Losing Ground: Soil Erosion in the Upper Iowa Watershed

Introduction

There are nearly 724 impaired waters across the state of Iowa, a number that has climbed 15 percent in the past two years (Figure 1). Additionally, Iowa watersheds have been identified by the Environmental protection Agency and the USDA as major contributors of hypoxia in the Gulf of Mexico. Iowa has a robust agricultural economy-leading the nation in pork, egg, and corn production. A commonly identified impairment for lakes is excess algae caused by large concentrations of nitrates and phosphorous from soil erosion off farm fields.

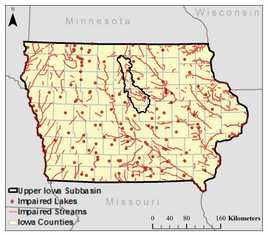


Figure 1.

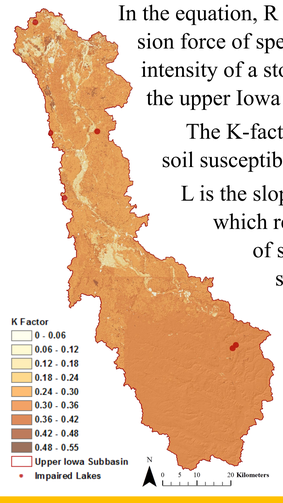
Using the Revised Universal Soil Loss Equation (RUSLE) to determine soil loss, I will estimate the tons of soil per acre per year that could be lost in the upper Iowa watershed from erosion. Depending on the results, farms vulnerable to soil loss may consider adapting farm production or management practices and adopting conservation techniques.

Methodology

The Revised Universal Soil Loss Equation (RUSLE) is a tool used to estimate the average soil lost from land in tons per acre per year. Since its development in 1965, originally USLE, has been the major conservation planning tool in the United States and other countries around the world. In 1978, with additional research and resources the RUSLE equation was revised to

$$A = R * K * LS * C * P$$

Upper Iowa K Factor



In the equation, R is rainfall-runoff erosivity factor and measures the erosion force of specific rainfall. It measures the amount of rainfall and peak intensity of a storm over an extended period of time. The R-Factor for the upper Iowa sub-basin was determined to be 150 [1].

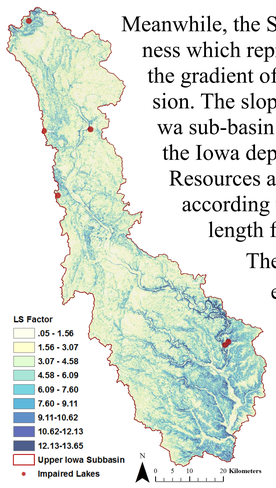
The K-factor is a measure is soil erodibility which represents both soil susceptibility to erosion and the rate of runoff [2].

Soil Type	K Value	Details
Clay	0.05-0.15	Resistant to detachment
Sandy	0.05-0.02	Low runoff but easily detached
Silt Loam	0.25-0.4	Moderate runoff, moderate detachment
High Silt	>0.4	Easily detached, high rates of runoff

Figure 2.

L is the slope length factor which represents the effect of slope length on erosion. Slope length for the Upper Iowa sub-basin was found by calculating the mean slope length representative value, found to be 38.47 Meters.

Upper Iowa LS Factor



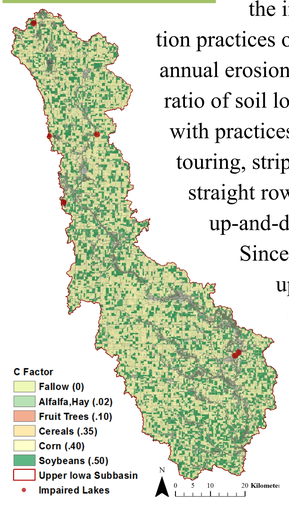
Meanwhile, the S is the slope steepness which represents the effect of the gradient of the slope on erosion. The slope for the Upper Iowa sub-basin was collected from the Iowa department of Natural Resources and then reclassified according to the average length factor [2] (Figure 2).

Slope (%)	Horizontal slope length for ~38 meters (126 ft.)
0.2	0.05
0.5	0.09
1.0	0.15
2.0	0.28
3.0	0.42
4.0	0.56
5.0	0.71
6.0	0.86
8.0	1.15
10.0	1.55
12.0	2.01
14.0	2.48
16.0	2.95
20.0	3.88
25.0	5.04
30.0	6.16
40.0	8.29
50.0	10.22
60.0	12.0

Figure 3

The C factor is the cover management factor and represents the effects of a specific crops biomass and soil cover on erosion [3] (Figure 3) .

Upper Iowa C Factor



The P factor represents the impact of conservation practices on the average annual erosion rate. It is the ratio of soil loss that occurs with practices such as contouring, strip cropping, or straight row farming on up-and-down slopes.

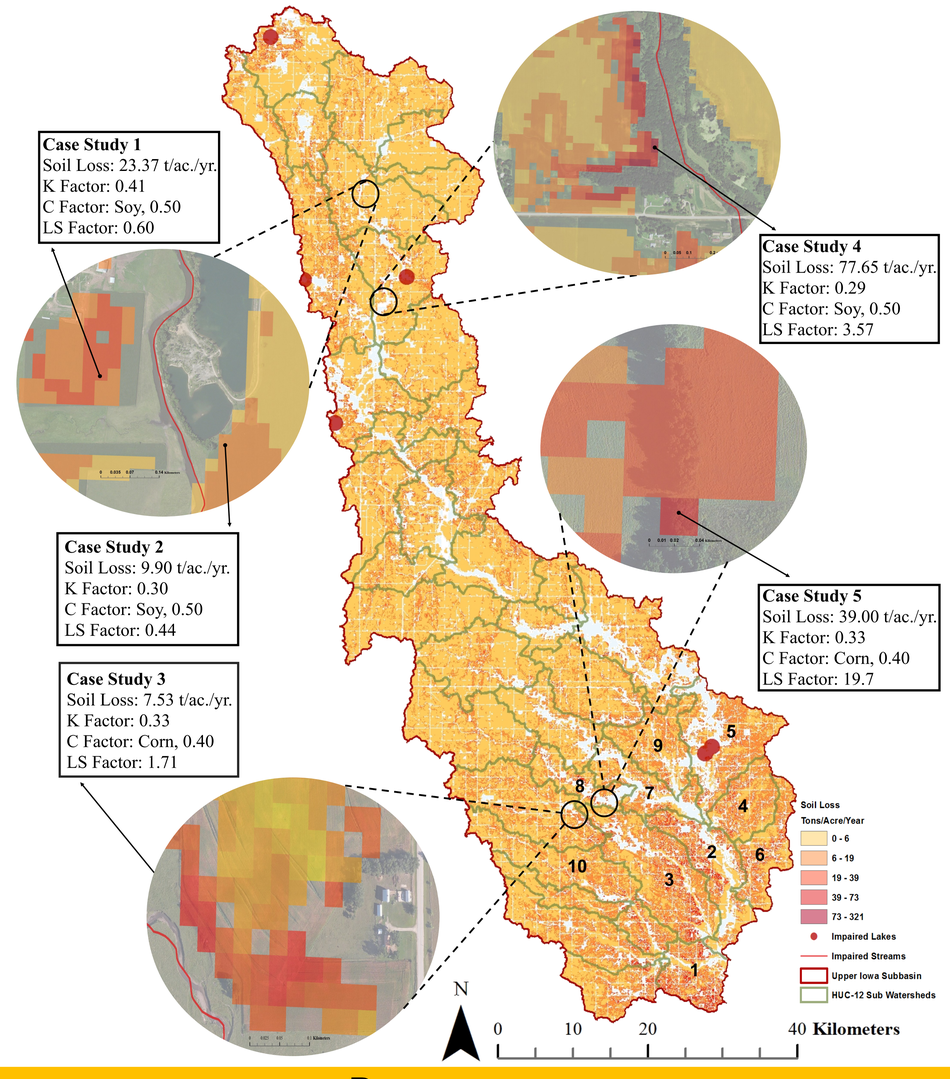
Crop Type	C Factor
Cereals (Spring and Winter)	0.35
Beans and Canola	0.50
Corn	0.40
Fruit Trees	0.10
Hay and Pasture	0.02

Figure 4.

Since the specific farming practices in the upper Iowa sub-basin were unknown a standard P Factor of 1 for up and down slopes was used [3].

Finally, each category was rasterized, reclassified, and the RUSLE equation was calculated to estimate the tons per acre per year of soil loss for each 900 m^2 cell.

RUSLE Soil Loss Estimates



Sub-basins Rated By Soil Loss

Results indicate that soil erosion in the Upper Iowa watershed is spatially variable. Analysis of the data shows that some sections of the watershed experience greater estimated soil loss than other areas. Greater estimated erosion occurs in the lower right portion of the watershed with the largest losses in Minerva Creek Sub-basin (1) (Figure 5).

Rating and RUSLE Map Identifier	Sub-basin	Area (Acres)	Mean Soil Loss (t/ac./yr.)
1	Minerva Creek	16,146	13.68
2	Dowd Creek-Iowa River	24,771	10.41
3	Honey Creek	38,304	10.38
4	Bear Creek	16,504	8.80
5	Pine Creek-Iowa River	33,652	8.78
6	Dowd Creek	17,309	8.48
7	Lower South Fork Iowa River	17,732	8.17
8	Tipton Creek	12,941	7.58
9	Beaver Creek	20,212	7.20
10	Headwaters Minerva Creek	35,246	7.12

Figure 5.

Discussion

The RUSLE soil loss model for the Upper Iowa Watershed can be used as a tool to better understand the problem of soil loss and sedimentation at the local level and target opportunities for conservation. Case studies 1-4 show varying sites throughout the Upper Iowa watershed where vulnerable soils are located near already impaired waterways. Each scenario allows stewards to target at- risk areas with conservation techniques such as grass buffers, cover crops, and reduced or no-till, among other conservation projects. It is difficult to quantify the accuracy of the RUSLE soil loss estimates because of missing data and limitations with data sources. For example, in case study 5 a cell is reported to have a high LS factor when in fact it may have been measuring the trees. It was also difficult to find specific data on practice factors used by farmers in the Upper Iowa watershed. Additionally, soils and crop data were bulky and may have over or under estimated the existence of some soil textures and crops within the watershed. The Agricultural Department says the sustainable rate of topsoil loss (T) for most of Iowa is 5 t/ac./yr. while the actual average annual soil erosion for the whole state of Iowa predicted using RUSLE is 5.2 t/ac./yr. However, the RUSLE Upper Iowa Watershed model estimates certain areas experience erosion losses much greater than T soil loss values and expected soil renewal rates. This justifies further research into soil erosion and greater conservation efforts.

Sources

Claire Loudis
Friedman School of Nutrition Science and Policy, Tufts University
Fundamentals of GIS for Food Agriculture and Environmental Applications. Spring 2017

Projection: Universal Transverse Mercator Zone 15N
1) Evaluation of the Relationship between the RUSLE R-factor and Mean Annual Precipitation, 2011, Kurt Cooper, Colorado State, accessed May 1st, 2017
2) RUSLE on-line soil erosion assessment tool, 2002, Published by Institute of Water Research, Michigan State University, accessed May 1st, 2017
3) Universal Soil Loss Equation, 2016, Published by Ontario Ministry of Agriculture, Food, and Rural Affairs, accessed May 1st, 2017
4) SSURGO, 2014, Published by ESRI, accessed May 1st, 2017
Projection: Universal Transverse Mercator Zone 15N
5) Cropland Data Layer,2016, Published by USDA, NASS, accessed May 1st, 2017
6) Iowa Department of Natural Resources, 2004, Published by Iowa Geological Survey, DNR accessed April 4th, 2017