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Deer, Humans, and Vegetation: A Case Study of Deer Management in the Chicago Metropolitan Area

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ABSTRACT: Many natural resource agencies are managing white-tailed deer populations in suburban areas and require information about deer populations, deer impacts on vegetation, and human preferences toward deer and deer management to support decision making. We utilized a multi-faceted approach to investigate common obstacles in suburban deer management and discuss findings from our study based in the Chicago Metropolitan Area during 2007-2011. We discuss the need for managers to examine suburban deer populations and management issues at a broader scale (i.e., countywide versus single community) and promote proactive deer management in lieu of the conventional paradigm of beginning management only when deer populations have become overabundant. Discussion topics include practicality and costs of deer density estimation and herbivory monitoring techniques over multiple plant communities and numerous study sites. In addition, we illustrate how a comprehensive human dimensions survey can identify determinants that contribute to the public's perceptions of deer density and assess the acceptability, conflict, and beliefs regarding deer management methods. Lastly, we describe the relationship between landscape characteristics and deer density; this information can be utilized to determine suburban lands that may be prone to high deer densities and inform land management practices. Our work provides suburban natural resource managers with techniques to identify management practices supported by their public constituents and information useful for managing deer populations.

KEY WORDS: conflict, deer management, density, human dimensions, Illinois, management techniques, *Odocoileus virginianus*, urban wildlife, vegetation surveys, white-tailed deer

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INTRODUCTION

As urban sprawl increases, natural areas intersperse the urban landscape and provide a haven for many wildlife species including white-tailed deer (*Odocoileus virginianus*) (Kilpatrick and Spohr 2000, Grund et al. 2002). Suburban and urban deer have readily adapted to their new environment, as evidenced by their smaller home ranges (Kilpatrick and Spohr 2000, Grund et al. 2002, Storm et al. 2007), use of artificial food (i.e., birdfeeders and ornamental plantings) (Kilpatrick and Spohr 2000), and use of residential and public areas (Kilpatrick and Spohr 2000, Grund et al. 2002, Storm et al. 2007). Consequently, deer populations are increasing in developed areas and as of 2010, 97% of deer biologists from states within the white-tailed deer range considered management of suburban and urban deer a concern (Urbanek et al. 2011a). High deer densities and their subsequent browse on vegetation are known to effect many taxonomic communities such as birds (Casey and Hein 1983), invertebrates (Shimazaki and Miyashita 2002), reptiles (Greenwald et al. 2007), small mammals (Smit et al. 2001), and humans (Decker and Gavin 1987, Kilpatrick and Walter 1997, Storm et al. 2007). Deer populations will continue to become even more adapted to developed areas which will ultimately complicate conservation and restoration efforts and increase deer-human conflict.

Although deer ecology and management has been

studied for decades, studies of deer in developed landscapes remain limited to 1-2 communities or natural areas in a single site. Resource management agencies and urban planners require information from larger-scale assessments of deer in developed areas to guide deer management and urban development. In this case study, we utilized a multi-faceted approach to investigate various problems associated with overabundant suburban deer populations. We provide concrete examples of common obstacles (e.g., estimates of deer density, deer herbivory monitoring methods, public involvement in the decision-making process) in suburban deer management and discuss findings from our study based in the Chicago Metropolitan Area (hereafter, CMA) during 2007-2011. We discuss the need and ways for managers to examine suburban deer populations from a broader scale (i.e., countywide versus single community) and promote proactive deer management in lieu of the conventional paradigm of beginning management only when deer populations have already become overabundant.

STUDY AREA

We investigated suburban deer management in Lake and McHenry Counties, Illinois. Lake County is located approximately 40 km northwest of downtown Chicago and 65 km south of Milwaukee, WI. McHenry County is adjacent to the western border of Lake County and is

approximately 60 km northwest of Chicago and 70 km southwest of Milwaukee. Lake County had a human density of 612 people/km² and McHenry County had a human density of 198 people/km² (USCB 2010). Both counties included expansive preserve districts that provided a combination of natural, recreational, educational, and cultural resources for county residents and tourists. During 2007-2011, the Lake County Forest Preserve consisted of >108 km² in 57 preserves and the McHenry County Conservation District consisted of >100 km² in 36 preserves. Since 1990, all CMA preserve districts, including the districts in this study, have combated high deer densities (>26 deer/km²) (Witham and Jones 1990). Consequently, only fair or poor plant quality existed in 82% of the preserves throughout the CMA at the time of this study (Glennemeier 2004). Deer management (i.e., archery hunts, gun hunts, sharpshooting) was employed on 24 McHenry County preserves since 2002 and 1 Lake County preserve since 1996. However, similar to many other metropolitan areas, deer populations in the CMA remain overabundant, suggested by an increase in observations of larger herds on preserves, deer-vehicle collisions (DVCs), and depredation of ornamental and native vegetation.

DEER DENSITY ESTIMATION

Wildlife biologists require density estimates for white-tailed deer to facilitate management. We compared traditional aerial survey methods (Beringer et al. 1998, Daniels et al. 2009) with a more novel technique called pellet-based distance sampling (PBDS) (Marques et al. 2001) during winters 2008 and 2009 on 6 Lake County forest preserves to evaluate the precision, bias, and cost-effectiveness of using each technique in a suburban landscape (Urbanek et al. 2012c). We found density estimates (range = 10-39 deer/km²) did not differ among techniques, and PBDS was 88% cheaper than aerial surveys (Urbanek et al. 2012c).

Problems with bias and precision exist with both aerial surveys and PBDS; thus, managers need to give serious consideration to which estimation method to use. The primary constraints with the aerial survey method was its dependence on snow cover, deer being missed during surveys, estimates derived from single surveys that are not representative of an entire season, and the need for an accurate correction factor if more than just population trends are being analyzed (Urbanek et al. 2012c). Pellet-based distance sampling avoids these problems; however, further research needs to address how to reduce coefficient of variations and confidence intervals for PBDS estimates so that differences among years can be better differentiated (Urbanek et al. 2012c). Given accurate pellet decay and deposition rates and a large sample size of pellet groups, PBDS may be advantageous to use primarily due to less bias in density estimates, no dependence on continuous snow cover, cheaper survey costs, and no need for elaborate equipment or for professional biologists to conduct surveys (Urbanek et al. 2012c).

DEER HERBIVORY MONITORING

The task of monitoring and assessing the effects of deer herbivory on plant communities is complex. Environmental

factors such as soil type, canopy closure, and soil nutrient quality all play key roles in plant survival and growth (Maschinski and Whitham 1989) which inevitably differs among study sites. These abiotic interactions coupled with varying deer densities and forb preferences make herbivory monitoring especially difficult when managers are investigating multiple study sites (e.g., preserves or parks). Managers are often faced with deciding which methods to use to monitor deer browse and many studies have utilized plots set along browse transects (Augustine and Jordan 1998, Augustine and Frelich 1998, Webster et al. 2001) or exclosures (Anderson et al. 2001, Frankland and Nelson 2003, Webster et al. 2005).

Prior to choosing a vegetation monitoring method, managers should be aware of the advantages, disadvantages, and costs of each technique. Thus, we compared the use of browse transects and associated 1-m² plots versus using small exclosed plots (1.4 m diameter × 1.6 m height) and 1-m² control plots to monitor the effects of deer herbivory in Lake County (Urbanek et al. 2011b). During May-July 2008-2009, we sampled vegetation in 2,560 plots along browse transects (Urbanek and Nielsen 2010, Urbanek et al. 2012a) and 600 exclosed and control plots (Urbanek et al. 2012b) on 8 Lake County forest preserves. Both monitoring regimes provided similar and valuable information on the effects of deer browse on plant community metrics (Urbanek et al. 2012a,b) and indicator species in 4 different plant communities (Urbanek and Nielsen 2010). The standardized cost of conducting a single browse transect (i.e., 10 1-m² quadrats) was 68.4% the standardized cost of sampling 5 pairs of exclosures and controls (i.e., 10 1-m² quadrats) using the exclosure method (Urbanek et al. 2011b).

Herein, we provide several recommendations to improve monitoring of deer herbivory in herbaceous plant communities. Many researchers rely on exclosed and control plots because they believe it results in higher quality data due to its experimental setup. However, observations inside an exclosure do not necessarily depict how the plant community would appear in the absence of deer herbivory, but rather contain vegetation that is in a stage of recovery (Suzuki et al. 2008). It may also take several years after the construction of exclosures to see differences between exclosed and control plots due to the legacy effects of chronic deer browsing (Russell et al. 2001, Royo et al. 2010, Urbanek et al. 2012b). Further, managers often use large exclosures for deer herbivory assessments, which can lead to a strong bias in results (Frankland and Nelson 2003). Hence, researchers must be cautious when drawing conclusions from observed differences between exclosed and control plots. Similarly, researchers must be equally cautious when using data collected from browse transects. Without control plots, multiple sites or years are required to gain any valuable data. When multiple sites are involved, researchers should be aware that differences in abiotic factors may confound results (Urbanek et al. 2012a). However, if researchers are only interested in overall differences between sites over time, data on stem heights or plant community metrics can be collected via browse transects as indices to monitor trends. Thus, although obstacles exist for both vegetation monitoring methods, both exclosures and browse transect

methods can provide the same quality data if studies are well designed.

We suggest managers consider using browse transects rather than exclosures to assess deer herbivory when deer are not restricted from specific areas or plants. The advantages of reduced cost, increased sample size, and ability to assess large areas may outweigh the use of exclosures in these situations (Urbanek et al. 2011b). However, if managers have the resources to continue monitoring deer herbivory using exclosures, it may help to determine the length of time required for restoration goals to be met following deer reduction.

We also recommend managers routinely monitor the species diversity, evenness, and floristic quality of target plant communities to assess the impact of deer populations in their area over time (Anderson et al. 2007, Waller et al. 2009, Urbanek et al. 2012a,b). These metrics will enable managers to compare multiple plant communities to identify the appropriate deer density that will promote restoration and conservation efforts without focusing on specific indicator species (Urbanek et al. 2012a,b). Assessing study areas containing >3 different deer densities for each plant community will create a better depiction of the effect of deer density and subsequent browse on herbaceous communities (Urbanek et al. 2012b). Managers could then use regression techniques to tease out whether differences in plant community metrics are attributable to deer density and subsequent browse, inherent differences in community structure among sites, or a combination of these variables (Urbanek et al. 2012b). Species diversity, evenness, and floristic quality trends also can be monitored to assess the effectiveness of managing deer herds within individual plant communities and provide information on the degradation of targeted communities (Urbanek et al. 2012a,b).

PUBLIC INVOLVEMENT

Contemporary deer management now requires training, experience, and stakeholder input for decision making (Siemer et al. 2001, Riley et al. 2002, Raik et al. 2006). Current human dimensions literature regarding suburban deer is focused in communities where the majority of respondents desire a decrease in deer density (Kilpatrick and Walter 1997, Stout et al. 1997, Kilpatrick et al. 2007), which is unsurprising given that urban and suburban deer populations are increasing in most states (Urbanek et al. 2011a). Managers should actively pursue knowledge regarding public acceptance and potential conflict regarding deer methods prior to implementing deer management, which may minimize controversy when management is eventually conducted. As deer management activities increase in developed areas throughout the nation, managers will also require information as to what drives a respondent's perception of and preference for deer density (i.e., deer acceptance capacity) when the matter is not pressing. Finally, managers should gather information as to why a deer management technique is acceptable or unacceptable which may help resolve disparities and be an invaluable aid in future management decisions (Urbanek et al. 2011a). Herein, we describe how we accomplished these tasks using a 2011 survey of 660 residents living adjacent to 22 McHenry County forest preserves and a

series of analytical methods.

Public Perceptions for Deer Density

Unlike most human dimension surveys of urban and suburban deer (Decker and Gavin 1987, Kilpatrick and Walter 1997), we explored predictors for a respondent's perception of too many deer and for a perception of too few deer in their neighborhood (i.e., dependent variables) (Urbanek 2012). Independent variables in our logistic regression models included a gradient of deer densities (2-36 deer/km²) and urbanization, socio-demographic variables (e.g., age, gender, education), human involvement with deer (e.g., DVC experience, hunter status), and the respondent's perceptions of local deer (e.g., perceptions of deer numbers changing, deer damage to personal property, general feelings toward deer) (Urbanek 2012). We found that public perceptions of deer numbers, perceptions of deer damage to personal property, and general feelings towards deer were the strongest predictors for a respondent's perceptions of deer density, whether the perception was too few or too many deer (Urbanek 2012).

Choosing a Deer Management Method

Conflict surrounding the acceptability of different deer management techniques is rarely assessed among public constituents. Most deer studies only report summaries of the percentage of respondents who think a management option is acceptable (Green et al. 1997, Stout et al. 1997, Kilpatrick et al. 2007); however, the disparity among respondents who accept and respondents who reject a method is rarely measured. The Potential for Conflict Index (PCI₂) (Vaske et al. 2010) was developed to statistically assess conflict regarding attitudes, beliefs, or behaviors. The PCI₂ is quantified on a scale of 0 to 1 where the greatest possibility for conflict occurs when PCI₂=1, indicating respondents were split on a bipolar issue (e.g., 50% rated an action highly acceptable and 50% rated an action highly unacceptable). Alternatively, an index score of 0 would indicate no conflict and would occur when 100% of respondents indicated the same answer (e.g., all rated an action highly acceptable).

We calculated the mean response (on a scale of strongly unacceptable–strongly acceptable) and conflict using PCI₂ of respondents countywide and in urban, rural, high- (mean: 18 deer/km²) and low- (mean: 6 deer/km²) deer-density forest preserves (Urbanek 2012). We identified archery hunts as the most acceptable and least controversial method in the county; there were no differences in acceptability or conflict between urban and rural residents or residents from high- and low-deer-density forest preserves (Urbanek 2012). However, we also examined the acceptability and PCI₂ on an individual site basis and identified 2 sites that preferred management options other than archery (Urbanek 2012). Thus, it is important to identify outliers to countywide results and understand that some methods may be better suited in select communities.

Public Perceptions of Deer Management Methods

Managers require information regarding respondent beliefs and perceptions of suburban deer management methods to make the decision-making process less

controversial. We used the expectancy-value model (Fishbein and Ajzen 1975, Ajzen 1991) to understand respondent beliefs and desires for 5 deer management methods: archery hunts, gun hunts, sharpshooting, fertility control, and no deer management (Urbanek 2012). The model, $A_B = \sum b_i e_i$, suggests people's attitudes towards certain behaviors (A_B) is proportional to the sum of people's beliefs that certain outcomes associated with the behavior will occur (b_i) multiplied by their evaluations of those outcomes (e_i) (Fishbein and Ajzen 1975, Ajzen 1991). We developed predictive models for accepting each deer management method using respondents' beliefs and evaluations of 9 possible management outcomes (e.g., a high cost of management will be incurred; deer will die and inhumane death; public may participate in the management process) (Urbanek 2012).

By using the expectancy-value model, we were able to obtain valuable information that may guide management decisions and could minimize disputes by identifying misconstrued public beliefs about specific methods (e.g., fertility control will quickly reduce deer densities). We also identified outcomes of specific deer management techniques that citizens desired (e.g., low costs, public participation, and decrease in property damage) which managers can promote to potentially increase public acceptance of a method (Green et al. 1997, Loker et al. 1997, Lauber and Knuth 2004). Alternatively, managers must also acknowledge that some citizens will be against any lethal methods due to their core beliefs that these are inhumane or unnatural (Urbanek 2012). Thus, those people may never be supportive of deer management (Fulton et al. 1996) unless non-traditional methods (e.g., fertility control) are employed. Nonetheless, understanding respondent beliefs and perceptions of deer management methods will ultimately allow managers to guide education, resolve some management disputes, and aid in future management decisions.

Survey Recommendations

Managers can assess public perceptions of deer density (i.e., deer acceptance capacity) by asking citizens 3 simple questions regarding damage to personal property, perception of changes in the local number of deer, and general feelings towards deer (i.e., like, dislike, indifferent towards deer) (Urbanek 2012). By limiting survey questions to information that may fit on a postcard, managers can easily obtain valuable information to use in predicting preferences at numerous sites and at low costs (Urbanek 2012). In addition, management goals can be adapted more frequently if citizens are asked these pivotal questions each year rather than after long sessions between more extensive surveys. If managers indeed ask these questions on an annual basis, citizens should become more salient to deer damage and local deer numbers which may unify public perceptions of deer density (Fishbein and Ajzen 1975).

We also recommend managers conduct surveys that incorporate PCI_2 and perceived and desired outcomes of deer management methods to gain information that may guide management decisions and reduce disputes (Urbanek 2012). Managers should also determine the acceptability and conflict regarding potential deer management methods

on an individual site basis in order to identify potential outliers in the county (Urbanek 2012).

URBAN PLANNING AND LAND MANAGEMENT

Similar to other developed areas, CMA deer biologists are combating high deer densities with limited ability to conduct traditional deer population management (i.e., hunting). We determined landscape factors that contribute to suburban deer densities in 20 McHenry and 20 Lake County forest preserves (Urbanek 2012). We regressed habitat variables (2001 National Land Cover Data) (Homer et al. 2004) pertinent to deer ecology (e.g., open water, open space, housing development, forest, agriculture, wetland) against deer densities obtained during 1999-2002 (Urbanek 2012). The interspersions of housing density had the strongest effect on suburban deer density: deer densities were lower in areas where medium- and high-intensity housing development patches were found closer to one another. Some evidence indicated that deer density was also lower where higher railroad densities existed around preserves (Urbanek 2012). Conversely, deer densities were higher as the mean patch size of forest cover increased within preserve borders (Urbanek 2012).

Given that forest patch size within preserves may be an indicator of high deer densities (Roseberry and Woolf 1998, Urbanek 2012), managers should focus deer management on highly-forested preserves (Kilpatrick et al. 1997, McNulty et al. 1997, Nielsen et al. 1997). Alternatively, managers can reduce the size of forest patches within natural areas (Gorham and Porter 2011) to potentially limit suburban deer population growth and deer-human conflict if deer management may not be readily feasible (due to safety concerns, conflicting social attitudes and perceptions about deer, hunting and firearm-discharge restrictions, and liability or public relations concerns). As a result, habitat diversity may increase which may also increase the biodiversity of other wildlife species (McKinney 2002). Managers can also collaborate with urban landscape planners (Gorham and Porter 2011) to predict areas where deer densities may be potentially limited in the future due to urban sprawl. By identifying where future housing developments are to be constructed, managers can preferentially focus resources on land management in other high-deer density forests that may not be negatively influenced by housing density in the near future.

CONCLUSIONS AND RECOMMENDATIONS

Although wildlife biologists have made admirable strides in understanding suburban deer populations and how to manage them sustainability and effectively, further work is needed to improve the state of suburban deer management. Most important is the need for proactive management which should not only include deer population reductions when appropriate, but also preemptive data gathering and monitoring on deer populations. We suggest managers assess the effects of deer on herbaceous communities and determine public opinions, beliefs, and preferences toward deer and deer management. Public constituents may be more willing to accept suburban deer management if dependable deer density estimates and scientific vegetation monitoring

exhibits evidence that deer management is necessary (Kilpatrick et al. 1997, Lauber and Knuth 2004). Public involvement in the decision-making process is especially crucial for a suburban deer management program to be successful (Siemer et al. 2001, Riley et al. 2002, Raik et al. 2006). Furthermore, real success in suburban deer management will only occur when local and state conservation agencies and citizen action groups (Guynn and Landry 1997, Kilpatrick and Walter 1997, Messmer et al. 1997) work together in metropolitan areas; deer, like all wildlife, do not recognize political boundaries.

We recommend future research to advance suburban deer management focus on population estimation and deer movements. Accuracy and precision of density estimation methods, specifically PBDS, warrants further investigation. Research on socio-demographic factors and microhabitat variables (e.g., landscaping features around housing developments) is needed to increase understanding of habitat factors that contribute to high suburban deer densities. Studies of deer home ranges in developed areas exist in the literature (Kilpatrick and Spohr 2000, Storm et al. 2007), but information is lacking regarding the permeability of the urban matrix for dispersal. Such information is needed to understand the potential for disease spread, both for zoonotic (e.g., Lyme disease) and epizootic (e.g., chronic wasting disease, hemorrhagic disease) diseases for deer in urban landscapes.

We also recommend future research in DVC countermeasures. In our study in McHenry County, 57% of survey respondents had been involved themselves or had a family member involved in a DVC (Urbanek 2012). This statistic is unsurprising given that >125,000 DVCs occur annually in the Upper Midwest states (Knapp et al. 2004). Knapp et al. (2004) conducted an extensive review of 16 DVC countermeasures and reported that only properly installed and well-maintained wildlife crossings and exclusionary fences have been proven to successfully reduce DVC occurrences. Qualitative and experimental research investigating the success of DVC countermeasures, specifically roadside habitat modifications, roadside reflectors, and speed limit reduction, requires further assessment (Knapp et al. 2004). Furthermore, advanced technology (e.g., GPS and camera radiocollars) should be implemented into DVC countermeasure studies to investigate deer behavior and decision making when deer confront roads (Gulsby et al. 2011).

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