Appendix B—Description of the Pheasant-Hunting Valuation Model

This analysis values changes in environmental benefits associated with changes in farmland use. The empirical analysis estimates the demand for pheasant hunting with a travel cost framework that combines a random utility model with a travel cost demand model (Feather, Hellerstein, and Tomasi; 1995). This approach is similar to that discussed in Appendix A.

While agriculture affects many wildlife species, this study looks at pheasants for two reasons. First, it is a very popular game bird. Data from the 1991 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (FHWAR) indicate that the pheasant is the most popular upland game bird throughout the Midwest. Second, pheasants are sensitive to changes in uses of agricultural lands. The continued specialization in agriculture and increased use of insecticides and herbicides have cost pheasants cover and food sources, thereby reducing nesting success and chick survival (Basore, Best, and Wooley, 1987; Hill, 1976; Jahn, 1988; Messick and others, 1974; Minn. Dept of Natural Resources, 1985; Warner, 1979 and 1984; Warner and others, 1984). Thus, pheasant populations have trended downward. For example, pheasant populations in South Dakota fell from an estimated 16 million in the mid-1940's to less than 2 million by 1986 (S.D. Dept. of Game, Fish, and Parks, 1988). This study includes those States with the historically most suitable environment for pheasants, which are the Lake States (Wisconsin, Michigan, and Minnesota), the Corn Belt States (Iowa, Illinois, Ohio, Missouri, and Indiana), the Northern Plains States (the Dakotas, Nebraska, and Kansas), and Montana.
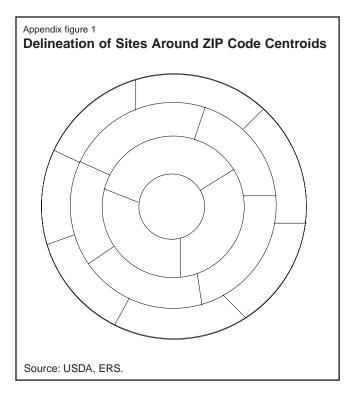
Ideally, we would like to estimate the travel cost demand model as a function of pheasant populations and use a biological model to quantify pheasant populations as a function of agricultural practices. However, biological studies on pheasants attempt to track habitat preferences of pheasants or the impact of habitat changes at single stages in their life cycle. While these studies indicate important environments for nesting, brood habitat, and winter cover and food supply, they do not model pheasant populations as a function of habitat. To overcome this lack of a biological model, we employ a "reduced-form" model, which is a combined biological-behavioral model. The reduced-form model includes the critical habitat variables that must be determinants of pheasant populations. Coefficients on the habitat variables represent both the biological and the subsequent behavioral responses.

Behavioral data used in this analysis come from the 1991 national FHWAR survey. To ensure that our sample included all potential pheasant hunters, we included those who indicated that they had hunted any species at least once in any of the past 10 years or thought they might hunt in the survey year. There is a total of 5,834 observations on potential hunters in the relevant States. The ZIP Codes of respondents were obtained for analytical purposes. Specifically, the latitude and longitude of the ZIP Codes served as an approximate geographic location of respondents' residences.

For each individual, a set of "possible destination sites" was constructed. Sites were defined by a geometric division of the surrounding land into semi-circular zones, with each of these zones treated as a possible destination "site." To be representative of potential sites, zones were large enough so that environmental quality might differ across sites yet small enough to ensure that environmental quality did not vary significantly within a site. For these reasons and because pheasants move a few miles throughout the year as habitat needs change, sites are defined in 25-mile increments around each ZIP Code center (Warner and Etter, 1985). The closest site is the area within 25 miles of the ZIP Code centroid. 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 range. All sites are of equal area. A total of 16 sites is defined for each respondent (appendix figure 1).

A Geographic Information System (GIS) was employed to obtain statistically representative measures of relevant site-quality characteristics for each site. Specifically, the average shifted histogram (ASH) technique was used to estimate environmental characteristics across geographic locations based on observed environmental quality measures (Scott and Whittaker, 1996). The ASH technique generates a "surface" of data on characteristics at all grid points. The grid scale used in this analysis was approximately 3.9 miles. The environmental characteristics of each site are assumed to be represented by the characteristics of that site's central grid point.

Appendix figure 1
Delineation of Sites Around ZIP Code Centroids

Source: USDA, ERS.

As with the water-quality model, observed environmental quality measures are taken from the 1992 National Resource Inventory (NRI). Also, the 1990 Census of Population provides the population and size of each census tract from which population densities are determined. The latitude and longitude of each NRI centroid and census tract are used to identify the geographic locations of these environmental quality measures.

The specifics on the distance traveled and State visited reported by FHWAR survey respondents are enough detail to identify the site visited for approximately 70 percent of the observations. When more than one site fit the distance/State criteria, an allocation heuristic based on the potential site with the highest pheasant population is used to designate the visited site. Pheasant population estimates are obtained from the North American Breeding Bird Survey (BBS). The BBS is a national survey that attempts to obtain counts of all bird species observed along designated routes on scheduled days (Bart and others, 1995). The BBS data is processed in a GIS model as are the other environmental characteristics.

Many environmental characteristics have affected pheasant populations over time but not all affect pheasant populations across space. Those pheasant habitat characteristics that tend to vary across sites include: hay and small grain crops (oats, barley, and

wheat), which provide marginal nesting cover (HAYGRN); corn and soybeans, which provide feed but poor early season cover (CRNSOY); pastures, which tend to be lesser disturbed than tilled soils and thus are a marginal nesting and feed source (GRASS); forest cover, which does not provide good habitat (FOREST); cropland not included in other variables, which tends to be a better source of habitat than excluded nonagricultural land uses (OTHCROP); and undisturbed cover, which provides good nesting cover, insects for newly hatched chicks, and winter cover (CRP) (Jahn, 1988; Kimmel and others, 1992; USDA, 1989; Warner and Etter, 1986). The percentage of all land in each of these uses is derived for each NRI polygon, converted to a geographic resource measure based on the latitude and longitude of the NRI polygon, and used in the GIS model to produce the site measures as outlined above.

As in Appendix A, Feather, Hellerstein, and Tomasi (1995) developed the modeling approach applied here. The first step in this approach uses a Random Utility Model (RUM) to model site selection. Important factors affecting site selection are the environmental amenities of the sites, the effect of crowding on the quality of recreational hunting at each site, and the travel cost to each site. Therefore, the independent variables of the RUM are:

1. **TC** represents the travel cost to the site.[17]

2. **lnCRP** is the natural log of the portion of a site's acres in CRP. The natural logarithm is taken to account for diminishing returns. To avoid a ln(0), 0.0001 is added to all CRP values.

3. **HAYGRN** is the portion of a site's acres in hay and small grain. The small grains included are oats, barley, and wheat as recommended in conversations with wildlife biologists.

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[17]Travel cost includes both the time cost and mileage cost. Time cost is based on the opportunity cost 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 in a recent recreation survey (Feather, Hellerstein, and Tomasi, 1995). Mileage costs are set at the American Automobile Association's estimated $0.30 per mile.

4. **CRNSOY** is the portion of the site's acres in corn and soybeans.

5. **GRASS** is the portion of acres in pasture.

6. **FOREST** is the portion of acres in forest.

7. **OTHCROP** is the portion of farmland in crops other than CRP, HAYGRN, CRNSOY, or GRASS.

8. **HAYGRNSQ** is HAYGRN squared.

9. **CRNSOYSQ** is CRNSOY squared.

10. **FORESTSQ** is FOREST squared.

11. **POP** is the site's human population density.

Following equation A.2, the systematic component of utility is given as:

(B.1) $V_{ik} = \beta_1 * TC_{ik} + \beta_2 * lnCRP_i + \beta_3 * HAYGRN_i$

$+ \beta_4 * CRNSOY_i + \beta_5 * GRASS_i + \beta_6 * FOREST_i$

$+ \beta_7 * OTHCROP_i + \beta_8 * HAYGRNSQ_i +$

$\beta_9 * CRNSOYSQ_i + \beta_{10} * FORESTSQ_i + \beta_{11} * POP_i$

All coefficients of the RUM are significant at the 99-percent confidence level and are of the expected sign (appendix table 4). The correct sign and statistical significance of the coefficients on lnCRP provide strong statistical support for the hypothesis that CRP acreage is critical to pheasant habitat. These results are used to estimate the expected travel costs, E(TC), and the expected site quality, E(Q), of the representative site visited from each ZIP Code. The quality vector, Q, includes lnCRP, HAYGRN, CRNSOY, GRASS, FOREST, OTHCROP, HAYGRNSQ, CRNSOYSQ, FORESTSQ, and POP.

With the number of trips an individual takes designated as T and the individual's socioeconomic characteristics and income contained in the vector S and variable Y, the participation model is specified in equation A.5. The participation model is estimated as a Poisson count data model because the dependent variable is a nonnegative integer (Creel and Loomis, 1990; Englin and Shonkwiler, 1995; Hellerstein, 1992). The parameters of the participation model are consistent with prior expectations. Coefficients are of expected sign, and all are significant at the 90-percent level (appendix table 4).

Both of the estimated models are directly employed to measure the change in consumer surplus to pheasant hunters due to a change in agricultural land use. The focus here is on changes in CRP acreage although the estimated models can also be applied to changes in acreage of corn/soybeans, hay/small grain, and pasture land.

To evaluate the change in consumer surplus resulting from a change in CRP enrollment, new NRI land use measures are derived with a simulation model that identifies those NRI observations that would be in the CRP under the new conditions and returns any NRI observations leaving the CRP to its use reported in the 1982 NRI (Osborn, 1993). The resulting new NRI land-use measures are used in the GIS to generate new land-use measures at grid points.

As with the original data, these simulated measures of land uses and populations at each site's center grid point are used to characterize the site. Using the RUM model, the expected travel cost, E(TC), and expected site characteristics, E(Q), are derived for each ZIP Code. Then, for each observation, the individual's E(TC), E(Q), income, and personal characteristics are used in the participation model to determine the consumer surplus. The change in an individual's consumer surplus associated with the change in CRP enrollment is the difference in consumer surplus before and after the change.

Appendix table 4—Empirical results

Variables	Random utility model[1]	Poisson model[1]
Constant		-1.97
		(4.18)
COST	-0.148	-0.0424
	(114)	(-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		$9.48*10^{-11}$
		(8.70)
WEIGHT		-0.000925
		(10.6)
WEIGHTSQ		$6.60*10^{-8}$
		(4.79)

See note at end of table.

—Continued

Appendix table 4—Empirical results—Continued

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;
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 the respondent resides in a rural community;
AGE	is the age of the respondent;
ED12	is a zero-one dummy variable equal to one when the respondent 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.
WEIGHT	is the sample weight of the observation;
WEIGHTSQ	is WEIGHT squared.

[1]t-statistics for the null hypothesis that the parameter equals zero appear in parentheses.
Source: USDA, ERS.