Too Many Hunters or Not Enough Deer?  
Human and Biological Determinants of Hunter Satisfaction and Quality

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This paper explores how the human dimensions of wildlife management (hunter density, contact with others, perceived crowding) are related to the biological dimensions of deer management (deer population, seeing, shooting, bagging) to produce satisfying and high quality hunts. In a series of hunter density experiments at the Sandhill Wildlife Demonstration Area in Wisconsin, this study compared these relationships between hunters who held either antlerless-only (doe) or trophy buck permits. A 1980 study of doe hunters at Sandhill showed that higher hunter density had a positive effect on hunter satisfaction. However, a 1982 study of trophy buck hunters could not replicate this finding. To sort out these relationships, this study...
analyzed results from 11 years of hunter density experiments at Sandhill. The results showed that effect of density can shift from a positive to a negative depending on the season framework. For doe hunters, higher hunter densities improved the odds of success, and increased satisfaction ratings and quality ratings. More hunters increased crowding, which decreased satisfaction. But higher hunter density was also associated with seeing more deer, shooting more, and bagging deer. Among trophy buck hunters, hunter density had no effect on seeing, shooting, and bagging a deer. Seeing, shooting, and bagging were only associated with deer density. For trophy buck hunters, increased hunter density reduced satisfaction and quality ratings. These negative evaluations were not offset by seeing more deer, shooting more, or bagging a deer.

Keywords white-tailed deer, hunter density, perceived crowding, hunting, quality, satisfaction, trophy bucks, doe hunting

Wildlife managers can readily manipulate three variables in their efforts to provide quality deer hunting experiences: deer density, season frameworks, and hunter numbers. As one might expect, wildlife managers traditionally have taken refuge in their biology by trying to increase deer density, and consequently the probability of hunter success. Gigliotti (2000) noted that “...many fish and wildlife managers still operate under the notion that harvest success and satisfaction are equivalent.” There is some merit to this. Consistently in the human dimensions literature, it has been shown that seeing, shooting at, and bagging game will enhance hunter satisfaction (Gigliotti, 2000; Langenau, Moon, Terry, & Cue, 1981). But there is not a 1 to 1 relationship between bagging and satisfaction. High animal density alone does not assure increased levels of seeing, shooting, and bagging.

Those focusing on human dimensions have noted that many things other than bagging a deer can enhance a hunt (Hammit, McDonald, & Patterson, 1990; Hazel, Langenau, & Levine, 1990; Hendee, 1974; Woods, Guynn, Hammitt, & Patterson, 1996), and that things other than not bagging a deer can detract from a hunt. This has been called the “multiple satisfactions approach.” Most of the components of the multiple satisfactions approach involve the individual’s motivation for hunting—such as being a social hunter or a meat hunter. (Gigliotti, 2000; Hendee, 1974). These are generally out of control of the wildlife manager. Whether one finds solitude, has a fight with a hunting partner, or otherwise achieves or fails to achieve nongame objectives that are orthogonal to bagging game is generally beyond the scope of direct management.

There are, however, two human dimensions variables that can be managed or at least objectively monitored and thus incorporated in management strategies. First is the season framework employed to manage a deer herd within desired management goals and parameters. This management technique determines the “when, where, what, and how many” of hunter behavior. It sets season dates—e.g., before, during, or after the rutting season. It can establish hunting zones with hunter regulations designed to achieve differential harvest goals. And it can deter-
mine what is considered legal game—e.g., does only, bucks only, either sex, adult only, or minimum antler sizes. Finally, the season framework establishes a per person limit on harvest.

A second human dimensions variable that can readily be managed is the number of hunters in an area. This can be controlled by access or limited by tag or license sales. Managing visitor numbers links the human dimensions of wildlife with a substantial literature on crowding in recreation settings (see Manning, 1999 for a review). Under the rubric of carrying capacity many researchers have studied the relationship between human density, contacts, perceived crowding, and satisfaction. Usually, increases in visitor numbers lead to more contacts with other recreationists and these, when they exceed a certain standard, lead to increases in perceived crowding (Shelby & Heberlein, 1986). Crowding is supposed to take away from the recreational experience and lead to lower levels of satisfaction. This last link between crowding and satisfaction is what has been called the “crowding model” (Manning, 1999; Shelby & Heberlein, 1986) is often not present (Stewart & Cole, 2001).

Can More People Create a Better Experience?

One reason for this weak relationship might be that the carrying capacity literature has been a bit myopic, considering visitor numbers and inter party contacts only as a negative influence on recreation quality. In many cases, however, one can think that fewer people could detract from a recreational experience and more people could enhance the experience. Playing baseball with five or tennis with one changes the character and reduces the quality of the experience. McConnell’s (1977) study of beach-goers identified considerable intersubject variability in how people respond to the presence of others. Some in this study were willing to pay more for solitude on certain beaches, while on other beaches they were willing to pay more when there were more bathers. He referred to the former as “wilderness beaches” and the later as “singles beaches.” In a study of boaters, Graefe, Donnelly, & Vaske (1986) used the specialization concept to identify intersubject variability. They found that the novice boater sometimes preferred to boat with more people in the area in case of trouble.

Indeed, in a 1980 study of consumptive recreation, the senior author and his associates (Heberlein, Trent, & Baumgartner, 1982) conducted a hunter density experiment by randomly assigning white-tailed deer hunters to high or low density settings at the Sandhill Wildlife Demonstration Area (SWDA) in Wisconsin. Their study provided evidence to support the “more-hunters-move-more-deer” hypothesis. The results showed that increases in the number of hunters was positively related to satisfaction because more hunters increased the number of deer that were seen, the probability that hunters would get shots, and the probability of bagging a deer. Thus the human dimension variable of increasing hunter density from 3–4 hunters/km² to 9–10 hunters/km² increased the biological indicators of
satisfaction (i.e., seeing, shooting, bagging). Participants in the hunt evaluated the presence of more hunters as better even though their crowding perceptions increased. The effect of perceived crowding was offset by the higher success rate.

In 1982, when results from the 1980 study were published, the senior author again had a chance to replicate the findings in another density experiment at the SWDA. To his chagrin, the original finding that more hunters “moved deer,” which increased seeing, shooting, and bagging, and which offset the negative effects of perceived crowding, failed to replicate in the second experiment. Hunters in the high density treatments were not more satisfied than low density hunters, as was the case 2 years earlier. While high density hunters saw more deer than low density hunters, they did not take more shots or bag more deer. Instead, high density hunters in 1982 felt more crowded, and the effects of feeling crowded on hunt satisfaction were not offset by more shooting and bagging success. In short, the 1982 results showed that crowds of hunters who move deer do not always guarantee more deer sightings, shooting opportunities, or hunt success. To figure out why the 1982 results differed from the 1980 results, even though the setting (Sandhill) and the activity (deer hunting) remained constant, density experiments were replicated at the SWDA in each year from 1983 until 1989. The current paper analyzes the entire data set from the annual Sandhill experiments (1979 to 1989) and examines the circumstances under which hunter density might sometimes be positive and other times be neutral or negative in hunt satisfaction.

The major difference between the 1980 hunt and the 1982 hunt involved a change in season framework. In 1980, antlerless deer (does) were the only legal game in the experimental hunt. In the 1982 hunt, does and bucks were legal, but most hunters were after trophy bucks. Are there systematic differences between doe hunters whose primary goal is meat for the table, and buck hunters whose primary goal is a trophy? Are there differences in the style of hunting between these two groups? From field observation and hunter reports, it appeared that hunters were behaving differently when they were hunting does than when they were hunting trophy bucks. Did buck hunters spend more time in a stand (sitting on a fixed stand waiting for deer to come by), and did doe hunters spend more time “still” hunting on the ground (slow stalking movements in the woods or underbrush), or driving deer out of their cover in the underbrush (groups of hunters moving systematically across terrain to flush out hidden deer)? If so, can these differences affect the biological outcomes of hunting, and in turn affect hunter satisfaction? Our working hypothesis is that there is something different about the way hunter density affects satisfaction and quality under these different season frameworks.

Satisfaction and the “More-Hunters-Move-More-Game” Hypothesis

Density and Satisfaction. Prior literature on hunting offers conflicting information about the density/satisfaction relationship—sometimes there are posi-
Hunter Density, Deer Density, and Satisfaction

The relationship between hunter density and satisfaction has been the subject of considerable research. Kennedy’s (1974) field study of Maryland white-tailed deer hunters was one of the first studies to examine the hypothesis that “more hunters move more deer.” His results showed that hunters were satisfied with their hunting experiences at very high hunter densities (35/km²) and low success (3% over a 7-day season). In spite of these conditions, 62% of the hunters reported a good or excellent hunt. Kennedy suggested that there may be positive effects of high hunter density because more hunters appeared to increase deer movement during the hunt. There may, however, be negative effects due to competition between hunters for a reasonable hunting opportunity. Concern about safe hunting in high density conditions may also decrease satisfaction. Kennedy’s data showed that as hunter density increased, the percentage of hunters who were “bothered” increased. Yet even in these high density conditions, 53% felt there were insufficient hunters to improve deer movement during the hunt. Both Kennedy (1974) and Heberlein et al. (1982) provided evidence in support of the idea that hunter density was a positive attribute that contributed to hunter satisfaction.

Other studies have shown either a neutral or negative relationship between hunter density and hunt satisfaction. Miller, Prato, and Young’s (1977) study of Colorado deer hunters found increased hunter densities led to lower satisfaction values on hunting experiences in hypothetical situations. Decreasing hunter density, however, did not lead to higher satisfaction values. This suggests that hunters, in principle, oppose density increases but are indifferent to decreases. Moreover, for specialized groups like muzzle loaders, doubling density had a larger negative effect than could be offset by doubling the success ratio. In a 1993 field study of Colorado Elk bow hunters (Fulton, Manfredo, Vaske, Johnson, George, & Kahn, 1995), however, the difference in satisfaction ratings between hunters in limited low-density hunting units did not differ from hunters in unlimited potentially higher density hunting units. Hunters in the limited hunting units saw fewer other bow hunters but more nonhunting recreationists than hunters in unlimited hunting units. Because of this, limited unit hunters felt significantly more crowded by the presence of nonhunting recreationists than did hunters in unlimited units. Hunter density, however, did not explain variation in perceived crowding or satisfaction among the two groups.

Seeing, Shooting, and Bagging. Because research offers conflicting evidence about the relationship between density and satisfaction, the human dimensions literature has looked for mediating factors that might lend clarity to this relationship. Most commonly, researchers have explored how hunter satisfaction is related to the biology of game management, which determines opportunities for seeing, shooting at, and bagging game (Gigliotti, 2000). Cue and Langenau (1979) and Cue (1978) analyzed data from 6 deer hunts where hunter density ranged from 10 to 60 hunters/km². They found that hunters felt there were too many other hunters. This judgment, however, did not affect hunter satisfaction after the buck kill and the number of deer seen were taken into account. The highest hunter
densities and most negative judgments about hunter numbers occurred in the units with high buck kills and high hunter satisfaction. Their data suggest that the increased levels of seeing deer, shooting, and bagging override the negative effects of hunter density. Hammitt et al.’s. (1990) analysis of deer hunters at the Big South Fork Recreation Area, however, showed that the negative effect of crowding on hunter satisfaction remained significant when controlling for the positive effects of seeing, shooting, and bagging deer. Consistently the human dimensions literature has shown that seeing deer, shooting at deer, and bagging deer all enhance hunter satisfaction (Gigliotti, 2000). But still, there is not a consistent and clear relationship between density, bagging, and satisfaction.

Preferences, Expectations, and Self-Selection. In each of these field studies, however, hunters were self-selected rather than assigned to hunting areas and density conditions. Kennedy (1974) and Cue (1978) observed that hunter preference for the number of hunters varies considerably. Some hunters prefer higher hunter numbers to “move deer” while others prefer low numbers to achieve solitude. In Wisconsin, 20% of the deer hunters prefer to see no other hunters, while 18% prefer to see 11 or more others (Heberlein & Laybourne, 1978). In addition, the highly satisfied hunters in Maryland were largely from urban areas (Kennedy, 1974), and the satisfied hunters in the Michigan study were from urban counties in southern lower Michigan (Cue, 1978). It is possible that hunters who preferred high density were attracted to the study areas in these cases and were not seriously troubled by hunter density. Deer hunters who differ in their skill level and preferred hunting style may also self-select to different hunting areas, choosing to hunt in areas with a certain type of terrain, vegetation cover, hunt method, or areas where higher deer densities occur.

Overall, comparing satisfaction and quality between various hunting areas remains difficult because this is affected by composition of hunters who are attracted to these areas. To address these biases and understand the effect of hunter density on satisfaction, it is necessary to randomly assign hunters to high and low density hunts. Random assignment is something scientifically desirable, but difficult to implement. The strength of the Sandhill experiments reported here is that we were able to randomly assign hunters to high and low density hunting conditions independent of their own preferences. This is a nearly unique opportunity in studies of crowding in outdoor recreation to eliminate selection bias experimentally.

In this paper, we examine how human dimensions variables—number of hunters—influences biological outcomes (seeing, shooting, and bagging) to produce satisfying and high quality hunts under alternative hunting season frameworks. Traditionally, crowding research has used density and other mediating variables as independent variables, and overall satisfaction as the dependent variable (Manning, 1999). This follows Wagar’s (1964) assertion that the goal of recreation management should be the provision of satisfying experiences. More recently, however, wildlife managers have talked more about managing for quality
experience. The management goal at SWDA during the 1979–1989 period of this research was to set the season framework in a way to increase the age structure of the deer population and sustain a larger number of older trophy bucks. In the earlier years of this strategy, managers required hunters to shoot more does. So some seasons were antlerless deer only seasons. In later years, managers allowed trophy buck seasons, where hunters could shoot either a buck or a doe, but most were trying to bag trophy bucks for which the area was being managed. Today this is called “quality deer management” and is being adopted officially or voluntarily in many areas of the United States (Miller & Marchinton, 1995; Woods, Guynn, Hammitt, & Patterson, 1996).

Is there really a difference between hunter satisfaction and hunting quality? We believe there is, and we argue that hunter satisfaction is a summary evaluation of experience outcomes, yet hunt quality is a multidimensional concept comprised of experiential moments that enhance or detract from the ongoing experience. If satisfaction is only a summary evaluation, this might explain the weak density/satisfaction relationship, and one might expect that the experiential components of a deer hunt—seeing, shooting, bagging, as well as hunter contacts and perceived crowding—could be more strongly related to quality than satisfaction. Thus, in addition to our goal of comparing the experiences of doe hunters and buck hunters, we also will compare the role of hunter density in hunter satisfaction and hunter judgements of quality for doe hunters and buck hunters.

Methods

Study Area

The Sandhill Wildlife Demonstration Area is 27 km southwest of Wisconsin Rapids, in Wood County, Wisconsin. Sandhill was operated as a private game farm from 1938 until 1962. The Wisconsin Department of Natural Resources (WDNR) now manages it as an experimental research unit, as a public demonstration area of wildlife management techniques, and as an environmental education center. The terrain is generally flat with large marshes interspersed with woodlands and fallow fields. Uplands comprise 51% of the area and wetlands, including open water, comprise 48%. Gravel pits, parking areas, gravel roads, and buildings occupy the remainder. Deer management at Sandhill promotes trophy bucks. The WDNR maintains a 3-meter-high deer-proof fence, first built in 1937, that completely encloses the entire 3,200-ha area. Their goal is to maintain the average age of bucks on the property at >4 years old, while the average age of bucks in the state during the study years was approximately 2 years old.

The Sandhill Hunt

The WDNR held annual gun deer hunts at Sandhill 1 week before the regular statewide firearm deer hunt from 1979 to 1989. The primary biological goal was
to have a season framework that could produce trophy bucks. This required hunters to shoot additional does and to pass up shooting at bucks that would be legal under a normal season framework. This special opportunity was announced by mailings, public notices, and as part of the published deer hunting regulations. Interested hunters had to apply for a Sandhill deer hunting permit by October 1st either singly or as a group of 2 to 4. Hunters were randomly selected and permits mailed by mid-October. About 5,000 to 6,000 hunters applied for the Sandhill deer hunt annually, representing less than 1% of the statewide firearm deer hunters. The only exception was during the second day of the 1982 and 1984 hunts when hunters were admitted on a first come, first serve basis.

The WDNR notified those selected to receive a permit in time for the hunters to scout the area before the day of the hunt. On the day of the hunt, hunters could enter the property in the morning at least 1 hour before legal shooting hours. All participants received a brief orientation before entering that included instructions to complete a short questionnaire after their hunt. This questionnaire addressed hunter perceptions of satisfaction, crowding, quality, and other factors that affected their hunt. Hunters were randomly assigned in advance to 1 of 4 quadrants within Sandhill, which included the Northwest (908.1 ha; 640.1 ha huntable), Northeast (744.1 ha; 564.0 ha huntable), Southwest (661.9 ha; 434.4 ha huntable), Southeast (847.7 ha; 689.5 ha huntable). Huntable area excludes deep marsh, water, and closed areas. Signs spaced at 75–100-meter intervals clearly mark compartment boundaries. Interior boundaries are not fenced and deer can move freely throughout the area. Following their hunt, all hunters could only exit through a single gate where questionnaires were collected. This exit requirement produced a nearly 100% participation rate among hunters, with more than 98% of the questionnaires usable for the analysis. WDNR personnel also gathered other hunter and deer data at this time.

**Season Framework**

The density experiments were conducted in 3 types of hunts from 1979-89 (Table 1): an antlerless-only format, an either-sex format, or a mixed format. In the antlerless only hunts (doe hunts), hunters could only shoot females or males with antlers less than 9 cm long. In the either-sex format (trophy buck I), they could shoot any deer, but because Sandhill is known for its trophy bucks, most were trying to shoot antlered males. The mixed format (trophy buck II) encouraged group hunting, where permits were more frequently issued to people who applied in groups of four. In this framework, 1 hunter in a group held an either-sex permit and the other 3 held antlerless only permits, but any 1 of the 4 people in the group could shoot a trophy buck regardless of who held the either-sex permit. Consequently, most hunters in the mixed hunt format spent much of their day hunting for trophy bucks. Because hunters in the either-sex format (trophy buck I) and hunters in the mixed hunt format (trophy buck II) did not differ significantly on
Hunter Density, Deer Density, and Satisfaction

most dependent variables, these two hunt formats were combined for analysis in this study. The analysis made principal comparisons between 7 doe hunts and 12 trophy buck hunts.

**Hunter and Deer Density**

Because the WDNR manages Sandhill as a wildlife management demonstration area, managers allowed us to manipulate hunter density by assigning permit holders to quadrants. The hunter density experimental design used three strategies on any given day: 1) high hunter density (5.0 to 10.7 hunters per km$^2$) in all 4 quadrants on 2 of the 19 days, 2) low hunter density (1.4 to 4.8 hunters per km$^2$) in all 4 quadrants on 8 of 19 days, and 3) high density in 1 quadrant with low density in

**TABLE 1** Hunter Density (per km$^2$), Deer Density (per km$^2$), Success (%), and Mean Satisfaction at the Sandhill Wildlife Demonstration Area, 1979–1989

<table>
<thead>
<tr>
<th>Year</th>
<th>Day</th>
<th>NW</th>
<th>NE</th>
<th>SW</th>
<th>SE</th>
<th>Hunter density by quadrant</th>
<th>Deer density</th>
<th>Percent success</th>
<th>Mean satisfaction</th>
</tr>
</thead>
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<tr>
<td>Doe hunts (Antlerless only)</td>
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<tr>
<td>1979</td>
<td>1</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>9</td>
<td>33.8</td>
<td>3.74</td>
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<tr>
<td>1979</td>
<td>2</td>
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<td>4.4</td>
<td>4.4</td>
<td>4.4</td>
<td>7</td>
<td>14.4</td>
<td>3.12</td>
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<tr>
<td>1980</td>
<td>1</td>
<td>8.6</td>
<td>4.7</td>
<td>4.1</td>
<td>4.6</td>
<td>12</td>
<td>21.2</td>
<td>3.60</td>
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<tr>
<td>1980</td>
<td>2</td>
<td>4.3</td>
<td>3.0</td>
<td>3.6</td>
<td>9.7</td>
<td>11</td>
<td>22.1</td>
<td>3.69</td>
<td></td>
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<td>3.1</td>
<td>3.2</td>
<td>2.6</td>
<td>3.1</td>
<td>11</td>
<td>22.1</td>
<td>3.38</td>
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<tr>
<td>1982</td>
<td>2</td>
<td>9.4</td>
<td>4.6</td>
<td>4.4</td>
<td>4.8</td>
<td>10</td>
<td>28.0</td>
<td>3.44</td>
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<tr>
<td>1984</td>
<td>2</td>
<td>5.0</td>
<td>6.4</td>
<td>6.2</td>
<td>6.3</td>
<td>11</td>
<td>33.2</td>
<td>3.63</td>
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<td>Trophy buck hunts I (Either sex)</td>
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<td>3.6</td>
<td>3.6</td>
<td>3.6</td>
<td>3.9</td>
<td>13</td>
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<td>12</td>
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<td>13</td>
<td>44.5</td>
<td>4.00</td>
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<td>Trophy buck hunts II (Mixed)</td>
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<td>1987</td>
<td>1</td>
<td>3.7</td>
<td>3.4</td>
<td>2.4</td>
<td>4.5</td>
<td>17</td>
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<td>7.6</td>
<td>8.7</td>
<td>7.6</td>
<td>8.8</td>
<td>15</td>
<td>34.0</td>
<td>3.36</td>
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<td>12</td>
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<td>1989</td>
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<td>12</td>
<td>28.8</td>
<td>3.42</td>
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3 quadrants on the remaining 9 hunt days (Table 1). Hunter density was treated as a continuous variable in the data analysis.

Deer density per km² was based on aerial surveys and trail counts (Kubisiak, 1979). Deer density ranged from 7 deer per km² on the second day of 1979 to 17 per km² on the first day of 1987 (Table 1). On average, Sandhill managers maintained the deer density of the area at just under 12 deer per km². Naturally, deer densities were lower the second day during all hunts. Further, surviving deer were probably more wary and difficult to bag, occupied the densest cover available, and preferred the remotest areas.

**Measurement—The Hunting Experience**

The questionnaire asked hunters to report the number of deer (bucks and does) sighted during the day. It also asked hunters to report the number of shots they fired during the day. Deer bagged was easily determined as hunters left the property and registered their deer. The questionnaire also measured hunter perceptions of crowding, satisfaction, and hunt quality. Perceived crowding was measured using a 9-point scale, which ranged from not at all crowded (1–2) to extremely crowded (8–9) as described by Shelby and Heberlein (1986) and Shelby, Vaske, and Heberlein (1989). The questionnaire measured satisfaction on a 6-point scale that ranged from “poor” (1) to “perfect” (6) according to Shelby and Heberlein (1986) and Vaske, Donnelly, Heberlein, & Shelby (1982). Hunt quality was measured on a 5-point scale that ranged from “very low” (1) to “very high” (5).

In addition to the density and hunting experience variables outlined above, the situation at Sandhill called for two types of control variables in the analysis. Specifically, doe hunts were more often held on the second day of the 2-day hunt when deer density was lower. Therefore, whether or not a respondent hunted on the first day was entered as a dummy variable to control for deer density and hunt framework. Second, researchers over the years observed quadrant differences in deer seen, shots taken, and success. Therefore, the dummy variables were created for 3 of the 4 compartments to control for variation in hunting experiences across quadrants.

**Analysis**

This study employed 2 analysis strategies. First, the data from all years (1979–1989) were combined into a single data set for a descriptive analysis. This part of the analysis looked at the relationship between density and crowding, comparing hunter contacts and perceived crowding between hunters who were experimentally assigned to high density quadrants and low density quadrants. This descriptive part of the analysis also looked at hunting under different season frameworks, comparing doe hunter and buck hunter responses to each of the biological and human dimensions variables included in the analysis.
Second, the combined data set from all the years was divided into two data sets by season framework, with one data set representing responses from doe hunters and the other data set representing responses from buck hunters. The causal nature of the data and their theoretical relationship suggested the use of path analysis for integrating the various individual equations (Duncan, 1966; Heise, 1975). In the path model, hunter density and deer density were exogenous variables that affected the number of hunters seen and the number of deer seen. These four variables then affected perceived crowding and the number of shots taken, which in turn affected hunter success. Finally, hunter satisfaction and hunt quality were dependent variables in the model.

The analysis employed the AMOS (Version 4) software package for structural equation modeling to estimate coefficients for four path models: (1) doe hunters and satisfaction, (2) doe hunters and quality, (3) buck hunters and satisfaction, and (4) buck hunters and quality. AMOS provides regression coefficients using maximum likelihood estimation, which allows for more accurate estimates of models with categorical variables, and which controls for unobserved measurement error. In evaluating the statistical significance of the model, we utilized a chi-square summary statistic and a comparative fit index (CFI) as measures of the model’s goodness of fit. In selecting the best fitting model, one seeks to minimize the chi-square value. The closer the chi-square value comes to insignificance, the closer the observed values from the data fit the expected values of the model—even though insignificance is often not achieved because of large sample sizes. The CFI provides a more standardized measure of how well the model fits the data, where the closer the CFI comes to unity (1.0) the better the data fit the model.

We report the results from the path analysis below in three steps. First, we detail differences in the hunting experience for doe hunters and buck hunters (Figure 1) by showing the relationships between the human dimensions variables in the model (hunter density, hunter contacts, and perceived crowding) and the biological variables in the model (deer density, deer seen, shots taken, and hunter success). Second, we show the direct effects of each independent variable in the model on satisfaction and quality for hunters in both season frameworks (Figures 2 and 3). While Figures 1, 2, and 3 only show a part of the full path model, the coefficients reported are estimated from the full model. Third, we decomposed the coefficients from the path model (Heise, 1975) to show the indirect effects of hunter density on satisfaction and hunt quality (Table 3). Decomposition of correlations allows the analyst to explore the processes of causality underlying the observed relationships and to specify the relative influence of alternate paths in the model on the dependent variable (Asher, 1983). The sum of the direct and indirect effects equals the total effects of hunter density on satisfaction and hunt quality. For example, the “more-hunters-move-more-deer” hypothesis would predict that the total effect of hunter density on satisfaction would be positive, because more hunters increase deer movement, which increases the number of deer
seen, which increases total shots and hunting success. Even though more hunters may make people feel more crowded which might take away from satisfaction, the negative effect of crowding would be offset in the total effect by the positives of seeing, shooting, and bagging.

Results

Descriptive Comparisons

Density and Perceived Crowding in a Controlled Experiment. In the high density units with >7 people per km², hunters reported seeing an average of 16.5 other hunters per day, yet those in the lower density units with < 7 people per km²

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Doe hunts</th>
<th>SE</th>
<th>Trophy buck hunts</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunter/km²</td>
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<td>5.93</td>
<td>.075</td>
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<td>Deer/km²</td>
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<td>13.12</td>
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</tr>
<tr>
<td>Total deer seen</td>
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<td>.108</td>
<td>6.65</td>
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<tr>
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<td>.061</td>
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<td>.047</td>
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<td>Deer bagged</td>
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<td>.012</td>
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<td>Satisfaction</td>
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<td>3.80</td>
<td>.036</td>
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<tr>
<td>Quality</td>
<td>3.07</td>
<td>.036</td>
<td>3.46</td>
<td>.028</td>
</tr>
</tbody>
</table>

TABLE 3 Direct and Indirect Effects of Hunter Density on Satisfaction and Quality in Doe Hunting and Trophy Buck Hunting Season Frameworks

<table>
<thead>
<tr>
<th></th>
<th>Doe</th>
<th>Buck</th>
<th>Doe</th>
<th>Buck</th>
</tr>
</thead>
<tbody>
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<td>.070</td>
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<tr>
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<td>-.039</td>
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<tr>
<td>Hunter density/Hunters seen</td>
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<td>-.032</td>
<td>-.053</td>
<td>-.028</td>
</tr>
<tr>
<td>Hunter density/Deer seen</td>
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<td>-.008</td>
<td>.038</td>
<td>-.008</td>
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<tr>
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<td>0</td>
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<tr>
<td>Hunter density/Deer seen/bagged</td>
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<td>0</td>
<td>.005</td>
<td>-.001</td>
</tr>
<tr>
<td>Hunter density/Deer seen/shots/bagged</td>
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<td>-.001</td>
<td>.005</td>
<td>-.001</td>
</tr>
<tr>
<td>Total Effect</td>
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<td>-.034</td>
<td>.115</td>
<td>-.104</td>
</tr>
</tbody>
</table>
Hunter Density, Deer Density, and Satisfaction

reported seeing 9.3 other people (F = 355.88, df = 2743, p < .001). Sixty percent of the hunters in the high density units felt some level of crowding, while 30% felt crowded in the low density units. When compared to 35 other studies at 59 settings using the same measure (Shelby et al., 1989), lower density hunts at Sandhill fell in the “suppressed crowding” category. This is the least crowded of their 5 categories where between 0% and 35% of the sample express some degree of crowding. The other categories include “low normal” crowding (35% to 50% feel crowded), “high normal” (50% to 65% feel crowded), “more than capacity” (65% to 80% feel crowded), and “much more than capacity” (80% to 100% feel crowded). At Sandhill, high hunter density units would be considered in the “high normal” category for crowding.

Doe vs. Trophy Buck Hunts. Hunters saw fewer deer and were less likely to bag deer during the doe hunts (Table 2), although they reported taking as many shots as trophy buck hunters. Doe hunters saw on average 4.54 deer (antlerless or either-sex deer), while trophy buck hunters saw 6.65 deer. In spite of seeing fewer deer, doe hunters took as many shots on average as trophy buck hunters (1.33 and 1.36, respectively). Only 1 in 4 doe hunters (25%) bagged a deer, while more than a third (37%) of the trophy buck hunters bagged a deer. On average, doe hunters felt slightly less crowded (\(\bar{x} = 2.59\)) than did hunters with either-sex permits (\(\bar{x} = 2.86\)). Doe hunters were less satisfied with their hunting experience (\(\bar{x} = 3.41\)) than trophy buck hunters (\(\bar{x} = 3.80\)). Doe hunters also rated their hunts as lower quality (\(\bar{x} = 3.07\)) than trophy buck hunters (\(\bar{x} = 3.46\)). The differences between the two types of hunting justified the development of two separate models for doe and trophy buck hunts.

The Relationship Between Biological and Human Dimensions of Deer Hunting

Four path models were estimated using AMOS (Version 4). With hunter satisfaction as the dependent variable, we estimated one model for doe hunters (\(\chi^2 = 1075.1, df = 17, p < .001, CFI = .94\)) and one model for buck hunters (\(\chi^2 = 2434.4, df = 17, p < .001, CFI = .91\)). With hunter evaluations of quality as the dependent variable, we estimated one model for doe hunters (\(\chi^2 = 1074.7, df = 17, p < .001, CFI = .94\)) and one model for buck hunters (\(\chi^2 = 2434.4, df = 17, p < .001, CFI = .91\)). The figures below show partial representations of these four models, but the estimates reported are standardized coefficients from each respective full model.

Hunter Density and Deer Density. Figure 1 shows how deer density and hunter density affect the hunting experience for doe and buck hunting. For both types of hunting, the higher the hunter density the more likely one was to see other hunters (B = .41 for doe hunters and B = .46 for buck hunters) and seeing more hunters led to feeling more crowded for both doe and buck hunters (B = .36 for doe hunters and B = .34 for buck hunters). But there was also a direct effect of
hunter density on perceived crowding net of the number of other hunters seen. That is, hunters can feel crowded even when others are out of sight. Hunters may notice others’ cars, they may hear them in the field, and can avoid areas where they suspect there might be other hunters. In this regard, buck hunters were more sensitive to hunter density. They reported more crowding than doe hunters independent of the number of hunters they actually saw in the field. (B = .26 for buck hunters vs. B = .15 for doe hunters).

The big difference between the two season frameworks was what affects seeing deer. In the buck hunts it was deer density. The correlation between seeing a deer and deer density was .24 (p < .001), but in doe hunts, the correlation was only .03 (ns). When we controlled for quadrant, day, and hunter density, deer density continued to have an effect on the number of deer seen for buck hunters—the standardized coefficient remained stable at .21. And, the coefficient for deer density’s effect on deer seen among doe hunting even became negative (B = –.08). When the deer population at Sandhill was higher, hunters under a buck hunting season framework saw more deer. This was not the case for doe hunters. All else equaled, increased Sandhill deer density failed to increase the number of deer seen during doe hunts. What did influence deer sightings in the doe hunting framework was the number of hunters in the field. When there were more hunters in the
Hunter Density, Deer Density, and Satisfaction

field, doe hunters sighted more deer ($B = .14$). On the other hand, the number of hunters has a negative effect on deer sightings in the buck hunting framework ($B = -.05$). Moreover, deer density directly affected the probability of bagging a deer in the buck hunt ($B = .06$), while no such effects were observed in doe hunting.

Seeing, Shooting, and Bagging. When hunters saw more deer, those hunting for does responded quite differently than those hunting for bucks. Doe hunters were 4 times more likely to take a shot at deer they saw than were buck hunters ($B = .40$ for doe hunters and $B = .10$ for buck hunters). In other words, doe hunters took 1 shot for every 2.5 deer seen, while buck hunters took 1 shot for every 10 deer seen. In addition, seeing deer increased the likelihood of a doe hunter bagging a deer net of taking a shot ($B = .14$). There was no direct effect, however, of seeing deer and bagging among buck hunters. Those hunting in the trophy buck framework were more selective in their shot selection, and may have passed up clear shots at numerous does while they waited for a trophy buck to pass within range. Finally, when the number of shots is held constant, hunters in both season frameworks were equally good shots. On average, both doe hunters ($B = .35$) and buck hunters ($B = .35$) successfully bagged a deer for every 3 shots taken.

Direct and Indirect Effects on Hunter Satisfaction and Hunt Quality

Direct Effects—Satisfaction. The analysis next looked at the direct effects of hunter density, hunters seen, deer density, deer seen, shooting, bagging, and perceived crowding on hunter satisfaction and their evaluations of hunt quality. Each of the effects reported in Figure 2 and Figure 3 was net of the effects of day hunted (1st or 2nd) and the quadrant hunted. All of the reported coefficients were significant at the $p < .05$ level or less.

The largest direct effect on satisfaction for both doe hunters and buck hunters was bagging a deer ($B = .32$ for doe hunters and $B = .40$ for buck hunters). The second largest effect was the number of deer seen ($B = .23$ for doe hunters and $B = .15$ for buck hunters). Shots taken have a positive effect on satisfaction as well ($B = .08$ for doe hunters and $B = .10$ for buck hunters). Crowding had a negative effect on satisfaction in both season frameworks ($B = -.08$ for doe hunters and $B = -.15$ for buck hunters), as did hunter contacts in the field ($B = -.08$ for doe hunters and $B = -.07$ for buck hunters). Net of crowding and hunters seen for hunter density increases satisfaction in buck and doe hunts, deer density had a direct effect on satisfaction in the trophy buck hunts ($B = .06$) but not in the doe hunts. Thus, the results indicated that the number of deer seen played a bigger role in hunter satisfaction for doe hunters, while bagging and deer density played a bigger positive role and perceived crowding played a bigger negative role in hunter satisfaction for buck hunters.

Direct Effects—Quality. The picture for quality is a bit different than for satisfaction (Figure 3). Bagging a deer ($B = .29$ for doe hunters and $B = .35$ for
buck hunters) and seeing deer (B = .27 for doe hunters and B = .16 for buck hunters) are still the strongest predictors of hunt quality. The number of shots taken had a positive effect for buck hunters (B = .09) on hunt quality but no direct effect for doe hunters. Hunter density had a positive effect on hunt quality ratings for doe hunters (B = .12) but no effect for buck hunters. Moreover, doe hunters who felt crowded do not feel the hunt was lower quality. They do, however, give lower quality ratings when they see more hunters in the field during their hunt (B = –.13). In a trophy buck hunt, both perceived crowding (B = –.16) and seeing more hunters (B = –.06) had a direct and negative effect on quality ratings. Finally, hunters in both season frameworks rated their hunt quality higher when deer density was higher (B = .11 for doe hunters and B = .06 for buck hunters). Thus, like hunter evaluations of satisfaction, the results showed that the number of deer seen played a bigger role in quality evaluations among doe hunters, while shooting at and bagging a deer played a bigger role in quality evaluations among buck hunters. But, unlike satisfaction, perceived crowding played no role in quality evaluations among doe hunters, even though hunter density and hunter contacts had a bigger influence on quality evaluations among this group.

Indirect Effects. When decomposing the correlations in the four path models, the differences between doe hunter and buck hunter evaluations of satisfaction
and quality become clear. The direct effect of density on satisfaction was similar for doe hunters and buck hunters. The direct effect in buck hunts was .080 and in doe hunts was .070. Nevertheless, the indirect effects of hunter density through crowding (B = –.012 for doe hunters and B = –.039 for buck hunters) and through hunters seen and crowding (B = –.012 for doe hunters and B = –.023 for buck hunters) had a negative effect on satisfaction, but especially for the buck hunters. Increases in hunter density reduced the number of deer seen for hunters, which has a negative effect on satisfaction (B = –.008) for buck hunters, but increased the number of deer seen for doe hunters which increased satisfaction (B = .032). Since hunter density increased the number of deer seen, shots taken, and bagging for doe hunters, it had a positive effect on satisfaction (B = .006). Since hunter density decreased the number of deer seen for buck hunters, it had the opposite effect on satisfaction (B = –.001). Adding the direct and indirect effects from this analysis showed that the total effects of hunter density on satisfaction were positive (B = .071) in the doe hunting season framework, and negative (B = –.034) in the buck hunting season framework.

When comparing doe hunter and buck hunter evaluations of quality, the total effect was more pronounced than the total effect on satisfaction. There was a direct effect of hunter density on quality for doe hunters (B = .120) but not for
For doe hunters, hunter density increased the number of hunter contacts, which lowered their hunt quality \( (B = -0.053) \). But all of the other effects among doe hunters were positive. The variable that is driving these positive effects is the number of deer seen. More hunters in the doe hunting framework increased the number of deer seen, which had a positive effect on quality ratings through several other variables. Like satisfaction, the total effect was positive \( (B = 0.115) \) for hunter density on quality ratings in a doe season framework. Conversely, hunter density had no direct effect on hunt quality among buck hunters. For hunters in this group, all but one of the coefficients was negative. Hunter density lowers quality rating though all of the mediating variables—through crowding \( (B = -0.042) \), through hunters seen \( (B = -0.028) \), and through the effect of hunters seen on crowding \( (B = -0.025) \). Hunter density even had a negative effect on quality though deer seen on shooting and bagging. The final effect was negative \( (B = -0.103) \) for buck hunters. For buck hunters, increases in hunter densities lower satisfaction and quality ratings, not only though increases in crowding and contacts, but because the presence of hunters does not increase the seeing shooting and bagging as it does in the doe hunting framework.

**Discussion**

*Density and Season Framework.* These data show that when wildlife managers change the season framework from buck to doe hunting, deer density and hunter density play a different roll in the experience. For buck hunting the number of deer present had a strong and consistent influence on the number that were seen and consequently shot at and ultimately bagged. For doe hunting, however, the number of other hunters had an effect on the number of deer seen. Under a buck hunting season framework, the hunters should hope for high deer densities. When hunting for does in an antlerless-only area, hunters should hope for high hunter densities. These results show that the finding from the 1980 Sandhill hunt (Heberlein et. al., 1982), which showed a positive effect of hunter density on satisfaction, was not wrong. Instead, the positive effect of hunter density holds only for doe hunting season frameworks. When the season framework is for trophy bucks, hunter density functions in the opposite way.

This opposite effect carried through the causal model to deer bagged. For doe hunters, hunter density increased the number of deer seen, seeing deer increases shooting, and shooting influences bagging. Thus, hunter density had a positive effect on bagging through a set of process variables, all of which had a direct effect on satisfaction and quality, net of bagging. For the buck hunter, it was deer density, and not hunter density, that affected bagging through the same process variables.

Our data showed that hunter density increased contacts and hence crowding for both buck and doe hunters. For both season frameworks, crowding decreased satisfaction and led to lower quality ratings in the buck hunting season frame-
work. But for doe hunters the increase in deer seen and the subsequent shooting and bagging offset the negative effect of crowding on satisfaction and quality. This was not the case for buck hunters where the indirect effect of density—net of seeing, shooting, and bagging—was almost uniformly negative.

**Density and The Hunting Experience.** These data provide evidence for the belief that more hunters move more deer—but among doe hunters only. Doe hunters often observe that an increase in hunter density is positive. They view other hunters who “still hunt” and who organize “deer drives” as helpers who “move deer,” rather than competitors who are going to shoot “their deer.” Doe hunters at Sandhill sometimes even asked to be assigned to a high density unit, since they wanted to see other hunters and to see deer. (They were, however, always randomly assigned to density conditions regardless of preferences.) But overall, they are more satisfied and rate the hunt as high quality if other hunters keep the deer moving during the day and allow them more opportunities to come home with a deer.

Those with trophy buck permits hunted quite differently than the doe hunters. They went to their stands early, and often sat all day hoping that the natural movement of the bucks during the rut would lead to a trophy animal passing their stand. We can see why hunter density had no effect on the number of deer seen for trophy buck hunters. Unlike the doe hunters, the trophy buck hunters were less likely to be moving so the deer were not moving either. Deer density, not hunter density, affected the number of deer seen and the odds of bagging a deer in the trophy buck hunts. For the buck hunters, more hunters brought no positive effects, only the negative effects of competition. For this reason, trophy buck hunters felt more crowded than doe hunters at the same level of hunter density. Feeling crowded for the trophy buck hunter had a stronger effect on their satisfaction than for the doe hunter. Moreover, feeling crowded reduced the quality rating for buck hunters but not doe hunters.

Deer density may also increase satisfaction and quality for buck hunters because more deer produce more deer sign—scrapes, rubs, trails, and scat. With all the evidence of deer, the trophy buck hunter can always hope the buck of a lifetime will appear any moment as he or she waits quietly in anticipation. The doe hunter will complain that deer sign means little if one does not successfully bag a deer, so the evidence of deer density, which thrills the trophy buck hunter, does little for the doe hunter. It can be frustrating when the doe hunter sees no deer at all after having high expectations based on abundant sign. This explains the differential coefficients between quality, deer bagged, and shots taken. The doe hunter rates it as a high quality hunt if he or she bags a deer. Getting a shot has nothing to do with it for them. Trophy buck hunters, however, are satisfied if they get a deer but say it was a high quality hunt if “I got a shot.” If these hunters at least got a shot at a trophy (even if they missed), they rated the hunt as higher quality.

**Crowding Research.** These findings challenge conventional crowding research in outdoor recreation in two ways. First it illustrates that visitor density or
use level can be a positive component of the recreation experience. Second, it also shows that density can have positive indirect effects through mechanisms that offset the negative effects of other variables. These data show that for both buck and doe hunting, increases in use level (hunter density) increase the number of contacts and increase perceived crowding. This is what we generally find in crowding studies. But for doe hunting (and not buck hunting) the increased number of hunters led to an increase in the number of deer seen, shot at, and bagged. For both buck and doe hunters feeling crowded lowers satisfaction, but seeing, shooting, and bagging deer increase satisfaction more than crowding can decrease satisfaction in the doe hunting season framework. The results of this study illustrate the problems of managing recreational use based on aggregated normative standards. These data show that a simple variable like visitor numbers (use level) can have different effects on satisfaction and experience quality even when the activity (deer hunting) and the setting (Sandhill) appear to be the same. Given this degree of variation among deer hunters at a single location, there is little wonder that the density/satisfaction relationship is consistently weak in the crowding literature (Stewart & Cole, 2001).

Although the findings of this study challenge the management policy of recreational use—i.e., use-limits based on “socially acceptable” standards—the experimental design of the study does confirm some basic assumptions in the crowding literature. Normally, people tend to choose recreational areas that reflect the kinds of density conditions they prefer. People who can tolerate crowds make visits to higher density areas or visits during crowded times. Thus, it may also be the case that the density/satisfaction relationship has been weak (Stewart & Cole, 2001) because preferred density conditions maintain respondent contacts and perceived crowding within acceptable bounds in these self-selected recreational sites. When selection bias is eliminated through an experimental design that randomly assigns hunters to high or low density areas, the expected relationship is observed. Higher density leads to more contacts, more contacts increase crowding, and crowding has a small negative effect on satisfaction and quality. Nevertheless, the results show that the relationship is modest. While crowding studies focus on human density, it is important to realize that in most recreation activities, other participants are merely one stimulus in a complex matrix.

The interesting thing for wildlife managers is that by changing season frameworks, increases in hunter density go from a positive to a negative. To provide more satisfying hunts and hunts that are rated as higher quality, hunter density should be higher in the doe hunts, and deer density, at least within the levels of variability we examined (7/ km² to 17/km²), has little to do with hunter ratings of satisfaction or experience quality. For buck hunts, hunter numbers should be limited and satisfaction and quality ratings will generally be higher. The positive direct effects of hunter density are offset by the negative direct effects of contacts with other hunters and seeing other hunters.

The focus of wildlife managers on the biological components of quality hunt-
ing experiences is quite understandable. No matter if one is hunting does or bucks, bagging a deer is the strongest predictor of satisfaction and quality. Seeing deer is the second strongest. For the things other than game populations that managers can manipulate, the effect on satisfaction is not consistent. Hunters are less satisfied with doe hunts than buck hunts, but increasing hunter density helps improve the ratings of doe hunts but reduces the quality of buck hunts. So wildlife managers should be growing lots of deer, (1) providing trophy buck hunts in low hunter density settings, and (2) providing high hunter density settings in areas where people are more concerned about providing meat for the table. He or she probably knew that before reading this paper. But now they know why.

Notes

1. The full model includes controls for the quadrant hunted and the day hunted. It also includes latent error terms for each single item measure.
2. The average deer density for doe hunts was 10.22 deer/km². The average deer density for trophy buck hunts was 13.12 deer/km².
3. All results reported from the path analysis are standardized coefficients.

References


