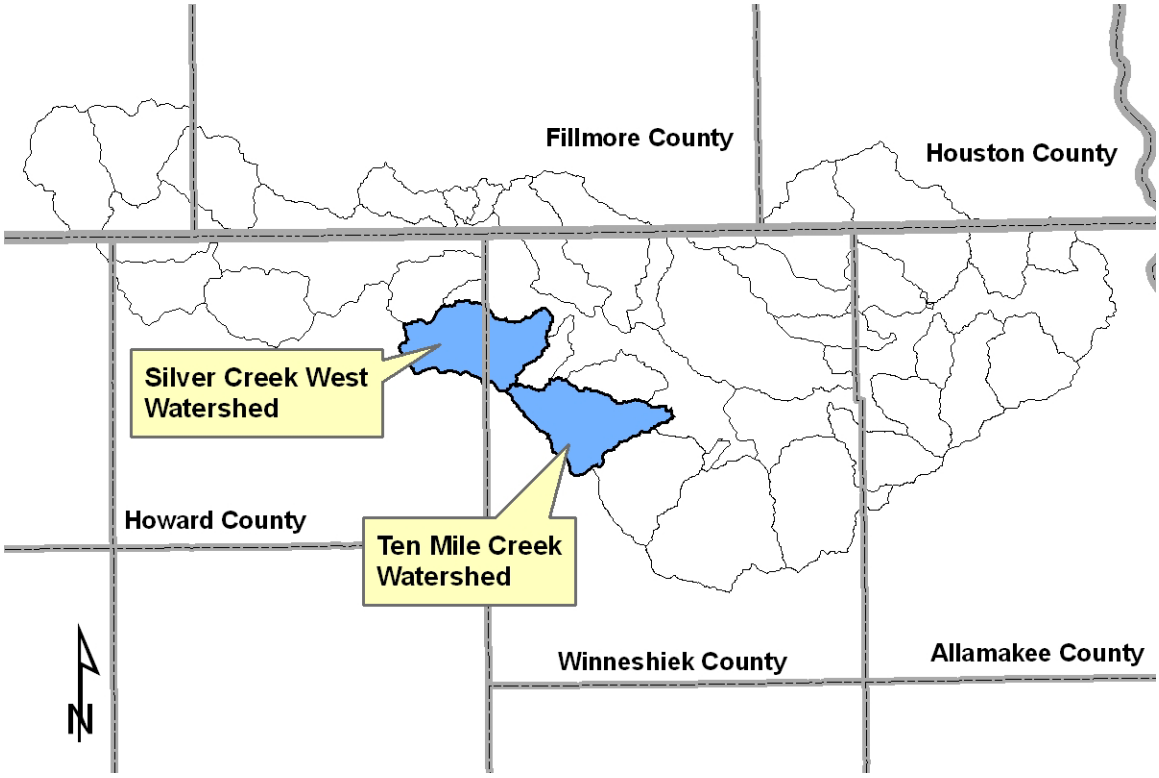
Paired Watershed Study of Ten Mile and Silver Creeks in the Upper Iowa River Watershed



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Abstract

A paired watershed study was conducted between Silver Creek West and Ten Mile Creek sub-watersheds in the Upper Iowa River Watershed to identify sources and solutions of poor water quality. Water testing results have shown noticeable differences in water quality between the two sub-watersheds, while sub-watershed size, location, and land-use appear similar. Results of this study investigate variables that may contribute to water quality in Northeast Iowa.

1 Introduction

1.1 Description

The Upper Iowa River Watershed (UIRW) Project has been able to identify the contributing factors to water pollution in some critical areas. Unfortunately there are other sub-watersheds where poor water quality is more complex. Sub-watershed problems may be easier to identify if a sub-watershed with poor water quality was compared to a sub-watershed of similar size, and land-use alteration that has better water quality. We feel this process will help us better understand failing watersheds. Several streams in the UIRW watershed; South Bear Creek, Ten Mile Creek and Trout River, all have better water quality than the streams around them. We feel the best candidates for a paired watershed study are Ten Mile Creek and Silver Creek West. Silver Creek West ranked as having some of the poorest water quality in the UIRW and has constantly high levels of all parameters measured by the UIRW Project, including ammonia, nitrate+nitrite-N, phosphorous, membrane fecal coliform bacteria, and turbidity. Ten Mile Creek is relatively low in most all parameters (Figure A). The study will take an in-depth look at stream and watershed characteristics including differences in clusters of land-use, vegetation placement, and other spatial differences that may be important to defining and understanding new critical management areas for similar watersheds.

Methods

Water quality event data was collected during the period from July 1999 to July 2004, also weekly water quality data was collected from Silver Creek West for the period of July 2002 to July 2003. These data were used to select Silver Creek West and Ten Mile Creeks for the study.

Characteristic comparisons for the paired watershed study were conducted using detailed field investigation and extensive use of geographical information system (GIS) analysis using ESRI's ARCMap v.9 software. In depth field investigations allowed for the collection of data that would otherwise be impossible to acquire. Data collected includes, livestock populations and locations, field level land-use characteristics, conservation practices, individual septic system locations, and possible pollutant point sources. Field investigations took place during the period of February to June 2004. All data collected was input into GIS databases allowing for in-depth location analysis. Data was also collected from existing data libraries; these data includes, but is not limited to, transportation infrastructure, census 2000 data, SSURGO soil data, stream order, groundwater vulnerability, sinkholes and karst feature locations, existing and historic land-cover, climate data, public and private utility locations, digital elevation models, and 2002 infrared air photography.

Once all relevant data was collected it was clipped to the extents of each sub-watershed boundary. Analysis was then conducted in ARCMap to determine differences or similarities in the two sub-watersheds.

Results

Water Sampling Comparison Analysis

Water sampling results taken from 30 locations across the Upper Iowa River Watershed revealed that Silver Creek West and Ten Mile Creek, however close in proximity, have varying water quality (Figure A). Silver Creek West has shown very high levels of all parameters in relation to other sub-watersheds in the Upper Iowa River Watershed. Analyzing the geometric means of the water sampling results reveals that Silver Creek West ranks in the top ten for all parameters measured; nitrates + nitrite-as N, total phosphate-as P, turbidity, atrazine, membrane fecal Coliform and ammonia nitrogen.

When looking at the average values for sampling results in the UIRW, Silver Creek West has a combined average ranking of 1, where as Ten Mile Creek has an average ranking of 14, with 1 being the poorest water quality and 30 being the best. Six parameters were measured and GIS analysis was preformed to identify differences in topography, land use, land cover, agriculture intensity, and other variables that may explain the varying water testing results. The following sections outline the sampling results and also touch on some possible repercussions of elevated levels.

Ammonia Nitrogen

Silver Creek West was recorded as having an ammonia nitrogen geometric mean level of .12 mg/L, Ten Mile was recorded as having a geometric mean level of .10 mg/L. Silver Creek West had a one-time sample high of 1.8 mg/L and Ten Mile Creek had a one-time high of 1.1 mg/L.

Phosphate

Phosphate levels in Silver Creek West were measured having a geometric mean of .70 mg/L; Ten Mile Creek had geometric mean level of .22 mg/L during the same period.

Turbidity

Turbidity was measured to gain insight into the amount of sediment in surface water. The effects of sedimentation on streams and rivers can be very drastic; high and sustained levels of sediment may cause permanent alterations in community structure, diversity, density, biomass, growth, and rates of reproduction and mortality (Henly 2000). Sediment input into streams and rivers may come from many sources such as roading, construction activities, and mining, but these are overshadowed by sediment input from agricultural sources (Waters 1995). Turbidity levels in Silver Creek West sampled over the course of a 3 year period during runoff events resulted in a geometric mean of 32.47 NTU and Ten Mile Creek resulted in a geometric mean of 28.56 NTU. Silver Creek West had a one-time high of 2,820 NTU, compared to a one-time high of 369 in Ten Mile Creek.

Atrazine

Atrazine is a herbicide that is primarily applied in corn cropland to control weeds. Atrazine is the most widely used herbicide in the major corn producing states, Iowa State University, Department of Ag and Biosystems Engineering reported that atrazine was applied to 68% of corn ground in the year 2000. The Department also reports that a total of 53,954,000 pounds of Atrazine was applied to corn ground in the year 2000.

Both Silver Creek West and Ten Mile Creek have high levels of atrazine in relation to other sub-watersheds in the Upper Iowa River. Silver Creek West and Ten Mile Creek rank fourth (4^{th}) and first (1^{st}) respectively, when looking at the geometric mean atrazine levels. Both watersheds have a high number of acres in corn, 27.4% or 5,542 acres of the Ten Mile Creek watershed is in corn and 29.1% or 6,521 acres of the Silver Creek West watershed is in corn. It should also be noted that soybeans account for 4,069 acres of the Ten Mile Creek watershed, and 5,725 acres in the Silver Creek West watershed. Assuming a corn and soybean rotation, the number of acres possibly receiving atrazine is significant in both watersheds. The State of Iowa Maximum Contamination Limit for atrazine is 3 ppb, both watersheds geometric mean is well below this number, however, a level of 9.2 ppb was measured in Silver Creek on May 18, 2000, and a level of 5 ppb was measured on May 15^{th}, 2001 in Ten Mile Creek.

The University of Nebraska Extension service outlines methods for reducing Atrazine loss, examples of these practices include installing terraces without outlets to retain runoff water, incorporating Atrazine after application to reduce amount on soil surface, and practicing no-till or ridge till to improve infiltration and reduce runoff.

Membrane Fecal Coliform

Of the six variables measuring water quality, the differences in membrane fecal coliform levels were the most drastic. According to the Iowa DNR membrane fecal Coliform is a type of bacteria found in the intestinal tracts of mammals, and the presence of fecal coliform bacteria in water is an indicator of pollution and possible contamination by pathogens. Fecal coliform levels are reported in colony forming

units/100 mL of sample (CFU/100mL). Fecal coliform levels in Silver Creek West were measured to have a geometric mean of 4,163 cfu/100mL, with a sample maximum of 690,000 cfu/100mL. In contrast Ten Mile Creek has a geometric mean of 790 cfu/100mL, with a sample maximum of 120,000 cfu/100mL. Geometric mean levels in Silver Creek West are over 5 times higher than those found in Ten Mile Creek.

Nitrates

Nitrate is a naturally occurring form of nitrogen. In an agricultural environment nitrates result primarily form animal waste and the use of fertilizers, but decaying plants, human waste and other organic materials are also sources of nitrates. Crops and plants use nitrates but in some instances nitrates are removed by rain water and transported into streams and rivers before plants have a chance to fully absorb the nitrates. Croplands have the greatest potential for nitrate loss due to the lack of thick density cover year-round, also cropland is the only major land cover where nitrates are applied.

Silver Creek West ranks second in geometric mean nitrate levels in the Upper Iowa River Watershed with a geometric mean of 7.74 mg/L, alternatively Ten Mile ranks 22th of 30 with a geometric mean of 4.92 mg/L. Silver Creek West had a nitrate sample maximum of 13 mg/L and Ten Mile Creek had a sample maximum of 14 mg/L. The State of Iowa maximum contamination limit (MCL) for nitrates is 10 mg/L.

Watershed Comparison Analysis

(See figure **B** for summary of results)

Watershed Size

The sizes of the Silver Creek West and Ten Mile Creek watersheds are 35 (22,410 acres) and 31.6 (20,229 acres) square miles respectively. The Silver Creek West watershed is approximately 5.5 miles north to south and 10 miles west to east. The Ten Mile Creek watershed is approximately 6 miles north to south and is also 10 miles west to east.

Elevation & Topography

The Silver Creek West and Ten Mile Creek watersheds, however close in proximity, have differing elevation and topography characteristics. The lower portions of the Ten Mile Creek watershed lie in the Paleozoic Plateau, which is characterized by having steep slopes and bluffs, higher relief, sedimentary rock outcrops, dense forests, and unique boreal microhabitats (Iowa DNR). The majority of the Silver Creek West watershed lies in the Iowan Surface which is dominated by thin glacial deposits, shallow limestone bedrock, and karst features such as sinkholes and sags (Iowa DNR).

GIS analyses of digital elevation models reveal that the Silver Creek West watershed has a much gentler mean slope of 3.92% as compared to 5.85% in the Ten Mile Creek watershed (Map 4). Also, the slope range in the Ten Mile Creek watershed is greater, 82.8% verses 59.3% in the Silver Creek West watershed. Analysis of soil surveys show that the Ten Mile Creek watershed has 5,146 acres of land with a “D” slope or greater, 2,744 acres more than the Silver Creek West watershed.

Steep slopes in the Paleozoic Plateau are a very sensitive area and conservation needs to be practiced in order to keep soil loss to a minimum. Both watersheds show that 32% of steep slopes are used as crop acres. It should again be noted that the Ten Mile Creek watershed has a greater number of acres of “D”

slopes or greater yet no differences in sediment load (turbidity) were noted during rain events, which may be a result of greater acres of riparian buffers or increased conservation practices on steep slopes.

Land Cover & Land Use

Land cover differences in the two watersheds are very notable and may play a crucial role in determining water quality in the two streams. Row cropland in the Silver Creek West watershed accounts for nearly 55% (12,302 acres) of the watershed, in contrast just over 47% (9,648 acres) of the Ten Mile creek watershed is in row crops, according to analysis done using 2002 Land Cover data (Figure C and Map 1). In addition, areas of the watershed that would impede soil loss and nutrient transport also differ, the Silver Creek West watershed is 39% timber or grass lands, and the Ten Mile Creek watershed is nearly 49% timber or grass lands, this ten percent equates to a difference of 1,122 acres. Studies of undisturbed forest lands in southwestern Wisconsin have shown that relatively little overland flow occurs, even from relatively large storms, also prairie vegetation in good condition is nearly as effective as forest vegetation in reducing surface runoff (Knox 1987). Based on the land cover analysis and forest/prairie runoff studies, differences in the amount of forest and grassland cover in the two watersheds may play a vital role in determining water quality in the two streams.

Conservation Practices

Enrollment numbers in the Conservation Reserve Program may give an indication into landowner interest in water quality. CRP lands in Silver Creek West out number CRP lands in Ten Mile Creek by just over 3:2. In Silver Creek West there are approximately 3,211 acres enrolled in CRP, in Ten Mile Creek there are 2,200 acres. An effort to identify spatial distribution was not undertaken, the distribution of CRP lands may play a role in determining water quality in the two watersheds.

Native Vegetation

Native vegetation in the two watersheds differs greatly; the Silver Creek West watershed was mostly prairie, 68.5% of its land; where as the Ten Mile Creek watershed was mostly transition lands between forest and prairie, 52.2% (Figure D and Map 6).

Riparian Areas

Current land cover data was analyzed to identify differences in riparian zone vegetation which could indicate possible sources of higher turbidity, and nutrient levels in Silver Creek West. A 500 foot buffer was established along all stream reaches in the two study watersheds and land cover data was analyzed using GIS. Results of the analysis reveal that riparian areas in Silver Creek West are being used for row crops at a greater percentage than areas in Ten Mile Creek (Figure E). 44.5% of riparian areas in Silver Creek are in row crops; in contrast 34.5% of riparian areas in Ten Mile are used for row crops. This 10% difference equates to over 575 acres in these critical riparian areas. Schlosser and Karr report that levels of suspend sediment and nutrients increase quickly during storm events when riparian vegetation is absent (Schlosser and Karr 1981). Studies have also shown that areas with riparian buffer strips had higher species richness, diversity, total density, and index of biotic integrity (IBI) of fish (Whitworth and Martin, 1990). It is important, therefore, to emphasize the importance of utilizing buffer strips along streams and rivers to reduce sediment load and nutrient transport.

Soil Loss & Soil Characteristics

RUSLE soils loss estimates, assuming no conservation practices, indicate that the Ten Mile Creek watershed has an average annual soil loss of 9.35 tons per acre; the Silver Creek West watershed is shown to have an average of 5.50 tons per acre per year (Map 3). Actual soil loss may differ if conservation practices are in place in the two watersheds. Experts believe that the most effective means to reduce sediment load are to implement conservation practices such as riparian buffer strips (Henley 2000).

Soil types in the two watersheds also vary, the majority soil type in the Ten Mile Creek watershed is Fayette soils, in the Silver Creek West watershed the majority soil is Rockton. Fayette soils consist of deep, well drained, moderately permeable soils formed in loess on uplands and high stream benches. Slope ranges from 0 to 40 percent. The Rockton soil series consist of moderately deep, well drained soils that formed in a mantle of loamy sediments and underlying clayey residuum from limestone over limestone bedrock. These soils are typically on glaciated uplands but in some areas are on terraces and lake plains. They have moderate permeability. Their slopes range from 0 to 25 percent. (USDA-NRCS Official Soil Series Descriptions)

Highly Erodible Lands

The Ten Mile Creek watershed, as mentioned earlier, is encroaching on the stepper areas of the Paleozoic plateau, has a much higher percentage and acreage of Highly Erodible Lands (HEL) than does the Silver Creek West watershed (Figure F and Map 5). When talking to landowners in the Ten Mile Creek watershed, some believe that the increased number of HEL acres in the Ten Mile Creek watershed forces farmers to practice greater conservation measures such as strip cropping and no-till. Some say that farmers that have very low number of HEL acres, or none at all may be less inclined to practice no-till or other conservation practices. This belief may explain the fact that the Ten Mile Creek watershed has a greater number of HEL acres but has measured improved water quality versus the Silver Creek West watershed.

Karst

Differences in karstification in the two study watersheds may have an impact on surface water quality but may also impact ground water quality not only in the watershed but neighboring areas may also be impacted. GIS analysis of sinkhole data reveals there are 79 sinkholes in the Silver Creek West watershed and only 9 in the Ten Mile Creek watershed. Field investigations also reveled that Silver Creek West has many loosing stream segments; at least seven have been identified to date. No disappearing stream segments have been identified in Ten Mile Creek Watershed, but in-depth field investigation may reveal locations not first identified. Karst features can permit water and pollutants to flow rapidly through complex underground drainage systems and caves into wells and streams (MPCA). Karst features are very critical areas and impacts from mismanagement can be detrimental to surface and ground waters. Protecting these sensitive areas from surface pollutants should be of highest concern. The combination of high pollutants in surface water and the presence of loosing stream segments in the Silver Creek West watershed may have damaging impacts on water quality, and could adversely affect drinking water coming from shallow wells in the area.

Human Impacts

Noticeable differences in population between the Silver Creek West watershed and the Ten Mile Creek watershed could have an impact on water quality in these two streams. The Silver Creek West watershed has a population of 3,272, of that, ~2,754 live in the City of Cresco (Map 7). Adversely, the Ten Mile Creek watershed has a total population of 535, of that, ~190 live in Ridgeway. The wastewater treatment plants for Ridgeway and Cresco are located in the two watersheds. Cresco uses an activated sludge treatment method and discharges into a tributary of Silver Creek. Ridgeway uses a waste stabilization lagoon and discharges into Walnut Creek, a tributary of Ten Mile Creek.

Rural populations in the two watersheds may also impact water quality by way of malfunctioning septic systems and drain fields. The Howard County Sanitarian estimates 80-90% of individual septic systems are outdated or not properly functioning. The Silver Creek West watershed has an estimated 165 rural housing units verse 142 rural housing units in Ten Mile Creek Watershed, based on census numbers and field investigations.

Livestock Production

Field surveys and visits with livestock producers allowed for the compilation of livestock numbers, densities, and distribution. It was found that the Ten Mile Creek watershed has 2,978 animal units and the Silver Creek West watershed has 2,448 animal units (Map 2). Calculated on a square mile basis, the Tem Mile Creek watershed has 94.2 animal units per square mile and the Silver Creek West watershed has 69.9 animal units per square mile. These numbers do not reflect on the increased e. coli levels in Silver Creek West, which suggests that spatial distribution, manure management, or other factors must be influencing e. coli levels, not shear numbers of livestock.

A spatial distribution of livestock from the mouth of the stream was conducted and reveled that the Ten Mile Creek watershed has very low numbers of livestock near the mouth of the stream; in fact, significant livestock numbers do not appear until 4 plus miles from the mouth (Figure G). In contrast, the Silver Creek West watershed has a much higher concentration of livestock near the mouth; Silver Creek West has 13 times as many animal units near the mouth as does Ten Mile Creek.

A spatial distribution of livestock near streams was also conducted; this analysis revealed that Ten Mile has greater numbers of animal units near flowing water than does Silver Creek West (Figure H). Ten Mile has 370 animal units within 1/16 of a mile of a stream, and Silver Creek has 52 animal units within that same distance.

When assigning locations of livestock, points were placed in a GIS shapefile based upon the locations of feedlots or farmsteads were livestock would spend the majority of the year. If no farmstead was near a group of livestock a point was assigned near the concentration of livestock at the time of the survey. Due to the seasonally transient nature of livestock, locations may not reflect the area of greatest impact. The survey does, however, give a good indication of livestock populations in the two watersheds.

Flow Modeling

Topography, land cover, and rainfall data was analyzed using TOPMODEL with the goal of predicting an accurate flow values for streams feeding into the Upper Iowa River. Analysis was conducted by Professor

Richard Bernatz at Luther College, in Decorah Iowa. The analysis found that during the same period, June 1-30, 2003, flow rates in Ten Mile Creek peaked at 24 cubic feet per second (cfs), in Silver Creek West the flow peaked at around 33 cfs. (Figure I)

Discussion & Conclusions

Land Use Practices Impact Soil Loss

Based on elevation and topography analysis it would appear that the Ten Mile Creek watershed could be very susceptible to soil erosion and sediment loss, but beneficial land cover in critical areas may be preventing sediment loss and soil erosion. The greater number of cropland acres and gentler slopes in the Silver Creek West watershed may act to prevent conservation practices such as no-till, and promote practices such as moldboard plowing, that result in increased soil loss (Al-Kaisi 2002). Combined with fewer acres of protective vegetation in riparian areas, this study concludes that the Silver Creek West watershed is more susceptible to soil loss. Greater percentages of stabilizing land uses, such as forest and grass, in the Ten Mile Creek watershed support this conclusion. Solutions for the Silver Creek West watershed include emphasizing the importance of conservation tillage and riparian buffers to stabilize the soil.

Land Use Practices and Riparian Area Vegetation Impact Nutrient Transport

Analysis of land use practices, riparian area vegetation, and water quality data found that increases in nutrient loads in Silver Creek West may be tied to increased cropland acres and a decreased amount of riparian buffers in the Silver Creek West watershed as compared to the Ten Mile Creek watershed. Other sources of increased nutrient loads in Silver Creek West may be coming from livestock numbers in close proximity to streams and malfunctioning septic systems and wastewater treatment plants. This study concludes that an increased importance be placed on improving riparian buffers and the exclusion of livestock near streams. This study also recommends an increased importance be placed on promoting conservation tillage in the Silver Creek West watershed, gentler slopes and more cropland acres are promoting practices that may be detrimental to soil and nutrient retention.

Livestock Distribution Impacts Fecal Coliform

Livestock surveys and human impact studies have helped to identify sources and solutions to elevated fecal coliform levels in the Silver Creek watershed. This study found that total number of animal units may not play as much of a role in determining fecal coliform levels in surface waters as does spatial distribution and management practices. This study concludes that streamside exclusion of livestock, especially near the mouth of the stream could have a beneficial impact on fecal coliform levels in the Silver Creek watershed. It is not known how much of an impact wastewater treatment plants have on fecal coliform levels, but discharge from the Cresco wastewater treatment plant and malfunctioning private septic systems also may have an impact. It is also important to emphasize the importance of proper manure management to prevent runoff during rain events.

Karst Features make Improving Water Quality in Silver Creek West Imperative

The great number of karst features, specifically sink holes and loosing stream segments in the Silver Creek West watershed make water quality improvements crucial. Conservation practices and water quality improvements go hand-in-hand. Conservation practices suggested previously may act to improve surface water but may also act to improve ground water resources in the area.

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Figure A

Water Sampling Results

Results are based on 10+ water samples taken from 7-99 to 7-04.

Ranking of watershed among 30 sub watersheds in Upper Iowa River Watershed appears in parenthesis. (1) indicates highest rank and (30) indicates lowest rank.

Average Comparison

	Silver Creek West	Ten Mile	All UIR Watershed Average
Turbidity-NTU	295.58 (4)	103.51 (14)	132.04
Atrazine-ppb	1.27 (15)	0.89 (21)	1.37
MembraneFecal Coliform-per 100mL	68,428 (2)	20,397 (15)	29592.24
Nitrate + Nitrite-as N (mg/L)	7.74 (11)	4.92 (21)	5.86
Ammonia Nitrogen-as N (mg/L)	0.24 (6)	0.10 (18)	0.25
Total Phosphate-as P (mg/L)	1.09 (2)	0.41 (12)	0.40

Geometric Mean Comparison

	Silver Creek West	Ten Mile	All UIR Watershed Geometric Mean
Turbidity-NTU	32.47 (6)	28.56 (10)	19.20
Atrazine-ppb	0.38 (4)	0.47 (1)	0.22
MembraneFecal Coliform-per 100mL	4163 (2)	790 (18)	611.20
Nitrate + Nitrite-as N (mg/L)	7.74 (7)	4.92 (22)	4.21
Ammonia Nitrogen-as N (mg/L)	0.12 (9)	0.10 (23)	0.11
Total Phosphate-as P (mg/L)	0.70(2)	0.22 (11)	0.18

Summary of Results

	Ten Mile Creek Watershed	Silver Creek West Watershed
Water Quality Ranking (1 being the poorest)	**14** out of 30	**1** out of 30
Watershed Size		
Size (sq miles)	31.6	35
Size (acres)	20,229	22,410
Elevation & Topography		
Slope Mean	5.85%	3.92%
Minimum Elevation (feet)	895	1,017
Maximum Elevation (feet)	1,311	1,315
Elevation Range (feet)	416	298
Elevation Mean (feet)	1,177	1,227
Acres of Land with "D" slope or greater	5,146	2,402
Percentage of watershed with "D" slope or greater	25.4%	10.7%
Land Cover		
Majority Land Cover (2002)	Corn (27.5%)	Corn (29.2%)
Forest- Native Vegetation	2,952 acres or 15%	504 acres or 2.2%
Prarie - Native Vegetation	6,416 acres or 32.7%	15,247 acres or 68.5%
Transition- Native Vegetation	10,260 acres or 52.2%	6,505 acres or 29.2%
Riparian Area Land Cover		
Grass	43.4% or 2056 acres	42.3% or 2,094 acres
Row Crop	34.7% or 1,646 acres	44.8% or 2,222 acres
Timber	19.4% or 919 acres	9.5% or 470 acres
Soil & Soil Loss		
Soils:		
Majority of Land Area	Fayette- 11.4%	Rockton- 9.8%
2nd	Racine- 11.3%	Bassett- 7.7%
3rd	Downs- 11.3%	Marlean- 7.3%
RUSLE Soil Loss Estimate for Watershed (tons/acre/yr)	9.35	5.50
Mean Organic Matter in the Soil (%)	2.90%	3.20%
% Watershed with Forest Formed Soils	15.00%	2.20%
% Watershed with Transitional Formed Soils	52.20%	29.20%
% Watershed with Prairie Formed Soils	32.70%	68.50%
Highly Erodible Lands		

Summary of Results

	Ten Mile Creek Watershed	Silver Creek West Watershed
Highly Erodible Lands (acres)	10,974	5,453
Percentage of watershed with HEL	54.2%	24.3%
Majority Land cover on HEL	Corn	Corn
Karst		
Sinkholes	9	79
Human Impacts		
Population (2000)	535	3,272
Population outsite Incroporated Places	345	518
Population inside Incorportated Palces	190	2,754
Housing Units (2000)	230	1,441
Housing Units outside Incorporated Places	134	186
Housing Units inside Incorported Places	96	1,255
Septic Systems	142	165
Livestock Impacts		
Animal Units	2,978	2,448
Animal Units/Sq Mile	94.2	69.9
Cattle Animal Units	2,542	2,135
Swine Animal Units	306	90
Other Animal Units	130	223
Streams & Wetlands		
Stream Segment Length - all orders (Miles)	40.6	41.8
1st Order Segment Length Total (miles)	21.3	23.1
2nd Order Segment Length Total (miles)	14.8	12.8
3rd Order Segment Length Total (miles)	4.4	5.9
BCW (Coldwater) Stream Length (miles)	10.6	0
BLR (Limited Resource) Stream Length (miles)	0	13.3
Wetland Acres (NWI)	296.37	220.07
CRP Acres		
Acres	2200.5	3211.9
Percentage of Watershed	10.87%	14.30%

Figure C

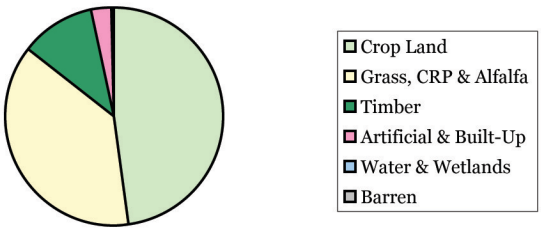
Land Cover Analysis

Source: GIS Analysis of 2002 15m Land Cover of the State of Iowa

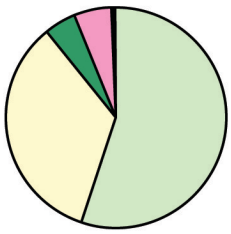
Generalized Land Cover

	Ten Mile Creek		Silver Creek West	
	Acres	**% of Watershed**	**Acres**	**% of Watershed**
Crop Land	9648.79	47.70%	12302.95	54.91%
Grass, CRP & Alfalfa	7680.35	37.97%	7646.72	34.13%
Timber	2203.55	10.89%	1114.41	4.97%
Artificial & Built-Up	644.51	3.19%	1210.04	5.40%
Water & Wetlands	42.22	0.21%	66.91	0.30%
Barren	6.56	0.03%	66.49	0.30%

Ten Mile Land Cover



Silver Creek West Land Cover



Detailed Land Cover

	Ten Mile Creek		Silver Creek West	
	Acres	% of Watershed	Acres	% of Watershed
Alfalfa	2531.93	12.52%	1191.36	5.32%
Barren	6.56	0.03%	66.49	0.30%
Bottomland forest	0.17	0.00%	0.61	0.00%
Commercial industrial	91.48	0.45%	190.96	0.85%
Coniferous forest	109.94	0.54%	138.35	0.62%
Corn	5558.54	27.48%	6552.00	29.24%
CRP grassland	979.92	4.84%	2148.88	9.59%
Deciduous forest	2093.44	10.35%	975.45	4.35%
Grazed grassland	1675.35	8.28%	1439.06	6.42%
Other Rowcrop	20.36	0.10%	25.52	0.11%
Residential	93.60	0.46%	386.91	1.73%
Roads	459.43	2.27%	632.17	2.82%
Soybeans	4069.89	20.12%	5725.43	25.55%
Ungrazed grassland	2493.15	12.33%	2867.41	12.80%
Water	9.53	0.05%	2.85	0.01%
Wetland	32.69	0.16%	64.07	0.29%

Figure D

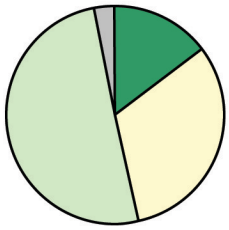
Native Vegetation Comparison

Source: GIS Analysis of 2002 15m Land Cover of the State of Iowa

Generalized Historic Vegetation

	Ten Mile Creek		Silver Creek West	
	Acres	**% of Watershed**	**Acres**	**% of Watershed**
Forest	2952	14.6%	504	2.2%
Prairie	6416	31.7%	15247	68.0%
Transition	10260	50.7%	6505	29.0%
Unknown	601	3.0%	154	0.7%

Ten Mile Historic Vegetation



Silver Creek Historic Vegetation

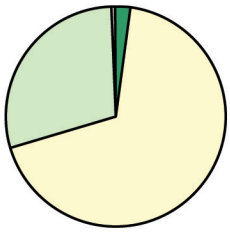


Figure E

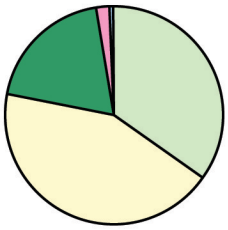
Land Cover Analysis of Riparian Areas

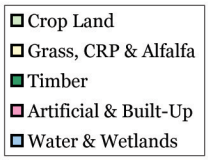
Source: GIS Analysis of 2002 15m Land Cover of the State of Iowa

Generalized Land Cover

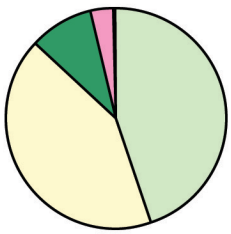
	Ten Mile Creek		Silver Creek West	
	Acres	% of Watershed	Acres	% of Watershed
Crop Land	1646.25	34.72%	2222.14	44.79%
Grass, CRP & Alfalfa	2056.98	43.38%	2094.44	42.21%
Timber	919.36	19.39%	470.93	9.49%
Artificial & Built-Up	98.05	2.07%	159.76	3.22%
Water & Wetlands	21.51	0.45%	14.47	0.29%

Ten Mile Land Cover





Silver Creek West Land Cover



Detailed Land Cover

	Ten Mile Creek		Silver Creek West	
	Acres	% of Watershed	Acres	% of Watershed
Alfalfa	728.94	15.37%	321.56	6.48%
Bottomland forest	0.17	0.00%	0.59	0.01%
Commercial industrial	10.19	0.21%	11.97	0.24%
Coniferous forest	88.08	1.86%	25.29	0.51%
Corn	859.09	18.12%	1102.72	22.22%
CRP grassland	203.53	4.29%	410.13	8.27%
Deciduous forest	831.11	17.53%	445.04	8.97%
Grazed grassland	452.35	9.54%	542.20	10.93%
Other rowcrop	1.72	0.04%	5.21	0.11%
Residential	18.79	0.40%	59.93	1.21%
Roads	69.07	1.46%	87.86	1.77%
Soybeans	785.43	16.56%	1114.20	22.46%
Ungrazed grassland	672.16	14.17%	820.55	16.54%
Water	5.29	0.11%	1.39	0.03%
Wetland	16.22	0.34%	13.08	0.26%

Figure F

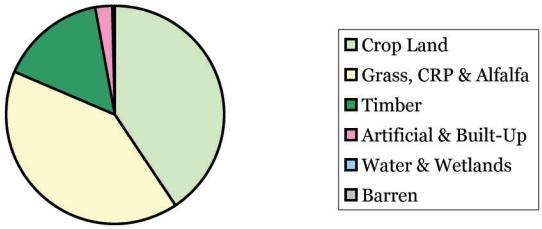
Land Cover Analysis of Highly Erodible Lands

Source: GIS Analysis of 2002 15m Land Cover of the State of Iowa

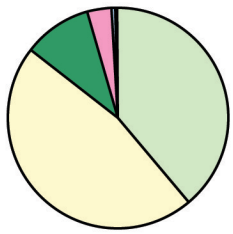
Generalized Land Cover

	Ten Mile Creek		Silver Creek West	
	Acres	**% of HEL**	**Acres**	**% of HEL**
Crop Land	4443.03	40.51%	2127.34	39.03%
Grass, CRP & Alfalfa	4480.87	40.86%	2529.72	46.41%
Timber	1740.57	15.87%	551.14	10.11%
Artificial & Built-Up	285.62	2.60%	203.41	3.73%
Water & Wetlands	17.03	0.16%	21.96	0.40%
Barren	0.61	0.01%	18.03	0.33%

Ten Mile HEL Land Cover



Silver Creek HEL Land Cover



Detailed Land Cover

	Ten Mile Creek		Silver Creek West	
	Acres	% of HEL	Acres	% of HEL
Alfalfa	1457.46	13.3%	409.37	7.5%
Barren	0.61	0.0%	18.03	0.3%
Bottomland forest	0.17	0.0%	0.55	0.0%
Commercial industrial	32.25	0.3%	17.08	0.3%
Coniferous forest	76.23	0.7%	74.84	1.4%
Corn	2651.63	24.2%	1245.76	22.9%
CRP grassland	734.27	6.7%	856.85	15.7%
Deciduous forest	1664.17	15.2%	475.75	8.7%
Grazed grassland	1061.74	9.7%	490.88	9.0%
Other rowcrop	8.00	0.1%	10.61	0.2%
Residential	50.52	0.5%	58.91	1.1%
Roads	202.84	1.8%	127.42	2.3%
Soybeans	1783.40	16.3%	870.98	16.0%
Ungrazed grassland	1227.39	11.2%	772.62	14.2%
Water	1.33	0.0%	0.00	0.0%
Wetland	15.70	0.1%	21.96	0.4%

Figure G

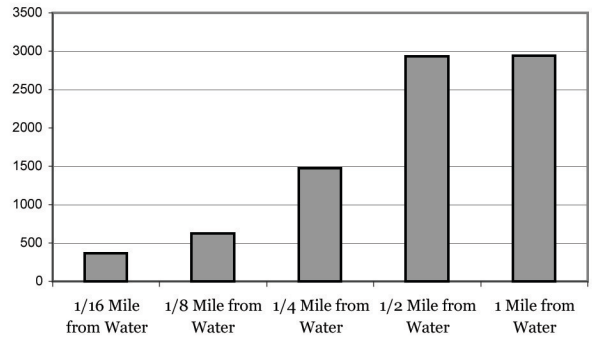
Livestock Spatial Distribution

Source: Livestock Survey, Spring 2004

Livestock Distribution from Flowing Water

	Ten Mile Creek Animal Units	Silver Creek West Animal Units
1/16 Mile from Water	370	52
1/8 Mile from Water	626	675
1/4 Mile from Water	1476	891
1/2 Mile from Water	2930	2261
1 Mile from Water	2945	2448

Ten Mile Distribution



Silver Creek West Distribution

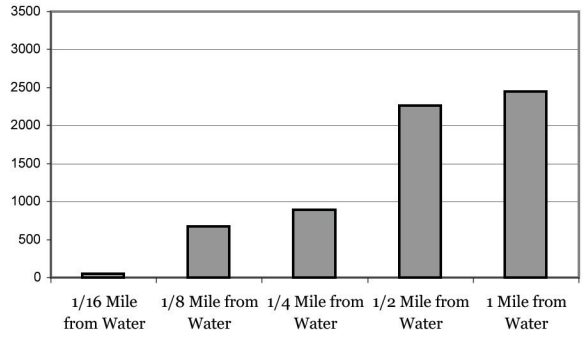


Figure H

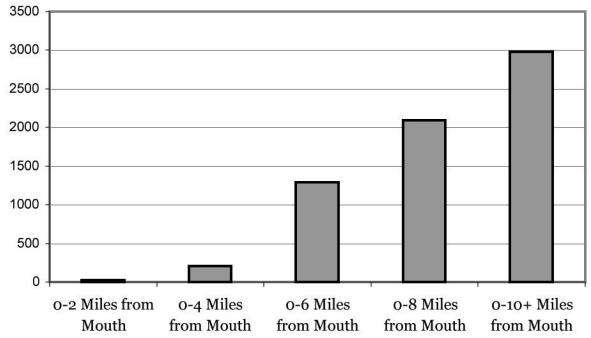
Livestock Spatial Distribution

Source: Livestock Survey, Spring 2004

Livestock Distribution from Mouth of Stream

	Ten Mile Creek Animal Units	Silver Creek West Animal Units
0-2 Miles from Mouth	27	362
0-4 Miles from Mouth	203	725
0-6 Miles from Mouth	1288	1576
0-8 Miles from Mouth	2096	2179
0-10+ Miles from Mouth	2978	2448

Ten Mile Distribution



Silver Creek West Distribution

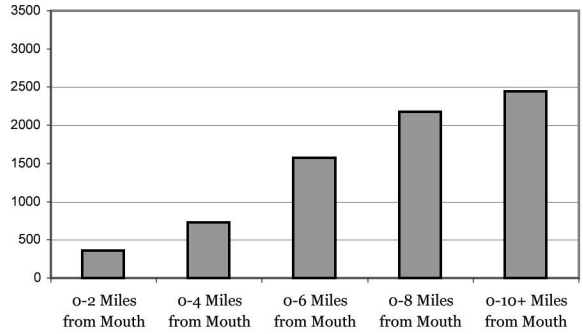
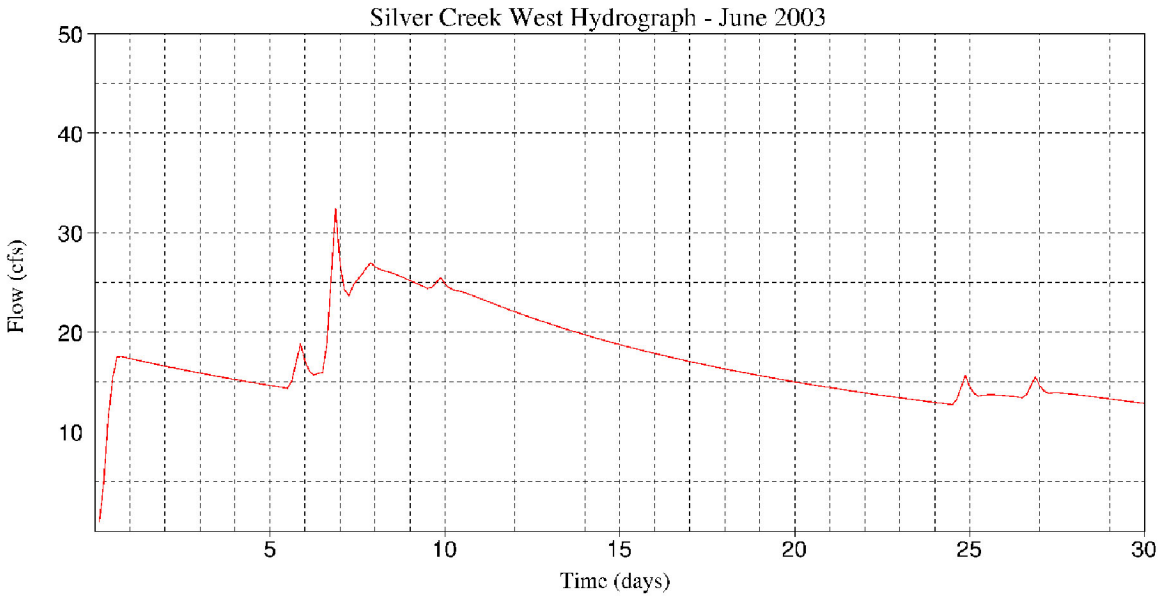
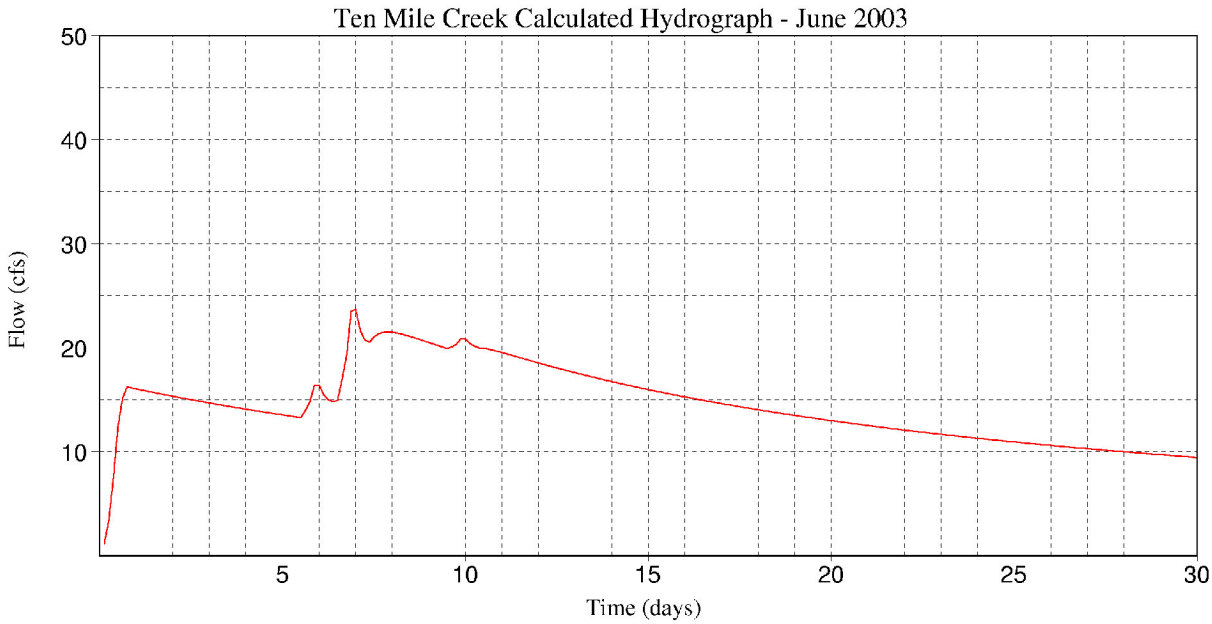


Figure I

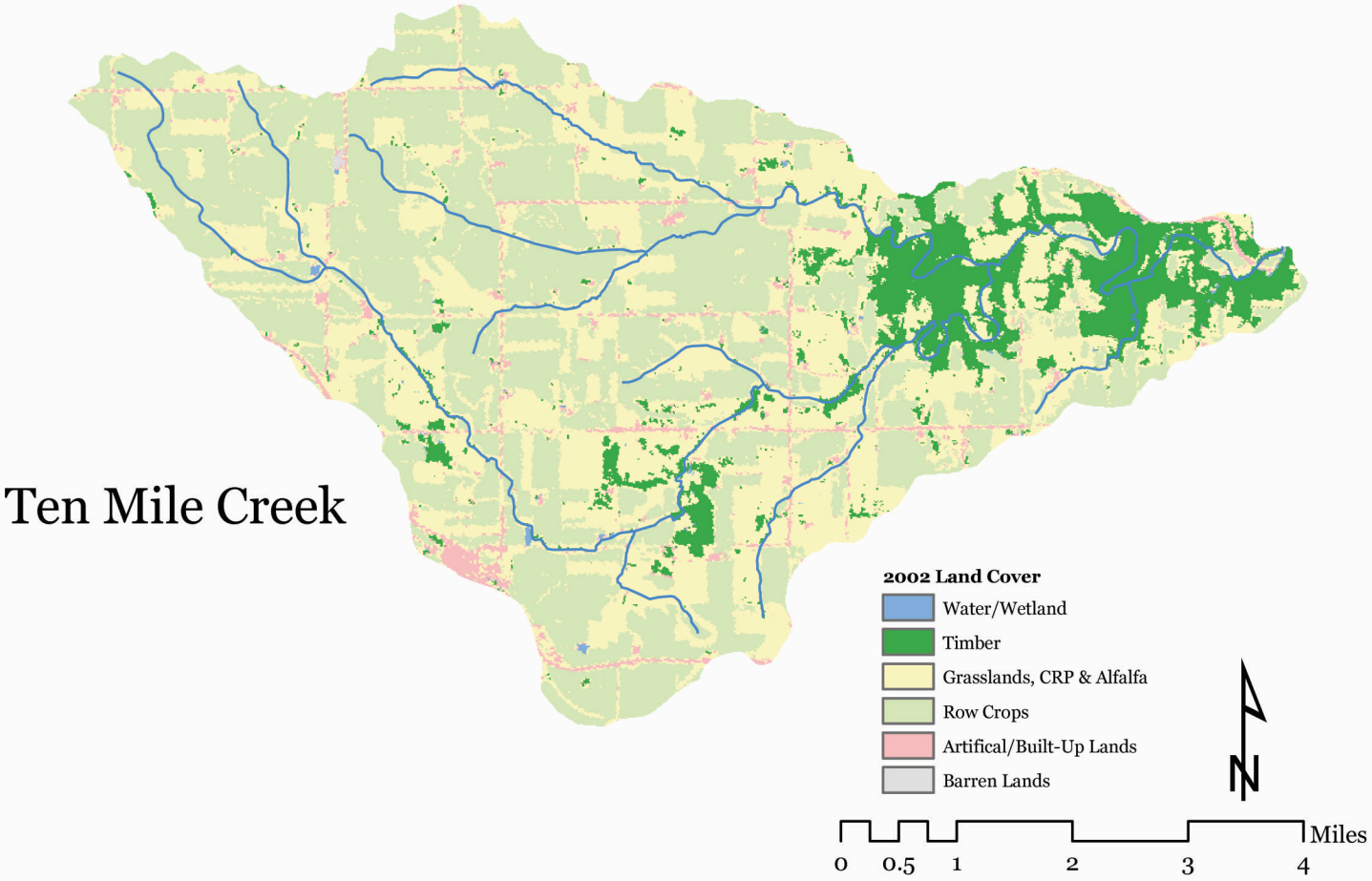
Predicted Flow using TOPMODEL

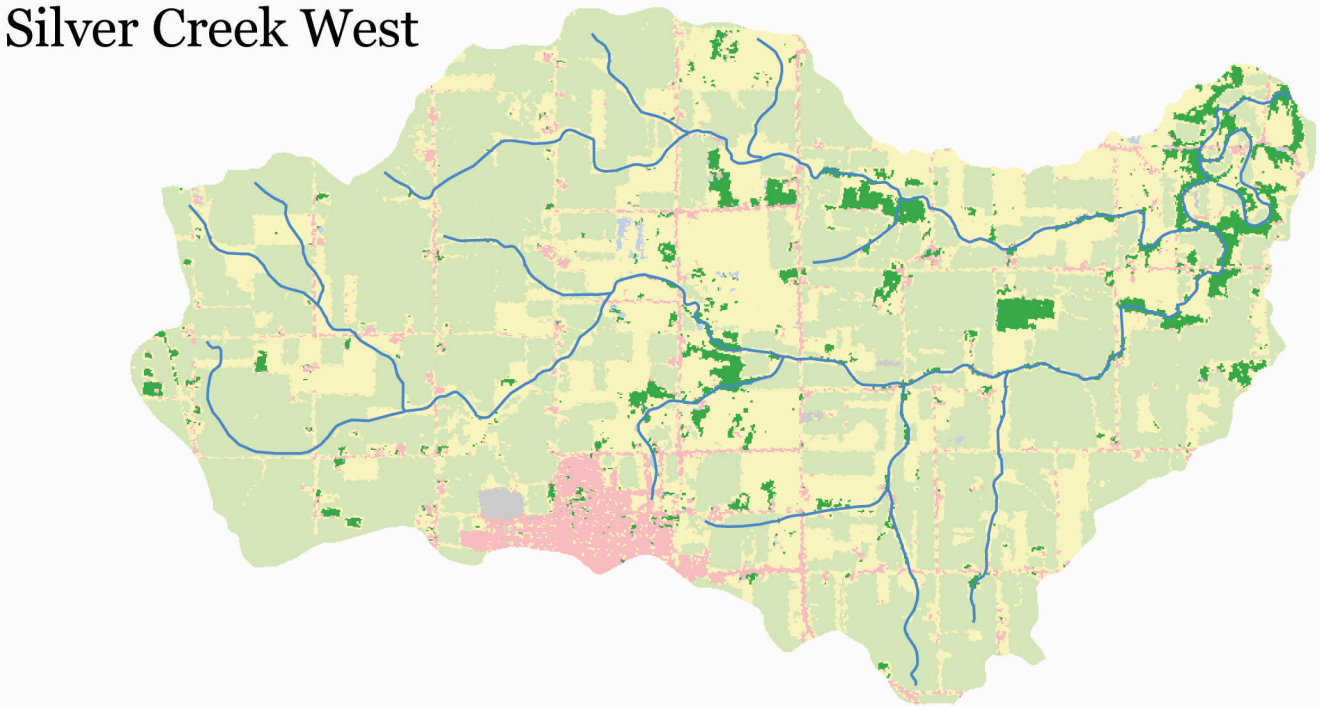




Paired Watershed Study

2002 Land Cover Comparision



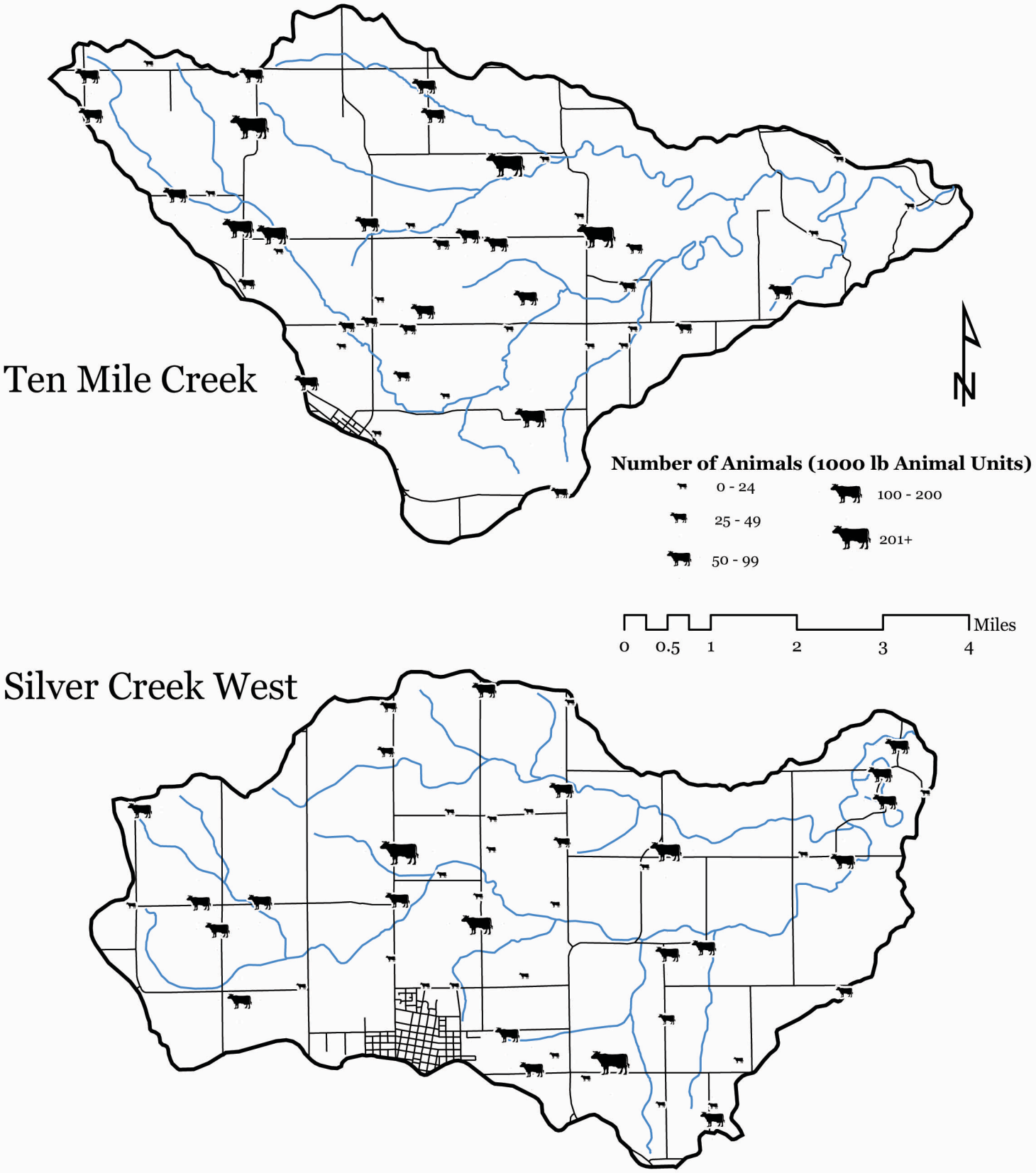


Data Source: 2002 Land Cover Grid of Iowa

Map Created by: Adam Kiel, Upper Iowa River Watershed Project

Paired Watershed Study

Livestock Distribution

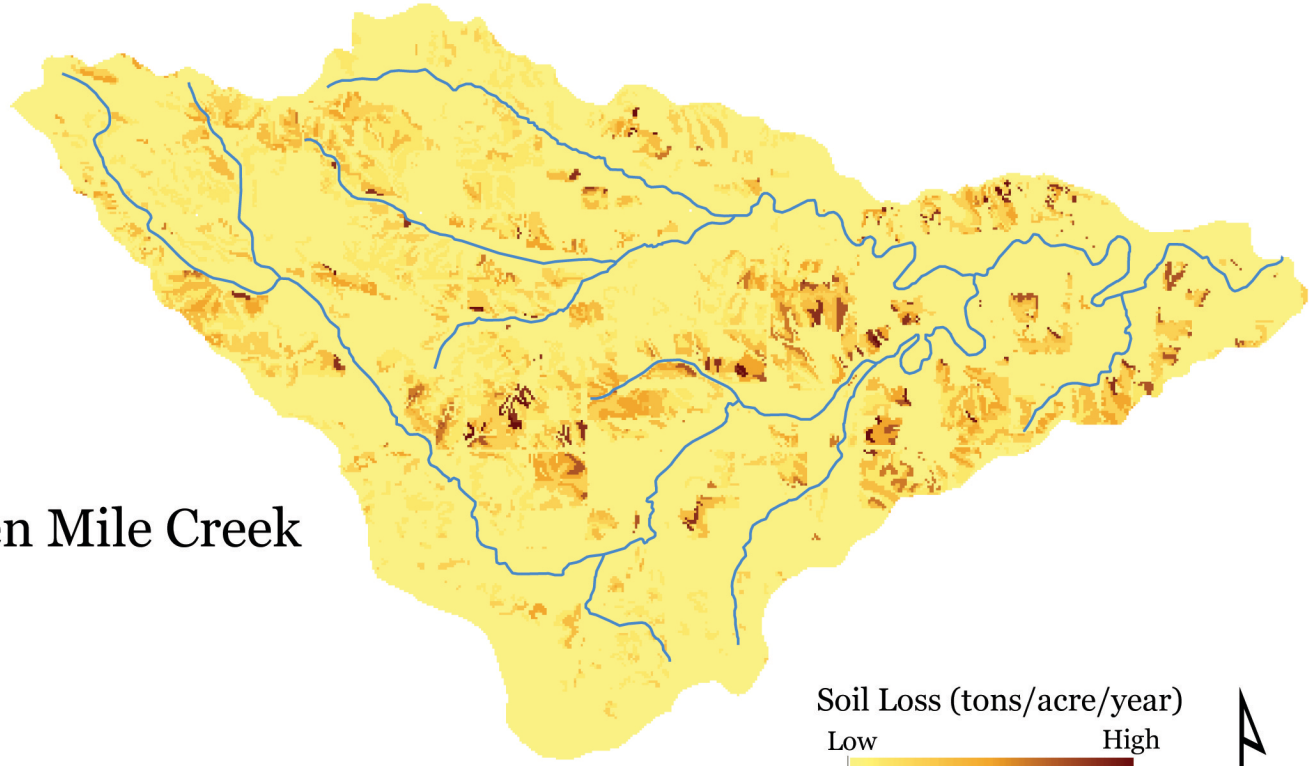


Data Source: Field Surveys, Spring 2004

Map Created by: Adam Kiel, Upper Iowa River Watershed Project

Paired Watershed Study

RUSLE Soil Loss Comparision



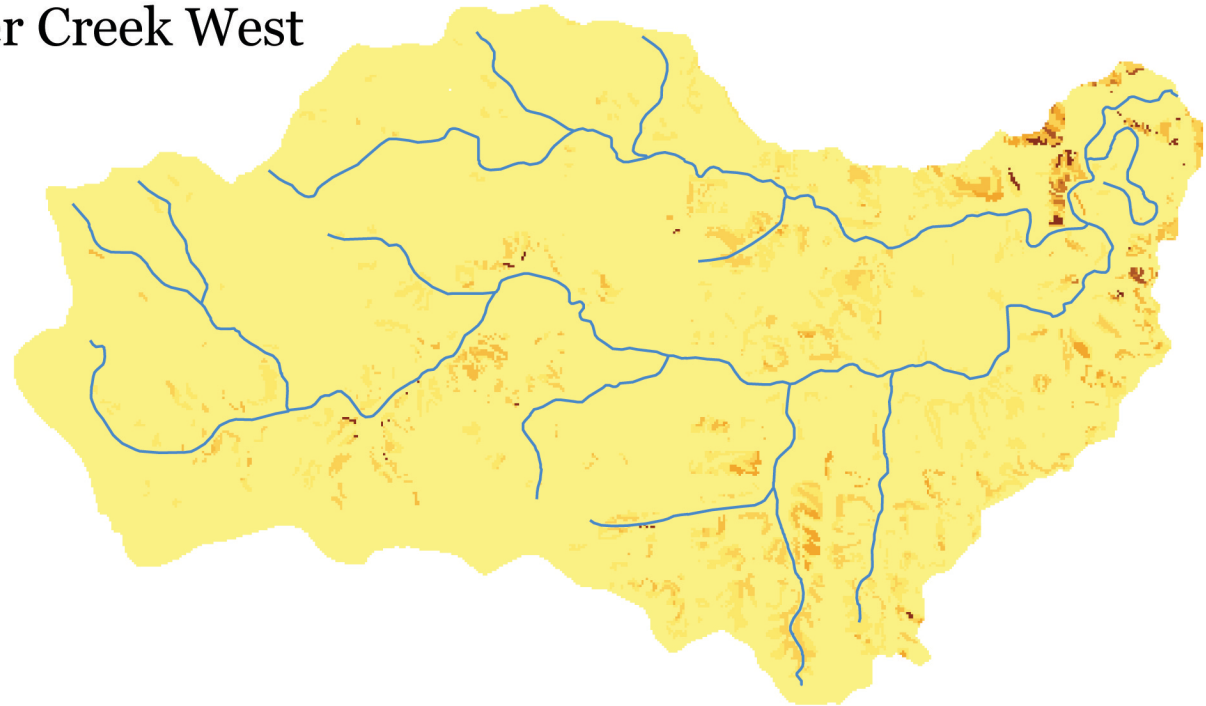
Ten Mile Creek

Soil Loss (tons/acre/year)
Low High
0 100+

N

0 0.5 1 2 3 4 Miles

Silver Creek West

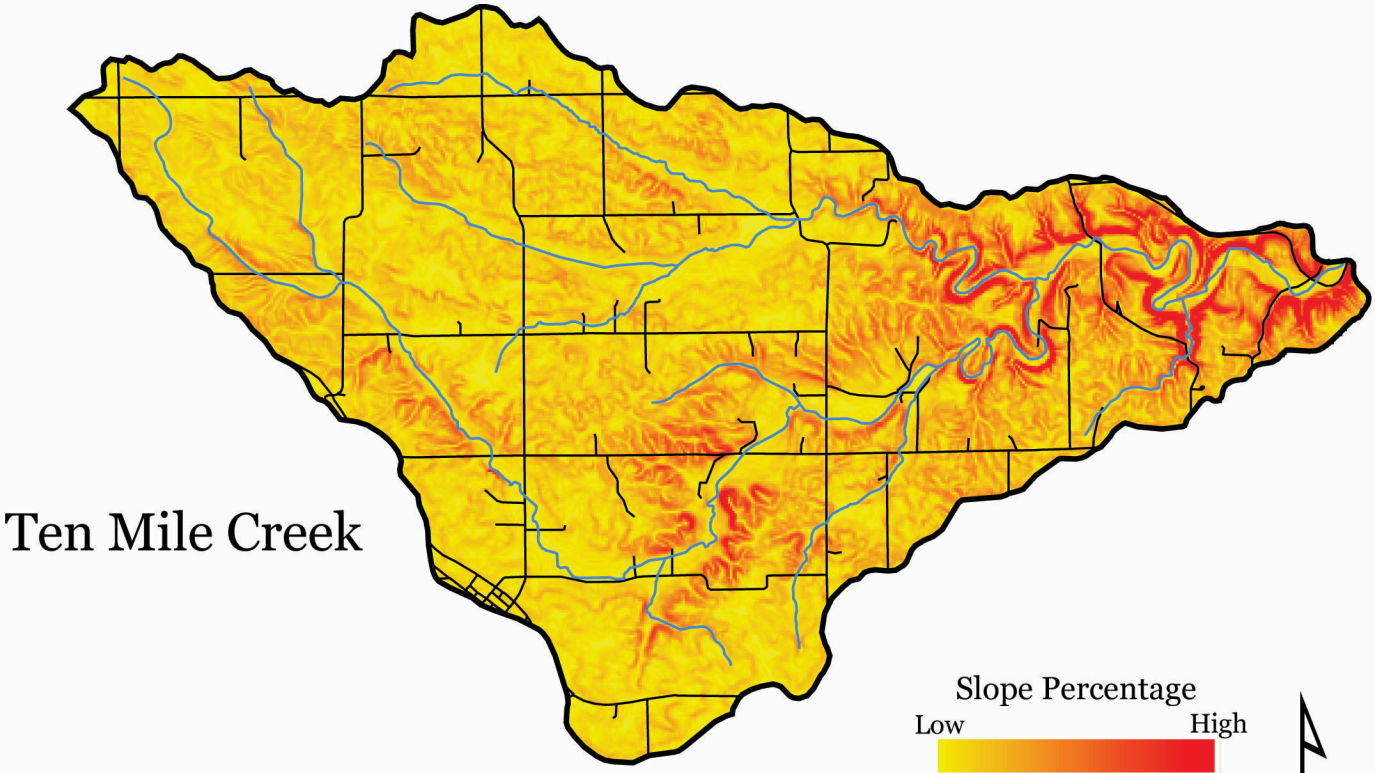


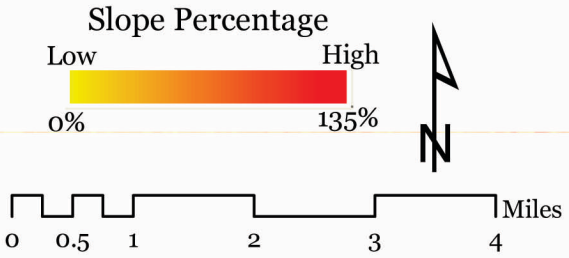
Data Source: Statewide RUSLE grid, assuming no conservation practices.

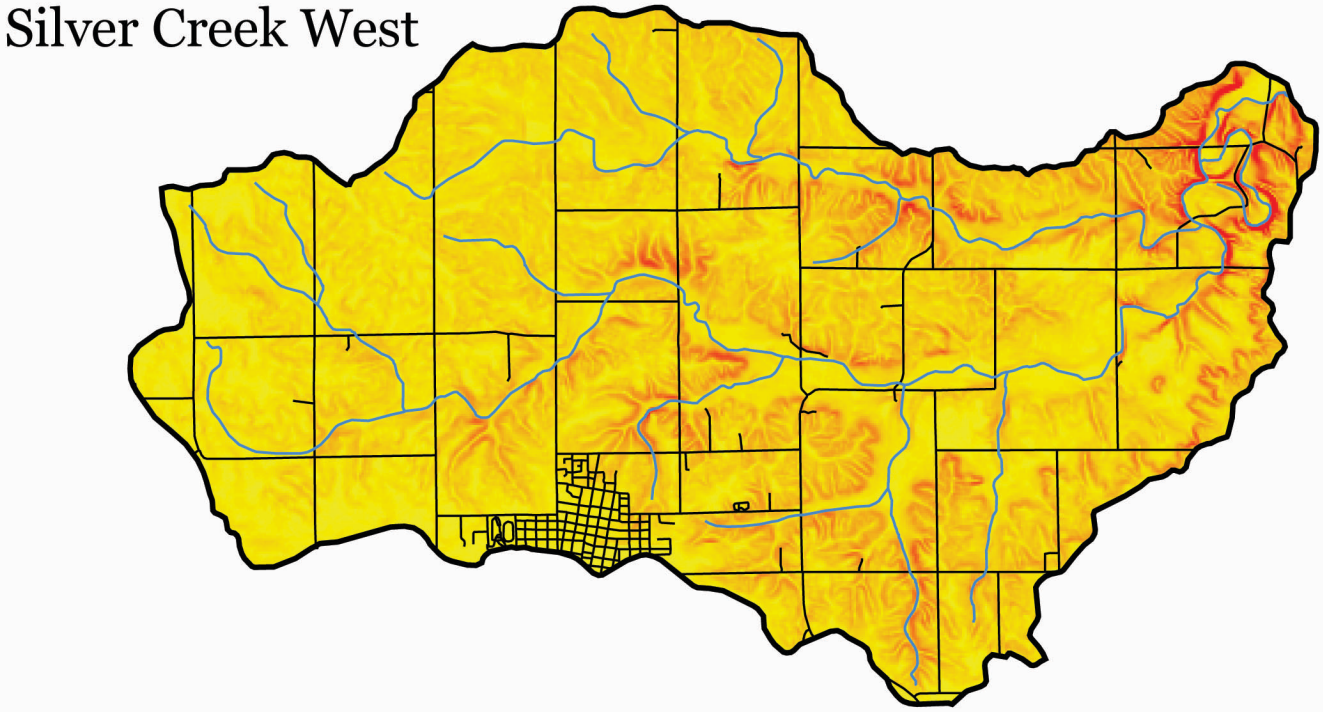
Map Created by: Adam Kiel, Upper Iowa River Watershed Project

Paired Watershed Study

Slope Percentage Comparision





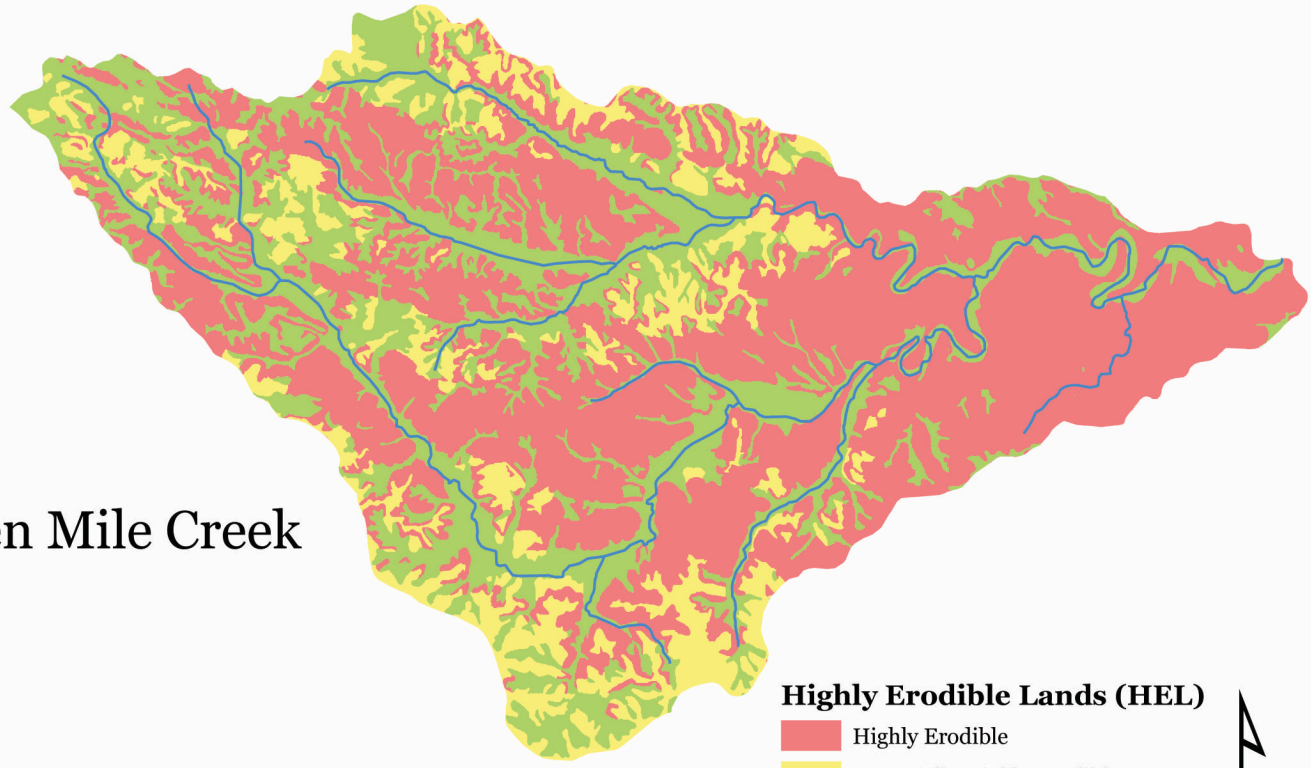


Data Source: Northeast Iowa Digital Elevation Model

Map Created by: Adam Kiel, Upper Iowa River Watershed Project

Paired Watershed Study

Highly Erodible Lands



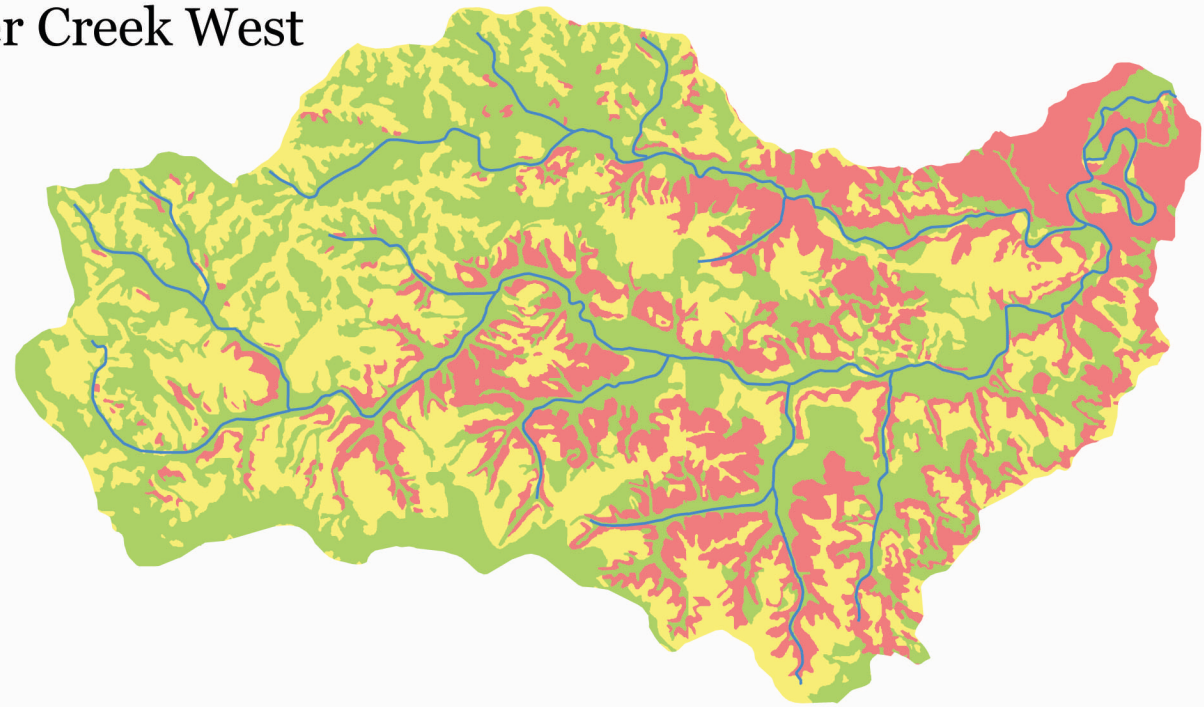
Ten Mile Creek

Highly Erodible Lands (HEL)

- Highly Erodible
- Potentially Highly Erodible
- Not Highly Erodible

N

0 0.5 1 2 3 4 Miles



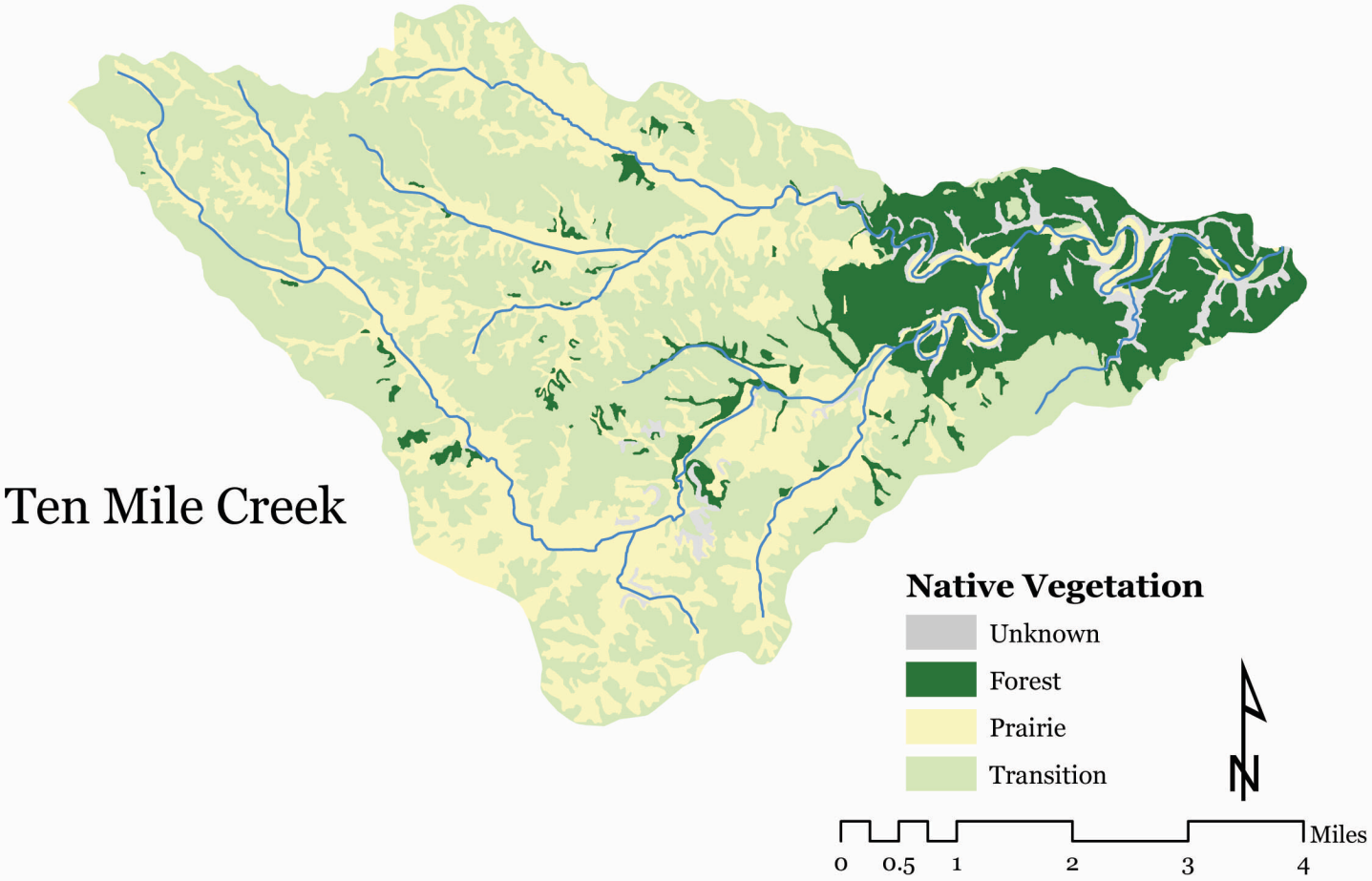
Silver Creek West

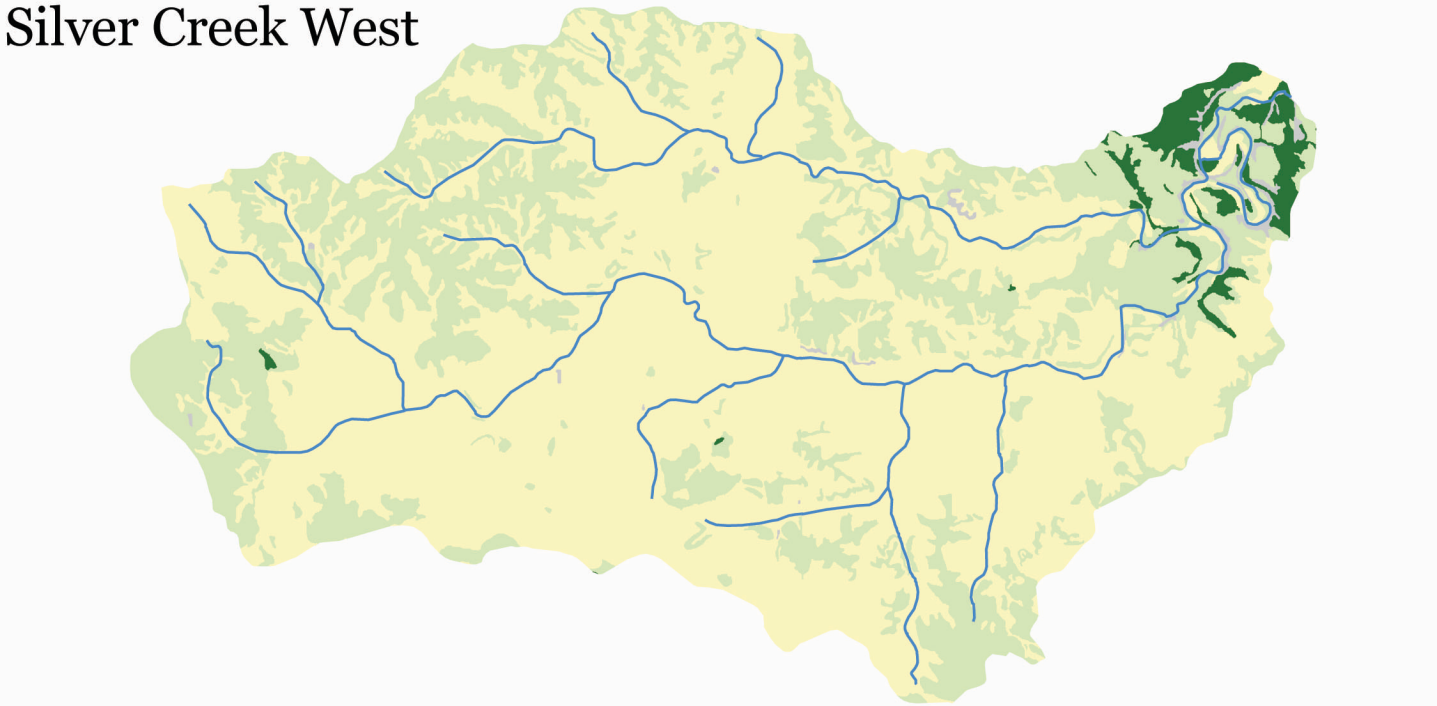
Data Source: County Soil Surveys - Winneshiek & Howard Counties

Map Created by: Adam Kiel, Upper Iowa River Watershed Project

Paired Watershed Study

Native Vegetation



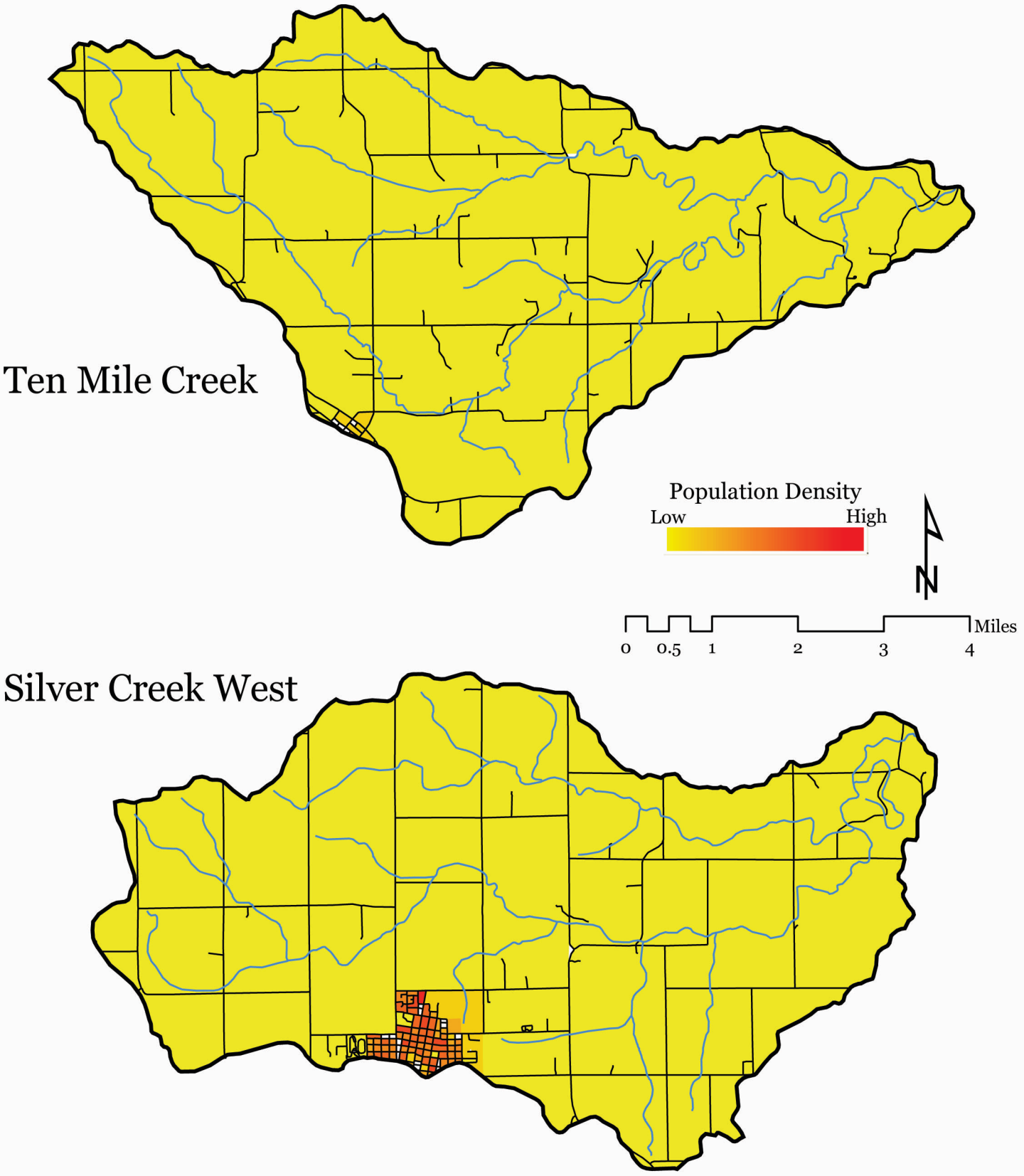


Data Source: County Soil Surveys - Winneshiek & Howard Counties

Map Created by: Adam Kiel, Upper Iowa River Watershed Project

Paired Watershed Study

Population Density



Data Source: 2000 Census Block Data

Map Created by: Adam Kiel, Upper Iowa River Watershed Project