Farmers' Perceived Costs of Wetlands: Effects of Wetland Size, Hydration, and Dispersion

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Abstract

We survey landowners to investigate the costs associated with the presence of permanent or seasonal wetland areas in cropland. We find, as predicted by our conceptual model, that dispersion of wetland areas imposes substantial inconvenience costs for producers but that costs respond nonlinearly and irregularly to changes in the frequency of hydration. Producer attitudes toward conservation and environmental regulation have a significant impact on perceived costs, as do some demographic attributes. The analysis suggests that incentives to aggregate dispersed wetlands into larger contiguous areas could benefit landowners while at the same time provide a net increase in wetland area.

Keywords: perceived costs, wetlands

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At the time of European settlement, the U.S. had about 215 million acres of wetlands, but by the mid 1970's less than half of these wetland areas remained (Blackwell 1995). According to Hansen (2006) about 15 percent (or about 16.6 million acres) of wetlands today are found on land used for crop production or pasture. Wetlands provide a number of benefits including habitats for fish and wildlife, filtering and purifying water, buffering the effects of storms and floods, and, in some cases, recreational services (Heimlich et al. 1998). But, because most of these beneficial services are non-market goods and cannot be sold, landowners have incentives to convert wetlands to agricultural use.

Although plains states such as Kansas and Nebraska have relatively small wetland acreages, the wetlands that do exist are unique natural resources and provide important ecosystem services. The Cheyenne Bottoms in central Kansas is viewed as the most important site for shorebird migration in North America (Collins, Collins, and Gress 1994). Small playa lakes in western Kansas, western Nebraska and eastern Colorado hold surface runoff following rain events and are the primary portals through which the Ogallala Aquifer is recharged (Stone 1990). Over 95% of the world's playa lakes are found in the Great Plains (Playa Lakes Joint Venture 2006).

Over the past few decades a number of policies have been introduced to preserve wetlands. The Swampbuster provisions of the 1985 Food Security Act deny federal farm program benefits to producers who convert wetlands to cropland, while the Wetland

Reserve Program (WRP) introduced in the 1990 Food, Agriculture, and Trade Act provides incentives for restoring farmed wetlands to their original condition through easement payments and cost sharing. Since the early 1990's the goal of federal wetlands policy has been one of "no net loss" with losses offset through restoration and creation of new wetland areas. The 2002 Farm Act provides for increased wetland restoration via expansion of both the Conservation Reserve Program (CRP) and the WRP. For example, of the 2.8-million-acre increase in the CRP, up to 500,000 acres could be used for restoration of farmed wetlands (Claassen 2003).

Both the benefits and costs of protecting wetlands must be quantified to evaluate these policies and proposed changes based on economic efficiency criteria. Perhaps because the benefits of wetlands were historically ignored and occur in the form of nonmarket gains, there is now a large literature on estimating the various social benefits from wetlands. Heimlich et al. (1998) compiled and reviewed the estimated nonmarket values of wetlands. Although the estimates vary across studies, the values are generally significant for a range of nonmarket goods and services, including recreation, species habitat, flood control, waste assimilation, and visual amenities.

The costs that wetlands impose on landowners have received comparatively little attention, and hedonic studies that have inferred these costs from agricultural land values have produced conflicting results. Norris, Ahern, and Koontz (1994) found that increased exposure to wetland regulation had little effect on land prices. Brown (1976) examined land sale prices in North and South Dakota and found that wetland easements had a significant negative impact on sales value in two of three study regions. Surprisingly, the presence of non-eased wetland areas did not have a significant impact on price, but Schultz and Taff (2004) pointed to a specification error in Brown's model that may have led to that finding. In their own study, Schultz and Taff found that non-eased permanent wetlands reduced land prices by $161/acre while permanent wetlands under easement reduced price by $321/acre. An unexpected finding was that temporary wetlands, whether under easement or not, did not have a significant effect on price.

An acknowledged limitation of the wetland cost literature, which may partially explain some of the ambiguous findings, is the inability to capture the highly contextual nature of the costs associated with the presence of wetland areas. Shultz and Taff (2004) note the limitations of earlier hedonic studies including lack of site specific data, and the inability to account for agricultural production potential. And while their study accounts for productivity and for important wetland characteristics (i.e., size, temporary or permanent, eased or not-eased), they acknowledge that other factors such as dispersion may also affect cost. Thus, a wetland that is highly dispersed in several small hydrated areas within a field will generate substantial "nuisance costs" from driving tillage equipment around each area. Furthermore, the frequency of wetness determines how often a crop can be harvested, and hence the probability distribution of returns from the field.

We develop a conceptual framework where wetland costs are derived using a model of production under uncertainty. For a field containing wetlands, the production returns on both the wetland acreage and the remaining upland acreage (i.e., the non-wetland portion of the field) are uncertain and depend on random rainfall amounts. The implicit cost of wetlands is defined as the certainty equivalent of the gain from converting all wetlands in the field to uplands. We show that this cost unambiguously increases with wetland dispersion, measured as the number of distinct wetland areas in the field. However, costs can either increase or decrease with respect to changes in the frequency that the wetlands are hydrated and the wetland acreage. These ambiguous results are due to the negative correlation between incomes on the wetland and upland acreage; wetlands are productive in years of low rainfall when there is likely to be a crop failure on the upland acreage. In some cases, risk averse farmers may benefit from increasing the wetland acreage or from an increased frequency of hydration on the wetland areas.

We apply this conceptual framework to empirically estimate the cost associated with the presence of wetlands. Using contingent valuation survey data from a sample of 982 Kansas producers, we estimate perceived wetland costs as a function of wetland characteristics, farm characteristics, and producer attributes and attitudes. Consistent with the prediction from the conceptual model, costs are found to increase with wetland dispersion but respond nonlinearly and irregularly to changes in the frequency of hydration. Producer attitudes toward conservation and environmental regulation have a significant impact on perceived costs, as do demographic attributes such as age and education level. We also find evidence of a small economies of scale effect, as farm size is associated with a slight reduction in perceived costs.

The Swampbuster Provision

While several policies have been adopted to preserve wetlands as discussed above, the policy affecting the greatest number of landowners is the “Swampbuster provision” included in all Farm Acts since 1985. Although this term does not appear in the statutes themselves, the Swampbuster provision is understood to refer to the regulations determining persons' eligibility for receiving certain USDA program benefits[1] (7 CFR 12). In order to remain eligible for farm program payments, Swampbuster requires that producers have neither converted wetlands after November 28, 1990 nor raised a crop on a wetland converted after December 23, 1985.[2] However, persons can be considered exempt from this eligibility requirement for a number of reasons. Beginning with the 1996 Farm Act, one of these exemptions is wetland mitigation, whereby "wetland functions and values [lost from wetland conversion] are adequately mitigated … through the restoration of a converted wetland, the enhancement of an existing wetland, or the creation of a new wetland...." (7 CFR 12.5 (b) (4)). Thus, at least in certain cases, "redistributing" wetlands is permitted, in the sense that one area can be converted if another is created or enhanced by an equivalent amount.

A common misconception is that Swampbuster protects all wetlands from farming activity of any kind. In fact, the regulations explicitly allow production activities on wetlands as long as woody vegetation is not removed. Thus, Swampbuster allows nearly all existing wetlands to be farmed, and in practice nearly all such areas in the Plains are planted to crops if it is economic to do so.[3] This implies that the welfare effects of Swampbuster are not from preventing production activity *per se*, but from preventing conversion activities that would allow production to occur more frequently. Farmers incur welfare losses equal to the additional income they could earn on wetland areas if those areas were converted, less the cost of conversion.

In this article we elicit the perceived costs associated with the presence of wetland areas in cropland. Prior studies (Schultz and Taff 2004) draw a clear distinction between costs associated with the presence of wetlands and the costs associated with regulations such as Swampbuster that restrict or prohibit the conversion of such wetlands. In the concluding section of the article we address the interpretation of the perceived costs we elicit, and how they are related to welfare losses arising from such regulations.

Conceptual Model

This section develops a conceptual model to establish a precise definition of wetland costs and to determine how these costs depend on wetland characteristics. Consider a farmer who owns an a-acre field. The field contains n distinct areas that are designated as wetlands, but the degree to which these areas are hydrated depends on seasonal rainfall. The amount of rainfall received, x, is a random variable with cumulative distribution function $F(x)$ and support $[\underline{x}, \overline{x}]$. If rainfall is at its maximum level $\overline{x}$, all n areas are saturated to their full extent and they collectively cover $a_w \leq a$ acres. As x decreases below $\overline{x}$, a smaller fraction of the a_w acres are saturated. The remaining $a - a_w$ acres are never saturated to the point of preventing production activity; they comprise the upland portion of the field.

The net return from crop production on the wetland portion of the field is $\pi_w(a_w, x; h)$, where h is a parameter that measures the proneness to hydration. Higher levels of h imply that a larger share of the a_w wetland acres are hydrated at a given rainfall level. The wetland net return function is increasing and weakly concave in a_w (if all wetland acreage is of undifferentiated quality then it will be linear in a_w), and satisfies $\pi_w(0, x; h) = 0$. Its dependence on the other two arguments is illustrated in figure 1. This figure traces out the relationship between wetland net returns and x for two fields that are otherwise identical but differ in their proneness to hydration ($h_1 > h_0$). As shown for both these cases, net returns initially increase with respect to rainfall, reflecting the fact that in dry years, most of the wetland acreage can be farmed with normal practices and additional rainfall will increase yields on this portion of the field. Beyond some level of rainfall, however, net returns decrease because yields are reduced from excessive moisture and because a larger share of the wetland acreage is too wet to be farmed at all. For the two functions shown in the figure, net returns reach zero when rainfall reaches x_1 and x_0, respectively.

Figure 1 also illustrates that the proneness to hydration affects the distribution of income in two ways. First, wetlands that are less prone to hydration generate positive income over a larger range of rainfall. While the wetlands on the “wetter” field (corresponding to h_1), generate a positive income with probability p_1, the wetlands on the “drier” field do so with probability $p_0 > p_1$. Second, as the figure illustrates, the change in h may either increase or decrease the level of wetland profits depending on the value of x. For the case shown, the “drier” field has lower wetland net returns for values of $x < \hat{x}$ but higher net returns for $\hat{x} < x < x_0$.

Uplands are assumed to be farmed in all rainfall conditions, and net returns on this portion of the field are $\pi(a - a_w, x, n)$. Similar to the wetland net returns, this function is increasing and weakly concave in its first argument (implying that $\partial\pi/\partial a_w \leq 0$), and has the property $\pi(0, x, n) = 0$. It is also concave in x. Upland net returns depend on the number of wetland areas, n, because equipment must be driven around the wetlands areas when they are hydrated. This additional tillage cost is assumed to increase with the number of wetland areas, so that $\partial\pi/\partial n \leq 0$. For a fixed wetland area a_w, larger values of n imply that the wetland acreage is more dispersed throughout the field. Accordingly, we refer to n as the dispersion parameter.

In sum, there are three wetland characteristics in the model: size or coverage, a_w; dispersion, n; and proneness to hydration, h. These three parameters determine the expected utility the farmer can obtain from a given field, $E[u(m)]$, where $u(\cdot)$ is a strictly increasing utility-of-income function. In particular, expected utility from the a-acre parcel is

$$U(a_w, n, h) = \int_{\underline{x}}^{\overline{x}} u\left(\pi_w\left(a_w, x; h\right) + \pi\left(a - a_w, x, n\right)\right) dF(x) \,. \tag{1}$$

Field Code Ch

Differentiating (1), the marginal effects of these parameters are

$$\frac{\partial U}{\partial a_w} = \int_{\underline{x}}^{\overline{x}} u'(m)\left(\frac{\partial \pi_w}{\partial a_w} + \frac{\partial \pi}{\partial a_w}\right) dF(x) \tag{2}$$

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$$\frac{\partial U}{\partial n} = \int_{\underline{x}}^{\overline{x}} u'(m)\frac{\partial \pi}{\partial n} dF(x) \tag{3}$$

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$$\frac{\partial U}{\partial h} = \int_{\underline{x}}^{\overline{x}} u'(m)\frac{\partial \pi_w}{\partial h} dF(x) \tag{4}$$

Field Code Ch

where $m = \pi_w\left(a_w, x; h\right) + \pi\left(a - a_w, x, n\right)$. Only the marginal effect with respect to n in equation (3) can be unambiguously signed. Because $u'(m)$ is positive and $\partial\pi/\partial n$ is negative by assumption, expected utility declines with the number of wetland areas. In equation (2), the first term inside the parentheses represents the change in wetland profits from an increase in wetland acreage, which is positive, while the second is the change in upland profits, which is negative. The marginal effect on expected utility depends on which of these effects is larger. Intuitively, an increase in wetland acreage may be beneficial for risk-averse farmers over some range of a_w, because this change would reduce overall production risk: in dry years when upland acreage produces small or negative profits, positive profits can be earned on the wetland acreage. Put differently, wetland and upland acreages are assets with negatively correlated returns; and risk-averse farmers may benefit by better diversifying their acreage portfolio. Regarding equation (4), the sign of $\partial\pi_w/\partial h$ may vary throughout the domain of x depending on the specific resource setting, as shown in figure 1. The net impact of h on expected utility therefore is also ambiguous.

We now turn to defining the perceived cost of wetlands. We begin by noting that an intuitive property of equation (4) is that if $a_w = n = 0$, $\partial U/\partial h = 0$ for all h; expected utility is independent of h when there are no wetlands in the field. We can therefore define the certainty equivalent of farming a field with no wetlands, $\hat{m}$, by the equation

(5) $$U(0,0,h) = u(\hat{m})$$

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The certainty equivalent of farming a field containing wetlands with parameters (a_w, n, h) will differ from $\hat{m}$ by some amount c_w, which we regard as the cost of wetlands. This cost implicitly depends on all three parameters, so that there exists a wetland cost function $c_w(a_w, n, h)$ defined by the relationship

(6) $$U(a_w, n, h) = u(\hat{m} - c_w(a_w, n, h))$$

Field Code Ch

The marginal effects of the parameters on costs can be found by differentiating (6). The effect of wetland acreage, for instance, is $\partial c_w/\partial a_w = -(\partial U/\partial a_w)/u'(\hat{m} - c_w)$. As $u'(\cdot)$ is positive, the sign of $\partial c_w/\partial a_w$ is opposite that of $\partial U/\partial a_w$ in equation (2). By identical arguments, the marginal effects of n and h on costs take on the reverse signs as those on U in equations (3) and (4). The model therefore predicts that wetland costs increase with the number of wetland areas but may either increase or decrease with wetland acreage and the proneness to hydration.

Data

Data were collected from a contingent valuation (CV) mail survey eliciting farmers' willingness to pay to rent land containing wetland areas. The CV method asks individuals to state their values for non-marketed goods – typically environmental amenities or improvements therein (e.g., preservation of wilderness areas, improved visibility). Our use differs in that our purpose is to estimate the value of a private good (land) containing a particular attribute (wetlands).

While widely used, the CV approach has been the subject of controversy (see Diamond and Hausmann 1994; Hanemann 1994). A central question is whether values elicited from hypothetical surveys reflect the amounts individuals would actually pay and evidence on this question is mixed. Several studies indicate an upward bias in CV values (e.g., Fox et al. 1998; Taylor 1998), and mechanisms such as "cheap talk" (Cummings and Taylor 1999) have been used to counter that bias. However, Carson et al. (1996) found the opposite – in a meta-analysis of 83 studies, they found that CV values tended to be slightly below their revealed preference counterparts. More recently, Cameron et al.

(2002) found that WTP derived from most of the common types of CV survey questions were statistically indistinguishable from revealed WTP.

The survey instrument was sent in two mailings to a sample of 2,311 producers comprising the membership of the Kansas Farm Management Association (KMFA). Given the availability of detailed farm business and financial records from KFMA members, this database is frequently used in survey research. The survey instrument was pre-tested in four one-on-one interviews with KFMA members. Prior to mailing, each of the KFMA fieldmen – agents who have regular contact with the members – was contacted and informed about the purpose of the survey. They were asked to encourage their clients to respond and to provide assistance or clarification if the need arose.[4] Of the 2,311 surveys sent in the first mailing, 638 were returned, and a second mailing to non-respondents resulted in an additional 344 responses. Thirty-six surveys were undeliverable, giving a response rate of 982 out of 2,275, or about 43%.

In addition to eliciting the contingent values of farmland with wetland areas, the survey also obtained characteristics of the respondent and his or her farm, along with the respondent's attitudes toward wetland protection and environmental issues more generally. These categories of data are discussed in turn below.

Contingent Rental Values of Farmland with Wetlands

Six questions on the survey asked respondents the maximum amount they would be willing to pay (WTP) per acre to rent quarter-sections of land containing various types of wetlands. Three questions dealt with permanent wetlands, while three similar questions dealt with seasonal wetlands. Figure 2 illustrates the presentation of the questions for permanent wetlands.[5] As shown in figure 2, the three quarter-sections with wetlands differed in the distribution of those wetlands – on one the wetland was contained in a single contiguous area, in a second it was dispersed in four separate areas, and on the third it was dispersed in sixteen separate areas. In alternative versions of the survey, the (combined) wetlands in each quarter section accounted for 1%, 2%, 3%, or 4% of land area. Within each version, 4 subversions of the question dealing with seasonal wetlands elicited rental values for land containing wetlands that were hydrated 1, 2, 3, or 4 years out of 5. Thus, there were a total of 16 alternative versions of the instrument.

Our elicitation format can be described as "open ended with anchoring." Respondents were told that "tracts of similar quality land with no wetlands rent for $35 per acre," and were asked to report the maximum rental rate they would pay for cropland containing different types of wetlands. While open-ended questions are simple and straightforward, they have been criticized because they may not be incentive compatible: when asked to report the cost of providing a public good, respondents would have an incentive to overstate their actual costs due to the well known free-rider problem. Because wetlands have public good attributes, it is possible that respondents exaggerated the cost of having wetlands by understating their rental values for land with wetland. However, if the extent to which this occurs is uniform across different scenarios, we will still obtain valid estimates of the *relative* costs of different wetland characteristics (e.g., the *difference* in cost for wetlands that are hydrated 1 year in 5 compared to those that are hydrated 4 years out of 5).[6]

The “anchor” of $35 per acre was used for a number of reasons. The primary purpose was to provide a common cue about land quality, so that we could control for unobservable differences in respondents’ beliefs about land productivity. The second purpose was to make the open ended questions easier to answer, by inducing respondents to compare the fields with wetlands to a market good they are familiar with (Arrow et al. 1993). Third, we believed it would focus the respondents’ attention on the relevant question – the additional costs of farming fields with wetlands – rather than their willingness to rent land in general.[7] The value of $35 was obtained from the KFMA database as a typical rental rate across all regions in the state.

Summary statistics for the WTP responses are in table 1. Producers are willing-to-pay slightly less for cropland that contains permanent wetland areas compared to land that contains seasonal wetlands. For example, for land containing 16 permanent wetland areas, the average WTP is $16.76/acre compared to $19.77/acre for land containing 16 seasonal wetlands**.** The data clearly show that higher numbers of wet areas are associated with lower rental values. For permanent wetlands, when the dispersion increases from 1 area to 4 areas, the average rental value falls from $31.43/acre to $27.12/acre.

An interesting result is the large number of zero values of WTP for quarter sections containing wetlands dispersed in 16 areas. Clearly, respondents interpret such a wide dispersion of wetland pockets as imposing very significant inconvenience costs for tillage operations. Nevertheless, for the analysis that follows we interpret zeros WTP values as “protest values” because it is reasonable to believe that they under represent the true value for the land area. These “protest values” are not included in the subsequent analyses. At the other extreme, there were several bids at $35/acre for quarter sections containing only one wetland area or four seasonal wetland areas. For example, for land containing one seasonal wetland, 289 of the 810 bids (35%) were at $35/acre, thus reflecting zero perceived cost associated with the presence of the wetland. Given the number of "zero cost" observations, our subsequent analysis of those bids employs the Tobit model. Our data also included six bids for land with wetlands that were above the $35 rental rate for land containing no wetlands. It is possible that some respondents viewed the presence of hydrated areas as beneficial (in fact, as noted below, respondents viewed the average productivity of farmed wetland areas as only slightly below that of their non-wetland acres). In the analysis we treat these observations as reflecting a zero cost for wetlands.[8]

The perceived cost of wetlands was calculated as the difference between the maximum amount a respondent was willing-to-pay (WTP) for land containing wetlands and the given rental rate for land with no wetlands ($35/acre). Thus for example, if a respondent indicated a maximum WTP of $30 per acre, then the cost of wetlands is taken to be $5/acre ($35-$30).

Producer Characteristics and Attitudes

Characteristics of the survey respondents, including summary statistics for gender, age, and education, are reported in the top half of table 2. The average respondent operated a total of about 1,300 cropland acres, of which 513 or 39% are owned and the remainder are rented. About 16% of respondents indicated that their farm contains areas designated by the Natural Resources Conservation Service (NRCS) as wetlands. A majority of these respondents indicated that they would drain or fill some of their wetlands if permitted to do so. On average, respondents with wetlands can harvest those areas 2.83 years out of five, and the average productivity of seasonal wetlands, when harvested, was only slightly below the average of surrounding non-wetland acres. About 55% of respondents reported average (30%) or above average (25%) productivity on wetland acres. Deer were the most commonly observed wildlife species – observed by over 97% of respondents on their land – and 25% of respondents indicated that they idled land or changed management practices for the specific purpose of helping wildlife.

Attitudes regarding wetlands and environmental legislation are reported in the bottom half of table 2. All responses were elicited using an inverted Likert scale (1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = strongly disagree). On average, respondents were neutral on whether or not draining or filling seasonal wetlands was beneficial to wildlife. However, respondents tended to agree that drainage restrictions reduced annual income and reduced the value of land – the average response was 2.01 to each statement. The average respondent was neutral or in slight agreement with the statements that endangered animals and plants in Kansas should be protected, and disagreed with the idea that the State of Kansas should buy more land to support endangered species. On average, respondents slightly agreed with the statement that the State of Kansas should make annual payments to producers for land management practices designed to benefit endangered species. Producers agreed with the statement that the prohibition of draining or filling wetland area is unfair to producers (the mean response was 2.0). Respondents agreed more strongly that the same restrictions imposed costs on producers. Finally, respondents agreed even more strongly (average response of 1.677) that environmental legislation is often unfair to producers.

Empirical Analysis of Perceived Wetland Costs

Tobit regression was used to estimate a wetland cost function using the data described above. The dependent variable was the imputed cost of wetlands based on the WTP responses, corresponding to c_w in the conceptual model; as discussed above, our observations of cost are censored at a value of zero. Independent variables included characteristics of the wetland as well as those of the producer and his farm operation.

The relevant wetland characteristics are the arguments of the wetland cost function (see equation (6)): wetland acreage (a_w), the number of wetlands (n), and proneness to hydration (h). While the conceptual model captures the relationships among these variables, it is uninformative about the shape of the cost function. The only unambiguous result was that costs increase in the number of wetland areas. Costs may either increase or decrease in the other variables, and in principle the direction of the response may change several times throughout a variable's domain. Most parametric functional forms are too restrictive to detect these types of irregularities, as they limit the number of inflection points and local minima and maxima.

In order to capture potentially irregular shapes in the cost function we first estimated a model in which each wetland characteristic was represented by a set of dummy variables. Thus, wetland acreage was represented by the dummy variables *2% Wetland Coverage*, *3% Wetland Coverage* and *4% Wetland Coverage* (with 1% wetland area as the omitted base group). Similarly, the number of wetland areas is captured by the variables *4 Wetland Areas* and *16 Wetland Areas*, and proneness to hydration by the set of variables *Wet 2 Years in 5, ..., Wet 5 Years in 5.* Next, to test the non-linearity of the cost function in those wetland attributes, we estimated a series of null models in which one of the three attributes was modeled linearly while the other two followed our dummy formulation. Likelihood-ratio tests indicated rejection of the null hypotheses that costs varied linearly with (a) the number of wetland areas and (b) frequency of hydration, but did not reject the hypothesis that costs varied linearly with wetland coverage (LR = 4.38, Chi-square = 5.99 at the 95% level of significance). Thus the model reported in table 3 specifies a linear relationship between perceived cost and wetland coverage.[9]

The farm characteristics included measures of scale, location, the presence of wetlands, and the presence of wildlife. The scale measure was total acreage, *Total Acres* = *Acres Owned* + *Acres Rented.* We expect *Total Acres* to have a negative coefficient if economies of scale are effective at reducing the cost of wetlands. Location is represented by a block of dummy variables delineating different regions of Kansas with North-Central Kansas as the omitted base group.[10] The effect of these variables on costs is an empirical question; they are included to capture any differences in perceived costs caused by regional variations in farming practices. The dummy variable, *NRCS Wetlands* tests for any systematic differences due to the respondent's level of experience with wetlands. The presence of wildlife is measured as the number of wildlife species observed on the respondent's farm (*Species Observed* = *Deer* + *Quail* + *Songbirds* + *Turkey* + *Pheasant* + *Other*). This variable depends on two attributes about the respondent: the actual wildlife population on his farm and his level of attention to wildlife. Our data do not allow us to disentangle these two effects, but if farmers place positive values on wildlife and believe that wetlands improve wildlife habitat, then this variable will have a negative impact on perceived wetland costs.

The characteristics of the farmer included both demographic attributes and attitudes toward environmental policies. The demographic variables included *Male*, *Age*, *Education*, *Primary Farmer,* and *Years Farming.* Again, the effects of many of these variables are empirical issues and they allow us to test to what extent costs are influenced by demographic factors. Two indices were created to represent attitudes toward (a) government regulation (*Accept Regulation*) and (b) environmental conservation programs (*Dislike Programs*). The first index was calculated as *Accept Regulation* = *Wetland Regs Unfair* + *Wetland Regs Costly* + *Environmental Laws Unfair*. Lower values of *Accept Regulation* indicate opposition to government regulation, while higher values indicate increasing acceptance of regulation. We hypothesize that *Accept Regulation* will be negatively correlated with the perceived cost of wetlands. The second index is *Dislike Programs* = *Protect Animals* + *Protect Plants* + *Buy Land For Habitat* + *Pay For Habitat*. Lower values of *Dislike Programs* indicate agreement with favourable statements about environmental conservation programs while higher values imply disagreement with these statements. We expect that *Dislike Programs* will be positively correlated with perceived costs. The correlation between the two indices was -0.17.

Results

Tobit estimation results for the wetland cost function are in table 3. The coefficient on *Percent Wetland Coverage* is positive, as expected, and statistically significant. The marginal effect indicates that an additional percent of wetland coverage (i.e., 1.6 additional wetland acres in the quarter-section) increases perceived costs by about $0.60/acre (or about $97 for the quarter –section).[11]

Increasing dispersion of the wetland area is viewed as contributing very significantly to reduced rental value. The marginal effect on *4 Wetland Areas* indicates that the additional cost of having the wetland dispersed in four separate areas instead of in one area is $4.23 per acre. The additional cost of having 16 wetland areas versus having one area with the same total coverage is $10.47 per acre. Clearly respondents viewed the inconvenience of having to farm around many smaller wet areas as being very costly.[12]

Frequency of hydration also affects costs nonlinearly. Relative to wetlands that are hydrated 1 year in every 5 (20% frequency), wetlands that are wet 2, 3, and 4, years in five have costs which are higher by $1.10, $1.01, and $1.17 per acre, respectively with no statistically significant differences among those three categories. As discussed in the conceptual section, one explanation for this behavior is production risk: over some range an increase in frequency of hydration may not increase costs because returns on the farmed wetland area are negatively correlated with returns on the upland acreage. Permanent wetlands (i.e., those hydrated 5 years out of every 5) are much more costly, with average costs $2.28 per acre above the base group.

Among the farm characteristics, *Total Acres* has a negative impact on perceived wetland costs, indicating the presence of economies of scale. However, the estimated elasticity at the mean (-0.069) suggests that the scale effect is small in magnitude. The coefficient on *NRCS Wetlands* is not statistically significant, suggesting no discernable differences in the responses of farmers with and without NRCS designated wetlands. The regional dummy variables representing western Kansas have positive and significant coefficients, suggesting that those producers place a higher cost on having wetlands that do those in the base area – North Central Kansas. *Species Observed* has a negative and significant coefficient, supporting the hypothesis that farmers who observe more wildlife view wetlands as less costly. As pointed out above, this result arises because farmers with more wildlife on their farm value the habitat that wetlands provide, or because an individual's attention to wildlife is likely correlated with their preference for environmental preservation.

Among the demographic variables, both *Age* and *Education* have significant correlation with perceived costs. Older producers view wetlands as more costly compared to younger producers, while more educated producers and respondents for whom agriculture is the primary occupation perceive costs to be lower. Gender and years farming the land do not systematically influence the perceived costs of wetlands. As hypothesized, the coefficient for *Accept Regulation* is negative, implying that producers with greater opposition to environmental regulation view wetlands as more costly. Also as hypothesized, *Dislike Programs* is positive—farmers with less favorable attitudes toward conservation programs perceive wetlands to be more costly.

Predicted costs from the tobit model (table 4) show average costs ranging from a low of $1.72/acre up to $15.31/acre for highly dispersed permanent wetlands. In our sample, producers with an interest in draining or filling wetlands indicated average costs of $282 and $350 per acre of wetland for doing so. Thus, even for scenario with the lowest perceived annual cost ($1.72/acre = $275 for the quarter section), the net present value of converting wetland areas is clearly positive. The predicted costs clearly illustrate the effects of dispersion viz-a-viz increases in wetland area. For example, the average cost associated with one seasonal wetland covering 1% of the area is $2.05/acre (i.e., the average of the 1st four entries in the 1st data column).   Quadrupling the wetland area to cover 4% increases costs by 64% to an average of $3.36/acre, while dispersing same 1% wetland coverage from one contiguous area to 16 separate smaller areas increases cost by over 450% to an average of $11.28/acre.

In sum, the wetland characteristics appear to be more important determinants of perceived wetland costs than the other groups of variables, and these characteristics generally affect costs in a nonlinear and irregular fashion. Over some range, perceived costs do not rise (and may actually fall) from increased frequency of hydration. The results also suggest that farmers would gain considerably from reducing wetland dispersion. These findings have some interesting policy implications, which are discussed in the following section.

Conclusions and Policy Implications

We analyze farmers' perceived costs of having wetland areas in cropland and our data suggests that those costs can be substantial: as high as 56% of farmland rental value in our survey of Kansas landowners. Both our conceptual and empirical models paid special attention to the effect of wetland characteristics. Like Shultz and Taff (2004) we find that permanent wetlands impose significantly greater costs than temporary wetlands, but within the category of temporary wetlands we found that varying the frequency of hydration between 40% and 80% does not impact perceived costs. [13] Our model predicts such outcomes as a consequence of the negative correlation between returns on wetland and upland areas.

We also find that perceived costs vary across respondents, implying that the social cost of regulations that restrict wetland conversion may depend on *who* bears those costs. Both age and education were significant determinants of perceived costs in our survey data; younger and more educated producers perceived wetlands to be less costly. Variation in perceived costs across farms has implications for how wetland policies should be targeted. Federal programs exist to provide cost sharing of wetland restoration or enhancement activities (Environmental Quality Incentives Program) and to remove wetlands from crop production (the Wetland Reserve Program). Our results suggest that these programs would be most effective if targeted to younger, more educated producers with larger operations. Furthermore, as suggested by a reviewer, another implication of the age and education results is that there is scope for public intervention (via extension education, training and demonstrations) to modify perceived costs.

The perceived costs we elicit do not directly reflect welfare losses that may arise from restrictions on wetland conversion (such as those embodied in the Swampbuster provisions). To illustrate, consider the market value of three land sections of otherwise equal quality – Section A containing no wetlands, Section B containing wetlands with no restriction on conversion, and Section C containing wetlands where, for simplicity, we assume the option to convert has been eliminated. In a well functioning market, the difference in price between B and C will reflect the cost imposed by the conversion restriction. However, this difference depends on both the costs and benefits of conversion, the benefits being the net present value of the annual costs associated with the presence of wetlands (i.e., reduced productivity, inconvenience) that are eliminated by the conversion. For example, suppose A is worth $100/acre and that the cost of converting the wetlands in Section B or C is $15/acre. Also suppose initially that the benefits of conversion are larger than the costs at $20/acre. In this case, B will be worth $85/acre and will be converted, (a potential buyer would obtain a parcel with a productive value of $100 but would have to pay the $15 conversion cost), while C will be worth $80/acre (a potential buyer would suffer the $20 in lost productivity from wetlands). Thus, when the benefits of conversion exceed the costs, conversion restrictions such as Swampbuster impose a cost equal to the difference between those benefits and costs ($5 in this case). Conversely, if the benefits of conversion are less than $15/acre (say $10/acre) then both B and C will be worth $90/acre and neither will be converted. The restrictions, in this case, impose no cost. Estimating the welfare impact of Swampbuster type provisions would thus require detailed information on the costs of conversion, which, like the benefits, undoubtedly also depend on wetland characteristics.

Consistent with the prediction from our theoretical model, our analysis found that wetland dispersion unambiguously increases the perceived cost associated with wetlands. We found, for example, that increasing dispersion of wetlands from 1 area to 4 areas contributes more to costs than either increasing the frequency of hydration from 20% to 100%, or increasing the size of a single contiguous wetland from 1% to 4% of the land area in a 160-acre quarter section. This finding suggests that there is scope for cost savings from flexible policies that allow landowners to “redistribute” wetlands. Since the 1996 Farm Act, producers have been allowed to drain or fill a wetland if an equivalent wetland area is restored or enhanced elsewhere. A farmer who operates a field with a highly dispersed wetland, say with 16 separate wetland areas, would save substantial annual costs if he were allowed to fill or drain those areas. The farmer must undertake a restoration or enhancement activity to offset this change, but the additional annual costs incurred from doing so may be small or even negative in some cases. Costs will be lowest if the restoration leads to an incremental increase in the size or frequency of hydration of an existing wetland which is not dispersed.

Even though annual wetland costs may be reduced by redistributing wetlands, the social net benefits would depend on the initial cost of filling one wetland and restoring another, as well as on the change in the stream of environmental benefits from the redistribution. Like the costs of wetlands, the benefits they provide are also highly contextual and the replacement of several smaller wetlands with a single wetland of equal total area may either increase or decrease the environmental benefits. This understanding is embodied in current federal rules governing redistribution. Restored or enhanced wetland must replicate the habitat and ecosystem services of the original wetland as nearly as possible, with the final authorization to be made by NRCS officials (Moore 1996). In situations in which contiguous wetlands are more beneficial for wildlife than several smaller dispersed areas, subsidies to encourage redistribution from dispersed to contiguous wetlands have the potential to deliver a net welfare benefit. Thus, while farmers are currently permitted to redistribute wetlands, there may be circumstances in which they should be encouraged to do so, and such encouragement would be consistent with the current federal goal of moving beyond “no net loss” to increasing the overall area in wetlands.

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Table 1. Willingness-to-Pay Values for Renting Cropland Containing Wetlands

Number and type of wetland areas	------- $ per acre -------		---- Number of Observations ----		
	Mean WTP	Standard Deviation	N	WTP = 0	WTP =(>)$35[a]
1 permanent	31.43	5.06	842	11	199(1)
4 permanent	27.12	6.31	839	13	42(0)
16 permanent	16.76	10.16	839	154	13(0)
1 seasonal	31.85	5.87	810	15	289(2)
4 seasonal	28.41	6.71	810	15	102(2)
16 seasonal	19.77	10.17	809	101	25(1)

[a] Note: $35/acre is given as the rental rate for similar quality land without wetlands.

Table 2. Producer Characteristics and Attitudes

Item	Variable Name[a]	Mean	St. Dev.
Farm and Producer Characteristics			
Acres owned	*Total Acres*	512.8	639.5
Acres rented		792.4	848.6
Land has NRCS-Designated Wetlands? (1=yes)	*NRCS Wetlands*	0.16	0.37
Would drain wetlands if allowed (1=yes)		0.71	0.50
Would fill wetlands if allowed (1=yes)		0.56	0.50
Frequency wetlands can be harvested (years/5)		2.83	1.31
Estimated wetland productivity[b]		3.35	1.32
Index of Species Observed	*Species Observed*	4.13	1.15
Deer+Quail+Songbirds+Turkey+Pheasant+Other			
Idle land to help wildlife (1=yes)		0.25	0.43
Age (years)	*Age*	54.5	13.2
Education (years)	*Education*	13.9	2.15
Gender (1=male, 0=female)	*Male*	0.98	0.13
Agriculture is primary occupation (1=yes)	*Primary Farmer*	0.91	0.28
Years farm has been owned	*Years Farming*	54.9	32.9
Children in household (1=yes)		0.92	0.27

Child likely to farm (1=yes)		0.55	0.50
Producer Attitudes			
Not draining or filling wetlands (Likert scale) [c]			
is beneficial to wildlife		2.82	1.14
reduces my annual income		2.01	0.92
reduces the value of my farm		2.01	0.98
Do you agree or disagree that (Likert scale) [c]			
Endangered animals should be protected		2.74	0.99
Endangered plants should be protected		3.00	1.00
State should buy land to protect species		3.90	1.11
State should pay farmers to protect species		2.37	1.14
Index – dislike for environmental programs	*Dislike Programs*	12.01	3.05
Wetland protection is unfair to producers		2.00	0.94
Wetland protection is costly for producers		1.91	0.87
Environmental laws are unfair to producers		1.68	0.78
Index – acceptance of regulation	*Accept Regulation*	5.58	2.16

[a] Variables used in the Tobit model (table 3); [b] 1 = 25% or more above the average of surrounding non-wetland acres, 2 = 10% above average, 3 = about average, 4 = 10% below average, 5 = 25% or more below average; [c] 1 = strongly agree, 2 = agree, 3 = neutral, 4 = disagree, 5 = strongly disagree

Table 3. Tobit Regression Results

Variable	Coefficient Estimate	Student t-ratio[a]	Marginal Effect
Wetland Attributes			
Intercept	-0.967	-0.65	
Percent Wetland Coverage	0.692	7.96	0.604
4 Wetland Areas	4.844	21.13	4.231
16 Wetland Areas	11.990	50.67	10.472
Wet 2 Years in 5	1.256	3.32	1.097
Wet 3 Years in 5	1.157	3.04	1.011
Wet 4 Years in 5	1.334	3.48	1.165
Wet 5 Years in 5	2.607	8.79	2.278
Producer/Farm Attributes			
Total Acres (000)	-0.400	-4.36	-0.371
NRCS Wetlands	-0.263	-1.00	-0.229
Species Observed	-0.205	-2.38	–-0.179
Accept Regulation	-0.249	-5.06	-0.218
Dislike Programs	0.071	2.09	0.062

Age	0.081	9.85	0.071
Education	-0.126	-2.64	-0.110
Male	-1.076	-1.18	-0.940
Primary Farmer	-0.967	-2.64	-0.845
Years Farming	0.003	0.95	0.002
North East (NE)	0.233	0.74	0.204
South East (SE)	0.254	0.86	0.222
South Central (SC)	-0.494	-1.59	-0.431
South West (SW)	0.727	1.96	0.635
North West (NW)	0.646	1.69	0.564
Observations	3995		

[a] At a significance level of 0.1, the critical value for a two-tailed test that a coefficient equals zero is 1.64.

Table 4. Predicted Cost of Wetlands ($ per acre)

	----- Wetland coverage -----			
Number and type of wetland areas (prob. wet)	1%	2%	3%	4%
1 seasonal (20%)	1.72	2.10	2.42	2.46
1 seasonal (40%)	2.26	2.79	2.99	3.68
1 seasonal (60%)	2.09	2.55	3.01	3.62
1 seasonal (80%)	2.13	2.58	3.05	3.66
1 permanent (100%)	2.93	3.47	3.89	4.45
4 seasonal (20%)	4.42	5.08	5.61	5.66
4 seasonal (40%)	5.34	6.17	6.46	7.44
4 seasonal (60%)	5.07	5.80	6.48	7.36
4 seasonal (80%)	5.14	5.83	6.53	7.41
4 permanent (100%)	6.38	7.13	7.73	8.45
16 seasonal (20%)	10.48	11.55	12.13	12.18
16 seasonal (40%)	11.78	12.58	13.19	14.21
16 seasonal (60%)	11.36	12.35	13.20	14.31
16 seasonal (80%)	11.48	12.09	13.08	14.08
16 permanent (100%)	13.01	13.78	14.57	15.31

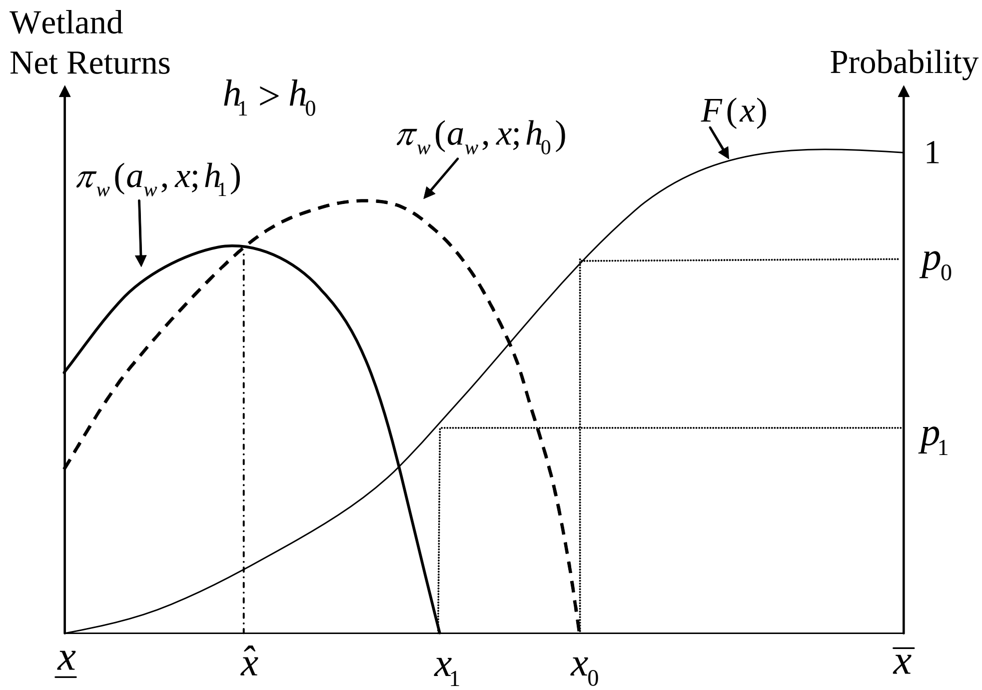


Figure 1. Effects of rainfall (*x*) and proneness to hydration (*h*) on wetland returns

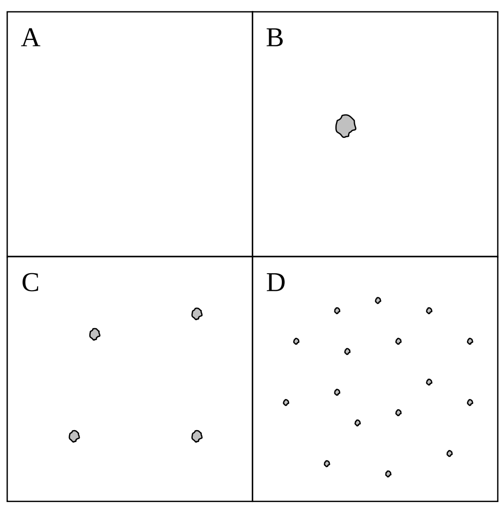
In this question, we want you to tell us the maximum rental rate you would pay for crop-land that contains some wetland areas that are **always** too wet to farm, when tracts of similar quality land with no wetlands rent for $35 per acre.

The diagram below shows a section of land divided into four quarter-sections of 160 acres. Section A contains no wetland areas and can be rented for $35/acre. Sections B, C, and D each contain 1.6 acres (1 percent) of wetland areas that are **always too wet to farm**. The shaded areas represent the wetland areas.

Please fill in the maximum rental rate per acre that you would pay for the entire acreage in each of Sections B, C, and D. Note that sections B, C, and D each contain **exactly the same total area** of wetlands.

A. NO WETLANDS
Rent is **$35/acre**

B. 1% WETLAND
Maximum I would
pay is _____ **$/acre**



C. 1% WETLAND
Maximum I would
pay is _____ **$/acre**

D. 1% WETLAND
Maximum I would
pay is _____ **$/acre**

Figure 2. Sample contingent valuation survey question for permanent wetlands

Footnotes

[1] Program benefits subject to this eligibility requirement include all types of production flexibility contract payments, price supports, marketing loans, farm credit program loans, contract payments under the Environmental Quality Incentives Program, and assistance under the Watershed Protection and Flood Prevention Act. This inclusive definition of farm programs implies a near universal impact on farmers in the plains states.

[2] The regulations define wetland “conversion” as activities including draining, dredging, filling, levelling, removing woody vegetation, or “any other activity that results in impairing or reducing the flow and circulation of water.” (7 CFR 12.2 (a)).

[3] Some areas however, are always too wet to cultivate – a category we refer to as permanent wetlands in our model below. Wetland regulations make a distinction between “farmed wetlands” and “wetlands farmed under natural conditions.” The difference is that “farmed wetlands” were manipulated in some way (e.g., partially drained or filled) before the 1985 cut-off date, while “wetlands farmed under natural conditions” are those that have been disturbed only by cropping activities and are otherwise in their natural state. Our “temporary wetlands” classification can be interpreted as including both these categories.

[4] As noted by a reviewer it is not desirable to have untrained personnel assist with the interpretation of survey questions. However, the handful of cases in which fieldmen were actually contacted involved issues such as when the survey should be returned and who was conducting the research rather than questions of interpretation.

[5] Seasonal wetland questions were identically presented except that respondents were told the wetland areas “**may be** too wet to farm,” and were given the average number of years out of every five these areas are too wet to harvest.

[6] An alternative format is a dichotomous choice question, which elicits a yes-no response to a given bid amount. Varying bids within a sample allows for estimation of a willingness-to-pay function, although more responses are required to obtain the same statistical properties because each response contains less

information. In our survey, employing a dichotomous choice format with four bid levels would increase the number of alternative versions from 16 to 64. We were also concerned that the normal variation in response rates across versions would result in some "cells" with very few responses, and create problems with the statistical analysis.

[7] As a reviewer pointed out, however, farmers' responses may still have been affected by their own operational constraints influencing their demand for rented land. Some may have reported low (high) bids for fields B, C, and D because their willingness to pay for field A was less (more) than $35 per acre. We attempt to control for these differences by including operational characteristics (e.g., acres farmed) in our empirical model. A related but more subtle issue is that respondents may not have viewed the three questions independently (e.g., they may have reported a low value for field D because they thought they had already committed to renting B and C). Unfortunately, we cannot test this hypothesis because the fields were always presented in the same arrangement. Finally, a reviewer also noted that respondents may have inferred something negative about the quality of the non-wetland areas in parcels with more wetlands. While that possibility cannot be eliminated, we would argue that the availability of *similar quality* land for $35/acre indicates to respondents that all the non-wetland area under consideration is of similar quality. Furthermore the issue of different quality for non-wetland areas was not raised by the participants in our pre-tests.

[8] Because there are only 6 such observations our results are not sensitive to the way they are treated.

[9] Polynomial functional forms were also rejected by the LR test. For example, when a quadratic term for percent coverage was added to the model reported in table 3, neither the linear nor quadratic coefficients were statistically significant and the log of the likelihood function increased by only 0.55. Gelso, Fox and Peterson (2007) contains results from these and other model specifications, in addition to a copy of the survey instrument.

[10] See http://www.agecon.ksu.edu/KFMA/new%20web/web04map.pdf for a map of the KFMA regions.

[11] In the dummy variable formulation, costs for fields with wetland coverage of 2% and 3% were $0.70/acre and $0.90/acre higher relative to fields with 1% coverage, and the difference between 2% and

3% coverage was not statistically significant. Costs for 4% coverage were estimated to be $1.95/acre higher than costs for 1% coverage.

[12] Following Johnston, Swallow and Bauer 2002, we also estimated models using an Edge/Area Ratio variable. However, because the shape of the wetland areas depicted in our instrument was identical in all its representations, the Edge/Area Ratio was highly correlated with the number of wetlands. Johnston, Swallow and Bauer 2002 also show how variation in the cartographic representation of a spatial feature can influence CVM responses. In our surveys, the spatial distribution of wetland areas was constant but it is worth noting that variation in that feature would probably have influenced our results.

[13] As suggested by a reviewer, results from hedonic studies based on market transaction data (such as Schultz and Taff 2004) will differ from ours depending on the frequency that landlords obtain "full rental value" for land containing (potentially costly) wetlands.