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Original Research Article

Comparing stakeholder attitudes toward white-tailed deer and rare plant management in Canaan Valley, West Virginia

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ABSTRACT

Canaan Valley, West Virginia, USA provides habitat for many plants considered rare in West Virginia. The local white-tailed deer (*Odocoileus virginianus* Zimm.) are a popular attraction for visitors as well as resident and nonresident hunters. However, concerns exist over the impact of white-tailed deer herbivory on rare plant communities in the wetlands. We evaluated stakeholder attitudes regarding white-tailed deer management and rare plant conservation by mailing surveys to property owners in Canaan Valley and Tucker County, WV, and providing surveys to visitors at Canaan Valley State Park and National Wildlife Refuge. Individuals that had incurred crop damage were more likely to view the Canaan Valley population as overabundant while nonresident landowners placed higher values on the conservation of rare plants and plant communities in Canaan Valley. We found that hunters were more likely than nonhunters to support white-tailed deer management actions. Results of this survey may help managers to direct management and education goals toward actual rather than perceived stakeholder attitudes.

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1. Introduction

Wildlife species are held in public trust; that is, they belong to the people, but are managed by state and federal agencies that must account for the health of the wildlife population, impacts on other plant and animal species, habitat quality, and the wishes of the public for the wildlife population. Public sentiment over management of white-tailed deer (*Odocoileus virginianus*) herds in the eastern United States has changed with deer abundance, levels of human-wildlife conflict, increasing rural development, and an increasing interest in nongame wildlife and noncommercial plant species (Holsman and Peyton, 2003). Public opinions toward white-tailed deer management vary with the extent of negative experience (Messmer et al., 1997; Loker et al., 1999; Siemer et al., 2018; West and Parkhurst, 2002), profession (West and Parkhurst, 2002), and participation in outdoor recreation such as hunting (Brooks et al., 1999; Holsman and Peyton, 2003). Wildlife is considered a public resource, so its management often involves input from the public (McShea and Rappole, 1997; Shafer-Nolan, 1997). Thus, state and local agencies charged with managing deer herds need to balance the attitudes of hunters, antihunters, and nonhunters with public safety and sound biology.

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In the 1940s, [Leopold et al. \(1947\)](#) found that it was difficult to convince hunters and the general public, who experienced firsthand the shortage of deer as a result of overhunting, that an overabundance of deer could exist at all, much less be a detriment to their habitat. Today, it remains difficult to convince stakeholders, defined here as those who have an interest in the management of white-tailed deer and rare plant conservation, and who may have experienced the lack of abundance of deer in earlier decades, that such a problem exists ([Diefenbach et al., 1997](#)). Since the early 1900s, the nation's general public increasingly has become disconnected with wildlife and its habitat ([Organ and Ellingwood, 2000](#)). Although urban sprawl has created suburban centers in what formerly was rural land, suburbanites who now occupy these centers do not embrace rural traditions such as the hunting heritage of rural America ([Applegate, 1984](#); [Organ and Ellingwood, 2000](#); [Warren, 1997](#)). In the eyes of some, white-tailed deer have become garden pests and road hazards ([Siemer et al., 2018](#); [Warren, 1997](#)). As hunting has decreased as a pastime, the perceptions of hunting as a management tool have also changed ([Rutberg, 1997](#)). Although the proportion of the public that actively hunt has declined, support still exists for hunting to manage human conflict or ecosystem damage, but nonhunters disapprove of "hunter-centric" motives for deer harvest ([Decker et al., 2015](#)).

Overabundance of a wildlife population has been defined as fitting into 1 of 4 categories: when an animal threatens human life or livelihood, when animals depress the densities of favored species, when animals are too numerous for their own good, and when their numbers cause ecosystem dysfunction ([Coughley, 1981](#)). Several studies have shown that threats to human life or livelihood may affect the attitudes of stakeholders toward populations of white-tailed deer. Deer-vehicle collisions ([Loker et al., 1999](#); [West and Parkhurst, 2002](#)), increased rates of Lyme disease ([Siemer et al., 2018](#); [West and Parkhurst, 2002](#)), and damage to crops and home landscaping ([Siemer et al., 2018](#); [Stout et al., 1997](#)) can lead citizens to view high-density deer populations in a negative light and seek methods of population reduction. In contrast, stakeholders are less likely to look negatively on high deer abundance in light of ecosystem dysfunction and depression of nongame wildlife species ([Diefenbach et al., 1997](#); [Holsman and Peyton, 2003](#)).

Canaan Valley, West Virginia (Tucker County), is home to Canaan Valley State Park and the Canaan Valley National Wildlife Refuge. Deer densities in Canaan Valley may be as high as 30 deer/km² in the southern end of the valley ([Cherefko et al., 2015](#)). Deer hunting is allowed by permit within the National Wildlife Refuge lands and is conducted on private holdings throughout Canaan Valley. However, hunting has been prohibited in southern sections of the valley (i.e., Canaan Valley Resort State Park) for at least 30 years prior to this study ([Michael, 1992](#)). Recently, the West Virginia legislature permitted hunting in state parks, at the discretion of the West Virginia Division of Natural Resources.

The formation of these public lands has centered on the protection of the unique wetland areas found in Canaan Valley. These provide habitat for over 580 plant species including 80 wetland plants and 34 wetland plant communities that are considered rare or endangered within the state ([Fortney, 1975](#); [Michael, 1992](#); [West Virginia Division of Natural Resources, 2012](#)). The wetlands of Canaan Valley support nannyberry (*Viburnum lentago*), considered rare and imperiled in West Virginia (ranked S2), woodland horsetail (*Equisetum sylvaticum*), considered rare and critically imperiled (ranked S1), and bog Jacob's-ladder (*Polemonium vanbruntiae*) (ranked S2) ([Rentch and Anderson, 2008](#); [West Virginia Division of Natural Resources, 2012](#); [Flaherty et al., 2018](#)).

Canaan Valley occupies 16% of the land in Tucker County, WV. Approximately 60% of Tucker County is made up of land that is owned and managed by either state or federal agencies ([Selin and Zepeda, 2015](#)). Large tracts of public land coupled with unique ecological features drive the outdoor recreation and tourism industry in Canaan Valley and the surrounding county. Many of these visitors are drawn from the more densely-populated eastern cities as Canaan Valley exists within a day's drive of 60% of the U.S. population ([Selin and Zepeda, 2015](#)).

Our objectives were to a) determine whether attitudes of residents of Canaan Valley and Tucker County differed from attitudes of nonresident landowners and visitors with respect to white-tailed deer management and plant conservation; b) determine whether attitudes of hunters differed from attitudes of nonhunters with respect to white-tailed deer management and plant conservation, and c) determine how negative experiences with white-tailed deer may influence stakeholder attitudes toward management decisions. We hypothesized that nonresident landowners and visitors to Canaan Valley may have a more urban or suburban background and thus might be less likely to participate in hunting or approve of lethal control methods, and more likely to view white-tailed deer management in an ecosystem context and thus favor the conservation of rare plant species. We hypothesized that hunters were more likely to consider a reduction in deer abundance as an unacceptable "cost" of rare plant conservation and therefore more likely to respond unfavorably toward rare plant conservation when it resulted in a lower deer population. Lastly, we hypothesized that respondents who had experienced negative interactions with deer were more likely to view local deer populations as overabundant and accept measures of deer management.

1.1. Study area

The Canaan Valley, located in Tucker County, West Virginia, USA is the largest high-elevation valley east of the Rocky Mountains ([Fortney, 1975](#)). It is 21 km long and ranges in width from 4.8 to 8.0 km. The valley encompasses about 176 km² (17,600 ha) of land. The average valley floor elevation is 980 m above sea level and the mountains surrounding the valley rise another 300 m in elevation. The high elevation and topography of Canaan Valley produce a climate more similar to northern boreal forests than to the deciduous forests of surrounding areas in West Virginia. Canaan Valley is home to sub-arctic bogs and stands of conifers such as balsam fir (*Abies balsamea*) and red spruce (*Picea rubens*).

About 20% of the land area is composed of various wetland community types and another 23% is northern hardwood forest (Byers et al., 2007). Of all the high-elevation wetlands in West Virginia, Canaan Valley is home to the largest contiguous wetland area (3000 ha) (Byers et al., 2007). Agriculture (10%), rural development (24%), and recreational land (23%) make up the remaining land area (Michael, 1992).

2. Methods

2.1. Selecting stakeholder groups

We chose 4 stakeholder groups that had the potential to influence wild plant conservation and white-tailed deer management in Canaan Valley and the surrounding areas. We surveyed residents of Canaan Valley as well as residents of Tucker County, WV, who might work or travel through Canaan Valley frequently, but whom did not live in the valley. Additionally, we sampled nonresidents who owned land in Canaan Valley as well as those who only visit Canaan Valley. We sampled residents and nonresident landowners in Fall 2005 using mail surveys sent to addresses selected by systematic sampling from Tucker County tax records. We selected every 10th property owner listed in county tax record books. With each mailed survey, we included a self-addressed, stamped envelope for the return of responses. To assess the attitudes of visitors to Canaan Valley, we supplied survey forms to the visitors' centers at Canaan Valley National Wildlife Refuge and Canaan Valley State Park in Fall 2005 which were completed by willing volunteers. Surveys also were distributed to Canaan Valley State Park Ski Lodge and several local businesses; however, no surveys were retrieved successfully from locations outside the state park and national wildlife refuge.

2.2. Questionnaire design

We created a survey that consisted of 21 questions (Table 1). Respondents also were asked about their age, sex, education level, and residency status. Respondents' views toward rare plant conservation and the status and management of white-tailed deer in Canaan Valley were assessed with 16 opinion questions. Responses to opinion questions were rated on the Likert scale with 6 categories: strongly disagree (−2), disagree (−1), neutral (0), agree (+1), strongly agree (+2), and no opinion. Participants' attitude toward hunting as a management tool as well as participation in hunting activities were addressed with 3 questions. Two other questions addressed personal experience with a deer-vehicle collision and property damage (e.g., crops).

2.3. Statistical analysis

We used only data from fully completed surveys. The 16 opinion questions were subjected to Principal Components Analysis (PCA) to minimize redundancy among the questions and to identify underlying constructs. We standardized and rotated our principal components using the varimax rotation method. We selected three principal components from the correlation matrix based on a scree plot and that each explained > 10% of the total variation in the data. We also assessed magnitude of the eigenvalues and interpretability in making this selection (Hatcher, 1994). We considered the loadings to be “large” for a question if it was > 0.5.

We modeled principal component scores as a function of 4 sociodemographic factors determined from the questionnaire (residency status, hunting participation from Question 19, deer-vehicle collisions from Question 7, and deer landscape/crop damage from Question 8) and their two-way interaction using a multi-factor analysis of variance (ANOVA) in program R (R Development Core Team, 2008). We maintained the 0.05 experimentwise α level using a Bonferroni correction; that is, the α level was set to 0.005 for individual tests. Post-hoc multiple comparisons were made using a Bonferroni procedure to compare least squares means between factor levels. Residual diagnostics were run to assess validity of the model assumptions. Additionally, we examined the principal components using a Potential for Conflict Index (PCI) (Vaske et al., 2006). The Potential for Conflict Index numerically describes the amount of disparity between respondents in a particular group by giving more weight to extreme responses and no weight to neutral responses. Thus, the higher the PCI value, the greater the range of responses within a group.

3. Results

We received 174 surveys from the 500 mailed, for a response rate of 35%. Additionally, we received 46 surveys from visitors. From the 220 total surveys, we removed 26 from analysis because of incomplete responses. Responses of participants are summarized in Table 1. The three retained principal components together accounted for 60% of the variation in the data (Table 2). Interpretation of the loadings on each principal component suggested that each component could be attributed to a distinct construct as measured by several original questions. Principal component 1 (PC1) dealt mainly with attitudes toward seeing deer and overabundance in Canaan Valley and West Virginia (Questions 1–4, and 10). Component 1 also included an opinion on using professional sharpshooters to reduce deer numbers (Question 21). Principal component 2 (PC2) focused on attitudes toward plant conservation and the relation to deer abundance (Questions 6, and 13–15). Principal component 3 (PC3) focused on management of white-tailed deer (Questions 9, 11, 12, and 17).

Table 1

Mean survey scores for 4 stakeholder groups regarding white-tailed deer in Canaan Valley, West Virginia, 2005. Unless indicated, scores were on a likert scale of -2 to 2.

No.	Survey Question	Canaan Valley Residents		Nonresident Landowners		Tucker County Residents		Visitors	
		\bar{x}	SE	\bar{x}	SE	\bar{x}	SE	\bar{x}	SE
1	I enjoy seeing white-tailed deer around/near my home.	1.0	0.2	1.6	0.1	1.3	0.1	1.3	0.2
2	I enjoy seeing white-tailed deer when I visit state or national parks, forests or wildlife refuges.	1.4	0.1	1.6	0.1	1.6	0.1	1.4	0.2
3	I believe deer are overabundant in the state of West Virginia.	0.5	0.4	1.4	0.2	0.2	0.3	1.1	0.2
4	I believe deer are overabundant in Canaan Valley National Wildlife Refuge and/or Canaan Valley Resort State Park.	0.8	0.4	1.2	0.2	0.7	0.2	1.5	0.2
5	I place value on wild plants and trees as sources of food and timber.	1.5	0.2	1.5	0.1	1.6	0.1	1.5	0.1
6	I enjoy seeing wild plants, flowers, and trees.	1.5	0.1	1.5	0.1	1.4	0.1	1.7	0.1
7	I, or a member of my immediate family, have been involved in a deer/vehicle collision ^a .	1.4	0.2	1.0	0.1	1.8	0.1	0.8	0.1
8	I, or a member of my immediate family, have incurred damage to landscaping, crops or other property (excluding vehicles) from deer.	0.4	0.2	0.2	0.1	0.3	0.1	0.1	0.1
9	I believe it is ethical to manage wild populations of white-tailed deer.	1.3	0.3	1.4	0.1	1.4	0.2	1.6	0.1
10	I believe white-tailed deer numbers should be increased in West Virginia.	1.6	0.4	1.5	0.2	0.8	0.3	1.9	0.2
11	I believe white-tailed deer numbers should be managed to increase hunter harvest.	1.1	0.4	0.8	0.2	1.2	0.2	1.0	0.3
12	I believe white-tailed deer numbers should be managed in balance with their environment.	1.0	0.3	1.3	0.1	1.3	0.2	1.7	0.1
13	I believe white-tailed deer may have a detrimental effect on some plant communities.	2.0	0.2	1.5	0.1	1.0	0.2	1.5	0.2
14	I believe rare or endangered plant species should be protected.	1.6	0.2	1.6	0.1	1.1	0.2	1.7	0.1
15	I believe rare or endangered plant species should be protected from white-tailed deer browsing if it reduces the abundance of those plants.	1.7	0.3	1.5	0.1	0.9	0.2	1.6	0.2
16	I would not have a problem seeing fenced areas to protect plants when I visit state or national parks, forests or wildlife refuges.	0.7	0.3	0.8	0.2	0.9	0.2	1.1	0.2
17	I believe hunting is an acceptable tool for managing deer populations.	1.4	0.2	1.2	0.1	1.5	0.1	1.8	0.1
18	I have participated in legal hunting activities within my lifetime ^b .	0.2	0.2	0.0	0.1	0.6	0.1	0.2	0.1
19	I have participated in legal hunting activities within the past year ^b .	-0.5	0.2	-0.6	0.1	0.2	0.1	-0.1	0.1
20	Another member of my household participates in legal hunting activities ^b .	-0.5	0.2	-0.4	0.1	0.5	0.1	-0.1	0.2
21	I believe professional sharp-shooting is an acceptable tool for managing deer populations.	1.1	0.5	0.5	0.2	-0.4	0.3	1.0	0.3
	Number of Responses returned	20		72		53		46	

^aQuestion 7 scores were scaled as 0 (no deer-vehicle collisions), 1 (deer-vehicle collision >5 years ago), 2 (deer-vehicle collision in past 5 years), or 3 (deer-vehicle collision in past year).

^bQuestions were yes (1) or no (-1).

Table 2

Principal components and constructs derived from survey dataset groups regarding white-tailed deer in Canaan Valley, West Virginia, 2005.

Component	Eigenvalue	Proportion	Cumulative Proportion	Construct
PC 1	5.4946	0.3434	0.3434	Deer abundance/tolerance
PC 2	2.1058	0.1316	0.4750	Rare plant conservation
PC 3	1.9480	0.1218	0.5968	Deer management

When we modeled the scores for PC1 with respect to the 4 factors (residency status, hunting participation, deer-vehicle collisions and deer landscape/crop damage), we found only deer landscape/crop damage was significant ($F_{1,163} = 12.87$, $p < 0.001$). We found that people who had experienced crop or landscape damage had significantly larger mean PC1 scores ($\bar{x} = 0.299$, $SE = 0.118$) than those who did not ($\bar{x} = -0.359$, $SE = 0.170$). Larger PC1 scores correspond with a lower tolerance of

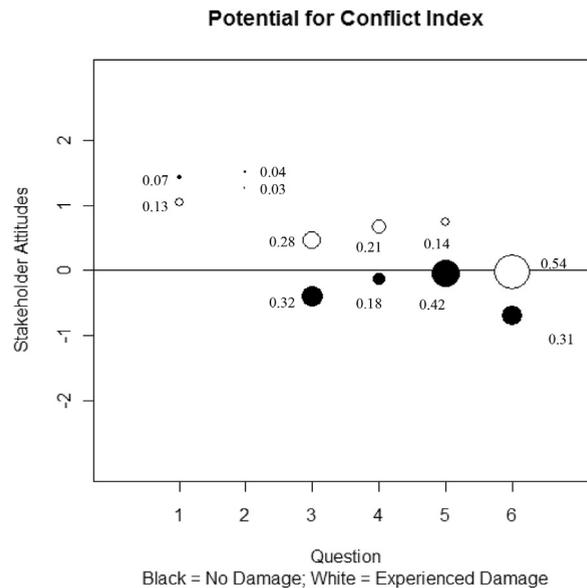


Fig. 1. Potential for Conflict Indices (PCI) for the six questions contributing to Principal Component One by respondents that had and had not experienced damage to crops or landscaping. Circles are centered on the mean response for each group where -2.0 corresponds to strongly disagree and 2.0 corresponds to strongly agree. Larger circles indicate higher potential for conflict within group members. PCI values are given next to the corresponding point. The questions are the following;

1. Question 1: I enjoy seeing white-tailed deer around/near my home.
2. Question 2: I enjoy seeing white-tailed deer when I visit state or national parks, forests or wildlife refuges.
3. Question 3: I believe deer are overabundant in the state of West Virginia.
4. Question 4: I believe deer are overabundant in Canaan Valley National Wildlife refuge and/or Canaan Valley Resort State Park.
5. Question 10: I believe white-tailed deer numbers should be increased in West Virginia (reversed scale).
6. Question 21: I believe professional sharpshooting is an acceptable tool for managing deer populations.

deer. Of the questions that drove PC1, the 2 groups differed most on the subject of overabundance in Canaan Valley and West Virginia, where those who experienced crop or landscape damage were more likely to describe deer populations as being overabundant. We detected substantial conflict among those who had experienced crop or landscape damage with respect to views on professional sharpshooting as a deer population management tool (PCI = 0.54; Fig. 1).

Modeling PC2 as a function of the 4 sociodemographic factors revealed significance only for the residency factor ($F_{3,163} = 4.91, p < 0.003$; Table 3). Tucker County residents ($\bar{x} = 0.578, SE = 0.145$) had higher PC2 scores on average than nonresident landowners ($\bar{x} = -0.172, SE = 0.153$) ($t = -3.55, p < 0.001$; Table 3). Larger PC2 scores indicated lower valuation of plants and plant communities. Tucker County residents also tended to value plants less than Canaan Valley visitors ($\bar{x} = -0.163, SE = 0.269$); however, we did not consider this difference ($t_{163} = 2.46, p = 0.015$) to be significant due to the conservative nature of the Bonferroni correction. For the most part, stakeholders agreed that they enjoyed seeing wild plants, but residents of Tucker County appeared less likely to agree that deer could harm plant communities and that plants should be protected from deer (Table 3). PCI scores were higher for Tucker County residents on these topics, indicating moderate conflict within that group.

Due to a violation of the assumption of normal errors under ANOVA, the Box-Cox procedure was used to select a normalizing power transformation for PC3 scores (Box and Cox, 1964). Hunters ($\bar{x} = 0.414, SE = 0.037$) had significantly higher PC3 scores on average than nonhunters ($\bar{x} = -0.308, SE = 0.049$) ($F_{1,163} = 14.80, p < 0.001$) when least squares means estimates were back-transformed to the original scale and the standard errors in the original scale were approximated via the Delta method. Larger PC3 scores corresponded to greater support for management actions for white-tailed deer. Although there was moderate conflict within the nonhunting group (PCI = 0.32), nonhunters were more likely than hunters to disagree that deer densities should be managed to increase hunter harvest (Fig. 2). We did not find an association between participation in hunting and attitudes toward deer abundance as measured by PC1 ($F_{1,163} = 3.59, p < 0.060$) nor did we find sufficient evidence of interaction between hunting participation and residency ($F_{3,163} = 2.67, p < 0.049$) as measured by PC1.

4. Discussion

We did not find differences among permanent residents, nonresidents, and visitors regarding white-tailed deer abundance as measured by PC1 ($F_{3,163} = 2.17, p < 0.093$). Many nonresident landowners and visitors surveyed came from urban or suburban centers such as Baltimore, MD, and Washington, D.C. These respondents may be more acquainted with issues of

Table 3

Mean and Potential for Conflict Index (PCI) values for four questions contributing to Principal Component 2 by resident group.

	Question 6 ^a		Question 13 ^b		Question 14 ^c		Question 15 ^d	
	Mean	PCI	Mean	PCI	Mean	PCI	Mean	PCI
Canaan Valley Residents	1.30	0.00	0.90	0.00	0.85	0.05	0.35	0.15
Nonresident Landowners	1.47	0.00	0.92	0.11	0.96	0.03	0.77	0.08
Tucker County Residents	1.22	0.02	0.26	0.33	0.24	0.30	0.02	0.33
Visitors	1.62	0.00	0.98	0.11	1.13	0.06	0.81	0.20

Mean values of -2 correspond to strongly disagree and 2 corresponds to strongly agree. Higher PCI values indicate higher potential for conflict among group members.

^aQuestion 6: I enjoy seeing wild plants, flowers, and trees.

^bQuestion 13: I believe white-tailed deer may have a detrimental effect on some plant communities.

^cQuestion 14: I believe rare or endangered plant species should be protected.

^dQuestion 15: I believe rare or endangered plant species should be protected from white-tailed deer browsing if it reduces the abundance of those plants.

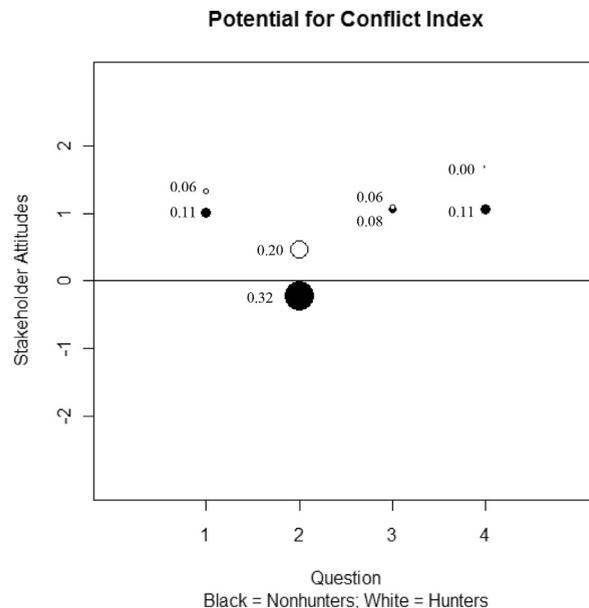


Fig. 2. Potential for Conflict Indices (PCI) for the four questions contributing to Principal Component Three by hunters and nonhunters. Circles are centered on the mean response for each group where -2.0 corresponds to strongly disagree and 2.0 corresponds to strongly agree. Larger circles indicate higher potential for conflict among group members. PCI values are given next to the corresponding point. The questions are the following:

1. Question 9: I believe it is ethical to manage populations of white-tailed deer.
2. Question 11: I believe white-tailed deer numbers should be managed to increase hunter harvest.
3. Question 12: I believe white-tailed deer numbers should be managed in balance with their environment.
4. Question 17: I believe hunting is an acceptable tool for managing deer populations.

deer overabundance in suburban parks and refuges (Raik et al., 2005). However, this did not lead them to view the Canaan Valley deer herd as overabundant. The lack of an urban-rural divide might be due to the values of stakeholders who choose to recreate in rural areas. Clendenning et al. (2005) found that many exurbanites seek a return to rural roots and therefore might have values that align more closely with residents.

In considering deer abundance in light of plant conservation (PC2), Tucker County residents were less likely than nonresident landowners and visitors to Canaan Valley to value rare and endangered plants, especially if it meant a need to protect those plants from the local white-tailed deer herd. However, all stakeholder groups tended to agree that rare plant species held value and should be protected from white-tailed deer browsing when necessary. Clendenning et al. (2005) found that there were differences between urbanites and rural residents on some aspects of wildlife management and that seasonal homeowners hold attitudes that support the preservation of the natural amenities around their homes.

Holsman and Peyton (2003) found that stakeholders expressed value for ecosystem management goals in the absence of costs and that deer hunters were unwilling to accept reductions in the deer herd to protect stands of white cedar (*Thuja occidentalis*). Similarly, others have found that participation in hunting was related to low support for biodiversity and other broad ecological management objectives (Holsman, 2000). We did not find sufficient evidence of an association between hunting participation and valuation of rare plant species as measured by PC2, nor did we find sufficient evidence of interaction between hunting participation and residency. It is possible that hunters may not have interpreted questions 6, 13, 14,

and 15 as support for a reduction in the deer herd and therefore were more likely to value rare plant conservation since no “cost” was involved.

There were lower percentages of hunters for the visitors and nonresident landowner groups. [Holsman and Peyton \(2003\)](#) found hunters tended to believe that there were fewer deer present in an ecosystem than other groups surveyed. Visitors and nonresident landowners were less likely than residents to have been involved in a deer-vehicle collision (Question 7; [Table 1](#)). There did not appear to be a desire for fewer deer among those who had recently been involved in a collision. There was no difference with respect to PC1 between those who had been involved in a collision and those who had not, nor did we find sufficient evidence of interaction between car collision involvement and residency. [Loker et al. \(1999\)](#) found that negative experiences with wildlife species did not necessarily result in a feeling of concern over that species.

While hunters were more likely than nonhunters to support management actions for white-tailed deer as measured by PC3, the vast majority of respondents from all groups accepted hunting as a tool to manage white-tailed deer populations (Questions 9, 12, and 17; [Table 1](#)) with the exception of management for the purpose of increasing hunter harvest (Question 11; [Table 1](#)). This suggests that the stereotype of the suburbanite “antihunter” might be unfounded in Canaan Valley and might be the result of a vocal minority ([Curtis and Hauber, 1997](#); [West and Parkhurst, 2002](#)). Some of the comments received as a part of the survey seemed to reflect this view. [Loker et al. \(1999\)](#) found that suburban residents were generally open to wildlife management, even lethal control options, and believed that managers should use caution in stereotyping the attitudes of suburban residents. The large degree of acceptance seen here might be due to the backgrounds of respondents who choose to visit or buy land in Canaan Valley ([Clendenning et al., 2005](#); [Heberlein and Ericsson, 2005](#)). High deer abundance once made Canaan Valley a popular hunting area within West Virginia. Many visitors and nonresident landowners might actually be coming to the area to hunt and therefore these results might not be applicable to other areas.

Overall, we found that respondents who had experienced damage to landscaping or crops were less likely to exhibit tolerance of high deer densities nor support an increase in the size of the deer herd. [West and Parkhurst \(2002\)](#) found similar results among landowners and producers in Virginia. [Lischka et al. \(2007\)](#) found a positive association between hunting participation and attitudes toward deer abundance and a negative association between farming and deer abundance. [Siemer et al. \(2018\)](#) found that hunters were more likely to favor an increase in deer numbers whereas those with concerns about deer (i.e. vehicle collisions, crop damage) were more likely to support a decrease in deer abundance in New York. People generally are willing to accept deer until they reach some threshold of deer-human conflict ([Stout et al., 1997](#)), after which they are more likely to be open to lethal control methods ([Messmer et al., 1997](#)).

Sharpshooting as a means of reducing deer populations was positive for all groups except for Tucker county residents (Question 21; [Table 1](#)). The mean response of stakeholders that had experienced crop or landscape damage was circum-neutral; however, the PCI score for this group was 0.54 indicating strong disagreement within the group ([Fig. 2](#)). [Messmer et al. \(1997\)](#) found that the general public had a low opinion of sharpshooting compared to other methods of herd reduction. [Stout et al. \(1997\)](#) also found low public support for sharpshooting as a management technique among suburban residents. However, they found that the level of acceptance did not change with increased deer densities. Through write-in responses, we also found that many respondents were unsure of the practice of herd reduction by this method and some mentioned that they would be likely to agree contingent upon the use of the deer afterward. Many of those opposed voiced a preference for a controlled public or permit hunt for West Virginia license holders.

We caution the reader that the results given here are exploratory in nature, and are not meant to be construed as confirmatory. The reason is because of the presence of possible sources of selection bias; namely, bias due to undercoverage, nonresponse, and voluntary response sampling. Our opportunistic sampling of visitors by voluntary participation did not allow us to identify non-respondents. Thus, we could not effectively compare the nonresponse bias of all of our participants. The presence of nonresponse does not ensure that a bias exists ([Groves, 2006](#)). Further follow-up would be necessary to assess the effect of nonresponse bias, if it exists, and to statistically account for it. Nevertheless, our conclusions are at least suggestive and could help Canaan Valley management organizations design more rigorous probability sampling designs that could be analyzed with the same formal approach we have developed here.

It is important to understand public perceptions to successfully execute management plans in the public domain ([Swihart and DeNicola, 1997](#)). Contrary to perceptions, the majority of the visitors and nonresident landowners in Canaan Valley thought that there were too many deer in Canaan Valley State Park and National Wildlife Refuge (Question 4; [Table 1](#)). These stakeholder groups also indicated that it was important to conserve rare and endangered plant species even at the expense of white-tailed deer herds (Question 15; [Table 1](#)). Management organizations in Canaan Valley including the West Virginia Division of Natural Resources and the United States Fish and Wildlife Service could use the information gathered in this study along with biological data to inform management decisions on the white-tailed deer herd in Canaan Valley.

4.1. Management implications

[Organ and Ellingwood \(2000\)](#) suggest that input from stakeholders increases support for management of nuisance species. Our study suggests that common ground does exist between stakeholders of different backgrounds in terms of deer management. However, there are areas of potential conflict that could arise when seeking a consensus. Although many of the views of residents and nonresidents were similar, Tucker County residents were less likely to favor rare plant conservation. Many of the visitors and nonresidents come to Canaan Valley specifically because of its unique characteristics and appear to place more value on these unique plants. Recognition of differences in attitudes between stakeholder groups could be helpful

in designing educational programs for users of natural areas (Brooks et al., 1999). In this case, education and emphasis on the importance of rare plant diversity in Canaan Valley may bring more local support for their conservation. Hunting is permitted by permit on the Canaan Valley National Wildlife Refuge. However, limited access may reduce the effectiveness of this option. Since the conclusion of this study, additional public land (Little Canaan Wildlife Management Area) has been acquired and opened to public hunting. Additionally, limited hunts have been conducted on the Canaan Valley State Park. Additional surveys should be used to determine the support of stakeholders for these recent management changes.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.gecco.2018.e00519>.

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