Valuation of Agriculture's Multi-site Environmental Impacts: An Application to Pheasant Hunting

LeRoy Hansen, Peter Feather, and David Shank

Pheasant hunting benefits of the Conservation Reserve Program (CRP) were approximately $80 million/year in 1991 in states where the CRP appears most critical to pheasant populations. To obtain this benefit measure, the demand for pheasant hunting was estimated using a recently developed multi-site demand model, a national survey on recreation, and environmental data processed through a geographic information system (GIS). Thus not only is the resulting evaluation of the CRP's environmental impacts more accurately assessed than through the use of the generalized, supply-demand equilibrium models of previous work, but, more importantly, the environmental benefits of program acreage can be compared across field locations allowing subtle changes in policy to be assessed and the design and operation of a program to be optimized.

Populations of birds indigenous to the natural grassland ecosystems of the north-central U.S. suffered with the introduction of agriculture while the ring-necked pheasant, introduced from Asia and Asia Minor, benefited with the agriculture's early mix of land uses (Knopf; Minn. Dept. of Natural Resources). Subsequent growth in field size, specialization in crop production, and further loss in grasslands have contributed to a subsequent decrease in pheasant populations. For example, pheasant populations in South Dakota fell from an estimated 16 million in the mid 1940s to less than two million by 1986 (S.D. Dept. of Game, Fish, and Parks). Even so, the pheasant remains the most popular game bird in the Midwest (U.S. Dept. of Interior, Fish and Wildlife Service).

Title XII of the 1985 Food Security Act authorized the Conservation Reserve Program (CRP) to reverse the adverse environmental effects of farming practices. Although the Act focused on the protection of the Nation's most erodible and fragile cropland in the field selection process, it also included the consideration of a number of additional environmental impacts (USDA, 1986).[1] Following the 1990 farm bill, the additional conservation impacts became part of the CRP's field selection process.

The objective of this analysis is to empirically value the impact of farm programs and practices on the quality of pheasant hunting. The approach employed here provides location-specific benefit estimates. Use of location-specific benefits has the potential to improve farm program decisions in two ways. First, such benefits can be used to improve the design and implementation of a program. And second, an estimate of the total welfare impact of a farm program is likely to be more accurate when totaled from the micro-level impacts. To obtain the location-specific benefit estimates: 1) observations on individuals are used to estimate the demand for pheasant hunting as opposed to the supply-demand equilibrium models used in previous national environmental assessments (Ribaudo, et al.; Hansen and Hallam) and 2) a Geographic Information System is employed to maximize the resolution of the geographic data used to characterize site attributes.

The discussion below will first describe the behavioral model and the estimation method applied.

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[1] The multiple goals of the CRP include: (1) reducing erosion; (2) protecting soil productivity; (3) reducing sedimentation; (4) improving water quality; (5) improving fisheries and wildlife habitats; (6) curbing production of surplus commodities; (7) providing income support for farmers.

After a review of the data, variables, and model's application to pheasant hunting, the estimation results are presented and their implications are summarized. The model is used to estimate the annual pheasant-hunting benefits generated by the CRP under current program acreage and under the likely distribution of acreage if all acreage had been selected based on criteria of a recent signup. These two evaluations of the pheasant hunting benefits of the CRP demonstrate how the estimated model can both evaluate the program's benefits and evaluate a redistribution of the program acres with an alternative program design.

Behavioral Model

The basic behavioral framework employed is the travel cost demand model where demand is estimated as a two-stage decision process similar to that developed by Feather, Hellerstein, and Tomasi. The first stage random utility model (RUM) allows each individual to choose from multiple sites. The second stage participation model allows each individual to choose the level of participation.

In the first stage, the site-selection stage, the utility from a single trip is:

$$(1) \qquad V_j + \epsilon_j = X_j\beta + \epsilon_j$$

where V_j is the systematic component of utility that the individual receives from site j. The systematic component is dependent on the site attribute variables (X_j) and a vector of coefficient parameters (β). Commonly, X_j includes site attributes such as the associated travel cost and measures of site quality. The random component of the individual's utility or the error term, ϵ_j, is known to the individual but not to the investigator.

The parameters of the RUM are estimated from observations on the visited site(s) and characteristics of all potential sites. Assuming that the ϵ_j's are *iid* extreme value with mean zero and a unit scale parameter, the probability of an individual visiting a site j, Π_j, is estimated with a multinomial logit model:

$$(2) \qquad \begin{aligned} \Pi_j &= Pr(V_j + \epsilon_j \geq V_k + \epsilon_k), \qquad \forall \quad j \neq k \\ &= \frac{\exp(V_j)}{\sum_{i=1}^{n} \exp(V_i)} \end{aligned}$$

where n is the number of sites availed to the individual. The RUM allows for the individual's substitution among site alternatives given site attributes. However, it cannot predict subsequent changes in seasonal participation. To accomplish this, the second stage participation model is employed. The participation model models the individual's trip demand as a function of the expected price, $E(P)$, and expected site attributes, $E(\alpha)$, given the site options that the individual faces. To derive $E(P)$ and $E(\alpha)$, we first use equation 2 to estimate Π_j, the probability of visiting site j, for all n sites the individual faces. Then, with P_j, α_j, and Π_j, the expected site attributes are:

$$(3) \qquad \begin{aligned} E(P) &= \sum_{j=1}^{n} \Pi_j P_j \\ E(\alpha) &= \sum_{j=1}^{n} \Pi_j \alpha_j . \end{aligned}$$

The expected site attributes are estimated for every individual and used in the participation model. Being a demand model, the participation model will also depend on characteristics of the individual, Y, thus is given as D($E(P)$,Y,$E(\alpha)$).

With the integer nature of the dependent variable representing the number of pheasant hunting trips, a count data model is most appropriate when estimating D($E(P)$,Y,$E(\alpha)$). Because the dependent variable has nonnegative integer values that are significantly skewed toward zero, a Poisson Count Model is most appropriate (Hellerstein; Creel and Loomis; Englin and Shonkwiler). Conceptually, the number of trips an individual takes, t, is assumed to be a random draw from a Poisson distribution with mean λ so that.

$$(4) \qquad f(t) = \frac{e^{-\lambda}\lambda^t}{t!} \qquad t = 0, 1, 2, 3, \ldots$$

Next, λ for an individual is assumed to be a function of the vector of parameters, Γ, and the participation demand variables, $W = \{E(P),Y,E(\alpha)\}$, so that:

$$(5) \qquad \lambda = e^{W\Gamma}.$$

Equations 4 and 5 are the standard formulation of the Poisson regression model (Haab and McConnell).

Within this behavioral framework, consumer surplus is:

$$(6) \qquad CS = \int_{E(P)}^{\infty} \lambda dP = -\frac{\lambda}{\Gamma_p}$$

where Γ_P is the estimated coefficient on $E(P)$.

The change in consumer surplus when an individual sees environmental quality change from α to α' is:

$$(7) \qquad \Delta CS = CS' - CS$$

where CS' is the consumer surplus an individual enjoys when environmental quality has changed to α'. The total change in consumer surplus is the sum of ΔCS across the relevant population.

Pheasant Hunting: Data and Variables

While agriculture affects many wildlife species, this study looks at pheasants for two reasons. First, as mentioned previously, the pheasant is the most popular upland game bird throughout the Midwest (U.S. Dept. of Interior, Fish and Wildlife Service). Second, pheasants are sensitive to changes in uses of agricultural lands. Specialization in production and the increased use of insecticides and herbicides have cost pheasants cover and food sources thereby reducing nesting success and chick survival (Jahn; Messick et al., Minn. Dept. of Natural Resources; Warner (1979; 1984); Warner, Etter, Joselyn, and Ellis; Hill; Basore, Best, and Wooley). Together, the popularity of the sport and the dependence of pheasants on agriculture suggest that the welfare impacts of changes in agricultural land uses may be very significant. Pheasant habitat is most suitable and their population most abundant in the Midwest (e.g., the Lake States of Wisconsin, Michigan, and Minnesota; the Corn Belt States of Iowa, Illinois, Ohio, Missouri, and Indiana; the Northern Plains States of the Dakotas, Nebraska, and Kansas; and Montana), an area representing more than half of all U.S. cropland.

To best estimate individuals' demands applicable in national policy analyses, one must make best use of available data and minimize the disadvantage(s) of any data shortcoming. In the discussion below, the available data are discussed along with an overview of advantages, shortcomings, and the approach used to overcome each shortcoming. Behavioral data are discussed first followed by details of the resource data. As a summary, the variables are defined.

Behavioral Data

Data on individuals' pheasant hunting were obtained from the 1991 survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR). This is a national survey on such things as equipment expenditures, respondent characteristics, days spent pheasant hunting, and the travel distance to the most commonly visited site. Based on survey responses, we selected a subsample inclusive of respondents who had hunted any species at least once within the past 10 years or thought they might hunt in the survey year. This subsample of 5,834 observations was thought to represent all potential hunters in the relevant (Midwestern) states.

There are a number of factors that must be considered when specifying the hunting quality of potential sites. Two characteristics of this amenity suggest that a site should be defined across miles. First, on a single hunting trip, an individual hunts on a collection of fields and these fields spread across a number of miles. Thus a site should include this collection of fields. Second, pheasants are known to move a few miles periodically as habitat needs arise (Warner and Etter 1985). This means that hunting quality might be very good in corn fields due to the good nesting habitat provided by CRP fields several miles away. Thus, because pheasant hunting quality at any one field can depend on land uses across a several-mile range, a site should include this broader array of habitats or fields relevant to the collection of fields hunted. While these two characteristics of the amenity suggest that the site should cover a number of miles, there is no certainty as to the appropriate number of miles. However, because the general pattern of farmland use within the study area (the corn and wheat belts) tends to remain unchanged across 30–40 mile ranges, sites of multiple miles can be specified without loss in amenity variation.

One strength of the FHWAR data is that respondents' zip codes are available. Zip codes are relatively small geographic areas whose centroids provide reasonable geo-referencing points for site specification. The land surrounding a respondent would be his/her closest site. Given the distance traveled by pheasants and by hunters and the consistency of farmland use across wide areas, it seems reasonable to include land within 25 miles of a respondent as the closest site. The next closest sites are those beyond 25 miles but within 50 miles. There are three sites defined in the 25 to 50 mile range, five sites in the 50 to 75 mile range and seven sites in the 75 to 100 mile ranges (figure 1). Under this specification, 16 sites of equal size are generated for each zip code.[2]

One weakness of the 1991 FHWAR survey is that it does not provide data on the direction traveled. The survey does identify (1) the distance traveled and (2) the state where the hunting took place. For those trips less than 25 miles, direction does not make a difference since the closest site includes all land within 25 miles. And for some trips exceeding 25 miles, the information on the state

[2] This study focuses on single-day trips because of limitations in the FHWAR survey. All trips less than 100 miles are assumed to be single-day trips. From the FHWAR survey, we know that more than 95% of all trips are less than 100 miles.

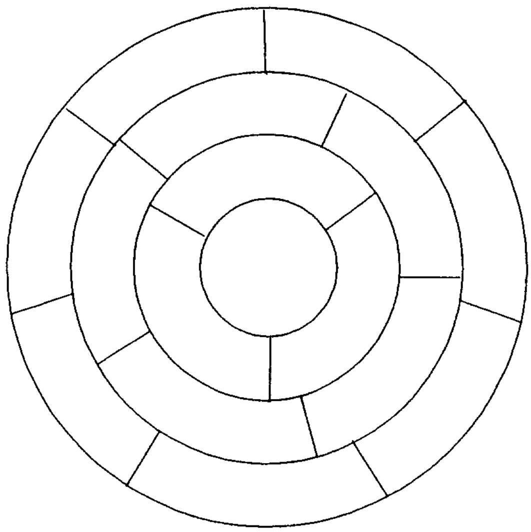

Figure 1. Delineation of Sites Around Zip Code Centroids.

where the hunting took place helped determine the visited site. Together, this survey information allowed sites to be identified for approximately 70% of the observations. When more than one site fit the distance/state criteria, we used data from the North American Breeding Bird Survey (BBS) to provide some basis for determining the selected site. The BBS provides surveyors' counts of birds species observed along designated routes on scheduled days.[3] We assume the selected site to be the potential site with the highest BBS pheasant count.[4] Although this approach is likely to assign some individuals to sites they did not visit, this is not expected to bias parameter estimates. This is because, for individuals assigned to the wrong site, there will be no correlation between that site's quality and other model variables. Admittedly, the standard errors of the site quality coefficient will be increased. In an alternative approach, each ring of sites is identified as a single site and resource quality is defined by the average and variance of the quality variables within the ring. A weighting scheme was employed to account for the variation in ring size. This approach provided very poor results in that coefficients on these resource variables were not significant. We believe that the poor results reflect the fact that land uses across a large land area are unrelated to the ecosystems' health. That is, by using the more aggregate site measures, the mixture of land uses can represent uses that are 150–200 miles apart and thus are not part of the same ecosystem. Although the variance terms are included to capture this effect, it is possible to have the same variance around different average measures; however, the effect of the variance is likely to be different in the two cases. Thus, in light of the results, we concluded that the mix of land uses on smaller sites would serve as the better indicator of the health of the pheasant ecosystem despite the identification problem.

Site Attribute Variables and Data

The 1992 National Resource Inventory (NRI) provides subcounty sample data on agricultural and nonagricultural land use. The 1990 Census of Population provides a measure of population densities. Population density is thought to represent crowding, which is assumed to adversely affect the individual's pheasant hunting demand.

The NRI subcounties, census tracts, and BBS surveyor route each represent different geographic areas. Each is also different from the sites defined in this study. To convert the NRI, Census, and BBS data into site data, a Geographic Information System (GIS) was employed. For each NRI, Census, and BBS variable, the average shifted histogram (ASH) technique was used to estimate a "surface" of values based on the variable's surrounding values (Scott and Whittaker). That is, variable values are estimated at specific grid points. The grid scale used here is approximately 3.9 miles which means values are estimated for each variable every 3.9 miles horizontally and vertically. Thus a plot of a variable's estimated values across the grid points generates a 3-dimensional surface. A surface is generated for each NRI, census, and BBS variable. The attributes of each site are derived from these surfaces. Specifically, values at the grid point closest to a site's center are assumed to reflect the attributes of the whole site.

Biological studies have yet to model agricultural's impacts on pheasant populations. With no biological model, a "reduced-form" model is employed (see footnote 3). The reduced-form model is a combined biological-behavioral model. The reduced-form model uses the habitat variables that

[3] Our first efforts were to estimate pheasant counts as a function of land uses/habitat so that counts could be used in the behavior model. However, variables in the pheasant-count model were not found significant for three possible reasons. First, although the BBS is the only national count of birds available, it lacks a consistency in bird counts due to changes in surveyors over space and time (Link and Sauer). Second, the CRP's added cover may reduce the portion of the (greater) pheasant population that surveyors see and, therefore, count. And third, biases due to routes being confined to roads have also been indicated (Sauer, Peterjohn, and Link and Bart, Hofschen, and Peterjohn).

[4] We also randomly selected from the potential sites without a significantly change in estimates of the behavior models.

are determinants of pheasant populations as independent variables. Coefficients on the habitat variables represent both the biological and the subsequent behavioral responses.

Some indications of the appropriate variables for a reduced form model are offered by studies that have looked at agriculture's impacts on a single life stage. Together, these studies indicate that pheasant populations are affected by the portion of land in: hay and small grain crops which provide some nesting cover (HAYGRN), corn and soybeans which provide feed but poor nesting cover (CRNSOY), pasture and range which also provide a degree of nesting cover (GRASS), forest land which is generally an unsuitable habitat (FOREST), and the permanent cover of the CRP which provides good nesting and winter cover and insects for newly hatched chicks (CRP) (USDA 1989a; Warner and Etter 1986; Jahn; Kimmel et al.).[5] There are other croplands (OTHCROP) that are expected to provide a reasonable habitat relative to the variety of non-agricultural uses not modeled such as residential/urban areas, water bodies, parks etc. Since FOREST represents an unsuitable pheasant habitat, it is likely to negatively affect hunting quality. However, the suitable habitat can become unsuitable should it become too dominant among land uses. Field research has shown that the 25% limit on CRP land in any one county appears to ensure that wildlife habitat does not become too dominant (Kimmel et al.). Thus diminishing and, except for CRP, negative returns are expected of the suitable habitat variables.

Together, these variables allow the systematic component of utility in the RUM to be specified as V(COST, CRP, HAYGRN, CRNSOY, FOREST, GRASS, OTHCROP, POP) where COST represents the site's round trip travel costs and POP represents the density of people living within the site.[6]

From the RUM, the expected cost, $E(P)$, and the expected land use, $E(\alpha)$, are estimated and used with the socioeconomic data to estimate the participation model, $D(E(P),Y,E(\alpha))$. The socioeconomic variables, Y, include MALE, RURAL, ED12, ED16, AGE, and INCOME which indicate the respondent as male, as having completed high school, as having completed college, and the respondent's age and income.

Empirical Results and Policy Evaluation

All coefficients in the RUM have the expected signs and are significant at the 99% confidence level (table 1). The natural log is taken of the CRP variable and second degree terms are included for other land use variables to allow for diminishing and negative marginal effects. All coefficients on variables of the participation model are significant at the 90% confidence level; all but three are significant at the 99% level. The signs on coefficients of the socioeconomic variables are as expected except for the negative coefficient on RURAL. Because people living in rural areas are thought to be more likely to hunt, the coefficient on RURAL was expected to be positive. However, since travel costs are likely to be lower for people living in the rural areas, the model results may still be consistent with the notion that people in rural areas hunt more. All suitable habitat variables have their expected signs. Acreage in GRASS and OTHCROP remained low and may explain why their diminishing impacts did not become significant. The significance of diminishing returns to CRNSOY in the RUM suggests that the marginal decision to hunt is affected by increasing portions of land in corn and soybeans but the lack of diminishing returns in the participation model indicates the marginal decision of days to hunt is not so sensitive to changes in the portion of land in CRNSOY. The forest variables also have their expected signs.

To calculate total consumer surplus, estimates of $E(P)$ and $E(\alpha)$ are derived from the RUM based on the observed land use variables around each individual. Then, $E(P)$, $E(\alpha)$, and the respondent's personal characteristics are used in the participation model (equation 6) to derive each individual's consumer surplus. Each respondent's consumer surplus is then multiplied by the observation weight and the product summed across all respondents. The annual consumer surplus enjoyed by pheasant hunters in the study area was found to total $184 million.

With approximately eight million days spent pheasant hunting in the study area, consumer sur-

[5] The small grains included are oats, barley, and wheat.

[6] Travel cost includes both the round trip time and mileage costs. Time costs is based on the opportunity cost of an hour of time multiplied by the estimated travel time. The opportunity cost of time is set at one third the hourly wage and the hourly wage equals annual income/2000 hours per year. Travel time is estimated by dividing the distance traveled by an average speed of 42 mph where 42 mph is the average rate of speed of respondents traveled in a recent recreation survey (Feather, Hellerstein, and Tomasi). Mileage costs are set at the American Automobile Association's estimated $0.30 per mile. There are two weaknesses in the AAA vehicle cost: first, it includes the fixed costs of insurance and vehicle depreciation; and second, it represents costs of the 'average' car although hunters commonly use pickups and sport utility vehicles—vehicles known to have higher operating costs. Since these costs could be offsetting and with no established means of correcting the AAA measure for either of these factors, we though it reasonable to go with the AAA's $.30/mile estimate.

Table 1. Empirical Results

Variables[1]	Random Utility Model	Participation Model
Constant		−1.97
		(4.18)
COST	−0.148	−0.0424
	(114)[2]	(4.57)
ln(CRP)	0.237	0.0713
	(11.1)	(1.73)
HAYGRN	0.0645	0.0773
	(9.40)	(5.35)
CRNSOY	0.0884	0.0559
	(18.2)	(5.78)
GRASS	0.0458	0.0184
	(16.7)	(3.86)
FOREST	−0.0448	−0.0433
	(5.51)	(4.89)
OTHCROP	0.0647	0.0139
	(17.5)	(2.21)
HAYGRNSQ	−0.000345	−0.00129
	(3.26)	(6.60)
CRNSOYSQ	−0.000558	
	(11.9)	
FORESTSQ	0.000928	0.000875
	(6.43)	(7.04)
POP	−0.00121	−0.00266
	(11.2)	(5.50)
MALE		1.83
		(17.0)
RURAL		−0.127
		(1.84)
AGE		−0.0186
		(8.39)
ED12		0.305
		(3.35)
ED16		0.194
		(2.82)
INCOME		0.0000137
		(2.70)
INCOMESQ		$-9.48*10^{-11}$
		(8.70)
WEIGHT[3]		−0.000925
		(10.6)
WEIGHTSQ		$6.60*10^{-8}$
		(4.79)

Constant	Is a constant term;
COST	is the travel cost = ((1/3 INCOME/2000 hours/year)/42mph + $0.30) * distance traveled;
ln(CRP)	is the natural logarithm of the portion of acres in the CRP;
HAYGRN	is the portion of acres in hay, wheat, barley, and oats;
CRNSOY	is the portion of acres in corn and soybeans;
GRASS	is the portion of acres in pasture;
FOREST	is the portion of acres in forest;
OTHCROP	is the portion of farmland in crops other than CRP, HAYGRN, CRNSOY, or GRASS;
HAYGRNSQ	is HAYGRN squared;
CRNSOYSQ	is CRNSOY squared;
FORESTSQ	is FOREST squared;
POP	is the population density measured in people per square mile;

Table 1. Empirical Results (continued)

MALE	is a zero-one dummy variable equal to one when the respondent is male;
RURAL	is a zero-one dummy variable equal to one when respondent views residence as in a rural area;
AGE	is the age of the respondent;
ED12	is a zero-one dummy variable equal to one when the respondent's has completed high school but not college.
ED16	is a zero-one dummy variable equal to one when the respondent has completed college;
INCOME	is annual household income.
INCOMESQ	is INCOME squared.
WEIGHT	is the sample weight of the observation;
WEIGHTSQ	is WEIGHT squared.

[1]Actual values of the amenity variable are used in the RUM model and expected values used in the participation model.
[2]t-statistic for the null hypothesis that the parameter equals zero appear in parentheses.
[3]WEIGHT and WEIGHTSQ are included to insure equality between actual and predicted trips. This means of model adjustment has more intuitive appeal than (1) ignoring the problem, (2) using a weighted estimator, or (3) computing and employing a calibration factor that would force equality of actual and predicted trips. The authors would like to thank Daniel Hellerstein of USDA Econ. Res. Service for providing his experience on this issue.

plus averages approximately $23 per trip.[7] In earlier research, per-day consumer surplus (converted to 1991 dollars) was reported at: $54.94 for hunting upland game birds in the Rocky Mountain area (Walsh, Johnson, and McKean); $42.04 for small game hunting in South Dakota ($32.64 for the United States); $24.91 for pheasant hunting in Oregon (Adams et al.); $40.36 to $207.57 for pheasant hunting in primary areas of Oregon (Shulstad and Stoevener); $22.43 to $62.38 for small game hunting in regions outside the area studied here

[7] We calculated this average consumer surplus by dividing the $184 million in total consumer surplus by the model's estimate of 8 million days pheasant hunting. A second way to calculate average consumer surplus is to divide by the number of days hunted given be a weighted sum across sample observations. While the model estimate and the number of days estimated directly from observations are very close, they are different enough to lower average consumer surplus to 21.70 per trip. We chose the model's estimate of days for consistency. A third means of calculating average consumer surplus is to use the first-stage model where: b is the coefficient on the COST (−0.148), the k subscript indicates an individual observation, P is the sample population, and other variables are as specified in equation 2 and table 1. This approach indicates that consumer surplus averages approximately $25.

$$\frac{\sum_{k=1}^{P}\left(weight_k * \frac{\log\left(\sum_{i=1}^{n}\exp(V_{i,k})\right)}{-b}\right)}{\sum_{k=1}^{P} weight_k}$$

(Walsh, Johnson, and McKean). Thus the $23-per-day estimate derived here is consistent with the more conservative of the earlier estimates.

To determine the consumer surplus attributable to the CRP, several steps were taken. First, the appropriate subsequent land use needed to be determined. In this study, it was assumed that CRP acres would return to their prior use as given in the 1982 NRI. Next, with this information, the GIS was used to estimate land use variables at each site. These new land use variables were used in the RUM model to generate new site choice probabilities and the subsequent steps are as discussed above. As a result, if there was no land in the CRP, consumer surplus would total $104 million annually. This $80 million reduction is an estimate of the consumer surplus attributable to the CRP. This translates to approximately $4.10 per acre when these benefits are averaged over the study area's 19.5 million CRP acres. Of course, per-acre benefits do vary depending on the surrounding land uses and the proximity of potential hunters. These factors vary significantly enough to cause regional variation in average benefits. Within the Corn Belt/Lake States, the per-acre benefits average $6.46 but average only $3.00 per acre in the Northern Plains. Previous research on the CRP's benefit to small game-hunters found relatively higher benefits in the Corn Belt/Lake State (Ribaudo et al.). This regional variation is thought to be due, primarily, to relative number of people affected.

Land is selected into the CRP based on a broad set of environmental goals. Furthermore, land rents also are considered. Thus while pheasant hunting benefits are much higher in the CornBelt/Lake States relative to the Northern Plains, other environmental benefits and the differences in CRP rental payments may well justify such a distribution.

When the CRP was first implemented, soil erosion control was the sole environmental eligibility requirement used to select program acres (USDA, 1989b). After passage of the 1990 farm bill, farmland offered for program enrollment was screened for a number of environmental improvements including: ground and surface water quality improvements, wildlife habitat improvements, the reduction in airborne soil particulates, reduced soil erosion, and an increase in forested land. Since the FHWAR survey data were collected in 1991 and most CRP acreage in 1991 had been enrolled in 10–15 year contracts prior to the 1990 farm bill, the estimated pheasant hunting benefits generally reflect the CRP acreage distribution that resulted when soil erosion control was the sole environmental factor used in selecting CRP acres.

The farmland selection procedure used after the 1990 farm bill, first, screens each CRP contract bid and rejects any having a proposed rental rate that exceeds the current soil-specific rental rate; second, awards points according to an Environmental Benefit Index (EBI); and third, maximizes the EBI scores across bids at the national level (Osborn 1997; Osborn et al. 1995). EBI points or scores are designed to be positively related to the environmental improvements and negatively related to the bid's proposed rental rate.

To determine the welfare impact to pheasant hunters if all CRP acres had been selected using an EBI instead of the erosion criteria used prior to 1991, we simulated a hypothetical enrollment based on the selection and cost criteria of the 1997 EBI.[8] Total program enrollment was constrained to the 34 million acres of the observation year. Qualified acres were identified using a simulation technique developed by Osborn (1993) that selects those acres (or NRI observations) that meet basic eligibility criteria, have high EBI scores, and are likely to become a contract bid. This last factor—that they are likely to become a contract bid—was based on partial budgeting and the acre's current use (i.e., irrigated land is not likely to be offered as a CRP contract since program rental rates are dry land rates). Consequently, some but not all NRI observations (or acres) now in the CRP fell out of the program while other acres were added. NRI acres leaving the CRP were assumed to return to their pre-CRP use as identified in the 1982 NRI. The GIS was then used to generate land use estimates at grid points from which land uses at sites were derived.

Under this hypothetical distribution, results suggest that the consumer surplus to pheasant hunters would fall $10 million to $70 million or $3.57 per CRP-acre (table 2). This result likely reflects the changes in the distribution of CRP acres—a distribution that would likely increase the travel costs for pheasant hunting. Specifically, the CRP acreage in the Northern Plains falls by close to one million acres while lesser populated parts of Montana gain one million acres. The Corn Belt loses more than 600,000 acres to increased enrollment in the less populated Lake States.

Despite this fall in consumer surplus, one cannot make any conclusions on what enrollment under this 1997 signup would do to total pheasant populations. This is because changes in pheasant popu-

[8] Specifically, this was the 15th signup for the CRP. The applications for this signup were accepted at local Farm Service Agency offices March 3rd through March 28th, 1997. The U.S. Department of Agriculture accepted 16.1 million acres into the program (USDA NEWS).

Table 2. Benefits to Pheasant Hunters and Program Costs of Various CRP Bid Selection Criteria Within the 13-State Study Area

Scenario	No CRP	Baseline	EBI*
Total Benefits (million $)	$104	$184	$174
Total CRP benefits (million $)	NA	$80	$70
CRP Benefits per CRP-acre	NA	$4.10	$3.57
CRP acres (million ac.)	0	19.5	19.7

*EBI = Environmental Benefit Index used to select the Conservation Reserve Program acres.

lations can have different impacts on consumer surplus in different parts of the country. For example, an increase in enrollment in one area can significantly increase pheasant populations but if travel costs to this area are high, the resulting gain in consumer surplus may be small. Conversely, a decrease in enrollment in another area may cause only a small decrease in pheasant populations but if travel costs are low, the loss in consumer surplus might be large. Thus changes in total consumer surplus and changes in total pheasant populations need not be correlated.

However, it is clear that the benefits of the CRP to pheasant hunters will depend, in large part, on the distribution of program acres. The acreage selection process has changed in the past and is likely to continue to evolve. Thus the evaluation of program benefits can be used to assess the welfare impacts of the program and to assess potential and actual changes in the farmland selection criteria.

Summary

This analysis estimated individuals' demand for pheasant hunting recognizing the multi-site nature of the decision to hunt. The estimated model was used to value the impact of the Conservation Reserve Program (CRP) on pheasant hunting quality. We also estimated how consumer surplus associated with pheasant hunting would change if all CRP acres were re-selected according to criteria of a recently developed Environmental Benefit Index (EBI).

With the estimates of individuals' demands for changes in environmental quality, the welfare impacts of farm programs are likely to be more accurately quantified as more micro-level program characteristics are accounted for in demand estimation as opposed to the supply-demand equilibrium models used in previous national analyses (Ribaudo et al.; Hansen and Hallam). Furthermore, the more geographically-specific benefit estimates allow welfare impacts of intercounty changes in land distributions to be assessed. The ability to evaluate intercounty changes in land use can contribute to evaluation of the design and operation of farm programs. Critical to this research was the use of the Geographic Information System (GIS) which improved the resolution of the geographic data so that site attributes are more accurately assessed and individual demands could then be estimated.

Our analysis had to overcome a lack of detail on exactly where the individual hunted; in a minority of cases, we were forced to 'guess' from potential sites. Our analysis also faced a lack of adequate biological models linking land uses/ecosystem characteristics to pheasant populations; we applied a reduced form model where measures of the agricultural and nonagricultural uses of land serve as independent variables. Alternative means were employed to overcome each of these problems but results indicated that the selected approach was most appropriate.

The total consumer surplus associated with pheasant hunting was estimated at $184 million per year. Of this, $80 million is attributed to the CRP. If all CRP land were to be redistributed based on a recently developed EBI, consumer surplus to pheasant hunters would fall by $10 million annually. This reduction in program benefits is thought to reflect the greater travel costs associated with sites where hunting quality would improve. However, it is important to note that, while pheasant hunting benefits were simulated to be lower, there are other environmental benefits relevant to agricultural programs and practices. Benefits of water-based recreation and of nonconsumptive wildlife-associated recreation have been assessed and were found to more than offset this loss (Feather, Hellerstein, and Hansen). While these, along with pheasant hunting benefits, do not provide a comprehensive assessment of impacts, they do provide frameworks applicable to valuing some of the other nonmarket impacts of agriculture.

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