Ag Decision Maker

File A1-75
August 2012
www.extension.iastate.edu/agdm

Value of Soil Erosion to the Land Owner

The amount of soil erosion has decreased in the United States and Iowa, but soil erosion still remains a serious problem, especially for some soils. In 1982 there was an estimated 7.4 tons per acre of soil erosion on Iowa cropland. By 2007 erosion in Iowa had decreased to 5.1 tons per acre. For the entire United States, erosion rates dropped from 4.0 tons to 2.7 tons per cropland acre over the same time period. (USDA/NRCS, 2)

Erosion represents costs to the farmers. These costs include lost fertilizer and soil carbon. Erosion also produces costs to society. These costs include clogged roadway ditches, increased turbidity in the water damaging fish and increasing the need for filtration, and displaced soil in the water that increases siltation of water control structures. These societal costs are borne by taxpayers or society in general. They are 'external' to the decisions made by the farmer.

There is a third category of costs not usually considered in a discussion of soil erosion. These are the costs to the land owners caused by a decrease in land value. Land owners may be the farmer, but increasingly they are not. In 2007 over half the farmland in Iowa was rented. In the United States, 38 percent of the farmland was rented.

This paper estimates the costs of erosion to the land owner. The focus is on Iowa soils.

Farmer and Societal Cost

There have been several studies estimating the costs of soil erosion in the United States. These studies have examined the costs to the individual farmer, the costs to society or both. Tegtmeier and Duffy estimated the external costs of agricultural production in the United States (primarily erosion related) to range from $14.09 to $45.68 in 2002 dollars. (Tegtmeier and Duffy)

The USDA has undertaken a number of different studies to estimate the costs of erosion. The majority of these studies were conducted as part of an estimate of the benefits from different conservation programs required by U.S. farm policy. The USDA/NRCS has done two benefit/cost analyses of the Environmental Quality Incentives Program (EQIP). (USDA/NRCS, 2003, 2010)

Additional studies have estimated the soil-saving benefits from programs such as the Conservation Reserve Program and conservation compliance. These studies estimate the benefits likely to accrue to the components of the program. The benefits estimated focus primarily on the non-market or societal benefits.

USDA/NRCS studies reported that each ton of soil eroded contained the equivalent of 2.32 pounds of nitrogen and 1 pound of phosphorus. The estimated costs per pound for nitrogen and phosphorus in 2012 were $.63 and $.64, respectively. (Duffy) Using these estimates, the cost to the farmer in lost fertilizer value alone is $2.10 per ton of soil loss. The USDA study estimated that for soils in the EQIP program, soil erosion was reduced by 8.6 tons per acre; assuming $2.10 fertilizer value per ton of soil lost, enrollment in the EQIP program saves the farmer $18.06 per acre.

The loss of fertilizer represents only a part of the cost to the farmer. There will be a cost to cure the erosion problem. This would mean adding soil amendments and/or an increase in the amount of fertilizer that would have to be used simply to maintain the yield before erosion.

The USDA/NRCS studies also estimated a per-ton benefit of $4.93 per acre for improved water quality benefits. The 8.6 ton per acre soil saving would result in a savings of $42.40 per acre for water quality improvement.

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Estimating the cost of soil erosion is extremely difficult and subject to a variety of assumptions. It is especially difficult to estimate the non-market benefits, both locally and nationwide. There are a number of variables that confound soil loss cost estimates. Regardless of the difficulties, the majority of the studies recognize there is a cost of erosion to the farmer and society. The USDA work provides scientifically derived estimates of the farmer and societal costs of erosion. Summing the values of fertilizer saved ($2.10 per ton of soil saved) and water quality benefits ($4.93 per ton of soil saved), USDA/NRCS estimates of EQIP program benefits to farmers and society are $7.03 per ton of soil.

The USDA/NRCS studies addressed the crop yield loss component of the cost of erosion. The studies presented a methodology that, by their own admission, had problems and was very site specific to calculate. There would be a cost to society from the lost production for the increase in food costs and the potential for a diminished food supply in the future.

The hypoxia, or dead, zone in the Gulf of Mexico can be directly related to the amount of erosion on farms as nutrients leave the fields and are deposited in the Gulf. These costs need to be included in the cost calculations.

One USDA Economic Research Service reported that, “The county level sums of the water-erosion benefit estimations range from $1.70 to $18.24 per ton”. (pg. 21, Hansen and Ribaudo) This ERS publication outlines how to estimate benefits from soil erosion abatement. It notes how benefits will vary by region, soil, type of costs and a host of other factors.

Crop losses due to soil erosion cost both the farmer and land owner because the value of farmland is determined by the income from the land. Soil erosion costs the land owners, whether or not they are operators. Estimating these costs is the subject of the following discussion.

Land Owner Costs

The following is a discussion of how this analysis was performed. The main data source was the Iowa Soils and Interpretive Data Base (ISPAID) Version 7.3. (Iowa State University, 2010) This data set lists all the Iowa soils and their characteristics by county.

Twenty Iowa counties were selected at random to use for the study. All of the soils in each county were segregated based on the soil map symbol (SMS). A map symbol has a number, a letter for the slope measurement and another number for the erosion phase. For example, an 83C soil is in the Kenyon soil series with a C slope and none to slight erosion (represented by no number at the end). Each soil map symbol has a unique set of characteristics outlined in the ISPAID data set.

The slope measurements are:

Blank	0 to 2%	slope
B	2 to 5%	slope
C	5 to 9%	slope
D	9 to 14%	slope
E	14 to 18%	slope
G	18 to 25%	slope

The erosion measurements are:

Blank	None to slight erosion; greater than 7 inches of A or A plus E horizon
2	Moderately eroded; 3 to 7 inches
3	Severely eroded; Less than 3 inches

The next step was to identify soils with the same map symbol except with a different erosion phase. To continue the example above, the 83C would have 5 to 9 percent slope and none to slight erosion. The soil map symbol 83C2 would be a Kenyon soil with 5 to 9 percent slope but moderately eroded.

Only soils within a county that had the same number and slope designation but different erosion phases were included in the study. In most cases, there was only one erosion phase difference, as in the example above. But there were instances where three erosion phases were found. For example, in Clayton County there was a Dubuque soil with three erosion phases: 183E, 183E2 and 183E3.

The soils were further separated based on the estimated corn yields. Soils without a corn yield were eliminated from the study. The remainder of the analysis includes only important farmland and soils with similar SMS except for the erosion phase.

Three of the soil characteristics were considered. The Corn Suitability Rating (CSR), the corn yield

and the soybean yield. The CSR is an index from five to 100 that can be used to rate soils relative to one another. (Miller)

The final step in constructing the data set was to calculate the difference in the soil characteristics based on the erosion phase. For example, in Chickasaw County the 83C Kenyon soil had a CSR of 69 and the 83C2 had a CSR of 67. This means going from no to slight erosion to moderate erosion resulted in a decrease of two CSR points. There was a difference of 9 bushels expected corn yield between the soils.

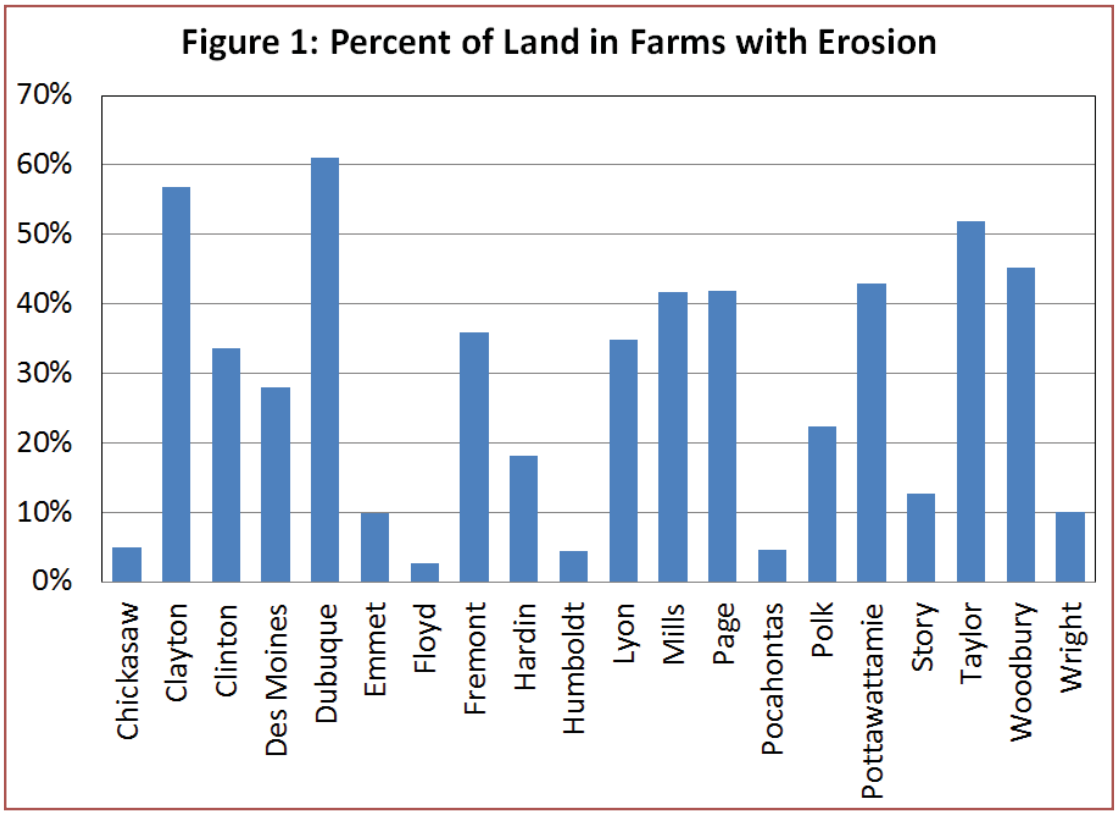
The final data set consisted of 20 randomly selected Iowa counties including only soils differing in the erosion phase. The data set contained the change in the CSR, corn yield and soybean yield going from one erosion phase to another.

The selected counties represented approximately 21 percent of the land area in Iowa. Figure 1 shows the percent of soil map units per county with moderate or greater erosion as indicated by the erosion phase in the SMS.

Table 1 shows the final break down of the number of soils included in this study. The percent of the farmland in each county represented by these eroded soils is also presented.

Table 1: Summary of Soils Used in Analysis

County	Number of Soils	Percent of Farmland
Chickasaw	5	4%
Clayton	8	44%
Clinton	7	15%
Des Moines	7	10%
Dubuque	15	43%
Emmet	4	4%
Floyd	6	2%
Fremont	14	36%
Hardin	1	1%
Humboldt	1	0.4%
Lyon	7	17%
Mills	15	43%
Page	18	40%
Pocahontas	1	3%
Polk	2	6%
Pottawattamie	11	34%
Story	4	7%
Taylor	22	46%
Woodbury	5	12%
Wright	1	0.1%



Analysis

Three alternative methods were used to evaluate the cost of degrading a soil from one erosion phase to another: a) Change in land value measured by decreased CSR rating; b) change in land value due to loss of yield potential; and c) change in land rent value due to the change in soil erosion phase.

Iowa State University (ISU) conducts a land value survey every year. The survey estimates county land values as of Nov. 1. (Duffy, 2011) The ISU land values estimated for November 2011 were increased by 4 percent based on quarterly estimates published by the Federal Reserve Bank of Chicago. (Oppendahl, 2012) Using the increased values more accurately reflects the current situation as of July 2012.

The ISU Extension Agronomy Department at Iowa State publishes an average CSR value for each county. (ISU Extension, 2012). The county level dollar value per CSR point was calculated by dividing the adjusted land value by the average CSR.

Table 2 presents the estimated loss in land value due to erosion based on the change in the CSR and the value in dollars per CSR point. The average percentage loss in value and the range of loss in value are presented. Notice that erosion can decrease the value of the land anywhere from 3 to 17 percent depending on the soil map unit. The average loss in value for all counties is 4.9 percent.

A second way to estimate the cost of the soil erosion is by estimating the impact of soil erosion on yield. The analysis is similar to the CSR analysis, but the difference in yield is the measure of the impact of erosion. This analysis includes continuous corn and a corn/soybean rotation.

The ISPAID data set contains the estimated corn and soybean yield associated with each SMS. To measure the impact of yield loss potential, the selling price for corn was initially assumed to be $5.50

Table 2: Estimated Decrease in Land Values Due to Erosion using Dollar Value per Corn Suitability Rating Point

County	Average Land Value	Average Dollar Value Lost	Percent of Land Value Lost	Range in Percent Loss High	Low
Chickasaw	$6,622	$303	4.6%	7.1%	2.9%
Clayton	$6,151	$377	6.1%	9.8%	3.9%
Clinton	$6,334	$226	3.6%	4.7%	3.1%
Des Moines	$6,492	$450	6.9%	7.6%	3.0%
Dubuque	$7,039	$388	5.5%	11.5%	3.8%
Emmet	$8,244	$354	4.3%	6.3%	3.1%
Floyd	$7,397	$326	4.4%	7.4%	2.9%
Fremont	$6,497	$396	6.1%	8.2%	3.3%
Hardin	$8,205	$208	2.5%		2.5%
Humboldt	$8,777	$240	2.7%		2.7%
Lyon	$8,689	$337	3.9%	6.8%	3.4%
Mills	$7,254	$484	6.7%	16.4%	3.3%
Page	$5,406	$300	5.6%	7.8%	3.1%
Pocahontas	$8,748	$233	2.7%		2.7%
Polk	$7,552	$207	2.7%		2.7%
Pottawattamie	$7,843	$483	6.2%	8.5%	3.4%
Story	$8,782	$314	3.6%	6.5%	2.6%
Taylor	$4,104	$311	7.6%	11.7%	3.3%
Woodbury	$6,670	$611	9.2%	16.7%	4.2%
Wright	$9,017	$240	2.7%		2.7%
AVERAGE		**$339**	**4.9%**		

and soybeans were assumed to be $12 per bushel. Production costs were the Iowa State University estimates for 2012. (Duffy, 2011) The costs were based on three yield categories and include land, labor and fixed machinery costs. The costs are for continuous corn, corn after soybeans and soybeans.

A single per acre corn yield potential is reported in ISPAID with no separation based on corn following corn versus corn following soybeans. Thus, a single corn yield potential was used for either rotation; however, corn production costs depended on the cost category and crop rotation used. The estimated corn and soybean yield in ISPAID were assigned to one of the three yield categories used in the cost estimates. Net returns (revenue minus cost per bushel) were calculated and differences between the returns based on erosion phase were summarized.

Table 3 summarizes estimated per-acre soil erosion costs based on loss of crop yield potential. The changes in value are presented using different capitalization rates.

Converting yearly income lost to a dollar value requires choosing a capitalization rate. Discussing all the nuances and factors of choosing the appropriate rate is beyond the scope of this paper. There are many different ways and methods to calculate the capitalization rate. The range presented in Table 3 represents possible current rates.

Notice in Table 3 that in all incidences the impact on the land value is less for the continuous corn rotation. This is because the average return from the corn/soybean rotation is greater. The higher the return the higher the land value and so the greater the erosion impact on land values.

A third way to estimate the value of the soil lost is using the rent data from the Iowa State University Cash Rent survey. (Edwards) The survey gathers

Table 3: Estimated Decrease in Land Values Due to Decreased Production by Rotation Using Alternative Capitalization Rates, Corn at $5.50 and Soybeans at $12

	CAPITALIZATION RATE							
	2.5%		3.0%		3.5%		4.0%	
	CC	C/Sb	CC	C/Sb	CC	C/Sb	CC	C/Sb
Chickasaw	$217	$261	$181	$217	$155	$186	$136	$163
Clayton	$196	$237	$163	$197	$140	$169	$122	$148
Clinton	$198	$239	$165	$199	$142	$170	$124	$149
Des Moines	$212	$284	$176	$237	$151	$203	$132	$178
Dubuque	$204	$251	$170	$209	$145	$179	$127	$157
Emmet	$218	$284	$182	$237	$156	$203	$137	$177
Floyd	$191	$249	$159	$208	$136	$178	$119	$156
Fremont	$232	$291	$193	$243	$166	$208	$145	$182
Hardin	$227	$273	$189	$228	$162	$195	$142	$171
Humboldt	$227	$273	$189	$228	$162	$195	$142	$171
Lyon	$198	$231	$165	$192	$141	$165	$124	$144
Mills	$254	$300	$212	$250	$182	$214	$159	$188
Page	$195	$249	$163	$207	$140	$178	$122	$156
Pocahontas	$243	$292	$202	$244	$173	$209	$152	$183
Polk	$210	$253	$175	$211	$150	$181	$131	$158
Pottawattamie	$259	$311	$216	$259	$185	$222	$162	$194
Story	$299	$351	$249	$292	$214	$251	$187	$219
Taylor	$202	$240	$169	$200	$145	$171	$127	$150
Woodbury	$276	$325	$230	$271	$197	$232	$172	$203
Wright	$250	$302	$209	$251	$179	$215	$156	$188

data on cash rent and the associated yields and other soil characteristics. In addition to the average, high, medium and low rents, the survey data reports the average rent per bushel of corn yield, per bushel of soybean yield and per CSR point. For example, in 2012 the average rent in Chickasaw County per bushel of corn yield was $1.55 per bushel, the average rent per bushel of soybean yield was $5.47 and the average rent per CSR point was $3.55.

Table 4 shows the value per acre using the three alternative rent measures: dollars per bushel of corn, dollars per bushel of soybeans and dollars per CSR point. Table 4 also shows the average of the three measures and the impact on land values using 3.5 percent and 4 percent capitalization rates.

Discussion

The direct change in land value measured by CSR change and the change in rent measured by dollars per point and capitalized at 3.5 percent produced similar estimates of the impact of soil erosion on land values. However, the decrease in land values due to a decrease in productivity using $5.50 corn and $12 soybeans and a 3.5 percent capitalization rate estimated was considerably lower than the other two estimates. (Figure 2) The biggest reason for this is that the land values and rents were determined when commodity prices were higher.

Figure 3 shows the difference in the estimated impact from erosion on land values using two commodity price scenarios: the low price is $5.50 for corn and $12 per bushel for soybeans; the high price scenario uses $6.25 for corn and $13 per bushel for soybeans. Notice the significant impact that the price scenarios have on the estimated decrease in value.

The average decrease in land value due to erosion using the three alternative methods of estimation is shown in Figure 4. The low price scenario is the lowest because it has the lowest net return. Using just the first three estimation techniques, the results are very similar. On average, without the low price scenario, erosion decreases land values by about $340 per acre.

Table 4: Average Erosion Loss Based on Rental Rate Survey

	Loss per BU		Loss per		Loss per Ac. by Cap Rate	
	Corn	Soybeans	CSR Pt	Average	3.5%	4%
Chickasaw	$12.40	$12.03	$11.36	$11.93	$341	$298
Clayton	$9.57	$8.19	$10.53	$9.43	$269	$236
Clinton	$10.83	$10.88	$8.82	$10.17	$291	$254
Des Moines	$13.18	$12.35	$13.58	$13.04	$372	$326
Dubuque	$11.73	$11.43	$11.50	$11.55	$330	$289
Emmet	$11.04	$11.47	$8.99	$10.50	$300	$262
Floyd	$11.13	$11.37	$9.48	$10.66	$305	$267
Fremont	$13.50	$13.03	$8.99	$11.84	$338	$296
Hardin	$12.38	$12.11	$6.68	$10.39	$297	$260
Humboldt	$13.27	$13.47	$7.60	$11.45	$327	$286
Lyon	$11.09	$11.23	$10.42	$10.91	$312	$273
Mills	$16.54	$16.02	$15.94	$16.17	$462	$404
Page	$12.25	$11.54	$11.63	$11.80	$337	$295
Pocahontas	$12.74	$13.17	$6.96	$10.95	$313	$274
Polk	$12.09	$11.52	$5.94	$9.85	$281	$246
Pottawattamie	$15.52	$15.61	$15.05	$15.40	$440	$385
Story	$18.26	$17.74	$9.57	$15.19	$434	$380
Taylor	$13.59	$13.02	$13.45	$13.35	$382	$334
Woodbury	$11.66	$12.26	$20.02	$14.65	$418	$366
Wright	$15.37	$15.81	$8.04	$13.07	$374	$327

Figure 2: Estimated Decrease in Land Values due to Erosion Based on Alternative Methods of Estimation

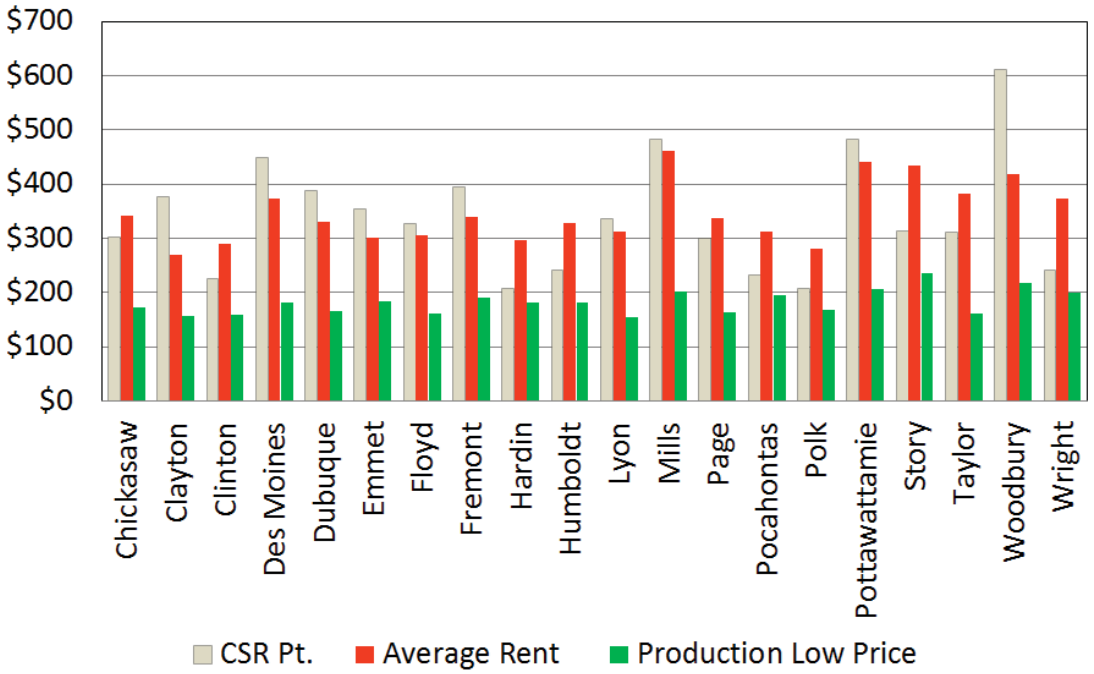
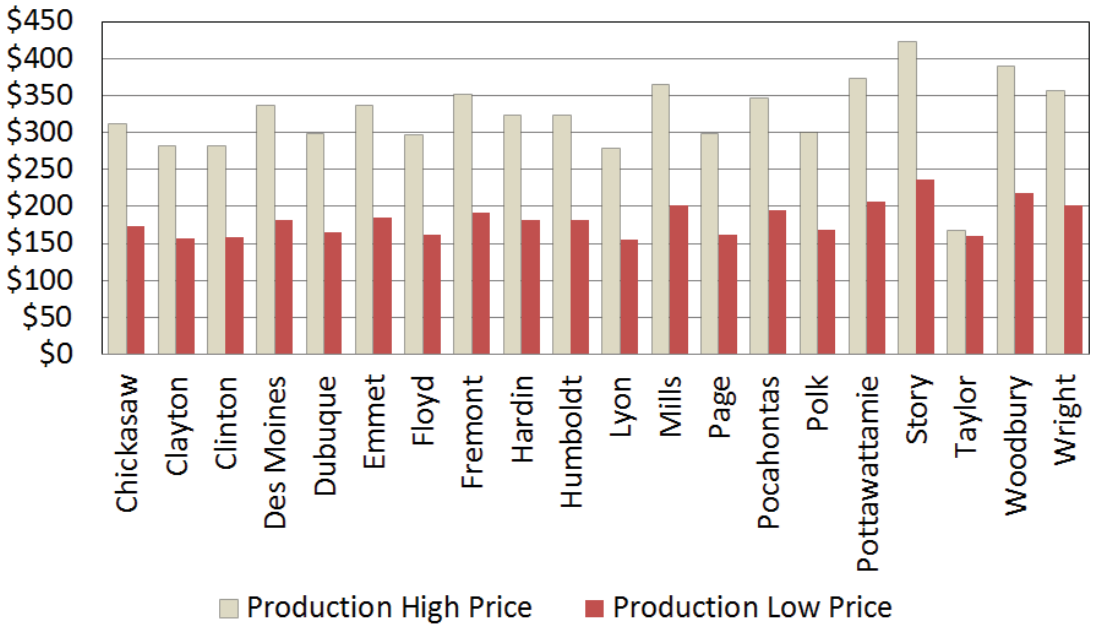


Figure 3: Estimated Decrease in Land Values Due to Erosion Using $5.25 Corn/ $12 Soybeans or $6.25 Corn and $13 Soybeans



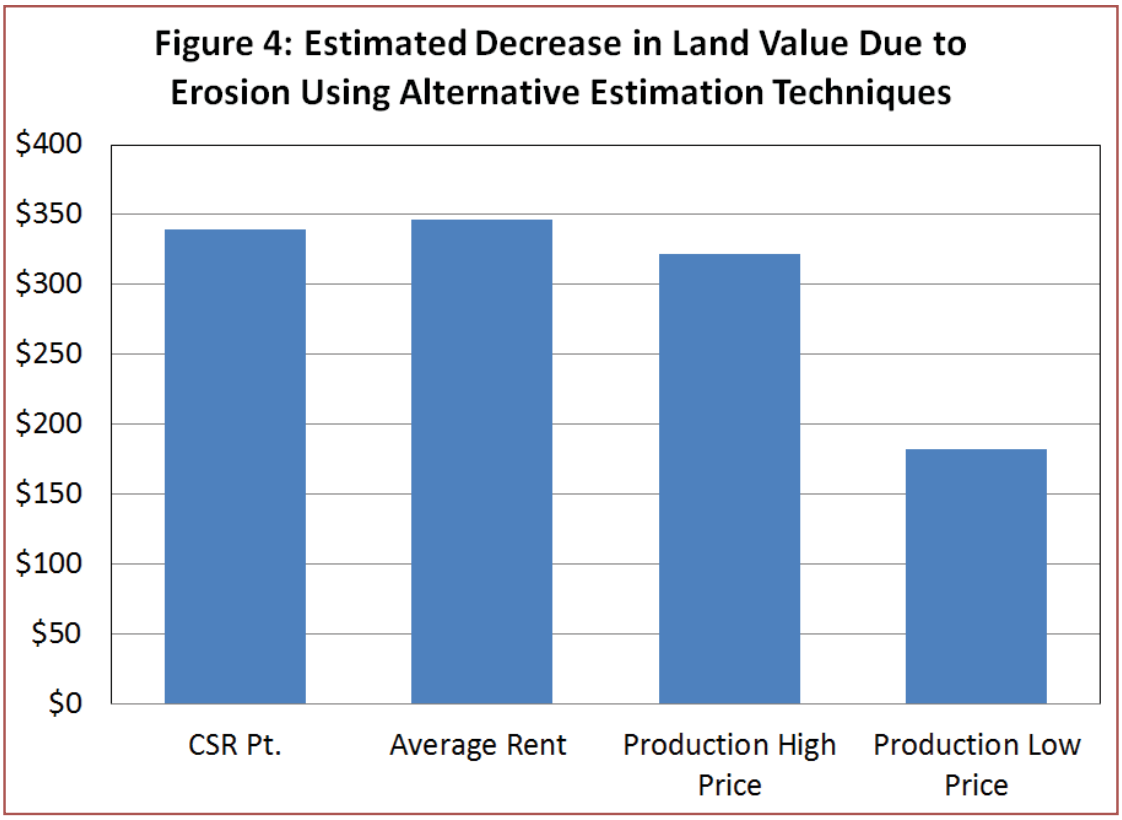


Figure 5 shows the average percentage loss in land values, by county, due to erosion. Figure 5 uses the high price production loss scenario and the Iowa State University land values adjust for the 4 percent increase in the first quarter of 2012. The average percentage loss in land value due to erosion is approximately 4.8 percent of the adjusted 2011 value.

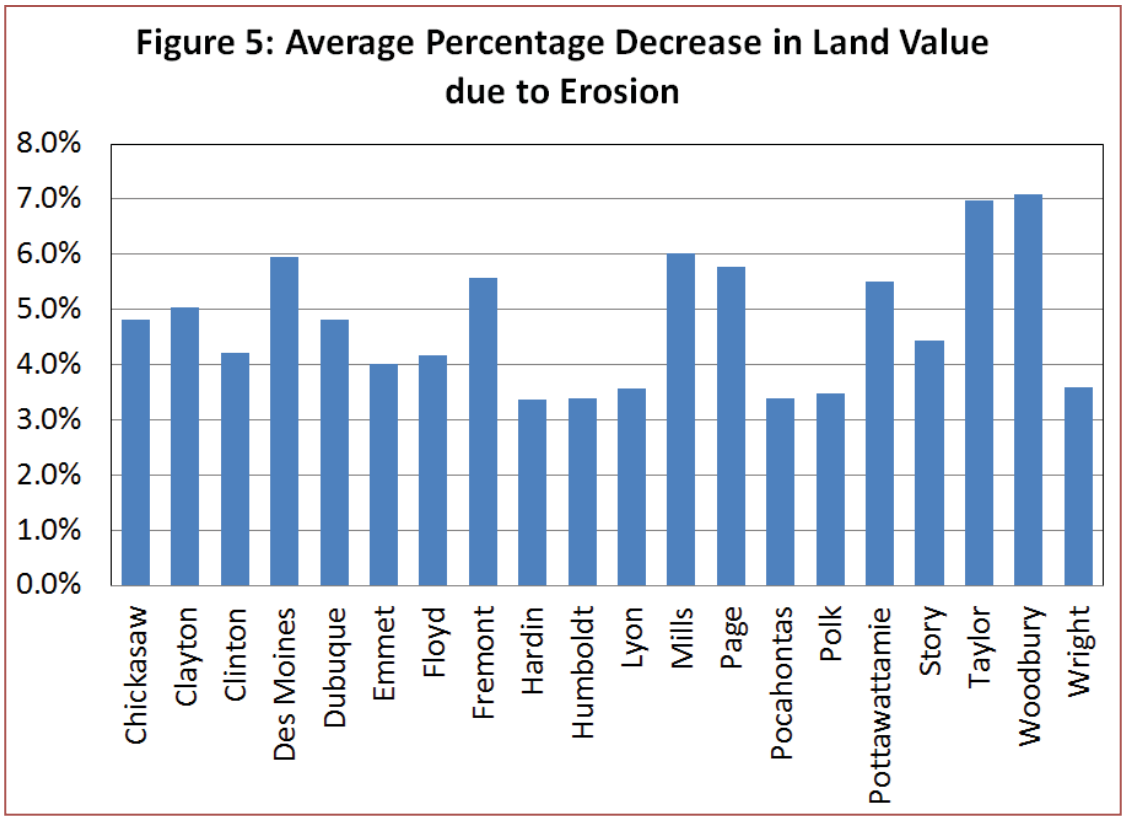
There is a large variation in estimated impact per county. The largest decrease in value due to erosion was in Woodbury County, where eroded soils were valued at 7.1percent less than non-eroded soils. The lowest decrease in value was 3.4 percent in Hardin and Humboldt Counties.

The dollar value or percentage decrease in land values due to moving from one erosion phase to another on the same soils may not seem like a lot. However, this does represent an economic cost that should not be omitted from the equation when discussing soil conservation.

If we assume there is 150 tons of soil in an inch of topsoil and that there is approximately 3 inches of soil lost moving from one erosion phase to another, the loss of a ton of soil would decrease land values by about $.75. If we assumed it took 7 inches of soil loss, then the decrease in value would drop to $.32 a ton. The NRCS study noted a loss of approximately 8.6 tons of soil per acre. At this rate, the range in cost to the land owner per acre per year would be from $2.75 to $6.45 an acre.

There is considerable difference between soils and counties with respect to the loss in value caused by erosion. Regardless of the estimate, however, soil loss through erosion does impact soil quality and productivity, and this loss will impact the value of the soil. As shown in Figure 5, estimated loss in value is expected to range from 3 to over 7 percent.

These analyses suggest it is possible to estimate the potential impact of erosion on land values; however, does this matter? In other words, will erosion loss show up in the sale price of the land, or will the erosion loss simply be a part of the overall price per acre because it is too difficult to separate the eroded and non-eroded land in a sale? Obviously that would depend upon the particular piece of land. But, in some cases (especially in highly erodible counties),



if one farmed in such a manner as to prevent erosion, the soil would have an increased value.

The impact of erosion would vary depending on the depth of the soil. Areas with deep, productive soil will be less affected by erosion than areas with shallow soils close to the subsoil.

Conclusion

Soil erosion can cause a decrease in land values. The three different methods used to estimate loss in value produced results that were reasonably consistent. The results hinge on the accuracy of the ISPAID estimates, but that is the best data available. The results will vary with changing prices, rents and overall land values. Regardless, soil erosion represents cost to the land owner due to lost productivity and possibly decreased sales price.

In 2007, 26 percent of the farm land owners in Iowa said they owned the land as a long-term investment. Another 22 percent of the owners said they owned the land for family reasons. (Duffy and Smith) Protecting the soil from erosion will protect the value of the investment, whether it is for a long-term financial gain or a family inheritance.

We often discuss the value of soil erosion from the farmer or society cost. These costs are substantial. But, if we are to truly consider the impact of erosion, we need to consider what it does to the value of our investment. Too often we apply more fertilizer or other crop inputs, masking the impact of erosion. We fail to account for decreased value of the land asset due to soil erosion. Higher expenses for the same yield mean lower profits, which lowers the value of the asset.

The value of the lost soil to the land owner may not be great; however, it is measureable and will have an impact over time. Soil for the land owner is a bit like the story of removing bricks from a wall: you can remove the bricks one at a time without any trouble until you remove one too many and the wall collapses. A land owner can tolerate soil erosion a little at a time, but at some point it is going to cost, and they won't know what they've got until its gone.

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Issued in furtherance of Cooperative Extension work, Acts of May 8 and July 30, 1914, in cooperation with the U.S. Department of Agriculture. Cathann A. Kress, director, Cooperative Extension Service, Iowa State University of Science and Technology, Ames, Iowa.