Value of Soil Erosion to the Land Owner

Levels of soil erosion have decreased in the United States (U.S.) and Iowa, but soil erosion still remains a serious problem, especially for some soils. In 1982 there was an estimated average of 7.4 tons per acre of soil erosion on Iowa cropland. By 2007 erosion in Iowa had decreased to an average of 5.2 tons per acre. For the entire U.S. 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 the displaced soil in the water will increase 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 their asset value. Land owners may be the farmer but increasingly they are not. In 2007 over half the farmland in Iowa was rented. In the U.S., 38% 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 U.S. (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 analysis 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 2011 were $.51 and $.59, respectively. (Duffy) using these estimates the cost to the farmer in lost fertilizer value alone is $1.77 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 $1.77 fertilizer value per ton of soil lost, enrollment in the EQIP program saves the farmer $15.22 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.

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 nation-wide. 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 ($1.77 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 $6.70 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 zone in the Gulf of Mexico is directly related to the amount of erosion on farms. These costs need to be included in the cost calculations.

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 owner, 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 (ISU) 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 letter). 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 plusE 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% slope and none to slight erosion. The soil map symbol 83C2 would be a Kenyon soil with 5 to 9% slope but moderately eroded.

Soils within a county that had the same number and slope 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 5 to 100 that can be used to rate soils relative to one another.

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 2 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.

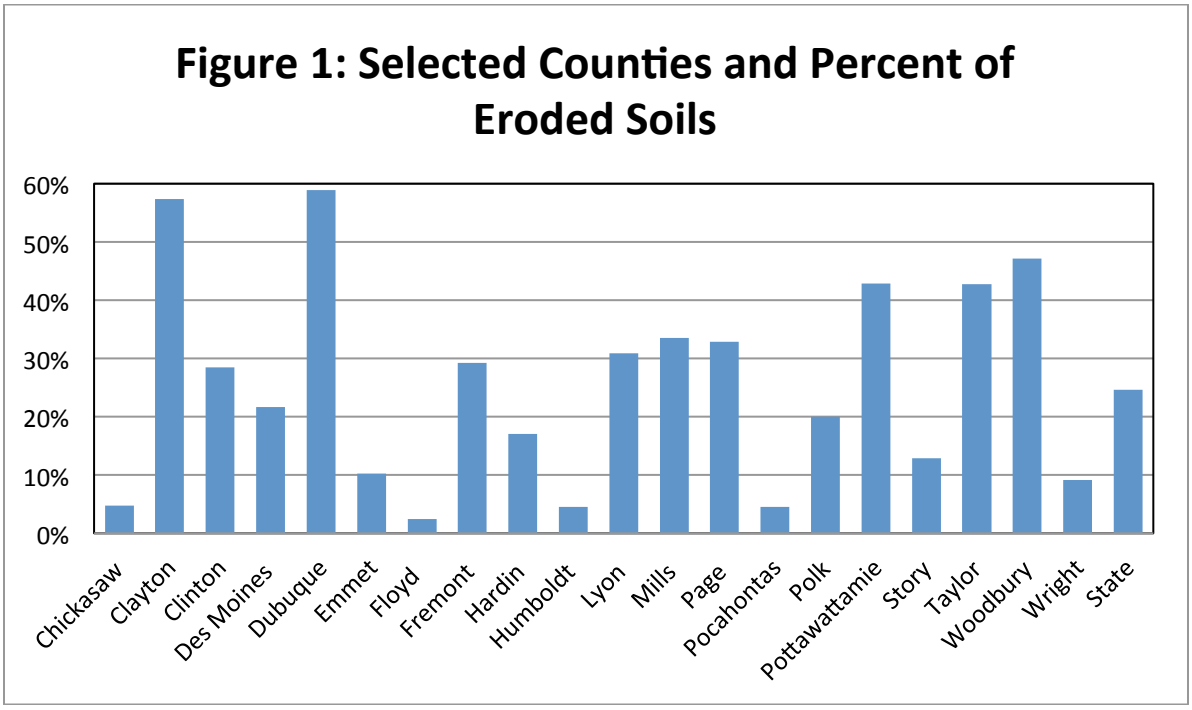


Table 1: Summary of Soils in Analysis

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 due to reduced 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 conducts a land value survey every year. The survey estimates county land values as of November 1st. The ISU land values estimated for November 2010 were increased by 17 percent to more accurately reflect the current situation July, 2011 (Duffy 2011, Pro Farmer)

The Iowa State University Agronomy Department publishes an average CSR value for each county. (ISU). 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 cost of erosion to the land owner based on the change in the CSR. 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 20 percent depending on the soil map unit. The average loss in value for all counties is 4.8 percent.

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	$ 5,674	$261.64	4.6%	2.9%	7.2%
Clayton	$ 5,222	$339.29	6.5%	4.2%	10.4%
Clinton	$ 5,233	$191.70	3.7%	3.2%	4.8%
Des Moines	$ 5,669	$411.37	7.3%	3.2%	7.9%
Dubuque	$ 5,956	$332.85	5.6%	3.9%	11.7%
Emmet	$ 6,973	$286.62	4.1%	3.0%	6.0%
Floyd	$ 6,364	$252.88	4.0%	2.7%	6.6%
Fremont	$ 5,366	$306.15	5.7%	3.1%	7.7%
Hardin	$ 7,004	$184.57	2.6%		2.6%
Humboldt	$ 7,463	$199.54	2.7%		2.7%
Lyon	$ 7,344	$282.13	3.8%	3.4%	6.7%
Mills	$ 5,991	$379.50	6.3%	3.1%	15.6%
Page	$ 4,465	$251.20	5.6%	3.2%	7.9%
Pocahontas	$ 7,423	$200.63	2.7%		2.7%
Polk	$ 6,498	$175.16	2.7%		2.7%
Pottawattamie	$ 6,497	$388.56	6.0%	3.3%	8.2%
Story	$ 7,527	$266.75	3.5%	2.6%	6.4%
Taylor	$ 3,427	$295.58	8.6%	5.7%	13.3%
Woodbury	$ 5,562	$492.39	8.9%	4.0%	16.1%
Wright	$ 7,667	$209.48	2.7%		2.7%
AVERAGE		**$285.40**		**3.4%**	**7.5%**

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 an estimated corn and soybean yield associated with each SMS. To measure the impact of yield loss potential the selling price for corn was assumed to be $6.00 and soybeans were assumed to be $13.00 per bushel. Production costs were the preliminary Iowa State University estimates for 2012. (Duffy, 2010) 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 level of yield 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 data are presented in terms of dollars per acre and then in terms of the value change per acre using two different capitalization rates.

Converting yearly income lost to a dollar value requires choosing the correct capitalization rate. Discussing all the nuances and factors of choosing the appropriate rate is beyond the scope of this paper. Instead two rates reflective of current situations are used (3.5 percent and 4.0 percent). The average capitalization rate reported by the Farm Credit System for 2010 in the 20 counties used for this study averaged 3.65 percent. The capitalization rate ranged from 2.7 percent to 5.0 percent.

Table 3: Estimated Yearly Loss and Loss in Land Value Due to Erosion Crop Loss

	Yearly Loss by Rotation		Loss per Acre by Capitalization Rate 3.5%		Loss per Acre by Capitalization Rate 4.0%	
County	**CC**	**CSb**	**CC**	**CSb**	**CC**	**CSb**
Chickasaw	$7.78	$8.75	$222	$250	$194	$219
Clayton	$7.02	$7.87	$201	$225	$175	$197
Clinton	$7.08	$7.99	$202	$228	$177	$200
Des Moines	$7.74	$9.59	$221	$274	$194	$240
Dubuque	$7.31	$8.43	$209	$241	$183	$211
Emmet	$7.98	$9.61	$228	$275	$199	$240
Floyd	$6.97	$8.42	$199	$240	$174	$210
Fremont	$8.42	$9.90	$241	$283	$211	$247
Hardin	$8.09	$9.14	$231	$261	$202	$228
Humboldt	$8.09	$9.14	$231	$261	$202	$228
Lyon	$7.06	$7.81	$202	$223	$177	$195
Mills	$9.14	$10.22	$261	$292	$229	$256
Page	$7.11	$8.41	$203	$240	$178	$210
Pocahontas	$8.66	$9.78	$248	$279	$217	$245
Polk	$7.51	$8.48	$215	$242	$188	$212
Pottawattamie	$9.29	$10.50	$265	$300	$232	$263
Story	$10.68	$11.85	$305	$339	$267	$296
Taylor	$6.65	$9.11	$190	$260	$166	$228
Woodbury	$7.87	$8.77	$225	$251	$197	$219
Wright	$8.94	$10.09	$255	$288	$223	$252
AVERAGE	**$7.97**	**$9.19**	**$228**	**$263**	**$199**	**$230**

A third way to estimate the value of the soil lost is to use the rent data from the Iowa State University Cash Rent survey. (Edwards) The survey gathers 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 Chickasaw County the average rent per bushel of corn yield was $1.23 per bushel, the average rent per bushel of soybean yield was $4.27 and the average rent per CSR point was $2.76.

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.

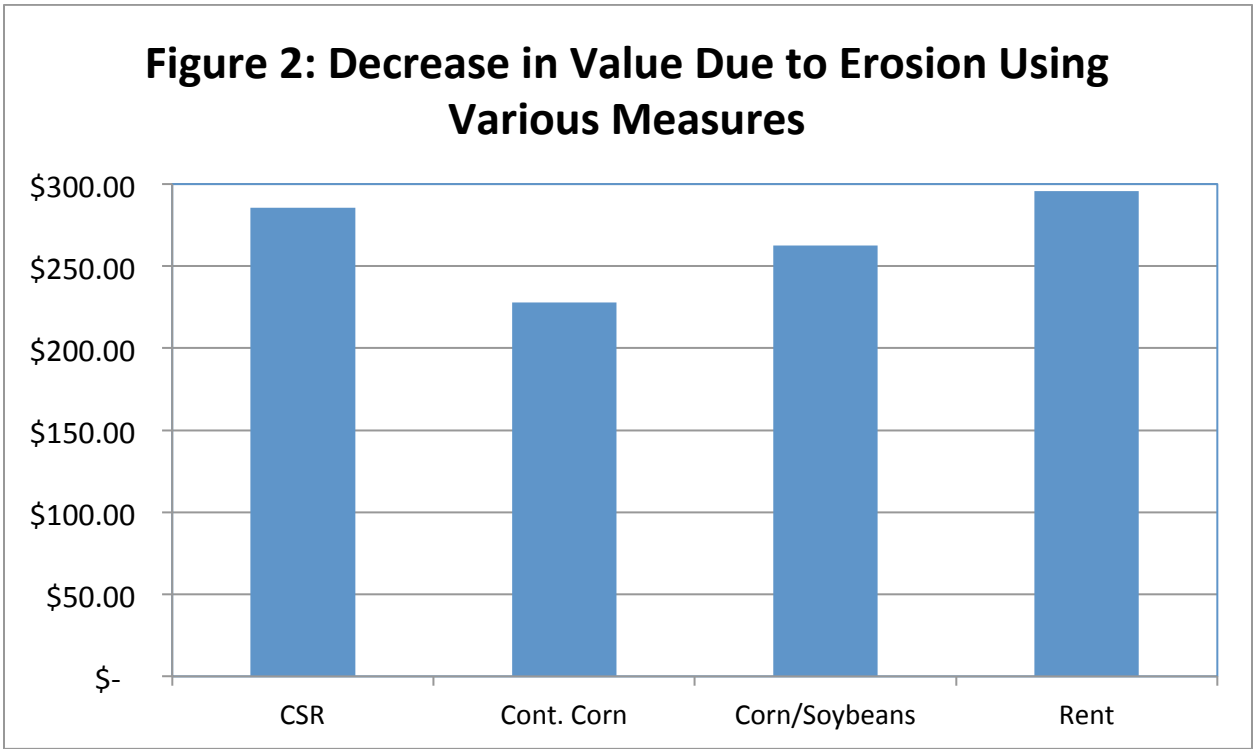
Table 4: Average Erosion Loss Based on Rental Rate Survey

	Loss per BU		Loss per		Loss per Ac. by Cap Rate	
	Corn	Soybeans	CSR Pt	Average	3.5%	4%
Chickasaw	$9.84	$9.39	$8.83	$9.36	$267	$234
Clayton	$8.77	$7.48	$9.47	$8.57	$245	$214
Clinton	$8.99	$9.19	$7.25	$8.47	$242	$212
Des Moines	$11.68	$11.26	$12.21	$11.72	$335	$293
Dubuque	$10.22	$9.99	$9.98	$10.06	$287	$251
Emmet	$9.30	$9.60	$7.56	$8.82	$252	$221
Floyd	$9.35	$9.39	$7.77	$8.84	$253	$221
Fremont	$11.48	$10.74	$9.73	$10.65	$304	$266
Hardin	$10.93	$10.63	$5.88	$9.15	$261	$229
Humboldt	$10.52	$10.87	$6.00	$9.13	$261	$228
Lyon	$8.55	$8.34	$7.82	$8.23	$235	$206
Mills	$12.50	$11.85	$12.08	$12.14	$347	$304
Page	$10.84	$9.95	$10.49	$10.43	$298	$261
Pocahontas	$11.18	$11.26	$6.00	$9.48	$271	$237
Polk	$9.54	$9.26	$4.76	$7.85	$224	$196
Pottawattamie	$12.21	$12.24	$11.85	$12.10	$346	$302
Story	$14.52	$14.40	$7.78	$12.23	$350	$306
Taylor	$14.46	$13.52	$14.36	$14.12	$403	$353
Woodbury	$13.88	$13.79	$17.51	$15.06	$430	$376
Wright	$12.60	$12.80	$6.52	$10.64	$304	$266
AVERAGE	**$11.07**	**$10.80**	**$9.19**	**$10.35**	**$296**	**$259**

Discussion

The three alternative methods to estimate the impact of soil erosion on land values produced similar results. Figure 2 summarizes the average estimated impact of erosion on per acre land value based on CSR change, the yield loss with a continuous corn or a corn/soybean rotation and the average loss using the three different rent methods. The estimations are relatively similar. Where there are differences the major differences can be explained.

The biggest difference is between the continuous corn estimate and the average of the rental methods. The difference is $68 per acre or 30 percent. The lower impact for continuous corn was expected because the greater input costs associated with that rotation reduces net returns. The corn/soybean rotation produced a $33 or 13 percent difference between it and the loss due to erosion using the rental method.



There also is a fair degree of consistency among the different types of estimates. Figure 3 shows the estimated decrease in the value of land based on erosion using a 3.5 percent capitalization rate. Notice the two methods using the CSR are almost identical. Using the land value survey method is only 2 percent higher than using the rent per CSR point.

The two yield loss methods produced different results depending upon the rotation. This is expected because the returns to the continuous corn rotation are lower and so the impact of erosion on the land in continuous corn would be less.

The two methods using the value of the rent per bushel produced the highest estimates of the decrease in land values due to erosion. The two estimates, using corn or soybeans, were within

2.5 percent. Both of these estimates were higher than the CSR estimates by approximately $47 or 18 percent.

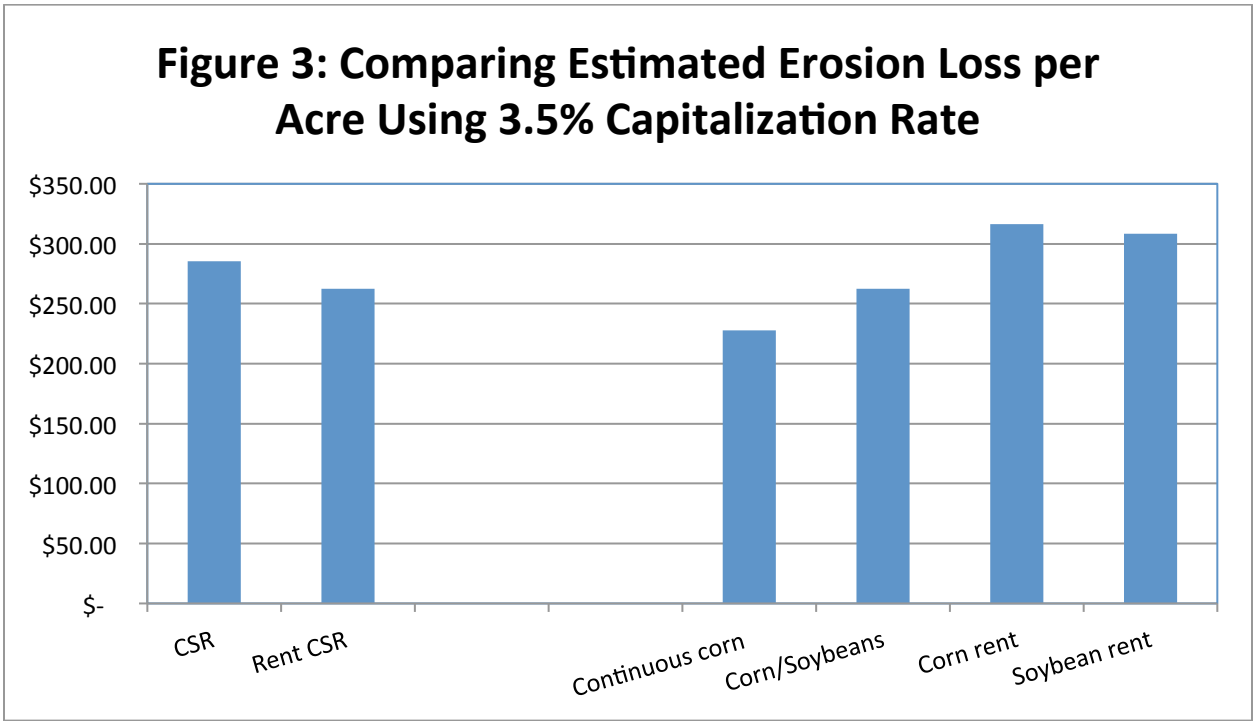


Figure 4 shows the average dollar loss per county in land values due to erosion using the three methods. The averages are calculated using a 3.5 percent capitalization rate.

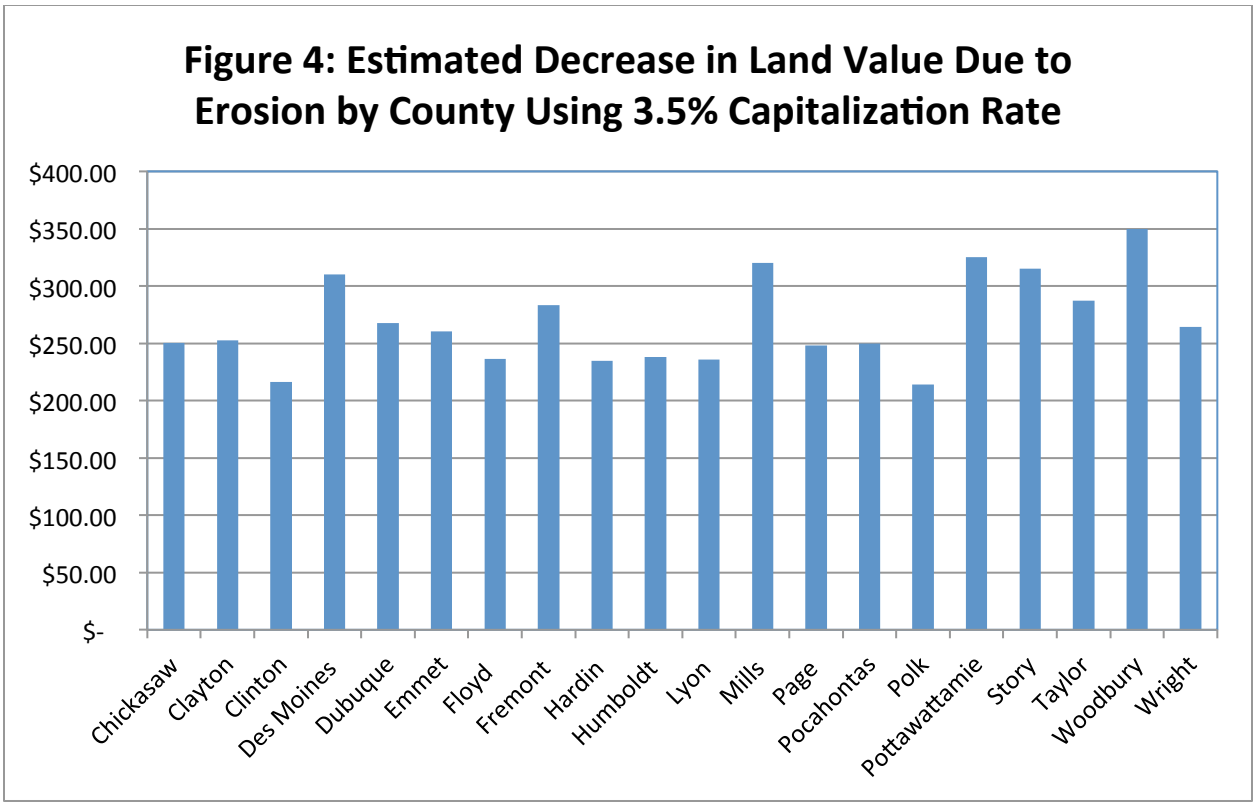
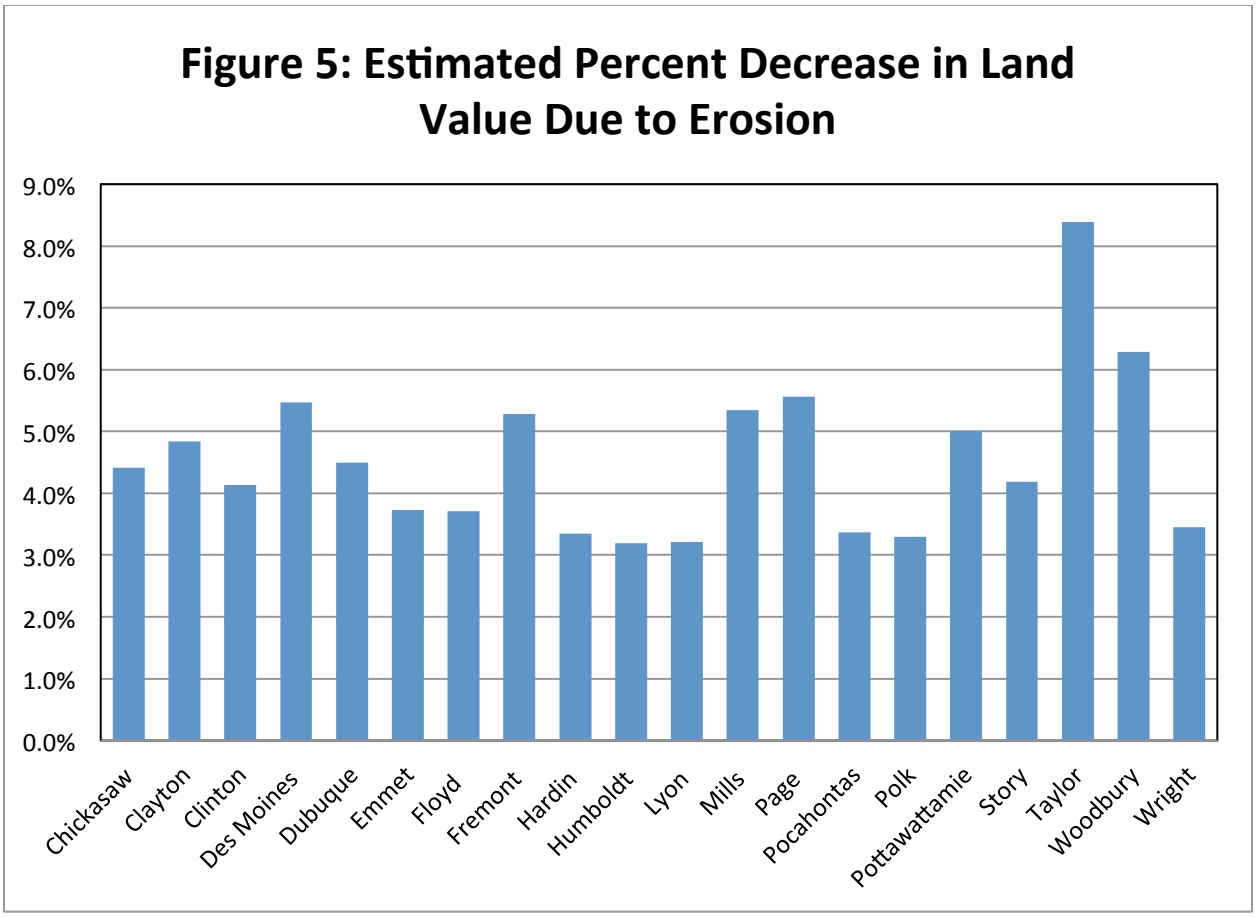


Figure 5 presents the estimated average losses as a percent of the 2011 estimated land values per county. Figure 4 assumes a 3.5 percent capitalization rate.



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 8 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 start of the rock layer.

Conclusion

Soil erosion can cause a decrease in land values. Allowing for difference in rotations, 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.

When you first examine the values presented here they don't seem like much on a per ton basis. Soil weighs roughly 154 tons per inch. If we assume that you are losing 4 inches as you move in the different erosion phases then you would lose 616 tons of soil. The average of all the estimates for cost of erosion was $268 an acre. This would mean the cost per ton decrease in value would be approximately $.44 per ton ($268 per acre/616 tons of soil). Using the 8 ton per acre soil loss figured by the USDA, we calculate a soil loss value of $3.48 per acre.

The value of the lost soil to the land owner is not 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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