# Determinants of Hunter Participation: Duck Hunting in the Mississippi Flyway

**Jon R. Miller and Michael J. Hay**

In this paper the authors study the relationship between habitat availability, hunter success, and the rate and intensity of participation in duck hunting in the Mississippi Flyway. Using socioeconomic data from the *1975 National Survey of Hunting, Fishing and Wildlife Associated Recreation,* and waterfowl habitat data from the 1970 Flyway Habitat Management Unit Project, they estimate probability and intensity of participation equations for duck hunting. The analysis differs from previous population-specific recreation studies in (*a*) the narrowly defined activity, (*b*) more precise definition of supply variables, (*c*) use of variables representing distance to hunting sites, and (*d*) the use of logit analysis to estimate participation probability equations.

*Key words:* hunting, logit analysis, recreation demand.

Increasing pressure for development of natural areas and continued growth in outdoor recreation emphasize the need for planning methodologies that improve decisions affecting recreation resources. In the case of wetlands, development is often incompatible with waterfowl hunting, an important recreational activity that requires natural habitat for a sustaining source of waterfowl and for hunting sites.

Acquisition of waterfowl habitat to prevent its alteration for agricultural purposes has been a high priority for years in the prairie pothole region of the Mississippi Flyway and is increasingly so in the Mississippi Delta bottomland area. Recently, however, there has been growing resistance to the acquisition program by those who believe agricultural development is a better use of wetlands than is their preservation as waterfowl habitat. Improved methods of estimating benefits of wetlands preservation will permit more quantitative analyses of the trade-offs involved.

Recreation, in the form of waterfowl sport hunting, is one of several important benefits provided by wetlands and the waterfowl populations they support. The focus of this paper is on the relationship between habitat availability, hunter success, and the rate and intensity of participation in duck hunting in the Mississippi Flyway. Equations such as those presented in this paper can be used to predict how the number of hunters (and how often they hunt) would be affected by continued loss of habitat and the resulting changes in hunter success. In addition, the change in days of participation may be converted to dollar magnitudes through multiplication by day values obtained from other sources.

Our analysis differs in some important ways from previous studies of determinants of recreation behavior (Kalter and Gosse; Cicchetti, Seneca, Davidson; Cicchetti 1972, 1973; Deyak and Smith). First, we examine the determinants of participation in a narrowly defined, wildlife-related, recreation activity, rather than a broad category such as general hunting or fishing. This permits more precise definitions of supply or availability variables (e.g., the use of waterfowl habitat and hunter success measures) and makes the analysis more useful for wildlife resource management. Second, we incorporate a measure of average distance traveled to hunt waterfowl as a proxy for access-related costs of hunting. Finally, in contrast to other population-specific recreation economics studies, we estimate probability of participation equations with logit analysis rather than the commonly used linear probability model.

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In the next section, we discuss the estimating equations. The third section is a discussion of data sources and variables. In the fourth section we discuss empirical results with emphasis on the supply variables measuring the availability of waterfowl habitat and average hunter success. We then illustrate how the methodology of this paper could be used in policy analysis. In a concluding section we summarize and make suggestions for improving recreation participation studies.

## The Estimating Equations

Any broadly based sample of individuals will include a large number who do not participate in duck hunting. Attempting to identify determinants of participation from such a sample by regressing days of participation on explanatory variables will result in a large concentration of values of the dependent variable at zero. This concentration of the dependent variable at a lower bound will result in underestimates of participation for those who participate. In such a case, the classical regression model is inappropriate (Goldberger, p. 252). To alleviate this problem we use a two-step estimating process: (*a*) estimation of probability of participation equations, and (*b*) estimation of the level or intensity of participation equations for those who participate. Estimation of the first step equation uses a logit estimation technique. Most previous recreation participation studies have used ordinary least squares (OLS) for estimation of linear probability equations in step one. Three major problems are associated with this approach: (*a*) the error terms are not normally distributed and violate the classical least squares assumption of homoskedasticity, resulting in inefficient estimators; (*b*) because the error terms are not normally distributed, *t*-tests of significance do not apply; and (*c*) predicted probabilities from the estimated equation could yield values outside the 0–1 probability interval (Goldberger, Nerlove and Press, Netter and Maynes, Zellner and Lee).

Alternative binary choice models avoid these problems. The two most popular alternatives are the probit and logit formulations.[1] The primary concept underlying these binary choice models is the threshold of response. In the context of this study, an individual either hunts waterfowl or does not. We assume an individual's participation decision is a function of socioeconomic characteristics and the availability of waterfowl habitat and populations. If the value of this function exceeds some threshold value for the individual, the individual will participate. For the *i*th individual, $Y_i$, is defined as follows:

$$(1) \qquad Y_i = \begin{cases} 1 \text{ if } I_i \geq I_i^* \\ 0 \text{ if } I_i < I_i^* \end{cases}$$

$I_i^*$ is the individual's response threshold, and $I_i$ is a linear function of the explanatory regressors, i.e., $I_i = \alpha + X_i' \beta$. The probit model assumes that $I_i^*$ is a normally distributed random variable. With $I_i^*$ distributed normally, the probability that $I_i > I_i^*$ is simply the value of the cumulative normal probability function evaluated at $I_i$. The cumulative normal function has an *S* shape with the probability values bounded by zero and one. Estimation is usually done with iterative maximum likelihood techniques.

Since the cumulative logistic probability function is basically similar in form to the cumulative normal function, it is often substituted for it because of its relative computational ease. In logit analysis, the probability that the individual will participate is

$$(2) \quad P_i = F(I_i) = \frac{1}{1 + e^{-I_i}} = \frac{1}{1 + e^{-(\alpha + X'_i\beta)}} .$$

The specification is more apparent if (2) is rearranged, i.e.,

$$(3) \qquad \log\left(\frac{P_i}{1 - P_i}\right) = \alpha + X'_i\beta .$$

Rather than the probability of the occurrence being a linear function of the explanatory variables, as in the standard linear probability model, the logit formulation assumes the log of the odds, or logit, is a linear function of the explanatory variables. The maximum likelihood coefficients are asymptotically consistent, efficient, and normally distributed, and the t-test is a valid test of significance. These desirable properties and the fact that the estimated probabilities are bounded by zero and one are the important advantages of logit estimation. While logit estimates are superior on theoretical and statistical grounds, compari-

[1] Most applications of logit and probit are based on the works of Berkson and Finney. More recent applications are Heckman, Amemiya, and in this *Journal*, Hill and Kau. Particularly readable presentations of the technique may be found in Wonnacott and Wonnacott (pp. 131–4) and Pindyck and Rubinfeld (pp. 245–56).

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sons of binary choice models show that when estimated probabilities lie within the extremes of the *S*-shaped curve, OLS or appropriately specified GLS estimates are similar to those of logit. Indeed, OLS-logit comparisons made in this study indicated little difference.

Our intensity-of-participation equation is based on the household production approach developed by Becker and recently adapted by Deyak and Smith for analysis of participation in outdoor recreation. While we believe the household production approach is theoretically appealing, reduced-form equations like the ones in this paper can also be derived from a more traditional supply-demand framework (e.g., see Cicchetti, Seneca, Davidson). In the household production framework, duck hunters are assumed to maximize utility functions expressed in terms of final service flows, one of which is measured as days of waterfowl hunting. The individual is both consumer and producer, combining purchased market goods, certain nonmarket goods, and time in the production of the final service flows. In the case of duck hunting, purchased goods include costs of travel, ammunition, and other equipment. Nonmarket goods include public duck-hunting sites and duck populations that are managed as common property resources by federal and state resource management agencies. As noted in the introduction, the influence of these latter variables is the prime concern in this paper. Waterfowl habitats and populations are viewed primarily as supply shifters, i.e., as the amount of habitat or the size of waterfowl populations increase, the cost to the hunter of a constant quality hunting day will fall and he will be induced to hunt more, other things remaining equal. Alternatively, availability could be viewed as a demand shifter, as the quality of hunting days would be expected to increase with availability. However, both influences are in the same direction, so we would expect the effect of availability of habitat and ducks on participation to be unambiguously positive.

The result, described in detail in Miller and Hay, and Deyak and Smith, is a reduced-form equation in which the number of days of duck hunting is a function of exogenous shifters of the individual's demand and supply (marginal cost) curves. Because it is a reduced form, the coefficients of this equation cannot be interpreted as either demand or supply structural parameters, but rather as measures of the joint effects of both supply and demand. The equations cannot be used to estimate economic values of hunting days or bagged ducks. Moreover, the lack of information in our survey data on the location of an individual's hunting activity, other than by state, precludes techniques such as the disaggregated travel cost approach (Brown and Nawas; Gum and Martin) to obtain value estimates. The methodology presented in this paper, however, is related to economic valuation. Recreation benefit evaluations typically provide estimates of participation and average or marginal values of a day of the activity under study. However, these evaluations are not designed to account for changes in participant numbers or level of activity over time as a result of changes in policy-related variables such as habitat and game populations. Participation studies, like the one presented here, help to fill this gap and permit broader use of such economic value estimates.

## Data Sources and Definition of Variables

The primary source of data used in our empirical estimates is the *1975 National Survey of Hunting, Fishing and Wildlife Associated Recreation* (U.S. Fish and Wildlife Service). The survey was conducted in two stages. The first stage consisted of a national telephone survey of a stratified sample of some 106,000 households nationwide. The telephone interview with the household head or other adult household member gathered demographic information about each member of the household and whether he or she had hunted or fished in the preceding year. The survey also asked if household members had engaged in wildlife watching or photography during the past year, and, if so, how often. Certain other data were also gathered. The second stage of the survey consisted of mailing questionnaires, with two follow-up mailings if needed, to a nationwide sample of hunters and fishermen identified in the telephone survey. In all, the survey resulted in usable information for more than 330,000 individuals in the telephone survey and more than 20,000 individual hunters and fishermen in the mail survey.

Estimating probability of participation in an activity based on survey data requires that the sample of individuals include some who participated in the activity of interest and some who did not. In our case, the telephone survey includes those who hunted in 1975 and those

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who did not, but does not indicate what kind of hunting was engaged in (waterfowl, big game, etc.). More detailed information was gathered in the mail, follow-up survey. Hence, we divide our first-step probability estimation into two substeps; first, the probability that an individual engaged in hunting of any kind in 1975, and then, given that he hunted, the probability that he hunted ducks. Due to the large sample size generated in the telephone survey, the equation in the first substep is estimated with a randomly drawn subsample of hunters and nonhunters from the telephone phase of the survey. A probability-of-participation-in-duck-hunting equation is then estimated using all of the sample hunters in the Mississippi Flyway, some of whom hunted ducks while others did not. The second-step or level of participation equation is estimated for only those Mississippi Flyway hunters who had hunted ducks.

Table 1 shows the explanatory variables used in our equations. Most of the variables are standard measures and require no further explanation. The supply-related variables are based on state level data from sources other than the 1975 Survey. They are assigned to each individual in the sample based on his state of residence. For example, the variable *ACRES* is a per capita measure of public recreation areas and commercial forests and is included in the probability-of-hunting equations to represent relative availability of open space for hunting. Data on public recreation land area are derived from the results of the U.S. Bureau of Outdoor Recreation's unpublished *1972 Public Outdoor Recreation Areas and Facilities Inventory*. Commercial forest

**Table 1. Definition of Variables**

| Variable Name | Definition | Units of Measurement |
|---|---|---|
| *AGE* | Age of respondent | years |
| *AGESQ* | Square of respondent's age | years |
| *INC* | Respondent's household's income | thousands of dollars |
| *SEX* | Sex of respondent | 1 – if male<br>0 – otherwise |
| *PREF* | Intensity of preference for waterfowl hunting | 1 – if waterfowl hunting is favorite activity<br>0 – otherwise |
| *METRO* | Metropolitan residence | 1 – if residence is in metropolitan area<br>0 – otherwise |
| *NONCON* | Nonconsumptive fish and wildlife participation | 1 – if respondent reported having observed or photographed wildlife in 1975<br>0 – otherwise |
| *BAG* | 1974 average season bag of ducks per hunter in the respondent's state of residence | number bagged |
| *MILES/DAY* | Total season round trip automobile miles driven by the respondent for migratory bird hunting divided by total days of participation in the activity | miles per day |
| *ACRE* | Acres of public recreation land plus acres of commercial forest in respondent's state of residence | acres per capita |
| *WHAB* | Acres of waterfowl habitat in respondent's state of residence | millions of acres |
| *WETHAB* | Acres of wetlands and permanent water habitat in respondent's state of residence | millions of acres |
| *UPHAB* | Acres of upland waterfowl habitat in respondent's state of residence | millions of acres |

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acreage is from U.S. Department of Agriculture (USDA, p. 20). Per capita measures of this variable are used to capture the effect of general population and congestion pressures on the availability of hunting opportunities. General population, rather than hunter population, is used as the per unit measure, since other activities may affect the availability or suitability of hunting sites.

The measures of waterfowl habitat (*WHAB*, *WETHAB*, and *UPHAB*) are based on the Flyway Habitat Management Unit Project (U.S. Bureau of Sport Fisheries and Wildlife). That project produced estimates for 1965 of the acreage of three types of waterfowl habitat in each of the coterminous forty-eight states. The three habitat types are wetlands, permanent water, and upland habitat. More recent estimates are not available. The bag (hunter success) variable is derived from data compiled yearly by the U.S. Fish and Wildlife Service and reported by state and flyway (Carney, Sorenson, Schroeder).

## Empirical Results

Three equations representative of the type of hunter participation analysis possible with the 1975 Survey data are presented here. More detailed empirical work may be found in Miller and Hay. Equation (4) is the estimated relationship between the log of the odds (logit) of hunting in general and hypothesized determinants of hunting. Equation (5) is a similar relationship for duck hunting. The coefficients represent the derivatives of the log of the odds with respect to the explanatory variables. The corresponding relationships to the probability of participation, $P$, are nonlinear. The partial derivatives of the nonlinear probability function evaluated at sample means appear below the asymptotic $t$-statistic shown in parentheses beneath the coefficients. The likelihood ratio index (*LRI*) is a logit analogue to the multiple correlation coefficient in least squares regression (Domencich and McFadden, p. 124), and is defined as

$$LRI = 1 - (\text{log likelihood at convergence/log likelihood at zero}).$$

$\bar{P}$ is the proportion of the sample that participated.

$$\begin{aligned}(4)\quad \ln\left(\frac{P}{1-P}\right) = {} & \underset{\substack{(8.92)\\0.001}}{-5.764 + 0.156\,AGE} \\ & \underset{\substack{(-9.02)\\ -}}{-\,0.002\,AGESQ} + \underset{\substack{(11.69)\\0.140}}{2.463\,SEX} \\ & + \underset{\substack{(1.33)\\0.015}}{0.264\,HEAD} - \underset{\substack{(-7.75)\\-0.015}}{0.933\,METRO} \\ & + \underset{\substack{(5.17)\\0.038}}{0.666\,NONCON} + \underset{\substack{(3.92)\\0.001}}{0.021\,ACRES},\end{aligned}$$

where $LRI = .263$, $\bar{P} = .137$, and $n = 2{,}752$. All coefficients in equation (4) are significant at the 1% level except the head of household dummy, significant at the 9% level. The quadratic relationship between *AGE* and the log of the odds indicates that increasing age affects hunting participation positively up to a point and then has an overall negative effect, other things being equal. Based on the coefficients of equation (4) the maximum probability of hunting occurs at age thirty-nine. This inverted U-shape relationship is in contrast to the findings of Cicchetti (1973), who reported that the probability of hunting was higher for young and for retired persons than for those in the middle age groups. Two other socioeconomic or demand-related variables have significant coefficients. Not surprisingly, men are more likely to be hunters than women. The negative *METRO* coefficient indicates that persons living in urban areas are less likely to hunt than individuals in nonmetropolitan areas, other things being equal. The coefficient of *ACRES* is significant with the expected positive sign. The positive coefficient of *NONCON*, the wildlife observation/photography dummy, suggests that consumptive (hunters) and nonconsumptive wildlife users (observers and photographers) may not comprise separate groups as is often suggested. Significant overlap exists. Hunters frequently take nonhunting, scouting trips to check potential hunting sites and game populations. In addition, a significant portion of the benefits of hunting is nonconsumptive in nature. Many people hunt primarily to experience nature, and to escape the stresses of the man-made environment. Hunters with such preferences likely take nonhunting trips for those types of benefits.

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Equation (5) presents estimates of the determinants of participation in duck hunting, conditional on being a hunter.

$$(5)\ \ln\left(\frac{P}{1-P}\right) = \underset{\substack{(8.06)\\ \phantom{-}0.187}}{2.673} - \underset{\substack{(-7.52)\\ -0.005}}{0.026}\,AGE + \underset{\substack{(3.57)\\ \phantom{-}0.187}}{1.004}\,SEX + \underset{\substack{(4.71)\\ \phantom{-}0.004}}{0.019}\,INC - \underset{\substack{(-1.81)\\ -0.034}}{0.180}\,METRO + \underset{\substack{(6.59)\\ \phantom{-}0.027}}{0.145}\,BAG + \underset{\substack{(6.28)\\ \phantom{-}0.058}}{0.313}\,WETHAB + \underset{\substack{(3.26)\\ \phantom{-}0.028}}{0.153}\,UPHAB,$$

where $LRI = 0.064$, $\bar{P} = .27$, and $n = 2{,}786$.

These estimates focus the analysis more narrowly. The analysis is restricted to duck hunting in the Mississippi Flyway, and some notable changes occur in comparison to the more general equation (4). Again, all coefficients are significant at standard levels. The effect of *AGE* on the probability of participation is distinctly different for duck hunting than for hunting in general. Here the effect is negative throughout, with no U-shape relationship as was the case previously. The coefficient of income is positive and significant in these estimates, whereas it was not a significant determinant of the probability of participation in general hunting. This means that, among hunters, as income increases, the probability that an individual hunts ducks also increases, holding age and other factors constant. The coefficient of *SEX* is again positive, indicating that if women hunt, they are less likely than men to hunt ducks. The variables included as measures of duck hunting opportunities have the expected positive coefficients and consistently high $t$-ratios.

Average season bag per hunter in the respondent's state of residence (*BAG*) is a measure of hunter success in 1974. Success in the preceding year was thought to be the relevant measure for the decision whether to hunt or not in 1975. Average bag in the year of the activity could be used as an alternative success variable, as hunters may be induced to hunt if they perceive the current hunt to be going well. Including both variables in the same equation, however, resulted in a high degree of multicollinearity.

The measure of habitat availability is disaggregated into acres of wetlands including permanent water (*WETHAB*) and upland habitat (*UPHAB*). The coefficients of both variables are significant, with the partial derivative of *WETHAB* twice as large as that of *UPHAB*. This means that changes in availability of wetlands as hunting sites have more impact on duck-hunting participation rates than do changes in upland habitat, other things being equal.

The interpretation of these statistical estimates of the effects of success and habitat when entered as separate explanatory variables is also of policy interest. The positive coefficient of *WETHAB*, holding the bag measure constant, means that the rate of participation in duck hunting is expected to decline if wetland acreage decreases, even if hunter success is maintained at current levels by more intensive management of remaining habitats. The reduction in participation may result from increased access cost as wetlands decline, and from the negative impact of increased congestion on remaining sites.

Equation (6) is a logarithmic specification of a level-of-participation equation. The sample consists only of respondents who hunted ducks.

$$(6)\ \ln(DAYS) = \underset{(0.39)}{0.202} + \underset{(2.70)}{0.110}\ln(INC) + \underset{(9.33)}{0.793}\,PREF + \underset{(3.00)}{0.252}\ln(BAG) + \underset{(1.87)}{0.079}\ln(WHAB) - \underset{(2.70)}{0.110}\ln(MILES/DAY),$$

where $R^2 = .21$, $F = 34.64$, and $n = 627$. Some variables appear in this equation but not in equations (4) and (5). Preference intensity, *PREF*, has a strong positive impact on days of participation. Hunters who indicated that waterfowl hunting was their favorite hunting and fishing activity hunted ducks more than twice as many days in 1975 as did those who preferred another activity, other things being equal.[2]

The addition of a distance-travelled-to-hunt variable improves the overall fit of the step two equation. Miles per day is included as a proxy measure for the cost of access to hunt-

[2] In the multiplicative functional form, an intercept dummy variable such as *PREF* has the effect of increasing the intercept term, $e^{\beta_0}$. Thus, when *PREF* = 1, the intercept is $e^{\beta_0+\beta_1}$ where $\beta_1$, is the coefficient of *PREF*, and $Y$ is $e^{\beta_1}$ times larger than when *PREF* = 0.

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ing sites. The most notable effect of the distance-travelled variable is that when *MILES/DAY* is included in the equation, *METRO* is no longer statistically significant. This suggests that the significance of *METRO* in the probability equations reflects the influence of access costs rather than urban-rural taste differences. Note that income has a positive effect on level of duck hunting, as it does in the probability equation. *WHAB*, measuring habitat availability, combines *UPHAB* and *WETHAB* which were not significant in equation (6) when entered separately.

Participation equations typically are used to test hypotheses about determinants of participation and to forecast numbers of participants and days of an activity. Hypothesis testing in terms of the effect of age, income, and other factors was discussed above. Forecasting, and the use of the estimates for policy purposes, can be illustrated by considering the effects on duck hunting of a 10% loss of waterfowl habitat in each state in the Mississippi Flyway, an average of 204,900 acres per state.

The reduction in habitat has the effect of reducing the number of duck hunters, as well as the number of days hunted by those who continue. Based on approximately 6.5 million hunters of all kinds in the flyway in 1975 and using partial derivatives from equation (5), a 10% habitat loss would reduce the probability that a hunter hunts ducks by .0087, resulting in 56,550 fewer duck hunters. If we assume those hunters would have hunted the sample average of 8.5 days per hunter, this implies a reduction of 480,675 hunter days. The days lost because those who still hunt ducks would hunt less often, estimated at .07 fewer days per hunter from equation (6), gives a further reduction of 118,892 days. Using $29 as the estimated consumer surplus value of a day of waterfowl hunting (Charbonneau and Hay), the total reduction of 599,567 days amounts to an annual loss of $17 million. Discounted at 7-3/8%, the annual loss has a present value of $235 million, representing an average value for duck hunting of $82 per acre of habitat. If, as one would expect, the loss of habitat leads to a lower average bag per hunter, there would be further reductions that could be taken into account by means of the bag variables in the probability and level of participation equations if the relationship between acres of habitat and hunter bag could be quantified.

## Summary and Conclusions

Our main purpose was to improve the analysis of the relationship between habitat availability, hunter success, and the rate and intensity of participation in duck hunting. We presented examples of probability and intensity of participation equations estimated with data from the *1975 National Survey of Hunting, Fishing, and Wildlife Associated Recreation.*

Several variables of policy interest were statistically significant in determining hunter participation, e.g., waterfowl habitat and average bag levels. Equations estimated in this paper can be used to assess the effects on hunter participation of policy-related changes in waterfowl habitat and hunter success. Probability-of-participation equations were used to predict the change in the number of hunters, and days of participation equations to predict the change in the level of hunter activity. The estimates indicate that the reduction in duck hunting that would result from a 10% loss of waterfowl habitat in the Mississippi flyway has a discounted present value of $108 million. Estimation of the indirect relationship between habitat, game populations, and hunter success would require additional information.

Data limitations require that our empirical results be used cautiously. Our inability to determine from the survey data the extent of multiday trips is important, as is the lack of precise information on the location of the activity. Studies of waterfowl hunting and other fish and wildlife-associated recreation would benefit from improved and more extensive data on wildlife populations and their habitats. These data should be organized in geographical units (e.g., states, counties, game management units) which lend themselves to policy studies.

Our analysis has shown that differences in habitat availability and hunter success influence both the probability and intensity of waterfowl hunting. Our methods for assessing these impacts have considerable promise. Improved data and additional studies like this one can build confidence in the estimation techniques and, therefore, encourage a broader use of empirical results in planning and analysis.

[*Received October 1979; revision accepted May 1981.*]

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