a vehicle and a unique visitor during a normal sampling day was $P_I = 0.229$ and $P_U = 0.467$ respectively. We used these adjustment factors, along with self-reported hunting party information, to obtain a final estimate of 32,374 weekend user groups, 61,122 individual weekend visitors, and 130,942 total weekend visits to WMAs in our study area during the 2015-2016 hunting season.

KEYWORDS: human dimensions, hunting access, Minnesota, visitor estimates, Wildlife Management Areas

INTRODUCTION

The Minnesota Department of Natural Resources (DNR) acquires, manages, and maintains Wildlife Management Areas (WMAs) to provide critical ecological and societal benefits to both wildlife and recreationists. The WMA land classification was established in 1975 (Minnesota Outdoor Recreation Act of 1975); the current system encompasses 0.52 million hectares and 1,400 units. The WMA system provides areas of high-quality habitat for “wildlife production, public hunting, trapping, fishing, and other compatible outdoor recreational uses" throughout a variety of ecological landscapes in Minnesota (http://www.dnr.state.mn.us/wmas/index.html). Minnesota's WMAs are an important hunting destination because there are no entrance fees and they are often located in areas that are dominated by private land ownership. Publicly available hunting land is crucial across the U.S.; in 2006, 4.9 million hunters indicated they used public land (U.S. Department of the Interior 2006; Harris 2011). State agencies have also recognized both the demand and importance that public lands provide to hunters (Knoche and Lupi 2012). These lands also provide access for hunters to obtain meaningful, satisfactory experiences that yield personal and societal benefits (Mayer et al. 2009; Manfredo and Driver 2002). Visitor-reported benefits include time spent outdoors, seeing game, improving skills, and developing positive memories as important outcomes to their outdoor experiences (Manfredo and Driver; 2002; Mehmood et al. 2003; Larson et al. 2014).

Hunting and other recreational activities on public lands provide numerous benefits to individuals and communities, and accessible public lands are critical for enduring recreational opportunities. In addition to these value-based benefits, state and local economies also benefit from hunters using these areas (Cline et al. 2011; Schorr et al. 2014). Beyond the hunting licenses and fees that are used to acquire and maintain public land (Heffelfinger et al. 2013), hunters also spend more than $38.3 billion on non-commercial related hunting expenses each year (Arnett and Southwick 2015).

For management purposes, it is important to have accurate information on the people who use public lands for recreational activities. While hunter numbers are measured through license sales and fees (U.S. Department of the Interior 2017) and individual states annually track licenses sales trends, visitor use on public lands is more difficult to measure because users typically are not required to register or pay user-fees. Furthermore, these sites are often dispersed across the landscape, making it unlikely that hunters will encounter agency personnel. Thus, obtaining accurate and cost-effective estimates of public land use is a challenging sampling and estimation problem (Eagles et al. 2000, Kelly et al. 2006; NPS 2002). Nevertheless, user information is an important component of land management, as managers need to know who, where, and why visitors are accessing public lands. In addition, estimates of visitation rates and total users, along with information on average trip expenditures, can be applied to formulate reasonable estimates of total economic benefits associated with public land use (Knoche and Lupi 2012; Knoche and Lupi 2013).

Statistical models can help address visitor estimation problems, but there are several assumptions that researchers must work with beyond the knowledge that these areas provide unrestricted access for a largely unknown user groups. The assumptions we included in our study allow for individuals who 1) may visit more than one site, and 2) observations made at individual sites reflects user visits, but not necessarily individual visitors (Fulton and Anderson 2003; Johnston and Tyrrell 2003). The primary advantage of using a model-based estimator is the ability to estimate total visitors across numerous sites, when logistical and financial constraints would otherwise prevent a full census. In doing so, model-based estimations can link site visitation and participant rates to actual user counts (Johnston and Tyrrell 2003). While there have been significant advances in the tourism field to build models for estimating regional visitation (Deville and Maumy 2004; Kelly et al. 2006), estimating visitation to a particular set of sites across broad landscapes are still being developed (Fulton and Anderson 2003, English et al 2002).

The purpose of our research was to obtain an estimate of visitation rates (groups/site-day) to determine total individuals using Minnesota WMAs during peak-use times (weekends) during the fall hunting season (September through December). We were also interested in identifying WMA attributes that are related to visitation rates. We focused on WMAs because of their importance in terms of public land access in Minnesota, their relative abundance, spatial distribution across the state, and their ability to provide areas of wildlife production for consumptive and non-consumptive purposes. This information is intended to help wildlife managers understand patterns in WMA use during the hunting season, provide baseline data needed to determine economic impacts of hunting on local economies, and help policy makers understand the importance of WMAs to Minnesotans.

STUDY AREA

Our study was conducted in the historic prairie pothole region of Minnesota, USA (Figure 1) during most of the fall hunting season of 2015 (26 September – 6 December). The grassland-wetland ecosystem of this region provides essential habitat for wildlife and is productive agricultural land (Gascoigne et al. 2013). The area is predominantly privately-owned; state-owned land makes up less than 5% of the area for most of these counties (MN DNR 2014; Land Management Information Center 1983). The study area encompassed 43 counties and 1,061 WMAs totaling 119,698 ha, or 75% of the total number of WMAs in the state. The WMAs in our study area covered a wide range of habitats, and depending on the site, provided hunting opportunities for white-tailed deer (*Odocoileus virginianus*; 90% of WMAs), ring-necked pheasants (*Phasianus cholchicus*; 75%), waterfowl (75%), and other small game species (88%), including ruffed grouse (*Bonasa umbellus*) cottontail rabbits (*Syvilagus floridanus*) and squirrels (*Sciurus* spp.).

METHODS

We divided the study area into 2 regions (northwest and southwest) based on the differences in relative abundance and size of WMAs found in these areas (Figure 1). The northern study area is best characterized by larger counties, and fewer but larger WMAs. Conversely, the southern study area has smaller counties and more, albeit smaller WMAs (Table 1). We opted to survey WMAs using cluster sampling to reduce overall project costs and maximize the number of WMAs surveyed in a short time span (Ahmed 2009). Using ArcMap 10.3, we created a sampling grid for each region, with grid size serving as a function of average county size within each region. Within each of the 21 grid blocks, we randomly selected 1 WMA and the 9 nearest neighboring WMAs to create a driving route for sampling visitor usage. The number of WMAs per route was modified in some cases because of access issues (e.g., closed to hunting, located on an island) and to ensure equal sampling effort. The final sample consisted of 228 WMAs organized into 21 driving routes (6 routes in the northwest and 15 routes in the southwest), which represented 21% of the WMAs in the sampling frame. WMAs are accessible from all points along their boundaries, which makes it difficult to count visitors when they are not required to park in specified areas (such as gated, controlled parking lots). Due to uncontrolled access and the dispersed nature of these sites, we surveyed each unit by counting vehicles parked along boundary edges or in parking lots, as they were available. We chose to follow procedures used to measure visitors at U.S. Fish & Wildlife Service Waterfowl Production Areas (WPAs) in western Minnesota and observed in visitors the field, as opposed to aerial estimators, seismic or infra-red counters, or game cameras (Fulton and Anderson 2003).

Field Survey Protocols

We measured visitor use over 20 weekend days from September 26, 2015 (the first weekend of waterfowl hunting) to December 6, 2015. We based our survey protocols on techniques used to quantify visitor use on federal, public lands (Gregoire and Buyoff 1999, Watson et al. 2000), including Waterfowl Production Areas in western Minnesota (Fulton and Anderson 2003). We opted to survey only during the fall season because levels of recreational use on isolated public properties in western Minnesota during non-hunting seasons is less than 5% of fall use levels (Fulton and Anderson 2003). We visually observed vehicles (user groups) at each WMA once per sample day (point-in-time intercept method), recorded unique identifying information (license plate numbers), and placed informational letters on windshields of all intercepted vehicles. The informational letters briefly explained the research project and asked WMA visitors to record information about the people in their party (ages of visitors, time spent at individual sites, date). Finally, intercepted visitors were asked to provide contact information for a future, more detailed mail-survey that would ask about hunting habits, attitudes, beliefs, and trip expenditures. Returned intercept letters were used to create a database of WMA visitors who were sent mail-surveys in spring 2016 (see Chapter I). Sampling was halted after December 6 because of the decline in the number of vehicles intercepted.

Because WMAs in our study were organized into driving routes, efforts were taken to ensure WMAs were not sampled at the same time of day each week. Technicians alternated the order they visited individual WMAs on each route between weekend days, and the order that overall routes were visited each weekend. For example, during the first weekend, a technician would drive forward on route A on Saturday and drive forward on route B on Sunday; during the second weekend the technician would drive backwards on route B on Saturday and then backwards on route A on Sunday. On a normal sampling weekend, each technician surveyed 1 route per weekend day over a 4 hour period in the morning. However, on weekends where we expected an increase in visitors (e.g., opening weekend of a season), technicians drove an additional route on Saturday afternoon to recruit more visitors for the self-administered spring mail survey. These afternoon shifts occurred on Saturdays during the first two weekends of pheasant season (October 10 and October 17, 2015) and the two weekends of firearm deer season (November 7 and November 14, 2015). We adjusted the starting time for intercept surveys based on legal shooting hours and sunrise times (Table 2).

In order to account for visitors who used WMAs in our study but were not observed during our single point-in-time intercept surveys, we conducted 5 spatially limited, intensive surveys. These surveys were intended to collect as many visitor counts as possible at a small number of locations over an entire day. Our intensive surveys were conducted over 3 Saturdays (October 31, one intensive survey; November 7, two intensive surveys; and November 14, 2 intensive surveys) at 18 different WMAs. To select the WMAs for intensive sampling, we randomly selected one of our 228 WMAs and then located the nearest 3-4 WMAs to create an intensive sampling route. Our intention was to visit each WMA in the intensive sampling route at least once per hour to measure visitation rates throughout the day, as described by Fulton and Anderson (2003) to estimate average trip duration and total number of user groups. Our surveys began at sunrise each day, and we surveyed at 4-5 WMAs in a continuous cycle (each WMA sampled 5-9 times per day) until sunset. We used data from the intensive surveys to identify peak-use times and to estimate the probability of observing a vehicle during our single point-in-time sampling. We used the latter to develop an estimate of total user-groups (vehicles) per site-day (i.e., mean car counts adjusted for probability of intercept).

Statistical Analyses

Model-based estimator – We estimated visitation rates and total weekend WMA user groups using a model-based estimator. We chose to use a model-based estimator rather than a design-based estimator (e.g., Fulton and Anderson 2003) because our sampling design, while providing a spatially balanced sample of WMAs, resulted in driving routes (WMA clusters) that crossed grid boundaries and therefore grid cells (potential strata) were not mutually exclusive and clusters were not well defined in the sampling frame. Furthermore, a model-based estimator allowed us to incorporate WMA site attributes from both observed and non-observed WMAs in the estimation process. For each of the 1,061 WMAs within our study area, we determined site attributes using

GIS data layers obtained from MN Geospatial Commons, (https://gisdata.mn.gov/dataset), with data processing accomplished using ArcGIS 10.3 (ESRI 2014). We obtained information on WMA name, county, areal extent, nearest town, game species present (including: white-tailed deer, ring-necked pheasants, waterfowl, small game, forest upland birds, sharp-tailed grouse [*Tympanuchus phasianellus*], turkey [*Meleagris gallopavo*], and doves [*Zenaida macroura*]), managed parking areas, dominant cover types, perimeter length, and easting/northing vectors. We also measured the Euclidian distance from each WMA to various points of interest: U.S. Fish and Wildlife Service WPAs, other WMAs, major roads, and towns of various population densities.

We used a linear mixed-effects model to explore the relationship between average car counts (average count for each site over the 20 weekend days sampled) and WMA attributes, with the goal of predicting mean car counts per weekend day for all WMAs in our sampling frame. We used route as a random effect to account for our clustered sampling design, and we treated all other WMA attributes as fixed effects. We fit our models using the 'lme4' package in the R Programming Language (Bates et al. 2015, R Core Team 2017). With the exception of area, all continuous predictor variables were normalized (centered and scaled) prior to analysis. Area was log-transformed to account for a positively skewed distribution. We started with a small set of models, based on logic and an exploratory data analysis of predictors only, where we looked at data limitations, correlations, and potential confounding. A priori, we expected WMA size (area) to have a strong, positive influence on mean car counts. We also predicted that distance to major roads would influence mean car counts, but we were uncertain about the direction of the effect. Likewise, we predicted that distance to metropolitan areas (e.g., Minneapolis/St. Paul and St. Cloud) might influence mean car counts, but we recognized this effect was partly confounded with other predictors (e.g., Easting and Northing). We recognized the presence of popular game species (ring-necked pheasants, ducks, small game, and white-tailed deer) might also be an important predictor of mean car counts, but it might be less important in our case because we averaged car counts over the fall hunting season. Furthermore, the presence of the 3 most popular game species (pheasants, ducks, deer) were positively correlated, especially on larger WMAs. We chose to use the presence of pheasants as a predictor because it better described variation among WMA units, although it was partly confounded with location predictors (i.e., Zone, Easting, Northing) because WMAs with pheasants were more common in the southern study zone. Thus, our starting model set consisted of:

Model A E(Y) = logArea + DistMajorRoad + Easting + Northing + (1|Route)

Model B E(Y) = logArea + DistMajorRoad + DistLargeTown + Pheasants + (1|Route)

Model C E(Y) = logArea + DistMajorRoad + DistLargeTown + Zone + (1|Route)

Based on residual plots from these models, we used a square-root transformation of the response variable, mean car counts per site-day, to meet the assumption of constant variance. We also used Moran's I statistic and a semivariogram (width = 1 mile) to investigate the need to account for a spatial correlation structure, but evidence for spatial correlation was lacking or weak and the random route effect accounted for our clustered sampling design. We compared models using the Akaike Information Criterion (AIC; Akaike, 1974). The best approximating model included fixed-effects for logArea, DistMajorRoad, Easting, and Northing. We then performed limited variable selection on this model using AIC and the "drop1" function in the R programming language (R Core Team 2017). Our final model (Model A2) consisted of fixed-effects for logArea, DistMajorRoad, and Northing, and a random effect for route. We evaluated the predictive performance of this model using a calibration plot, a pseudo-r-squared statistic, and K-fold cross-validation (Stone 1974, Nakagawa and Schielzeth 2013).

We then applied our mixed-effects model to the sampling frame (containing all 1,061 WMAs) to predict mean car counts per site-day for each WMA. Our random effect for route only applied to our sample of WMAs; therefore, our predicted mean values were based on the population-level mean function (i.e., where the random effect was set to 0). Next we extrapolated the predicted mean count per site-day to a total predicted mean car count for the season by multiplying by 22 (the number of weekend days in our survey season) and summing across WMAs. We only sampled on 10 weekends and therefore we assumed the 1 non-sampled weekend (Oct 31 – Nov 1, 2015) had a distribution of car counts similar to those observed on the 10 sampled weekends. We converted user-groups to visitors using the self-reported, average number of people per party (vehicle).

Adjustment for probability of intercept –We defined probability of intercept as the mean proportion of total daily user-groups (vehicles) that are observed in a single-visit survey. For each intensive survey, we determined the number of vehicles observed during each stop and total unique vehicles (based on license plates) observed per site-day. A priori we predicted that probability of intercept would be highest in the morning (period of highest hunter activity), lowest during mid-day, and increase slightly in the afternoon/evening. However, data from our point-in-time sampling was averaged over visits and time of day for analysis, and therefore we needed to compute an overall mean probability of intercept. To accomplish this while accounting for temporal differences in probability of intercept, we constructed a binary predictor for morning (<1200 hr) and afternoon/evening (>1200 hr) surveys, and then used the 'glm' function in the R Programming Language (R Core Team 2017) with an events-per-trial format and a binomial link function to estimate mean probability of intercept for morning and afternoon/evening surveys. We computed an overall mean probability of intercept, P_I, by weighting the predicted probabilities from the above model by the proportion of point-in-time surveys that were conducted in the morning and afternoon/evening, respectively. We then used P_I to compute a mean predicted visitation rate R (mean user groups/site-day, where R_i was averaged over sample WMA $i = 1, \ldots, 1{,}061$). We also fit a model where time was modeled as a continuous covariate (24-hr clock) in order to explore our a priori assumption about how probability of intercept varies with time of day.

Adjustments for unique user groups – Ultimately, but not in this publication, we wanted to relate mean trip expenditures/group to total unique user groups visiting WMAs on weekends during the hunting season. We assumed that most trips included at least 1 weekend, and therefore we used "weekend" (Sat and Sun) as our temporal unit for computing "unique" user groups and estimating total trip expenditures. We defined “unique” as the number of unique user groups that visited $\geq$1 WMA during a weekend visit that could encompass 1 or 2 hunting days. Our estimate of mean groups/site-day likely included user groups that visited $\geq$1 WMA/day and/or hunted both Saturday and Sunday. In other words, our estimate of the mean visitation rate R was likely positively biased due to the inclusion of non-unique groups in our sample data and when expanding to the sample frame using our model-based estimator. In order to adjust the point estimate for unique user groups, we had to consider both the proportion of user groups that visited multiple WMAs per day and hunted on both Saturday and Sunday of a weekend trip. If we define the former as P_{MSD} and the latter as P_{SS}, we can estimate total unique user groups per day, $\widehat{U}_d$, as the product of $\widehat{G}_d$ and 1-P_{MSD}, where $\widehat{G}_d$ is an estimate of total user group visits/day, adjusted for P_I, and the 2nd term subtracts users that visit >1 WMA/day. If we treat Saturday of any given weekend as our first sampling day, then we need to account for user groups that also hunted on Sunday. To get an estimate of total unique user groups per weekend, $\widehat{U}_w$, we set $\widehat{U}_w = \widehat{U}_d + \widehat{U}_d * [1 - P_{SS}]$, which is equivalent to $\widehat{G}_d * [1 - P_{MSD}] * [2 - P_{SS}]$. We defined $[1 - P_{MSD}] * [2 - P_{SS}]/* 2^{-1}$ as the mean probability of a user group being unique in any site-day count, P_U, and used P_U to compute an adjusted estimate of total unique weekend user groups for the 10 weekends in our sampling season. We initially attempted to compute P_U using license-plate data from our point-in-time samples, but our estimate of P_U was unrealistically high (0.97), which we attributed to the extremely low probability of intercepting user groups more than once in our point-in-time sampling design. Therefore, we used information in our follow-up mail survey to compute estimates of P_{MSD}, P_{SS}, and P_U. More specifically, we let P_{MSD} = the proportion of respondents that reported visiting >1 WMA per day (given trip duration = 1 day), and P_{SS} = the proportion of respondents that reported trip length > 1 day for detailed questions related to trip expenditures, trip duration, distance traveled, etc. We restricted our analysis to respondents that were intercepted during our point-in-time sampling (n = 277).

Bootstrap estimate of uncertainty – We had several endpoints of interest, with each being a product of multiple estimation parameters. For example, our estimate of mean visitation rate R was the product of $\sum_{i=1}^{N} E(Y_i|X_i)^2 / N$ and P_I^{-1}, where i = 1, …, 1,061 WMAs in our sample frame. Likewise, our estimate of total weekend visitors for the hunting season, π_V, was: $\hat{\pi}_V = R * N * 22\ days * P_u * \bar{S}$, where $\bar{S}$ was our estimate of mean group (party) size. Because each of our endpoints was the product of estimated parameters and each parameter had some sampling uncertainty, we bootstrapped the entire estimation procedure 10,000 times to generate 90 percentile confidence bounds for our endpoints. Our bootstrap included both parametric and non-parametric (sampling with replacement) methods, depending on the estimation parameter being bootstrapped. More specifically, for each bootstrap iteration, we:

1. Randomly selected, with replacement, 21 driving routes (WMA clusters) and then randomly selected, with replacement, 9-12 WMAs within driving routes. This approach accounted for both our random selection of WMA clusters but also variation in cluster size. We then used the bootstrap sample of WMAs to create a bootstrap dataset of car counts for step 2.

2. We fit our best approximating linear-mixed model to the bootstrapped dataset (created in step 1) to generate predicted mean car counts/site-day for the entire sampling frame. We assumed our model structure was correct and did not attempt to account for model selection uncertainty in the bootstrap. We justified this choice based on our small model set (3 models) and the fact we did very limited variable selection. Furthermore, exploratory analyses suggested the distribution of predicted mean counts was similar among the 3 models. Nevertheless, we acknowledge that our estimate of sampling uncertainty does not include model-selection uncertainty.

3. To generate bootstrap estimates of P_I, we randomly selected a sample of intensive-survey sites, with replacement, and recomputed mean probabilities of intercept using the same logistic regression model and data structure used previously (i.e., using an events per trial format with a binary predictor for morning vs afternoon/evening surveys). We again computed P_I by weighting predicted probabilities of intercept by the proportion of point-in-time surveys conducted in morning vs. afternoon/evening, except we allowed for some binomial variation in the weights by treating the frequency distribution of point-in-time surveys with respect to time-of-day as random variables drawn from a multinomial distribution with probabilities equal to the observed sampling weights.

4. To generate bootstrap estimates of P_U, we treated P_U as a random variable drawn from a beta distribution with $\alpha = \left(\frac{1-\hat{P}_U}{\widehat{Var}(\hat{P}_U)} - \frac{1}{\hat{P}_U}\right) * \hat{P}_U^2$, and $\beta = \alpha * \left(\frac{1}{\hat{P}_U} - 1\right)$.

5. To generate estimates of mean group size $\bar{S}$, we randomly sampled with replacement from the observed vector of group sizes and recomputed $\bar{S}$ for each bootstrap iteration.
6. We then recomputed each endpoint for each bootstrap iteration and stored the values in a matrix, which we used to summarize the bootstrap distribution of each endpoint and contributing parameter.

RESULTS

Summary Statistics

We conducted 1,042 hr of point-in-time intercept surveys over 10 weekends during our 2015 field season. Surveyors intercepted 2,093 vehicles on 228 WMAs (range: 0 to 66 vehicles/site) during the sampling season. Sampling effort varied over the sampling season, with more effort on Saturdays associated with the ring-necked pheasant opener and deer-season weekends (n=2) in order to increase our intercept list of users for the follow-up mail survey (Figure 2). However, we averaged car counts over the sampling season by WMA (i.e., with each sample day getting equal weight); thus, our response metric (mean observed car count/WMA/day) should be representative of average use of WMAs on weekend days during the hunting season, especially after adjusting for probability of intercept. Furthermore, the average number of visits (survey days) per WMA was 10.9 d (median = 11; range: 4 to 17), which indicates that most WMAs were surveyed at least 1x per weekend. Eighty-six percent of our intercept surveys were conducted in the morning (<1200 hr) and 56% of the surveys were conducted on Saturday. We distributed 2,046 mail-survey invitations to WMA users during the field season and 405 were returned with information about their party (20%

return rate). Party size ranged from 1 – 11 people, with an average of 1.89 people per vehicle. The average length of stay per WMA visit was 4.3 hr (range: 0 to 17.5 hr).

Naïve visitation rates (mean observed cars/site) ranged from 0.00 to 6.00 cars/site-day (median = 0.50, mean = 0.83), although the mean rate was similar between the two study areas (northwest: n = 66 sites, $\bar{x}$ = 0.82 cars/site-day; southwest: n = 162 sites, $\bar{x}$ = 0.84 cars/site-day). We failed to observe visitors at only 23 WMAs (10%; 11 in north zone, 12 in south zone) during the sampling season, but 99.6% of WMAs had at least one sampling occasion where zero cars were observed. Our best-supporting model suggested that naïve visitation rates were positively correlated with WMA size and distance to nearest major road, and increased on a south-to-north gradient (Figure 3). The predictor "Easting" was also in the starting model but the effect was small (95% CI on $\hat{\beta}$ = -0.095 to 0.034) and variable selection based on AIC suggested that it could be removed (Table 3). Therefore, our final model for predicting naïve mean visitation rates included fixed effects for logArea, DistToMajorRoad, and Northing. The marginal R^2 statistic (Nakagawa and Schielzeth 2013) for our mixed model was only 0.442, but the calibration plot (Figure 4) indicated a reasonably good relationship between observed and predicted mean counts (intercept = –0.102, SE = 0.089; slope = 1.31, SE = 0.103), except for WMAs with relatively large naïve visitation rates (>1.5 cars/site-day; 15% of WMAs) where the model tended to underestimate E(Y). Thus, our estimates of mean naïve visitation rate and total group visits to WMAs during the sampling season, derived by applying our predictive model to the sampling frame, are likely conservative.

Probability of intercept – As predicted, probability of intercept P_I was highest in the morning, declined toward mid-day, increased in the afternoon, and was lowest in the evening (Figure 5). When we modeled time-of-day as a binary predictor (morning: ≤1200 hr; afternoon/evening: >1200 hr), the probability of intercepting a vehicle during morning surveys (P_I = 0.244, SE = 0.033) was higher than during afternoon/evening surveys (P_I = 0.135, SE = 0.022). Given that 86% of our point-in-time surveys occurred in the morning, our estimate of $\bar{P}_I$ was more heavily weighted toward morning surveys (i.e., $\hat{\bar{P}}_I$ = 0.229). Thus, on average, our point-in-time surveys intercepted 23% of total user groups visiting WMAs on any given weekend day during the hunting season.

Adjustment for unique user groups – We received mail-back surveys from 245 visitors who were intercepted during point-in-time surveys and provided useable information on trip length (mean trip length = 3.5 days, range = 1 – 28 days). Of these visitors, 64% reported taking trips >1 day in duration. Thus, based on the assumption that most trips encompass at least 1 weekend, our estimate of the average proportion of user groups that hunt both days of a weekend, $\hat{P}_{SS}$, was 0.641 (SE = 0.031). In our mail survey we failed to collect information on total number of trips; however, we received 99 useable hunt summaries (by county and target species) where the respondent reporting hunting 1 day and using at least 1 WMA. We used this information to estimate the parameter P_{MSD}, which we defined as the proportion of user groups that visited >1WMA/day. Based on these data, 45% of pheasant hunters (*n* = 78 hunt summaries), 7% of waterfowl hunters (*n* = 15 hunt summaries), and 33% of deer hunters (*n* = 6 hunt summaries) reported visiting >1 WMA/day. We then weighted these point estimates by the relative distribution of total hunt summaries (n = 291) by species (0.564, 0.032, 0.117 for pheasants, waterfowl, and deer, respectively), which resulted in $\hat{\bar{P}}_{MSD}$ = 0.313 (SE = 0.027). We then substituted our estimates of P_{SS} and $\bar{P}_{MSD}$ into equation $P_U = [1 - P_{MSD}] * [2 - P_{SS}] * 2^{-1}$ to get an estimate of the average proportion of total WMA user groups, adjusted for P_I, that were unique to any given sample day, $P_U = 0.467$ (SE $= 0.031$).

Primary Endpoints and Estimates of Uncertainty – The mean predicted visitation rate, adjusted for P_I, was 2.97 user groups/WMA/day (90% CI: 2.41–3.96; range among WMAs: <0.1 to 12.9). The estimated total number of user group visits and visitors (non-unique) to WMAs in our sampling frame during the 22 weekends of the 2015 hunting season was 69,355 (90% CI: 56,219 to 92,334) and 130,942 (90% CI: 105,314 to 174,605), respectively. We estimated there were 32,374 (90% CI: 25,960 to 43,344) unique weekend user groups and 61,122 (90% CI: 48,619 to 82,270) unique weekend visitors.

DISCUSSION

This research was designed as a first-of-its-kind measurement of users of Minnesota's extensive WMA system. As such, there were multiple project goals, including estimating visitation and recruiting participants into a mail-back survey that measured use, attitudes, beliefs, and economic activity. To generate that estimate, we intercepted visitors in a structured and randomized (though clustered) fashion, rather than spend more time at a smaller number of larger, more popular WMAs. This design allowed enabled us to determine the probability of intercept and probability of unique visitors from supplemental information gathered in the field and through the mail-back survey. We showed that over 100,000 non-unique visitors used WMAs in our study area just during the hunting season, which substantiated other research on the importance of public lands for hunting (Montgomery and Blalock 2010; Knoche and Lupi 2012). However, we believe more observational data would have strengthened our final estimate (Smith 1995).

Many of our a priori predictions about visitation rates were supported by the data, including: 1) WMA size had a strong positive influence on mean car counts, 2) distance to major roads was positively correlated with visitation rate, and 3) visitation rates were highest in the morning compared to the afternoon and evening. In addition, the positive correlation between visitation rates and distance to major roads suggests that WMAs do not need to be located directly near major roads in order to be utilized, and thus wildlife managers concerns about ease of access may be less important than originally believed.

Our results demonstrate that outdoor recreation is important and hunting in particular drives visitors to these small, dispersed areas in Minnesota. Previous research has indicated there are multiple benefits to spending time outside and that continued visitation to special locations can form place attachment bonds to areas where people recreate (Payton, Fulton, and Anderson 2005; Anderson and Fulton 2008; Moore and Graefe 1994). We believe that WMAs are an important part of the Minnesota hunting tradition and provide the only opportunities for many people to hunt in this region (Chapter 1). It is important that WMAs are acquired, maintained, and improved to remain attractive to resident and nonresident hunters. Hunter numbers are declining nationally

(U.S. Department of the Interior; 2012; Vrtiska et al. 2013) and as hunting license sales provide the primary capital for wildlife management, the reduction in hunters means a reduction in available resources for wildlife agencies (Schorr et al. 2014). Through WMA maintenance and improvement, these areas should remain an important cornerstone to Minnesota hunters.

We suggest that future research examine the differences between public and private land owners in these areas (see Knoche and Lupi 2012). Although WMAs were created to produce high-quality wildlife habitat, their relatively small size and juxtaposition with intensively farmed private lands (and roads) may create future hunter crowding issues (Diefenbach et al. 2005). Other research has reported that roads influenced where hunters chose to hunt and most harvest management programs establish season regulations and quotas without consideration of hunter distribution or effort (Thomas et al. 1976; McCullough 1996).

Finally, this project highlighted several important factors in obtaining visitor estimates, including limitations to our original data collection. In the future, the intercept letter placed on all vehicles should include several more questions including "How many WMAs did you visit today", "How many days do you intend to spend on WMAs during this hunting trip", and "How many trips do you intend to take this year". We believe that the response rate to this smaller questionnaire given to individuals observed in the field at the time of the activity would yield higher results than sending out a survey months later. We collected license plate data during this study; however, we found that it grossly overestimated unique visitors and proved of limited utility. Finally, while there are multiple methods for collecting visitor use data (seismic counters, aerial photography, infra-red; Fulton and Anderson 2003), due to budget and time constraints inherent with a project of this scale, we believe direct visitor observations were best suited for the dispersed, open-access nature of this type of public land system. Furthermore, we suggest future research investigate mid-week use of public lands, as our data collection only occurred on weekends. While previous research has indicated use-levels during the week might be lower, we believe understanding the difference between mid-week and weekend users is important.

MANAGEMENT IMPLICATIONS

Land managers and policy makers recognize the importance of public lands for both conservation and recreational activities. Potential land acquisitions are often challenged by local units of government and state legislatures through the enactment of 'no net public land gain' policies. Consequently, it has become increasingly difficult to acquire new lands in a polarized management environment. Wildlife managers are often required to present proposed acquisitions to local governments (e.g., township boards, city councils) and are questioned about acquiring parcels to the detriment of historic activities (e.g., agricultural production). Although our study examined WMA use across a broad area, we believe our results can be used at the local level in an effort to increase the amount of public land available for hunting. We believe that wildlife managers must provide a rational basis for acquisition and ultimately, high quality recreational experiences; thus, it is critical they understand the people who are using public lands. Using the visitor estimates found here, MN DNR will be able to apply trip expenditure data obtained during the mail-back survey to estimate economic activity generated by hunters during a single season. In addition, these visitor estimates can used as an example to local units of government and state legislatures to demonstrate the importance of public lands in terms of bringing hunters to their community.

Table 2.1. Comparison of differences between northwestern and southwestern study areas. Grid sizes used to select WMA sites for sampling were a reflection of the area differences. The northwest area contains larger counties, and larger but few WMAs. Comparatively, the southwest study area contains small counties, and smaller but more numerous WMAs.

	Northwest Region	Southwest Region
Number of Counties	14	29
Total Area (km^2)	35,835	51,621
Average county size (km^2)	2,558	1,779
Total WMAs per region	313	748
Average WMA size (ha)	181.8	84.0

Table 2.2. WMA sampling schedule for fall 2015, with start times that reflect legal shooting hours (i.e., waterfowl and big game shooting hours begin ½ hour before sunset; pheasant shooting hours begin at 9am). During weekends where we anticipated heavy use of WMAs by hunters, we conducted additional surveys on Saturday afternoons to recruit as many participants as possible into the mail-back survey database. October 31 and November 1 were skipped in an effort to conserve funds and to allow us to continue sampling into December.

Weekend IDs	Date	Start Time	Afternoon Sampling	Major Events
Weekend 1	26-Sep	6:30 AM	-	Waterfowl Opener
	27-Sep	6:30 AM	-	
Weekend 2	3-Oct	6:30 AM	-	
	4-Oct	6:30 AM	-	
Weekend 3	10-Oct	8:00 AM	2:00 PM	Pheasant Opener
	11-Oct	8:00 AM	-	
Weekend 4	17-Oct	8:00 AM	2:00 PM	
	18-Oct	8:00 AM	-	
Weekend 5	24-Oct	7:30 AM	-	
	25-Oct	7:30 AM	-	
31-Oct to 1-Nov: not sampled				
Weekend 6	7-Nov[1]	7:30 AM	1:00 PM	Firearm Deer Opener
	8-Nov	7:30 AM	-	
Weekend 7	14-Nov[1]	7:30 AM	1:00 PM	Final Weekend of Firearm Deer Hunting
	15-Nov	7:30 AM	-	
Weekend 8	21-Nov	7:30 AM	-	
	22-Nov	7:30 AM	-	
Weekend 9	28-Nov	8:00 AM	-	Thanksgiving
	29-Nov	8:00 AM	-	
Weekend 10	5-Dec	8:00 AM	-	
	6-Dec	8:00 AM	-	

Table 2.3. Comparisons using number of parameters (K), Akaike's Information Criterion (AICc), relative differences (ΔAICc), relative likelihood of the model (ModelLik), model weights (AICcWt), log-likelihood of model (LL), and cumulative model weight (Cum.Wt) for models predicting naïve visitation counts, including a null model. Predictors (WMA attributes) used in modeling were selected through a priori predictions, however, we refined our findings with a limited variable selection to achieve this top model.

Model Names	K	AICc	ΔAICc	ModelLik	AICcWt	LL	Cum.Wt
Model A2	6	184.8	0.0	1.000	0.475	-86.233	0.475
Model A	7	186.0	1.2	0.556	0.264	-85.755	0.739
Model B	7	186.7	1.8	0.399	0.189	-86.087	0.928
Model C	7	188.6	3.8	0.151	0.072	-87.059	1.000
Null Model	3	308.3	123.4	0.000	0.000	-151.082	1.000

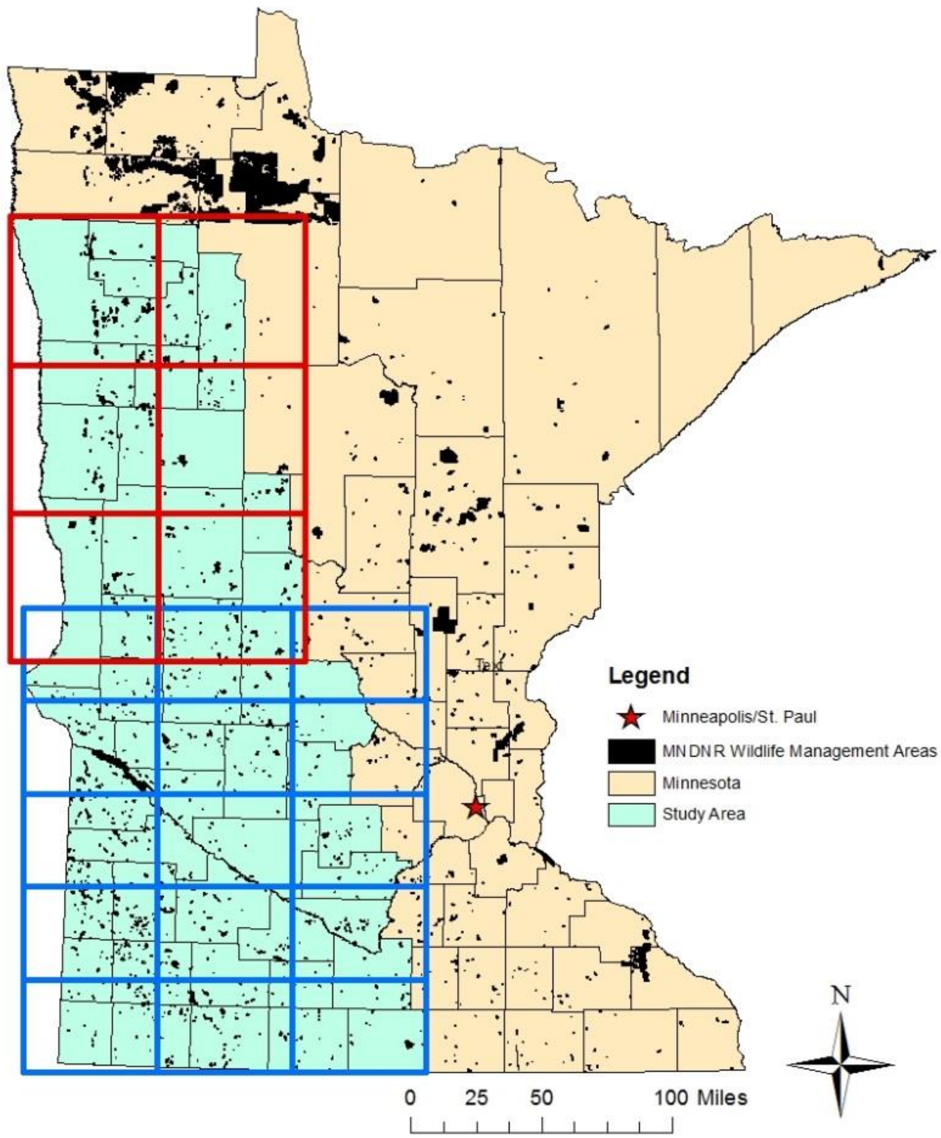

Figure 2.1. Overlay of northwest and southwest grid blocks on corresponding counties. Note the larger counties in the northwest were sampled with larger, fewer grids, while the smaller counties in the southwest were sampled using a higher number of smaller grids.

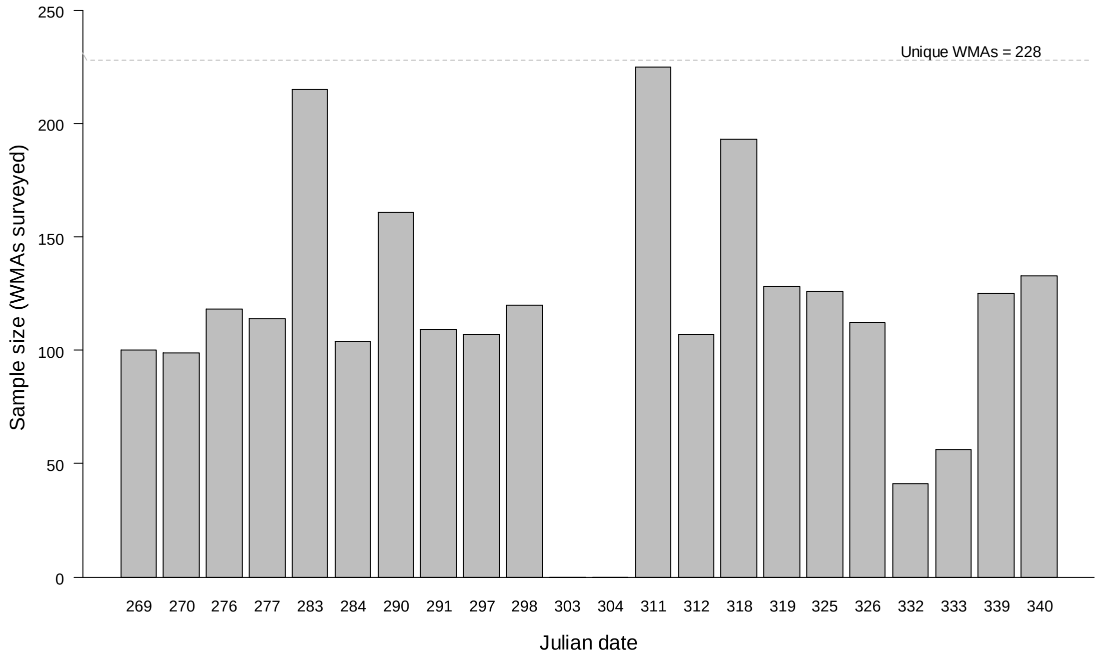

Figure 2.2. Bar graph depicting sampling effort for each day we conducted WMA surveys. Note that no sampling occurring during Julian dates 303-304, and we had a reduced number of technicians sampling on Julian dates 332 and 333. Additionally, we conducted an extra sampling shifts on the following Saturday afternoons to recruit additional WMA users into a database to be sent a mail-back, user-experience surveys: Julian dates 283, 311, and 318.

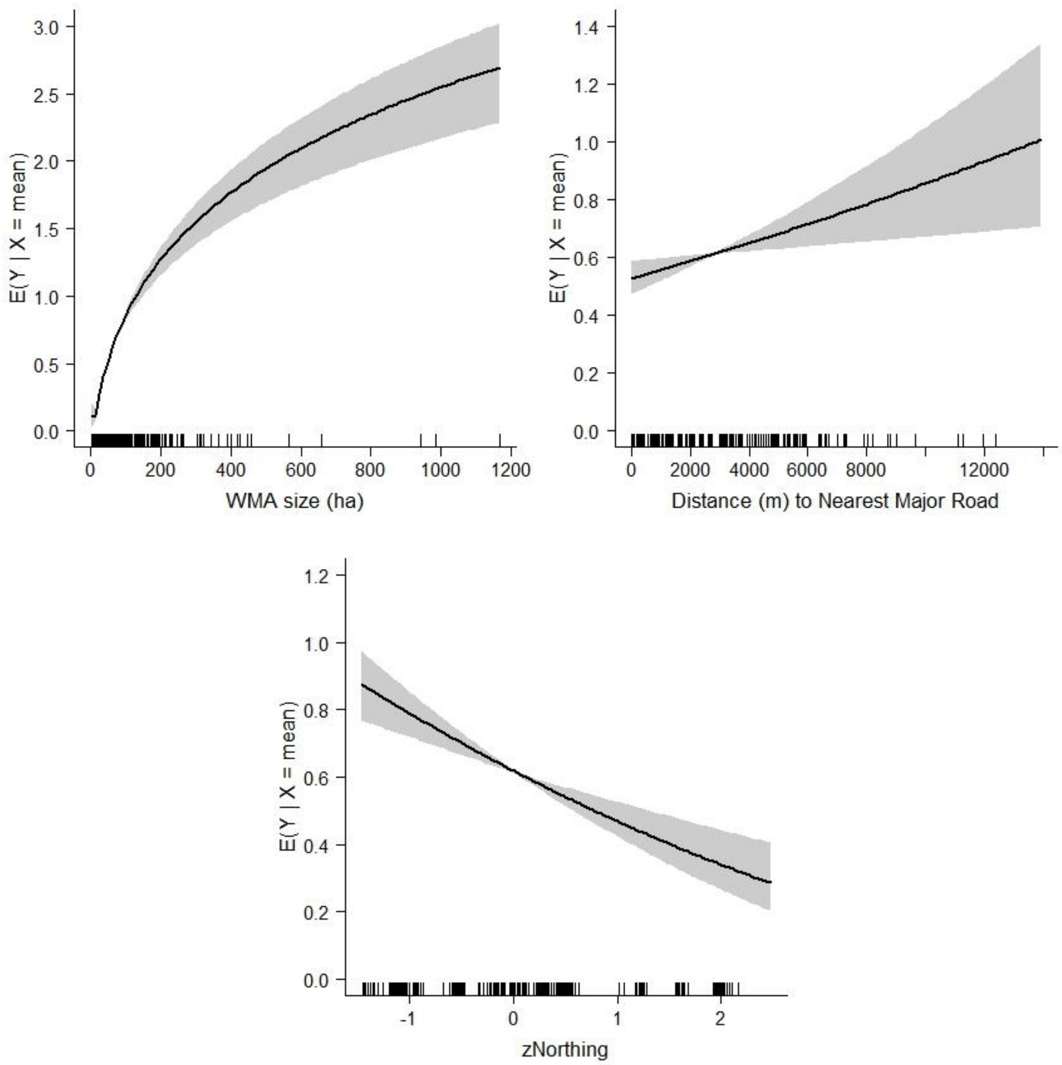

Figure 2.3. Relationship between naïve mean visitation rates and select WMA attributes. Rugs along x-axis represent distribution and range of WMA attributes. of Shaded regions represent 90% confidence intervals.

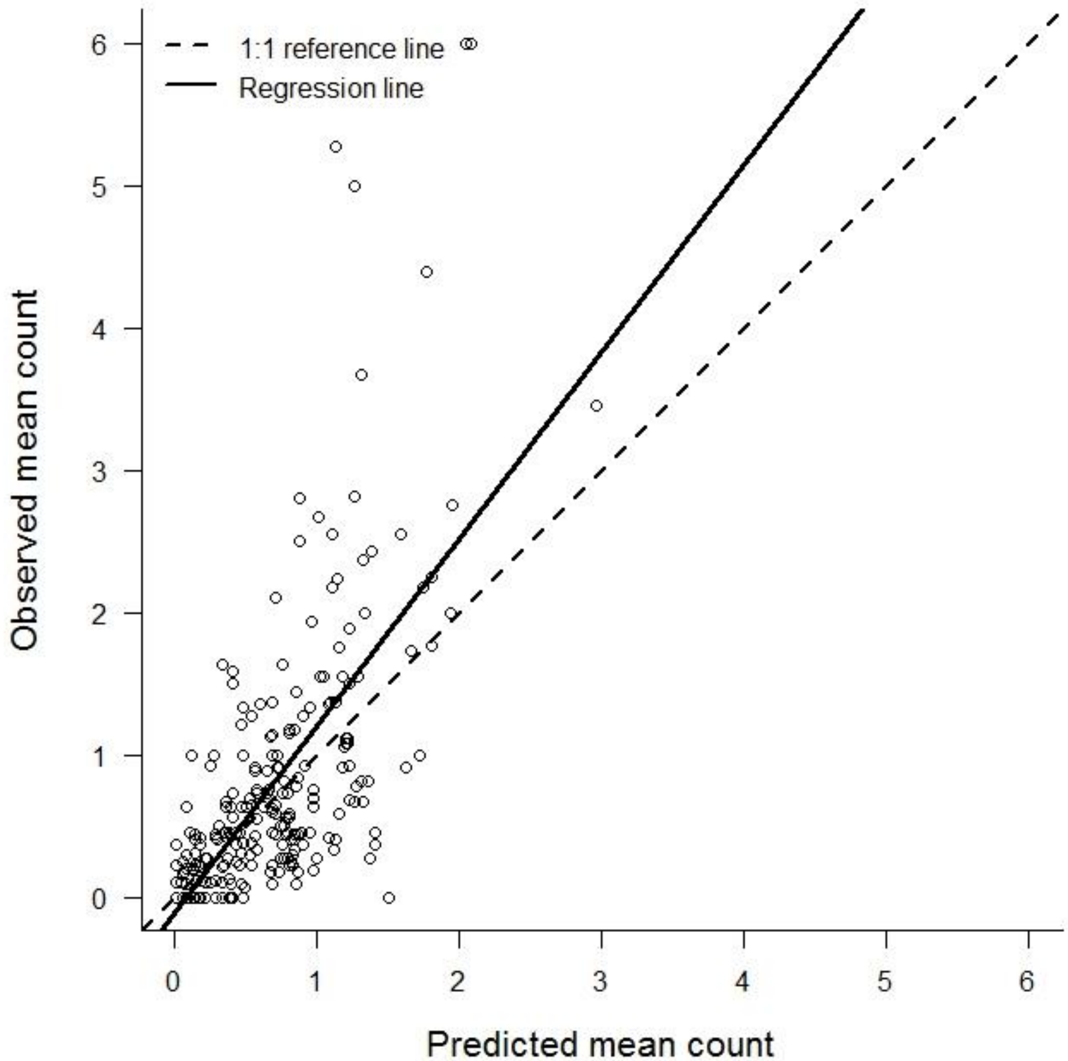

Figure 2.4. Modeling predictive performance of the best model (Model 2A from Table 3) using a calibration plot. The dotted line represents a 1-1 ratio depicting perfect predictive powers.

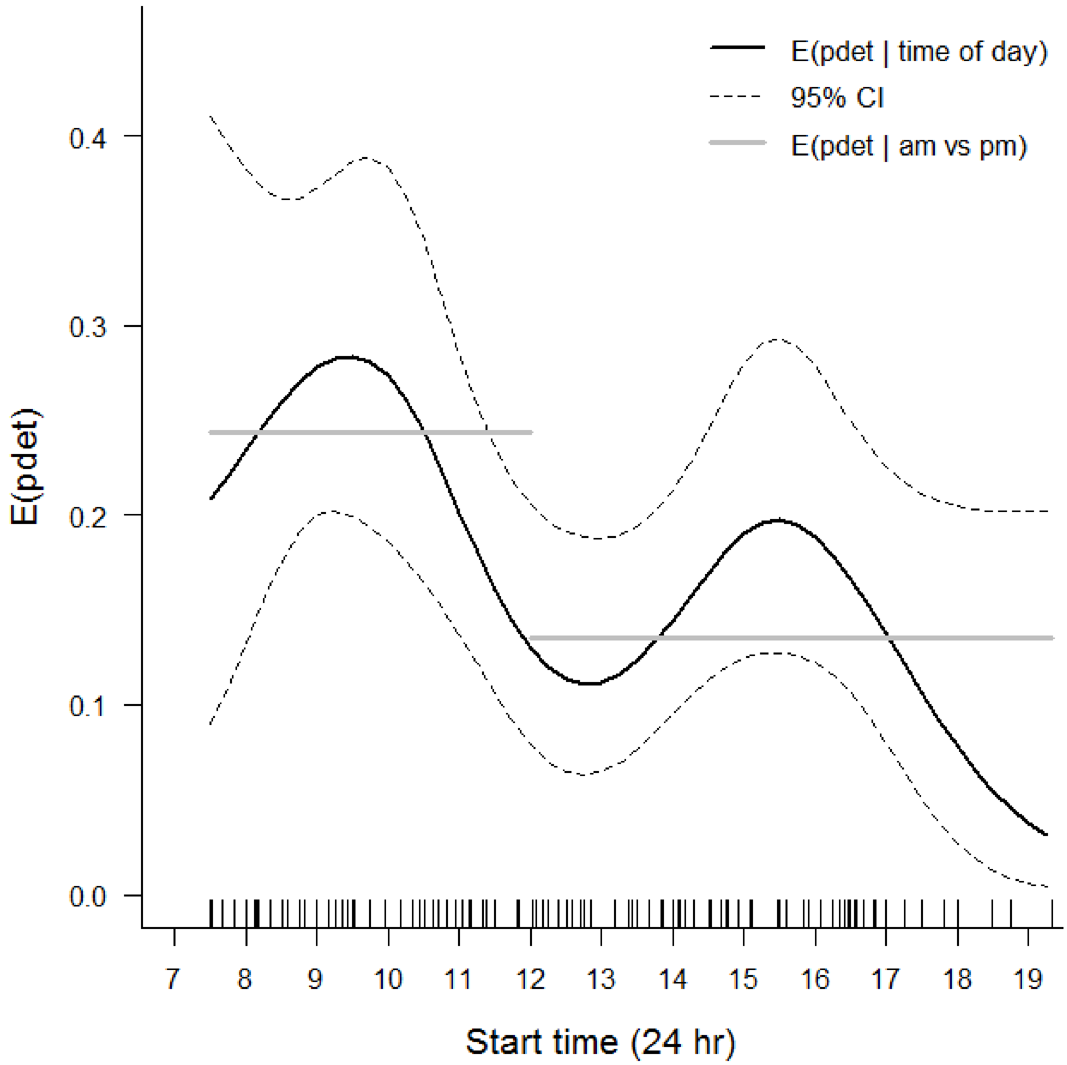

Figure 2.5. Results of our intensive surveys which allowed us to estimate probability of intercept during a single point-in-time observation. WMA use is highest in the morning, with a secondary peak in the afternoon, and lowest use was seen during the evening. Using time-of-day as a binary predictor (morning: $\leq$1200 hr; afternoon/evening: >1200 hr), the probability of intercepting a vehicle during morning surveys (P_I = 0.244, SE = 0.033) was higher than during afternoon/evening surveys (P_I = 0.135, SE = 0.022).

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