# WESTERN REGIONAL RESEARCH PUBLICATION

W-133
BENEFITS AND COSTS OF RESOURCES POLICIES AFFECTING
PUBLIC AND PRIVATE LAND

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# INTRODUCTION

This volume contains the proceedings of the 1999 W-133 Western Regional Project Technical Meeting on "Benefits and Costs of Resource Policies Affecting Public and Private Land." Some papers from W-133 members and friends who could not attend the meeting are also included. The meeting took place February 24th - 26th at the Starr Pass Lodge in Tucson, Arizona. Approximately 50 participants attended the 1999 meeting, are listed on the following page, and came from as far away as Oslo, Norway.

The W-133 regional research project was rechartered in October, 1997. The current project objectives encourage members to address problems associated with: 1.) Benefits and Costs of Agro-environmental Policies; 2.) Benefits Transfer for Groundwater Quality Programs; 3.) Valuing Ecosystem Managment of Forests and Watersheds; and 4.) Valuing Changes in Recreational Access.

Experiment station members at most national land-grant academic institutions constitute the official W-133 project participants. North Dakota State, North Carolina State, and the University of Kentucky proposed joining the group at this year's meeting. W-133's list of academic and other "Friends" has grown, and the Universities of New Mexico and Colorado were particularly well represented at the 1999 W-133 Technical Meeting. The meeting also benefitted from the expertise and participation of scientists from many state and federal agencies including California Fish and Game, the U.S. Department of Agriculture's Economic Research and Forest Services, the U.S. Department of Interior's Fish and Wildlife Service, and the Bureau of Reclamation. In addition, a number of representatives from the nation's top environmental and resource consulting firms attended, some presenting papers at this year's meeting.

This volume is organized around the goals and objectives of the project, but organizing the papers is difficult because of overlapping themes. The last section includes papers that are very important to the methodological work done by W-133 participants, but do not exactly fit one of the objectives. -- I apologize for the lack of consistent pagination in this volume.

**On A Personal Note...** Any meeting or conference is successful (and fun!) only because of its participants, so I would first like to thank all the people who came and participated in 1999 - listed below. I also want to thank Jerry Fletcher for all his help at this meeting and prior to it, and John Loomis who passed on his knowledge of how to get a meeting like this to work, and who continues to have the funniest little comments to lighten the meetings up. I especially thank Paul Jakus, who helped me to organize this conference and have a lot of fun during it and afterward. Finally, I want to thank Nicki Wieseke for all her help in preparing this volume, and Billye French for administrative support on conference matters.

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June, 1999

P.S. P.F. and J.C. - As far as I can tell, that darn scorpion is still dead!

*Paper Presentation: 1999 W-133 Meetings, Tucson Arizona*

# Implicit Prices of CRP Enrollments, Wetlands, and Soil Quality in North Dakota

**By**

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## Abstract:

The hedonic valuation method is used to quantify the determinants of farmland rental rates in North Dakota at the county level of analysis. Rental values are specified to be a function of soil based productivity indices, the existence of wetlands and gross farm returns, and county CRP enrollments. CRP acreage was endogenized and resulted from CRP payment levels and the extent of cumulative CRP enrollments. Crop returns, soil productivity and CRP enrollments exerted significant positive influences on farmland rental rates. Increased wetland acres negatively affected county rental rates. Specific research methodologies for conducting such hedonic analyses at township and farm levels of analysis are proposed and discussed.

## Introduction:

The determinants of farmland rental values in North Dakota are not fully understood which makes it difficult to evaluate and plan agricultural policy and rural development efforts. For example, it remains uncertain as to why farmland rental values are stable or increasing in many parts of the State while net farm income is decreasing. Similarly, it is not known how factors such as soil based productivity indices, levels of Conservation Reserve Program (CRP) enrollments, the existence of wetlands, farm profits, and farm ownership patterns interact with each other and influence farmland rental values throughout the State.

The hedonic valuation method (HVM) is a commonly used technique to quantify the determinants of farmland rental values with farmland rental rates or values being the dependent variable and a variety of farm characteristics including infrastructure, location, and soil productivity indices being the independent variables. However such hedonic studies of farmland rental rates have to date been limited due to their inability to incorporate information concerning CRP enrollments and the existence of wetlands, and other site specific information.

This present research will be focussed on two issues: The ability to estimate the determinants of cropland rental values at the county level of analysis, and the impact of soil productivity, agricultural market conditions, CRP enrollments and the extent of wetlands in a region on cropland rental values. This information should help to provide farmers and government officials with a better understanding of the impacts of various agricultural policy and rural development

## A Review of the Literature:

### Past Hedonic Studies Focused on Farmland Values:

The hedonic valuation method (HVM), commonly referred to as the hedonic or price attribute methods, uses the relationship between the prices and characteristics of a market good to estimate the value of particular characteristics associated with that good. One of the earliest applications of the HVM to value land as a differentiated factor of production was conducted by Palmquist (1989).

Past hedonic studies associated with farmland valuation have focused either on soil characteristics (Ervin and Mills 1986; Gardner and Barrows 1985; Miranowski and Hammes 1984), soil conservation, drainage technologies, or institutional factors (King and Sinden 1988; and Palmquist and Danielson 1989), and urbanization (Chicoine 1981; Pardew et al., 1986 and Shonkwiler and Reynolds, 1986.). These studies conclude high levels of farmland productivity positively affect values and that high levels of erosion, wetland acres and poorly drained soils negatively influence farmland values, that urbanization pressure positively influences farmland values, and that farm size has an ambiguous or mixed effect on farmland values.

### Past Hedonic Studies Focused on Farmland and JAS Data:

A series of recently published papers by agricultural economists focused on the potential of using site specific June Agricultural Survey (JAS) land value and farm characteristics data for: hedonic analyses of farmland values (Roka and Palmquist, 1997), capitalizing government payments into farmland values (Barnard et al., 1997), and separating the effects of environmental characteristics from the other determinants of farmland values (Boisvert et al., 1997).

The focus of the Roka and Palmquist (1997) research was to examine the use of land value data from the JAS to estimate hedonic price functions in a five-state region of the cornbelt. To supplement soil attributes, crop yield and other bio-physical data missing from the JAS survey, the authors attempted to integrate (spatially reference) National Resource Inventory (NRI) data to the JAS data but his was not very successful as NRI and JAS sampling frames and scales of analysis did not coincide. Therefore, the authors used county level corn yields averaged over three agricultural censuses as a proxy measure of productivity and the percentage of land designated as 'prime farmland. The study concluded that land values from the JAS were reliable and could be potentially useful for estimating hedonic models of farmlands, especially at the national level. However, at the same time it was realized that the lack of site specific information from JAS data, specifically soil quality and productivity data, greatly diminished the ability to estimate the determinants of farmland prices.

The research project which focussed on the effect of government program payments on farmland values (Barnard et al., 1997) also used JAS land value data as the dependent variable while the explanatory variables used (farm size, soil productivity, government payments, etc) came from county level data sources. The measure of soil productivity was the 'soil relative productivity indices at the county level calculated by the NRCS. These county level explanatory variables were not found to be sufficiently detailed or site specific which limited the predictive strength of the estimated models. However this research did show that there exists a wide spatial variability (nationally) in the percentage of direct government payments that are capitalized into cropland values.

This limitation associated with hedonic studies of farmland rental rates is related to the difficulty of integrating highly site specific farmland rental rate data with GIS

based land use, soil productivity, wetland and CRP related data. As noted by Reynolds (1997), none of the previously mentioned hedonic-farmland studies that used JAS or USDA Area Data were able to effectively integrate such GIS based data into their study designs. Recently available GIS data relevant to hedonic studies of farmland values include: GIS soil databases (STATSGO and SSURGO) distributed by the NRCS, the National Wetland Inventory (NWI) from the USFWS, and CRP enrollment data being compiled digitally in some States by a variety of different agencies (these issues are discussed in greater detail in the next section of the proposal).

Finally one of the AJAE papers focused on the effects of environmental characteristics from the other determinants of farmland values. This approach regressed farmland rental values (from direct farmer surveys) against field level (site specific) data describing the characteristics of the parcels, land productivity, operator characteristics and environmental variables (presence of a conservation plan, leaching and runoff measures and environmental vulnerability indices). The results showed that the value of agricultural land can be directly related to levels of farmland productivity, spatial orientation, and environmental vulnerability. However the authors explicitly stated that additional empirical testing across other regions of the country with different soil, productivity indices, cropping patterns and environmental vulnerability measures was needed.

In summary the past research on the determinants of farmland values have been limited by the lack of detailed and/or site specific data describing farmland characteristics. In order to fully evaluate the factors effecting farmland values in an entire state or in a region, more complex and larger databases are needed. It is highly

unlikely that such improvements in data detail and scope will be possible without the use of GIS technologies and better access to JAS or NASS farmland valuation data.

**Farmland Rental Values in ND**

Farmland across the country is subject to low levels of turnover (less than 3% of farmland is sold annually). Therefore, the most commonly reported and used estimates of land value are often based on farmer's self-assessments of their land values. Such self-assessed farmland value data has been collected annually since 1994 by the USDA's June Agricultural Survey (JAS). In ND the JAS is administered by the NDASS and is based on 420 randomly selected land segments (tracts) of approximately 1.5 square miles each that involve surveys with approximately 1500 individual farm owners.

Rental values for farmland in ND are also collected annually (in January) in a separate survey by the NDASS. Such rental data may be very indicative of conditions in the agricultural economy since a large percentage of farmland in ND is rented (for example, up to 1/3 of all farmland in the Red River Valley is rented). This data, which is reported at the county level of analysis, is based on survey reports with 850 hayland farmers, 1390 pastureland farmers, and 2036 cropland farmers. Considerable range in rental rates occur between counties throughout the state as well as within individual counties.

Farmland values in ND are often classified and analyzed by 3 land use types: non-irrigated cropland, non-irrigated pasture land, and non-irrigated hayland. Further stratification results in a regional level of analysis, with the common regions being the North Red River Valley (NRRV), South Red River Valley (SRRV), Southeast Central

(SEC), Northeast Central (NEC), Northwest Central (NWC), Southwest Central (SWC), Southwest (SW), and Northwest (NW).

Preliminary analyses have shown that nominal ND rental rates and land values are currently at a 10 year high, in spite of decreasing farm incomes in most of the State. However, the real rents have remained flat for the last 10 years. Although there are no known studies to quantify and explain why farm rental values have been increasing, it has been hypothesized that the following factors may be influencing farmland rental values: high levels of CRP enrollments that tend to put a floor under rental values, low interest rates that make land ownership a competitive investment alternative, and a stable and diversified economy across the state. (Swenson, 1998)

An econometric analysis of representative farms in ND which treated cropland rental values as a moving average of annual return to land multiplied by the long-run capitalization rate, plus taxes on has estimated that in the next 10 years cropland values for medium sized farms will decrease 0.8% while cash rents will fall by 13.6%. For farms expected to experience average profits, cropland values will increase by 13.6% while cash rents will fall by 4.8% (Koo, Taylor and Duncan, 1998).

There remains considerable debate and uncertainty as to why farmland rental values are stable and/or increasing in many parts of the State while net farm income is decreasing. Similarly, it is not known with any certainty whether and how factors such as conservation reserve program (CRP) enrollments, soil and climatic conditions, distance to markets, commodity prices and net profit for particular crops, and farm ownership patterns interact with each other and influence farmland rental values. This paper represents an initial effort to understand the factors influencing rental rates.

## The Demand for Rental Land

Consider the profit maximizing farmer seeking rental land to expand his farming operation in a particular year. For simplicity, we consider an appropriately aggregated production process to represent the farmer's problem as maximization a single output problem. The farmer's restricted problem can be framed:

*Maximize* $pf(\mathbf{x},\mathbf{z};\mathbf{a}) - \mathbf{w}'\mathbf{x} - \mathbf{r}'\mathbf{z}$

Where **x** is a vector of variable inputs, excluding land, **z(h)** is a vector of available rental parcels differentiated by characteristics such as soil productivity, proportion of land unusable due to flooding, roads, shelterbelts, etc., and **a** is a vector of factors quasi-fixed in the relevant planning period. The vectors **w** and **r** are corresponding prices for the factors, p is output price, and f(·) is the production function.

Finding first order conditions and application of the implicit function theorem results in explicit demand functions for rental land of various characteristics, $\mathbf{z}=\mathbf{z}^*(p,\mathbf{w},\mathbf{r};\mathbf{a})$. For given levels of the arguments of the demand function for **z***, quantities of land demanded of specific characteristics can be derived.

The supply of rental land results from individual landowner's decision to personally farm the land or to make the land available on the rental market. . Ignoring for this iteration of the model the decision to rent or to farm the land himself, the landowner may still decide to enroll a portion of his land in the Conservation Reserve Program (CRP). Acres under CRP designation cannot be farmed while under contract, and hence reduce the supply of land available for either cash or share rent. The effects of placing

land under CRP will affect the rental land market in a fashion similar to other land characteristics that reduce the supply of productive rental land.

Enrolment in CRP by the owner of the land is also presumed to result from solution of an optimization problem. The owner who has land to rent faces the following constrained revenue maximization problem:

$$\textit{Maximize} \qquad r(z_f)z_f + cz_c$$

$$\textit{Subject to} \qquad z_f + z_c = Z$$

For simplicity, we assume that the landowner has land of a single quality and the land is differentiated solely on the basis of his decision to enroll some or all of the acres in CRP. Farmable acres are $z_f$ and $z_c$ are acres of the farmer's total parcel Z enrolled in CRP. Price c is the per acre CRP specified in the farmer's contract with the Farm Service Agency, the USDA agency administering the CRP program. We presume that the per acre rental rate received by the landowner is influenced by the total number of farmable acres available, $r(z_f)$.

First order conditions for the landowner's problem framed as a Lagrangian are:

$$\frac{\partial L}{\partial z_f} = r_f(z_f)\, z_f + r(z_f) - \lambda = 0$$

$$\frac{\partial L}{\partial z_c} = c - \lambda = 0$$

$$\frac{\partial L}{\partial \lambda} = Z - z_f - z_c = 0$$

Subscripts on $r(z_f)$ indicated first partials of the rental function with respect to farmable acres $z_f$. The implicit function theorem allows rewriting of the first order conditions in terms of the single parameter c (ignoring Z),

$$
\begin{aligned}
& r_f\left(z_f^*(c)\right) z_f^*(c) + r\left(z_f^*(c)\right) - \lambda(c) \equiv 0 \\
& c - \lambda(c) \equiv 0 \\
& Z - z_f^*(c) - z_c^*(c) \equiv 0
\end{aligned}
$$

Comparative statics relationships can be found by taking the second derivatives of the first order conditions:

$$
\begin{bmatrix} z_f r_{ff} + 2r_f & 0 & -1 \\ 0 & 0 & -1 \\ -1 & -1 & 0 \end{bmatrix}
\begin{bmatrix} \partial z_f / \partial c \\ \partial z_c / \partial c \\ \partial \lambda / \partial c \end{bmatrix}
= \begin{bmatrix} 0 \\ -1 \\ 0 \end{bmatrix}
$$

By the second order conditions for constrained maximization, the coefficient matrix must be positive definite, implying $z_f r_{ff} + 2r_f < 0$. Since

$$
\begin{aligned}
& \left(z_f r_{ff} + 2r_f\right) \partial z_f / \partial c - \partial \lambda / \partial c = 0 \text{ , and} \\
& \partial \lambda / \partial c = 1,
\end{aligned}
$$

this results in the unambiguous comparative static result $\partial z_f / \partial c < 0$. Given the constraint of the problem, we can further expect $\partial z_c^* / \partial c > 0$ for the revenue maximizing landowner. As payments to land enrolled in CRP increase, acreage enrolled will increase. As acres in CRP increase, the supply of rental acres available for farming

decreases. As supply decreases, we would expect equilibrium prices for rental land to increase.

Combining the renter's demand for rental land and the availability of parcels containing different proportions of CRP acreage based on the owner's decisions results in an inverse demand function for rental land of different categories, $\mathbf{z} = \mathbf{z}^*(p,\mathbf{w},\mathbf{r};\mathbf{a})$. However, lack of a suitable number of observations on land in each of the different characteristics available in North Dakota results in an aggregate demand model for rental land, where factors differentiating land characteristics are treated as explanatory variables in determining rental value, $z = z(p, \mathbf{w}, r, \mathbf{h}; \mathbf{a})$, where **h** is a set of land characteristics, including extent of participation in CRP for the aggregate land parcels considered.

We make various simplifications in determination of the land rental model. First, aggregate output prices are not available for each of the 53 North Dakota counties. We use instead the county level gross crop receipts per acre RCPAYA, lagged one year, to represent expected returns from farming (i.e., *p*). Land characteristics considered in the set **h** are the average soil productivity index for the county, SOILPRO and county acres in wetlands, WET. Finally, landowner decisions to place land in CRP each year are represented by DELCRP.

The resulting hedonic model is thus:

$$(1) \qquad RENT_{it} = f(RCPAYA(-1)_{it}, SOILPRO_{it}, WET_{it}, DELCRP_{it})$$

Observations are available for each county i over the time period 1989-1997. The explanatory variable DELCRP is itself a function of landowner decisions to enroll additional acres in CRP based on the revenue maximization model discussed above.

Consequently, estimation of a hedonic model based on (1) was conducted using two-stage least squares. Additional instruments included were CRP per acre payments (i.e., *c*), lagged one year, as well as the percentage of land within the county already enrolled in CRP. The latter term was added to represent county acres remaining eligible for CRP designation. All prices and returns were converted to 1997 dollars.

Summary statistics for the variable levels are listed in Table 1 and 2SLS results are in Table 2.

**Table 1. Variable summary statistics**

| | Mean Levels | Standard Deviation |
|---|---|---|
| Rent | 32.065 | 11.808 |
| RCPAYA(-1) | 87.647 | 53.262 |
| SOILPRO | 46.774 | 17.058 |
| WET | 45,493 | 40,379 |
| DELCRP | 1,297 | 4,648 |

Preliminary model results show significance for all variables chosen as well as correct signs as expected from the behavioral models posited above. Approximately 70.72% of the variation in RENT was explained by the model. First stage estimation of the endogenous variable DELCRP resulted in the expected positive (and significant) influence of CRP payments per acre. Mean county rental values are positively affected by agricultural market conditions, as expressed in the previous year's crop returns per acre for the county. Coefficients on site characteristics were also of the expected sign.

Better soil productivity within a county positively affected rental rates. Acres of wetland within the county have a depressing effect on land rental values.

**Table 2. Two-stage least squares estimation results of county level mean rental values:**

| | Estimated Coefficient | Standard Error | t-statistic |
|---|---|---|---|
| Constant | 6.18200 | 1.0253 | 6.0295 |
| RCPAYA(-1) | 0.14529 | 0.01250 | 11.628 |
| SOILPRO | 0.27432 | 0.03802 | 7.2148 |
| WET | -0.324E-4 | 0.9E-5 | -3.6020 |
| DELCRP | 0.00138 | 0.00016 | 8.8171 |

Of special interest to the objectives of the research is the strong positive influence exerted by CRP additions on land rental rates within the 53 North Dakota counties. A very loose interpretation of the results might indicate that, given the average increase in CRP land enrolled each year across the state (1,297 acres as seen in table 1), land rental rates within the "average" county are increased by $1.80 per acre. This is an approximate 5.6% increase in land rental values attributable to enrollments in CRP within the state of North Dakota.

**Future Research**

Model results at the county level provided fairly good explanation of cropland rental values. However, land characteristics may be very different within a single county, wetland acreage may be concentrated within smaller areas within a county, and crop incomes may vary around a county based on climate differences and other environmental

factors. Consequently, the next step in analyzing factors affecting farmland rental rates will assemble data at the township level in order to further isolate the effects of environmental factors on rental rates.

Land characteristic data is available at the township level of analysis (in 5 individual ND counties). Rental values at the township level are potentially available from two sources. One option is to obtain rental data from surveying farm operators. Another option to obtain farmland rental values at the township or even more disaggregated levels of analysis would be to use farmland rental value data collected annually by the June Agricultural Survey (JAS) that is administered by NDASS. JAS data also includes various farm production information collected at the tract level of analysis (resolution of approximately 1.5 square miles). However, a preliminary request to access JAS through the NDASS has been rejected due to confidentiality concerns. Further requests are currently being investigated.

In order to identify the range of soil productivity across counties or townships (which may be important for areas with highly heterogeneous soils) it will be necessary to perform analyses on spatially referenced NRCS soils databases. Two such databases have already been obtained: the first is the STATSGO soils database at the 1:250,000 scale of analysis for the entire State, and at the more detailed and site specific 1:20,000 scale (the SSURGO database) which is presently available for only 5 counties in the State. Soil productivity indices will be estimated using the same criteria as the 1960 NDSU soil productivity classifications (based on soil types and characteristics and climatic factors) and aggregated by counties (n=52) and townships (n=180).

In order to estimate cropland acres planted at the township level it will be necessary to utilize a satellite imagery database of cropland types compiled for ND in 1997 by the NDASS.

In order to determine wetland acreages at the township level of analysis it will be necessary to utilize the NWI database. Wetlands can impose impediments to planting and harvesting nearby fields and may also be associated with poorly drained soils and are therefore expected to decrease cropland rental rates.

In order to determine the percentage of CRP lands and corresponding CRP rental payments occurring at the township levels of analysis, it will be necessary to access CRP contract files contained in county FSA offices. Permission to this data has been granted from the State FSA office.

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