Explaining Deer Population Preferences: An Analysis of Farmers, Hunters and the General Public

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Wildlife managers must consider the public's preferences for wildlife population levels when determining management policies. In 1996, Maryland farmers, hunters and the general public were surveyed to determine their preferences for increasing, maintaining, or decreasing deer population numbers. Using a random utility theoretic framework with an ordered response probit model, the factors that explain preferences such as residential location, socioeconomic characteristics, landscape damage, agricultural yield loss and vehicle accidents were analyzed.

White-tailed deer (*Odocoileus virginianus*) provide different types of benefits to individuals (Conover 1997a). Previous studies have documented that the general public benefits from the deer population (Connelly et al. 1987; Decker and Gavin 1987; Hay 1988b; Loomis et al. 1989; Cornicelli et al. 1996; Waddington et al. 1994; Conover 1997b). Similarly, research has examined the economic benefits from hunting opportunities and bagged game that deer hunters experience (Kennedy 1974; Hay 1988a; Mackenzie 1990; Decker and Connelly 1989; Cooper 1993; Waddington, Boyle, and Cooper 1994). Surveys have found that farmers obtain benefits from observing and hunting deer on their land and will accept crop loss up to a certain level (Flyger and Thoerig 1962; Conover and Decker 1991; Brown et al. 1977, 1978, 1980; Decker et al. 1981; Decker and Brown 1982; Decker et al. 1983; Decker et al. 1984; Tanner and Dimmick 1984; McNew and Curtis 1997). However, surveys have also documented that as deer numbers increase in suburban and urban areas, individuals are concerned about more frequent vehicle accidents, damage to landscape plants, incidence of Lyme disease, and the appropriateness of wildlife management techniques such as hunting (Connelly et al. 1987; Decker and Brown 1986; Decker and Gavin 1987; Decker et al. 1990; Sayre et al. 1992; Stedman and Decker 1993; Conover 1995; Conover et al. 1995; Messmer et al. 1997; Stout et al. 1993, 1997; Conover 1997b). Maryland residents have raised these types of concerns. For example, protests have occurred when Maryland proposed special hunts to decrease deer numbers (Wheeler 1996; Burkitt 1997; Argetsinger 1996). A recent survey found that yield losses on farms have increased (McNew and Curtis 1997).[1] Sandt (1997) estimates that there were 10,000-plus vehicle-deer collisions in Maryland in 1996. Determining a management strategy to incorporate these stakeholders' preferences and increased deer population levels has also become more complex (Decker and Gavin 1987; Decker and Richmond 1995; Doiga 1995; McAninch 1995; Messmer et al. 1997).

In Maryland, as in other states, deer are a state-owned and managed resource. In 1902, deer had been nearly extirpated from Maryland, and deer hunting was prohibited (Sandt 1997). Due to their scarcity and economic value to society, management efforts protected deer from unregulated exploitation. Restocking efforts were made at the end of World War II. However, since the 1980s, Maryland's deer population has grown rapidly and in 1996 the deer population was estimated to be in

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[1] McNew and Curtis (1997) found that 92% of Maryland farmers experienced yield loss from deer in 1996.

excess of 300,000 animals, necessitating new management objectives. Many previous deer management programs sought to provide satisfying hunting experiences while maintaining a stable deer population. With the concerns expressed by the general public and farmers, wildlife managers today have found the need to incorporate these groups' preferences into management decisions. If the wildlife managers' objective function is to maximize society's welfare from deer, they need to understand the public's preferences for changes in deer population. At current deer population, do individuals think the costs imposed by the deer exceed the benefits attained? Are there characteristics or other factors that explain an individual's population preference? Do hunters, farmers and the general public share preferences or do their preferences diverge?

Similar to the "Inquisitive Approach" outlined by Decker and Chase (1997), the Maryland Department of Natural Resources (DNR) surveyed the opinions, attitudes, and experiences of three stakeholder groups: farmers, hunters and the general public. This paper uses the survey responses to address these questions, using an ordered response probit model. As one of a few surveys that have been conducted on the three stakeholder groups simultaneously,[2] we can investigate similarities as well as differences among the stakeholders. By using a limited dependent variable model, the marginal contributions of each characteristic that affect respondents' preferences can be isolated. Several studies including Wessells et al. (1996) have used this methodology to determine consumer perceptions on issues such as seafood safety.

Model and Estimation

Each individual experiences both costs and benefits from deer. People may benefit from viewing deer, yet at the same time incur deer-imposed damage to their landscaping. Preferences for population changes should reflect a trade-off between costs and benefits. Individuals are hypothesized to choose their preferred population (increase the population, maintain the current population, or decrease the population) by comparing the expected benefits from the deer to the expected costs. Benefits are assumed to be a function of the deer population, D, as increased numbers of deer increase the viewing opportunities as well as the number of potential bagged animals. Costs are also assumed to be a function of the level of the deer population. Vehicle-deer accidents, which can cause human injuries or car damage, increase with the deer population, as does agricultural yield loss. Home and business landscapes experience increased plant damage as deer move closer. For individual i, levels of deer population have a utility level represented by

$$U_i = B_i(D,x_i) - C_i(D,x_i) + \epsilon_i \tag{1}$$

where D is the number of deer, B_i is the benefits achieved from the deer, C_i is the costs imposed by the deer's presence or the costs incurred to limit deer damage, x_i is a vector of individual characteristics and experiences with deer, and ϵ_i is a random error component. While exact benefits and costs are difficult to determine, using a stated preference approach an individual's preference for a deer population change can be elicited. This approach is based on random utility theory, which permits discrete choices in a utility-maximizing framework. Each individual would compute his or her marginal benefits and costs. Taking the first order derivative of equation (1) with respect to D, one would hypothesize that if $B_i' - C_i' > 0$ (the marginal benefits of an additional deer to person i are greater than the marginal costs), this individual would prefer the population to increase. Similarly, if $B_i' - C_i' = 0$, the individual would prefer that the population stay the same. If $B_i' - C_i' < 0$, the individual would prefer that the population decrease.

Since these discrete choices have a natural order (increase, stay the same, decrease), an ordered-response model is used. If the true preference is Y_i as a function of x_i, then $Y_i = \beta' x_i + u_i$. The vector, x_i, includes characteristics of the individual (age, education, gender, geographic location, income), deer-related experiences (vehicle accidents, damage to crops, damage to landscape plants), actions taken by individuals to avoid deer damage (deer repellents, fencing, hunting), attitudes (opposed to hunting), and deer numbers in the county. The error is assumed to have a standard normal distribution so that $u_i \sim N(0,1)$. The true preference, Y_i, is not observed, but the stated preference on the survey question, y_i, can be used. The observed or stated preference is used as the dependent variable assuming that

$$y_i = \mathit{increase} = 0 \quad \mathit{if}\ \alpha_{-1} < Y_i \leq \alpha_0$$
$$y_i = \mathit{stay\ the\ same} = 1 \quad \mathit{if}\ \alpha_0 < Y_i \leq \alpha_1$$
$$y_i = \mathit{decrease} = 2 \quad \mathit{if}\ \alpha_1 < Y_i \leq \alpha_2$$

such that $\alpha_{-1} < \alpha_0 < \alpha_1 < \alpha_2$. The α's are free parameters and bind the ranges containing the true

[2] For example, Stedman and Decker (1993) analyze hunters and nonhunters together.

preference, Y_i. No significance is assigned to the unit of distance between the stated responses, y_i's. We set $\alpha_{-1} = -\infty$, $\alpha_2 = +\infty$ and anchor α_0 at zero. Y_i is assumed to be within the j^{th} range if $\alpha_{j-1} < Y_i < \alpha_j$ ($j = 0,1,2$). The prob($y_i = j$) is the probability that Y_i is in the j^{th} range. Let $Z_{ij} = 1$ if Y_i is in the j^{th} range, and $Z_{ij} = 0$ otherwise (Greene 1995).

The equation estimating the probability that an individual's response was answer j is

$$(2) \qquad \text{Prob}(Z_{ij} = 1) = \Phi(\alpha_j - \beta' x_i) - \Phi(\alpha_{j-1} - \beta' x_i)$$

where Φ is the cumulative density function for the normal distribution, x_i is a vector of exogenous characteristics of individual i, and the α's and β's are coefficients to be estimated. The likelihood function is

$$(3) \quad L = \prod_i \prod_j [\Phi(\alpha_j - \beta' x_i) - \Phi(\alpha_{j-1} - \beta' x_i)]^{Z_{ij}}$$

and the log likelihood is

$$(4) \quad \log L = \sum_i \sum_j Z_{ij} \log[\Phi(\alpha_j - \beta' x_i) - \Phi(\alpha_{j-1} - \beta' x_i)]$$

No closed form solution exists; therefore the likelihood is maximized iteratively. We used Limdep 7.0 to maximize the likelihood, using an algorithm based on the method of Davidson, Fletcher, and Powell (Fletcher 1980; Greene 1993).

Three different models were estimated to examine deer preferences. These models were chosen to provide relevant information to wildlife managers at the state level.[3] Wildlife managers desired information about stakeholders, about differences between geographical areas, as well as an overall explanation of the public's preferences for deer population changes. For example, the state may provide farmers with additional permits to hunt deer on their land if farmers want fewer deer. Similarly, eliciting information about hunters' preferences may aid in developing hunting policies such as bag limits aimed at specific management objectives. In the first analysis, we examine the stakeholder groups separately. This permits hunters to have different marginal values for variables that explain deer population preferences than the general public or farmers.

Similarly, deer numbers and possible management options may vary by the region of the state. Therefore, determining whether a particular region differs in preference may provide useful information to deer management policymakers. Estimating the regions separately allows the marginal contributions of the variables to preference formation to differ by the region where the person lives.[4] In the third model, the underlying process generating the preferences between the stakeholder groups and the geographic areas is assumed to be the same. Assuming regional and stakeholder group differences do not exist for most variables (although they may result in a shift of the intercept of the regression), this formulation presents a more general model for policymakers. Aside from intercept shifts, in this regression only the damage incidence and use of prevention technique variables is assumed to result in different marginal contributions to preferences between the stakeholder groups.

Data

In 1996, the Maryland Department of Natural Resources (DNR) conducted a telephone survey to determine the public's attitudes about and experiences with deer. They surveyed the general population, hunters, and farm landowners to ensure adequate representation of all stakeholder groups in determining deer management policies. For example, hunters and farmers are assumed to have specific experiences and opinions on deer, but as a small percentage of the overall Maryland population they may not have been well represented in a randomly drawn sample of the general public. Each of these target populations completed 300 survey instruments for a total sample of 900, of which 849 observations were usable. A description of the survey procedures, the data collected and the questionnaire itself can be found in DNR (Dept. of Nat. Resources 1996a). A summary of the data used in this paper is presented in table 1.

The dependent variable was based on the question, "Would you like to see the deer population in the area where you live to: increase? stay the same? decrease?" A majority responded "stay the same" (51%), 22% responded "increase," and 27% responded "decrease." Many farm landowners had experienced deer damage in the previous year (66%), compared to 14% of the general public and

[3] On a reviewer's recommendation, we estimated a model based on the Swallow et al. (1994) paper which provides disaggregate results based on individuals' characteristics or subpopulations. This approach has the potential to provide useful analyses to streamline and improve policy decisions as well as determination of the distributional impacts or equity of a policy. With our analysis however, it did not provide additional information, thus the simpler models were reported.

[4] It is possible that respondents may be determining population preferences for the geographic area where they hunt instead of the geographic area where they live.

Table 1. Summary Statistics of the Samples

	General Public %	Hunter %	Farm Landowner %
Prefer deer population increase	20.7	31.3	10.7
Prefer deer population stay the same	57.0	49.7	42.0
Prefer deer population decrease	17.3	16.7	46.0
Suffered damage in last year	13.7	21.3	66.3
Has hunted deer	29.7	100.0	37.3
Car accident with deer in last year	9.0	13.0	13.7
Car accident cost >$500	6.0	6.3	6.0
Friend had car accident	41.0	52.7	44.0
Some college education+	52.4	44.0	49.0
Income <$15k	14.0	10.7	11.3
Income $15–$25k	15.3	11.0	10.7
Income $25–$35k	17.7	20.7	10.7
Income $35–$50k	12.7	22.0	11.3
Income >$50k	22.6	27.6	25.6
Income: don't know/refused to answer	17.7	8.0	30.4
Age 18–24	11.3	10.7	1.3
Age 25–44	40.3	54.0	18.7
Age 45–64	28.3	28.7	37.7
Age 65+	14.3	5.0	37.0
Refused to give age	5.7	1.7	5.3
Live in a rural area	19.7	36.0	67.0
Live in a small city or town	48.7	33.0	17.0
Live in a big city or suburb	30.0	29.3	13.0
Amount willing to pay for higher bag limit		$4.59	
Crop damage over $1000			18.95
Opposed to deer hunting	19.7	0.0	9.7
Gender: male	46.3	88.7	60.0

21% of the hunters. Twelve percent of the sample had a car accident involving a deer in the past year. Six percent of the sample had a car accident resulting in repairs of over $500. Many in the general public (41%), farm landowners (44%) and hunters (52.7%) had a friend who had a car accident with a deer.

Almost 20% of the general public and almost 10% of the farmers were opposed to hunting.

Household income was divided into five categories: less than $15,000 (12%), $15–25,000 (12%), $25–35,000 (16%), $35–50,000 (18%), and more than $50,000 (26%). Age was divided into 4 categories: 18–24 years (9%), 25–44 years (39%), 45–64 years (32%), and 65 and older (12%). Males made up 65% of the overall sample. Education was included as a binary variable equal to 1 if the person had some college or a higher degree (49%). Residential location was self-defined as either rural (42%), small town or small city (32%) or urban (big city or suburb of large city) (26%).

In addition to the DNR survey data, 1995/96 deer harvest data by county was obtained as a proxy for local deer population. Exact deer numbers are not available and the DNR uses deer harvest numbers to make population estimates. Harvest numbers are a function of the underlying deer population only in areas where hunting is permitted. In the suburban counties in the Baltimore-Washington corridor that have stringent regulation on hunting, the proxies used for deer numbers may be low and are thus less reliable as estimates of deer numbers. No other estimates of the deer population for these counties could be found. The square of the harvest term is included to capture any nonlinearity in deer population preferences. As modeled, preferences depend on the deer population level. Respondents may want an increase in population when the population is low; however, as the population increases, the concurrent costs and problems experienced may exceed the public's tolerance, in which case they may prefer a decrease in the deer population.

We have few variables that can be used for proxies of direct benefits. We include residential location as an indicator of how likely residents are to see deer near their homes. We hypothesize that rural residents have more viewing opportunities, but also higher costs from a higher deer population. We hypothesize that deer numbers are lower in an urban area and these residents may have more tolerance and want deer numbers to increase or stay the same. We would also expect, all else the same, that hunters would prefer more deer as this could increase hunting opportunities. People who are opposed to hunting are hypothesized to want deer numbers to stay the same or increase, either because they receive greater marginal utility from wildlife such as deer than other individuals or because hunting has been the primary management tool used in Maryland to decrease population levels. To prevent future hunting possibilities, they may state a preference for an increase in the deer population. In the hunter regression, the monetary amount an individual indicated that he would be willing to pay if he were permitted a higher bag limit was included as a variable. On the survey, hunters were asked if they would be willing to pay more for a hunting license if the deer bag limit were increased but the hunting opportunities remained the same. If a person said yes, he was asked how much more he would be willing to pay.

We added variables that reflect the cost deer might impose on the three stakeholder groups. One question on the survey collected information about monetary damage levels from farmers. This variable is included in the farmer regression as a binary variable equal to one if the amount of damage caused by the deer on the individual's farm was greater than $1000.[5] Although the survey asked about damage incidence and the use of various deer damage prevention techniques—fences, repellents, dogs, hunting—it did not inquire about expenditures on deer damage prevention or costs of damage incurred by the general public or the hunter. For the hunter and general public regressions, damage incidence and prevention use were included as binary variables equal to one if damage was reported or prevention methods were used. Respondents who reported deer damage were assumed to prefer fewer deer. Similarly, people who had used prevention tools were considered more likely to prefer a decrease in the deer population. Because a monetary figure could not be included, in the general model the damage binary variable was interacted with the stakeholder group variable—farmers, hunters, and the general public—assuming that the level of damage may vary between these groups. Farmers may have 100 acres of crops while a suburban resident may have less than 1 acre of landscape plants. The monetary impact of damage to the farmer thus could be higher than to the general public. However, the homeowner may be less tolerant of a similar damage level. As another cost of deer, a binary variable indicates if the individual had personally experienced a vehicle accident with deer in the last year. Because this binary variable was not significant in the first two sets of regressions, in the general model we include only those individuals who had car accidents causing more than $500 in damage.[6] In addition, a binary variable equal to one was included if an individual had a friend who had a car accident involving a deer.

Demographic variables such as age, gender, education and income were also included in the analysis.

Regression Results

The results of the estimated ordered probit models are presented in tables 2, 3, and 4.[7] The dependent variable is coded such that a stated preference for an increase in the deer population equals zero. Therefore, negative and statistically significant coefficients indicate a preference for increased populations. In the stakeholder regressions (table 2), few coefficients on variables are significant in explaining population preferences. As a whole, the estimated coefficients for the general public were not significant in explaining preferences. None of the individual variables had significant estimated coefficients, except that people 65 and older were more likely to want a decrease in the population. For farm landowners, the amount of damage incurred significantly affected population preferences. Those with any damage and those with damage over $1000 wanted the deer population to decrease. Farmers with a friend who had a vehicle accident were also more likely to want a decrease in population (10% significance level). Use of preventative techniques did not impact population preference nor did deer harvest numbers. None of the estimated coefficients for demographic variables was statistically significant. The hunter regression provided similar information. Hunters who had experienced damage or who had a friend who had a car accident involving a deer were more

[5] Because an earlier study by Brown, Decker and Dawson (1978) found that farmers who wanted slight or moderate decreases in deer populations have mean estimated crop losses of greater than $521, we chose the next largest category (more than $1000) from the survey results as the estimated revenue loss that would impact deer population preferences.

[6] As one reviewer pointed out, a vehicle accident (9% of sample) may result in time-consuming repairs which impose costs on individuals, but in our sample, only the accidents over $500 appear to marginally impact population preferences.

[7] A reviewer suggested that the lack of significance for most of the coefficients in these equations could be due to multicollinearity. While some variables appear to be correlated, most of the independent variables are not. For example, rural residence and small city residence have a correlation coefficient of 0.58. Farmers with damage and use of hunting as a prevention technique have a correlation coefficient of 0.397. Most of the other correlation coefficients were less than 0.25.

Table 2. Regression Estimates for Stakeholder Groups' Ordered Probit Models

	Landowner (N = 285)		Hunter (N = 284)		General Public (N = 279)	
Variable	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Constant	0.9403	0.6510	0.5865	0.5448	−0.0510	0.5139
Suffered damage	0.7546**	0.1783	0.6260**	0.1656	0.2292	0.2357
Prevention Methods						
Fence	−0.0056	0.3891	−0.2080	0.2765	−0.1709	0.2593
Repellent	−0.3403	0.3538	−0.2471	0.2328	0.1096	0.2246
Dogs	0.3198	0.5512	−0.7143	0.5909	0.0053	0.2310
Hunting	0.1172	0.2030			0.3348	0.2639
Had car accident	−0.0353	0.2567	0.1714	0.2151	0.2515	0.2837
Friend had car accident	0.2817*	0.1633	0.3593**	0.1530	0.0578	0.1607
College education	−0.0195	0.1683	0.2440	0.1521	0.0865	0.1826
Income $15–$25k	−0.1363	0.2538	−0.0054	0.2898	−0.0163	0.2452
Income $25–$35k	0.1315	0.2702	−0.1839	0.2229	0.2873	0.2177
Income $35–$50k	−0.0227	0.2657	−0.1617	0.2304	0.2882	0.2988
Income >$50k	−0.0923	0.2219	−0.3388	0.2320	0.3071	0.2379
Age 25–44	−0.7193**	0.3722	0.1592	0.2276	−0.1773	0.2111
Age 45–64	−0.2875	0.3638	0.1668	0.2583	−0.1539	0.2431
Age 65+	−0.1213	0.3642	−0.4020	0.3579	0.6517**	0.2741
Rural address	−0.2440	0.2226	−0.1906	0.2146	−0.1536	0.2963
Small town address	−0.0859	0.3086	−0.3580	0.2213	−0.0029	0.2202
Gender: male	0.0829	0.1758	−0.1381	0.2442	−0.0582	0.1553
Region 2	0.0154	0.3078	−0.0720	0.3043	0.4387	0.3149
Region 3	0.0099	0.3276	−0.0659	0.2955	0.1703	0.2812
Deer numbers	0.0004	0.0003	0.0000	0.0002	0.0003	0.0002
Deer numbers squared	−0.0008	0.0006	−0.0002	0.0004	−0.0003	0.0004
Oppose hunting	−0.5768	0.3724			−0.2649	0.2418
Crop loss >$1000	0.5018**	01.2234				
WTP for bag limit increase			0.0069	0.0115		
Parameter: α_1	1.5910	0.1300	1.5291	0.1072	1.7946	0.1231
Log-likelihood	−235.6509	χ^2 = 73.688	−267.4863	χ^2 = 40.8637	−251.4458	χ^2 = 27.3418

*Significant at the .05 level.
**Significant at the .10 level.

likely to want a decrease in the population. The monetary level of willingness to pay for an increased bag limit did not affect a hunter's population preference.

In the geographic regional regressions (table 3), more of the coefficients were significant in explaining population preferences. Estimated parameters on damage incidence were significantly different from zero for all 3 regions and suggest that experiencing damage results in a preference for a smaller deer population. The estimated coefficients on deer numbers were significant at the 10% level in Region 1 and Region 3. However, they do not have the expected sign. For low population levels as proxied by deer harvest numbers, the coefficient suggests that people would want decreases in the population. Yet a negative coefficient is found for the deer population squared term, suggesting that as deer numbers increase, preferences change, with people wanting the deer population to increase. In Region 1, hunters were more likely (10% level) than the general public to prefer an increase in the population. In Region 3, farmers were more likely than the general public to prefer a decrease in the population. The coefficient on having a friend who had a car accident involving a deer in Region 2 (5% level) and Region 1 (10% level) suggests that such an individual is more likely to want a decrease in the deer population. In Region 1, the coefficients for individuals living in a rural area (10% level) or in a small town (5% level) suggest that those individuals are more likely than urban dwellers to want an increase in deer numbers. In Region 3, people opposed to hunting were more likely than those who were not opposed to want an increase in deer (10% level). The coefficient on deer numbers is significant at the 10% level but again has a positive sign for low numbers or suggests a preference for a decrease in the population. The coefficient on the squared term has a negative sign for higher deer numbers or suggests a preference for an increase in the population.

We also estimated a general model for all three stakeholder groups and regions simultaneously.

Table 3. Regression Estimates for Geographic Regions' Ordered Probit Models

	Region 1 (N = 288)		Region 2 (N = 276)		Region 3 (N = 284)	
Variable	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Constant	−5.3022	4.2474	0.7071	0.3524	−0.9741	0.8851
Hunters	−0.3478**	0.1976	−0.3448	0.2169	−0.1933	0.2476
Farmers	0.1611	0.2295	0.2911	0.2421	0.5210*	0.2539
Suffered damage	0.7217*	0.1789	0.6270*	0.2002	0.5404*	0.1789
Prevention methods						
Fence	−0.3610	0.2577	−0.2776	0.2464	−0.0036	0.4027
Repellent	0.0520	0.2463	−0.0574	0.2891	−0.4067**	0.2459
Dogs	−0.0609	0.2789	−0.2255	0.4892	0.0620	0.2726
Had car accident	0.0903	0.2179	−0.0370	0.2891	0.3312	0.2117
Friend had car accident	0.2606**	0.1477	0.3628*	0.1577	0.1645	0.1534
College education	−0.1402	0.1521	0.0197**	0.1785	0.3158**	0.1649
Income $15–$25k	0.1738*	0.2199	−0.4927	0.2951	−0.0111	0.2783
Income $25–$35k	−0.0027	0.2090	0.2009	0.2453	0.0138	0.2392
Income $35–$50k	0.1115	0.2462	0.3535	0.2704	−0.1449	0.2418
Income >$50k	−0.0407	0.2390	0.0277	0.1961	0.1084	0.2339
Age 25–44	−0.4299	0.2177	−0.3276	0.2436	0.3125	0.3105
Age 45–64	−0.2766	0.2441	−0.1043	0.2713	0.3803	0.3102
Age 65+	−0.0207	0.2640	0.3047	0.3211	0.6039**	0.3277
Rural address	−0.3987**	0.2205	−0.0533	0.1973	−0.0984	0.3650
Small town address	−0.4255*	0.2115	0.1213	0.2444	0.0144	0.3683
Oppose hunting	−0.5087	0.3451	−0.1111	0.2629	−0.7336**	0.4065
Gender: male	−0.0722	0.1814	0.0607	0.1679	−0.1544	0.1943
Deer numbers	0.0038**	0.0023	−0.0000	0.0003	0.0011**	0.0006
Deer numbers squared	−0.0051**	0.0029	0.0001	0.0008	−0.0021**	0.0013
Parameter: α_1	1.6804	0.1212	1.5387	0.1100	1.6559	0.1176
Log-likelihood	−257.7319	χ^2 = 72.6726	−253.9212	χ^2 = 61.4188	−253.3696	χ^2 = 73.8564

*Significant at the .05 level.
**Significant at the .10 level.

Parameter estimates are presented in table 4. We interacted damage incidence with each stakeholder binary group to determine if this variable's impact on population preference varied by group. In addition, farmers who used deer damage prevention techniques were assumed to expend more money on them than the general public or hunters. Therefore, the farmer binary variable was interacted with prevention techniques alone. Prevention technique variables were also interacted with the general public and hunters combined. The coefficients for damage for both farmers and hunters were significantly different from zero and suggest that farmers and hunters who have experienced damage by deer prefer a decrease in the deer population. The estimated parameter on damage for the general public was not significant, suggesting that the general public may be more tolerant of damage than farmers and hunters, or that other variables influence their population preferences. Although we had distinguished farmers from the rest of the sample when analyzing prevention techniques to allow for any unique effect associated with farming, we found that none of these variables had any statistically significant effect on preferences for deer population change. The estimated parameters on use of prevention techniques were also not significant for the general public or the hunters.

The incidence of a car-deer collision in the last year with damages greater than $500 has a significant effect on population preferences. If the survey respondent had such an accident, he or she is more likely to want a decrease in the deer population. If the respondent had a friend who had a car accident with a deer, the respondent was also more likely to prefer a reduction in deer numbers.

The only demographic variable with a significant coefficient was on one of the age variables, 65 plus years old. People in this category were more likely to want a decrease in the population.

The county harvest variables were used as proxies for deer numbers. The signs on these variables are different than expected but similar to the estimates in the other regressions. At low population levels, fewer deer are preferred. On the squared deer number variable, the coefficient was negative, suggesting more deer are preferred at higher deer numbers. Both of the variables are significant. Because urban areas have less deer hunting, deer harvest numbers are low even though deer population

Table 4. Regression Estimates for General Ordered Probit Models ($N = 849$)

	Coefficient	Standard Error
Constant	0.478	0.222
Suffered damage: general public (GP)	0.300	0.185
Suffered damage: hunters (H)	0.431**	0.141
Suffered damage: farmers	1.010**	0.124
Damage Prevention Methods		
Fence: GP & H	−0.196	0.177
Fence: farmers	0.108	0.348
Repellent: GP & H	−0.009	0.141
Repellent: farmers	−0.217	0.345
Hunting: GP & H	0.126	0.126
Hunting: farmers	0.226	0.187
Had car accident >$500	0.196**	0.079
Friend had car accident	0.221**	0.082
College education	0.114	0.085
Income $15–$25k	−0.063	0.140
Income $25–$35k	0.011	0.124
Income $35–$50k	0.021	0.131
Income >$50k	−0.017	0.118
Age 25–44	−0.146	0.134
Age 45–64	0.010	0.143
Age 65+	0.331**	0.154
Rural address	−0.177	0.113
Small town address	−0.184	0.108
Oppose hunting	−0.230	0.181
Gender: male	−0.148	0.092
Deer numbers	0.0003**	0.000
Deer numbers squared	−0.001**	0.000
Parameter: α_1	1.578	0.063
Log-likelihood	−783.094	$\chi^2 = 181.5841$

*Significant at the .05 level.
**Significant at the .10 level.

	Predicted			
Actual	**0**	**1**	**2**	**Total**
0	11	163	10	184
1	10	371	52	433
2	0	132	100	232
Total	21	666	162	849

may be high. These urban residents may prefer a decrease in the deer population. Similarly, in areas with more hunting activity, people may want an increase in the number of deer. Thus at high population estimates (high harvest numbers), respondents appear to have indicated a preference for the deer population to increase.

Simulations

When estimating a logit or probit model, one usually reports marginal effects for the parameter estimates. However, because the data used in this paper consists primarily of binary variables, simulations are conducted instead to examine the impacts of changing a particular characteristic on a respondent's preferences. Simulations permit discrete changes from male = 1 to male = 0 that are easier to interpret; a man versus a woman rather than a respondent who was 65% male becoming 64% male. Marginal effects for the continuous variables (deer numbers) are reported below.

Equation (2) gives the probability of $y_i = 0, 1,$ or 2 given x_i. For the mean of all the variables, the general model predicts that 25% of respondents prefer a decrease in deer numbers, 57% prefer the population to stay as it is, and 18% prefer an in-

Table 5. Preferences for Deer Population Change

	Decrease %	Stay the same %	Increase %
1 Male, lives in big city, 45–64, income $25–35k	18	57	25
2 Female, lives in big city, 45–64, income $25–35k	22	57	21
3 Male baseline & friend has car accident with deer	24	57	19
4 Female baseline & friend has car accident with deer	29	56	15
5 Male baseline & has accident with deer costing >$500	24	57	19
6 Female baseline & has accident with deer costing >$500	28	56	16
7 Male baseline & lives in a rural area	14	55	31
8 Female baseline & lives in a rural area	17	56	26
9 Male baseline & lives in small city	14	55	32
10 Female baseline & lives in small city	17	56	26
11 Male baseline & opposes hunting	13	54	33
12 Female baseline & opposes hunting	16	56	28
13 Male baseline, general public & had deer damage	27	56	17
14 Male baseline, hunter & had deer damage	32	55	14
15 Male baseline, farmer & had deer damage	54	41	5

crease in the population. The actual survey responses were 27%, 51% and 22%. Thus although the model does not perform well when predicting an individual's actual survey response of "increase" (see the predicted/actual table at the bottom of table 4), it does predict aggregate probabilities relatively well.

Preferences for deer population changes could be impacted by a variety of characteristics. To examine how changes in characteristics might alter population preferences, two reference baselines or representative people were created. The first baseline is a male, big city dweller without a college education, 45–64 years old and earning $25–$35,000 a year. The second is a female with the same other characteristics. For each baseline, the probability of a specific population preference is reported in the first two rows of table 5. The first row is the male baseline, with 18% likely to prefer a population decrease, 57% likely to prefer the population to stay the same, and 25% likely to prefer an increase. Comparing the two baselines, women are more likely than men to prefer a decrease in the deer population, 22% compared to 18%.

Changes in the probability of a preference for a representative person with different characteristics are also reported in table 5. These representative types' computed probabilities can be compared to the two baselines. For example, in row three, the probabilities for a male with characteristics similar to row one but who also has a friend who had a car accident involving a deer are reported. The probability that this representative person would like to see the deer population decrease is 24%, a 6 percentage point increase above the baseline. For females, there is a 7 percentage point rise in the number preferring a decrease in the deer population. Similar percentage changes in the probabilities are found for a person who has had a car accident involving a deer and incurred damage greater than $500.

Simulations for people living in small cities or rural areas were compared to people living in a big city or suburban area. People in small cities or rural areas are 6 percentage points more likely to want the population to increase compared to the big city resident baseline. This result countered the original hypothesis that people living in big cities who have fewer interactions with and a higher tolerance for deer would thus be more likely to want the deer population to stay the same or increase.

Stated opposition to hunting also impacted preferences. A man opposed to hunting is 8 percentage points (7 percentage points for females) more likely to prefer to see the deer population increase compared to the baseline.

The final three rows in table 5 report the simulation results for individuals who have experienced deer damage. In row 13, the general public with landscape damage in their yard or garden in the last year were 9 percentage points more likely than the baseline to want the deer population reduced. This difference in preferences increases to 14 percentage points above the baseline if the individual is a hunter and to 36 percentage points if the individual is a farmer. The difference for farmers may reflect the financial loss they incur. Only 5% of farmers with deer damage would like to see the deer population increase.

Since the deer number variables were continuous variables, marginal effects of a population change were computed on the probabilities of falling into each of the following categories: increase, stay the same, or decrease. The marginal effect was zero. Marginal changes in the deer population do not affect people's deer population preferences. Since the marginal change is an increase of only one deer, one can see why this marginal change might not change preferences.

Conclusions

The most striking result from this analysis is the constancy of the number of people who would like to see the deer population remain at the same level. More than half of those surveyed, regardless of personal characteristics or experiences, want the deer population to stay the same with the notable exception being farmers who have had deer damage. This finding is consistent whether the models are run by stakeholder group, by geographic region, or as a general formulation. In the simulations, the percentage of people who want the deer population to decrease never exceeds one-third in the simulation results, except for the farmers with deer damage. In addition, the percentage of those who want a deer population increase only exceeds one-third in the case of men who oppose hunting. These results suggest that the majority of people benefit from deer and want to keep deer populations at current levels. Most Maryland respondents appear to find that the marginal benefits of the deer equal the marginal costs. If deer numbers increase and more damage and vehicle accidents occur, these preferences may change, as suggested by the results for farmers and the increased likelihood to prefer a decrease in the deer population if one had a car accident with damage greater than $500 or a friend who had a car accident.

Using an econometric analysis framework, specific recommendations can be made to enable wildlife managers to focus efforts and their limited funds to the uses and areas that need them the most. Individual effects of variables on population preference were isolated. For example, individuals who have had deer damage are much more likely to prefer a reduction in the deer population. While this appears logical and self-evident, increased damage incidence may be correlated with living in rural areas where there are more deer. Therefore, even though it is those people who have more damage from deer who prefer fewer deer, one thinks that it is individuals in rural areas who prefer fewer deer.

This type of analysis can direct management emphasis to areas of heavy damage, such as farms in certain areas. We found the effect of damage was to shift the preferences of farmers who have had crop loss. This was especially true for farmers with losses greater than $1000. This coincides with an earlier study by Brown, Decker and Dawson (1978) which found that farmers who wanted slight or moderate decreases in deer populations have mean estimated crop losses of greater than $521. Management efforts may be best targeted to agricultural areas with large deer populations. In Maryland, policymakers could provide these areas with additional deer damage permits that permit hunting out of season and harvests over the usual bag limits. For the general public and hunters, damage also impacted population preferences. Previous studies such as Connelly, Decker and Wear (1987) also found that suburban residents preferring population decreases listed damage to plantings as their primary concern with deer.

In this study, other characteristics such as age, income, education and residential location have minor or no impacts on preferences. Property damage, crop loss, landscape damage, and car accidents appear to be the biggest concerns of the three Maryland populations surveyed: farmers, hunters, and the general public. Wildlife managers in the state could use these results to steer state resources to the most pressing needs.

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