Effects of Cattle Grazing and Bank Land Use Practices on Trout Populations in Three Stream Sections of the Whitewater River, Minnesota

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Abstract

Agriculture and livestock rearing have always been valuable assets to many rural communities across the United States. They provide a successful livelihood for farmers, as well as an essential resource for the general public. Agricultural and livestock impacts are especially noticeable in the Whitewater River Watershed, where use of river banks and instream habitats for cattle grazing and watering has caused severe degradation of trout populations of the Whitewater River and its tributaries.

This study evaluates livestock grazing impacts on trout populations in three stream sections with varying degrees of degradation within the Whitewater River system. A Geographic Information System (GIS) approach was implemented to assess grazing and bank land use impacts on trout populations within sections of Trout Run, the Middle Branch, and the South Branch of the Whitewater River system. Trout Run had very little degradation, the Middle Branch underwent drastic habitat improvements to improve the degraded habitat, and the South Branch section was severely degraded with no control measures in place. Each of the three sample sections were divided into three land cover/land use classifications, pasture/grazing land, forest, and miscellaneous. Analysis was made on each of the sample sections using Digital Elevation Models (DEMs) and Digital Orthoquad Quarter Quadrangles (DOQQs) as overlays for the areas. Trout population data was obtained from 1996 through 1999 for 150-meter sections of the sample stream sites. The trout population was the highest within Trout Run. The Middle Branch had a population that has recovered and is near that of Trout Run. The South Branch site had the lowest trout population due to the severely degraded site. These results show that the presence and extensive use of pasture/grazing land adjacent to streams without the use of any control measures directly affects the trout population.

Introduction

Native and naturalized trout populations have been declining across the Midwestern United States over the past few decades. This is directly related to the increase in stream and river habitat degradation as a result of agricultural and grazing practices that do not support protection of the riverine ecosystem.

Increased sediment input from agriculture may come directly from land use activities which result in increased upland soil erosion, or indirectly from changes in hydrological regimes resulting in higher bank and channel erosion rates (Cox and Vondracek, 1998). Due to an increase in dairy and beef needs and a decrease in farm land, the use of all available pastureland has led to the “cow-stomping” of stream banks and instream habitats of rivers and streams. Excessive sedimentation can result in filling of stream gravels with fine sediments, reducing the survival of some fish eggs and newly hatched fish due to lack of oxygen (FISRWG, 1998).

Erosion of the adjacent lands and instream sediments can be caused by increases in cattle grazing and limited available land. Continuous grazing along streams often causes loss of vegetative cover, soil compaction, stream bank destabilization, and increased runoff and erosion (Lyons, 2000).

New technologies have helped in the battle to save trout habitats. Through the use of Global Positioning System (GPS) data and Geographic Information Systems (GIS), habitats can be mapped and the surrounding landscapes can be assessed for determination of stream and habitat quality. The speed and flexibility of GIS have led many resource management agencies and other organizations to adopt this technology based on the assumption that they will be able to produce better and easier-to-use data quickly and cost effectively (Harris, 1997).

The Whitewater River and its tributaries contain perfect examples of areas that have been affected by agricultural practices. The most detrimental of these practices to the river ecosystem is cattle grazing. The Whitewater River also contains stream sections that have been rehabilitated, with trout populations restored after having been depleted due to cattle grazing. The Whitewater River also has sections that are relatively pristine and undisturbed.

The Whitewater River Watershed is located in Southeastern Minnesota. Three major branches of the Whitewater River pass through six rural towns within the watershed (Figure 1). There is a definite need for educating local farmers about alternative grazing practices that can help improve degrading trout habitats and the overall ecosystem of the Whitewater River. It is also essential to emphasize that the personal costs to the farmers will be very minimal. Riparian buffer strips can improve streams damaged by continuous livestock grazing, but they involve farmer costs that limit their application (Lyons, 2000). Over the past decade, the Minnesota Department of Natural Resources (MDNR) has implemented programs that improve and restore degraded habitats of many areas that have depleted trout populations. The main target areas of these improvements are river sections that have been “cow stomped” and show signs of eroding banks and reduced bank vegetation.

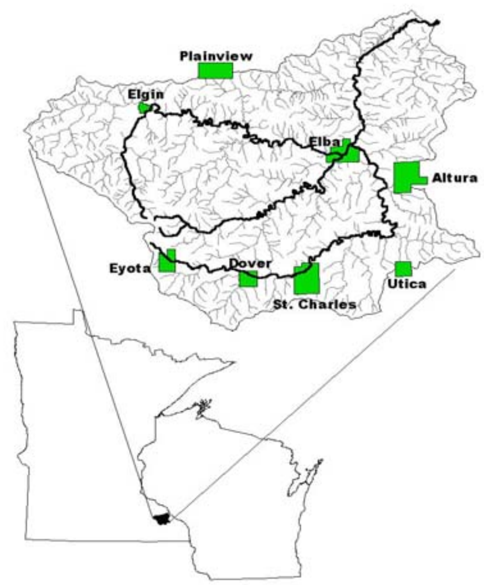

Figure 1. The Whitewater Watershed is located in Southeastern Minnesota, predominantly in a rural area.

Bank failure and instream coarse sediment loss due to “cow stomping” has caused river sections to become uniform throughout, with wide, shallow areas, few bends, and mainly run and pool habitats. This, in turn, causes the loss of instream trout habitats such as deep water, riffles, and overhanging vegetation that are essential to the survival and success of trout populations, as well as the prevention of additional erosion. Based on data from Mundahl (1999), it appears that the Whitewater River stream sites with the best fish and invertebrate assemblages were usually cool or cold, narrow, and shallow, with extensive riffle habitat and clean substrates, protected and shaded by a broad, wooded buffer.

This paper will be used to outline the possibilities of restoring degraded river sections, and how adjacent land use practices directly influence trout populations. Three steam sections were used in this study. The first stream section studied was Trout Run, a tributary of the Middle Branch of the Whitewater River within Whitewater State Park. Trout Run has very little habitat degradation and a relatively undisturbed ecosystem, with an extremely high, naturalized trout population. The second section examined was in the Middle Branch of the Whitewater River, an area that has experienced major trout habitat improvement by the MDNR in the early 1990's. This stream section had been severely degraded due to livestock grazing practices on adjacent land. Trout populations and the river ecosystem have reestablished themselves after these improvements made to the stream and surrounding habitat. The final study section was in the South Branch of the Whitewater River, an area with severely degraded instream habitats and adjacent lands. Extreme levels of bank land erosion are present, with high levels of instream disturbance by cows.

In this study, the severity of the degradation will be assessed to determine the level of improvements to be made. The surrounding landscape's slope and sediment composition must also be considered for improvements. The age structures of the trout populations in the three sections will be used to determine if reproduction was sufficient to produce and maintain adult populations. Fish habitat, especially for gravel spawning species, such as trout can be reduced when pools and riffles become filled with sediment, leading to a more homogenous streambed with fewer clean gravel spawning sites (Cox and Vondracek, 1998).

This paper attempts to answer two questions. First, does the presence of and overuse of pastureland by cattle, negatively affect the trout population in the adjacent stream section? Second, if the overgrazing of adjacent pasturelands is present, how can both pastureland and healthy, productive trout populations survive in conjunction with each other?

Restoration, as defined in this document, includes a broad range of actions and measures designed to enable stream corridors to recover dynamic equilibrium and function at a self-sustaining level (FISRWG, 1998).

Background

Whitewater Watershed Landscape

The Whitewater River is located in the Whitewater Watershed in Southeastern Minnesota. The Whitewater Watershed encompasses eighteen townships within Olmsted, Wabasha and Winona Counties. The Watershed has a highly variable land cover. Much of the eastern portion is comprised of valleys surrounded by bluff land, whereas the north and west portions of the watershed are dominated by agricultural and pastureland.

Trout Population and Agricultural Land

The first question posed in this study is, does the presence of and overuse of pastureland by cattle negatively affect trout populations in the adjacent river section? Overgrazed pastureland may directly decrease the population and health of trout inhabiting streams and rivers that flow through or are adjacent to the pastureland. This does not imply that, due to the presence of pastureland, trout populations of adjacent rivers will suffer. That is only the case when no regulatory or preventative measures are utilized.

The second question is, how can both pastureland and healthy, productive trout populations survive in conjunction with each other? The most reasonable answer to this would be a regulatory and preventative approach, in which the amount of grazing in one particular area is lessened through rotational grazing. The only way for this to occur is with the cooperation of the landowner.

Regulatory and Preventative Strategies

The use of regulatory and preventative strategies may need to be altered to meet the specific needs of each stream site. This is determined by the amount and severity of cattle grazing impacts on the trout population, as noted through habitat loss and degradation. The strategies that have been examined in this study are those that deal with severe degradation to the habitat in and surrounding the stream section.

The types of habitat improvement strategies used at one of the sample sites within this study are: rotational grazing, instream habitat improvements (overhanging vegetation, artificial bank cover, and rock and pebble substrate), stream narrowing and riffle installation, fenced stream buffers and designated areas for cattle crossing complete with corrugated rubber lining on the stream bottom to prevent erosion.

Methods

Data Collection/Preparation

GPS Data Collection

A GIS were created through the use of a Global Positioning System (GPS) receiver, from which data of the land cover was collected. This allowed for very little error in the actual, real-world, locational information of each of the points taken. The coordinates for each point collected were recorded in latitude/longitude as x and y positions.

The process of collecting the field data using the GPS began with the determination of the land cover types present at each of the three sample sites. The stream site and land cover areas were then marked for proper analysis using the GPS data receiver. The actual stream section at each site was also marked and recorded using the GPS receiver. The sample site within the total stream section was also marked and recorded. To properly catalogue the data, the total sample area of each sample site was also marked according to the land cover/land use practices of the areas adjacent to the stream margins.

To establish the sample site boundaries, specific land features were used as the outer boundaries. Trout Run is surrounded by wooded hillsides with breaks in the tree lines being used as the outer boundaries of the sample area. Pastureland fences and hill bottoms were used to determine the boundaries of the Middle and South Branch. By using a varying length of river, the sample sites at the three river sites were kept at similar acreages.

Each sample land cover/land use area was categorized as grazing/ pastureland, forest, and various other cultural features present in the sample area. Each area was recorded as a separate file within the memory of the GPS receiver. This allowed for proper documentation and analysis of the areas when the files were downloaded. Pathfinder Office software was used to differentially correct the data and map each of the sample land cover/land use areas and the stream sections of each sample site. Each file was exported as a shapefile theme to be viewed in Environmental Sciences Research Institutes (ESRI) Arcview software.

Trout Population Data Preparation

To further the process of creating a GIS, trout population data for each of the stream sample sites were analyzed. The data used in this study were collected from 1996 to 1999. Trout population data at all sites, using 150-meter sample sections, were collected with the aid of a backpack electrofisher.

The trout population data were categorized by species and by specific size classes (young-of-the-year (YOY), adult, and adults over 30 cm) at each sample site for each year. These data were processed in tabular form and analyzed for relationships across year, site and size class. Trout population data for these stream sections were received in tabular form from Dr. Neal Mundahl of the Winona State University Biology Department. Dr. Mundahl has been working in conjunction with the Minnesota Pollution Control Agency on the Whitewater Watershed Project since its inception.

Various Coverage Data

Various coverages were obtained for analyzing and interpreting the land cover/land use themes. The data provided were in the form of Digital Orthoquad Quarter Quadrangles (DOQQs) and Digital Elevation Models (DEMs). Both the DOQQs and DEMs were used to interpret the actual landscape of the land cover/land use areas that were collected. Feature data in the form of watershed boundaries, roads and the entire Whitewater River Branches and tributaries also were used. These data were obtained from the Whitewater Watershed Project Manager, under contract with the U.S. Fish and Wildlife Service.

DOQQ Data Analysis

The DOQQs for each sample site were used to show the actual landcover/ landuse of the sample sites. Once the themes were imported into Arcview, each of the themes was reprojected, using the Projector Arcview Extension, from the original GPS projection of Latitude/Longitude into Universal Traverse Mercator (UTM), North American Datum of 1983 (NAD83), Zone 15 to match the projections of the DOQQs. This conversion allowed for the sample data to properly overlay on the DOQQs.

To properly import the DOQQ images into Arcview, the DOQ/DRG

Tools and DOQ Reader Arcview Extensions were used. Two DOQQs were used during this study: Elba and Altura. The Middle Branch and Trout Run sample sections are contained within the Elba DOQQ and the South Branch sample section is contained within the Altura DOQQ.

The land cover/land use themes and stream section themes were then overlayed on the corresponding DOQQ to show sample area relationships to the surrounding environment. The DOQQs were used specifically to show the land cover/land use of each of the sample sites to give a relative representation of the area not only within the sample site, but also the areas adjacent. This allowed for better analysis using actual digital photography to demonstrate the land cover/land use types that can further impact the river.

DEM Data Analysis

Digital Elevation Models (DEM) were used to analyze the relative elevations of the landscape within and adjacent to each of the sample sites. Each DEM consists of a series of grid cells represented by their elevation. The reprojected land cover/land use and stream section themes also were used and properly displayed on the DEMs. Elba and Altura also were the only DEMs used.

Each of the themes was overlayed on the corresponding DEM to properly represent the elevation data of each sample site. The entire area surrounding each sample site also was used to show the contour of the landscapes adjacent to each sample site.

The use of the Spatial Analyst Arcview Extension allowed for the slope and hillshade of each of the sample sites to be calculated and displayed. The slope of each sample site and its adjacent landscape was used to determine the relative steepness of the valley surrounding each site. Hillshading the DEM allowed for the contour of the landscape to be viewed, which further emphasized the elevation changes within the Watershed.

The reason for such emphasis on elevation, slope, and hillshade is due to the runoff potential of lands surrounding the river sections. This will be explained in further detail in the discussion portion of this paper.

Overall Analysis Method

Throughout this study, land cover/land use types are used as the basis for analysis of the quality of the fishery within the section of river sampled. This relates directly to the interpretation of the actual physical properties of each specific stretch of river and the adjacent lands. Land cover/land use of the adjacent bank land directly affected the river section itself, and in turn impacted the trout fishery within that portion of river.

The use of a GIS to interpret the overall landscape and impacts to each of the sample river sections is just a tool in the analysis procedure. In this particular project, GIS was used to show the physical attributes of the landscape of the watershed. The use of DOQQs showed the landcover throughout the watershed. DEMs were used to analyze the change in elevations throughout the watershed and in particular, the sample sections. Various tools within the Spatial Analyst Arcview extension allowed for more particular analysis of the contours of each of the sample sections. A slope analysis was one of the tools within Spatial Analyst that displayed the steepness of each of the adjacent lands at each sample site. Hillshading was another tool within Spatial Analyst that was used to display, with better contrast, the elevations of the adjacent lands. Hillshading was used strictly for its aesthetic value rather than actual interpretation.

The final form of analysis was the use of area calculations. Each land cover/land use polygon at each sample site was calculated for area in terms of feet and acres. This then allowed the percent of total land cover for each land cover/land use type to be determined.

Results

Area Analysis

Each of the sites examined in this study showed significant differences in both the physical conditions of the land and the land cover/land use types present. Without any control or improvement methods, pasture/grazing land without any control measures has the greatest and most devastating impact on the trout habitat and population within the Whitewater Watershed. It was the intention of this study to keep the total acreage sampled at each of the three river sections similar. This allowed for associations to be made among each of the land cover/land use types across the three sample sites. Table 1 shows the strong similarity in the abundance of pasture/grazing land between the Middle and South Branch, thus demonstrating the similar landscapes. This, in turn, showed that the amount of grazing land did not have to decrease to improve the trout populations as long as the land is managed properly.

At both the Middle and South Branch sample sites, pasture/ grazing land dominate the landscape (Table 1). What distinguishes the Middle and South Branch stream habitats are protection of the bank areas by fencing and the placement of instream habitat structures in the Middle Branch. This demonstrates that, without the loss of much grazing land, trout populations can thrive.

DOQQ Landscape Analysis

Through the use of DOQQ images, the overall landscape can be viewed (Figure 2). Major Whitewater River branches, tributaries, Whitewater State Park, and the sample stream sections are shown. The entire project area showed significant land cover/land use changes throughout the sample area (Figure 2). The DOQQ images are of the Altura and Elba quarter quadrangles.

Each of the three sites displayed considerable variation in land covers across the landscape, but overall forest and pastureland dominated.

Table 1. Total area of all sample sites showing land cover/land use type and percent of total in parentheses.

	Middle Branch	South Branch	Trout Run
Total Area (Acres)	36.62	38.82	43.08
Pasture/Grazing	24.92 (68%)	26.86 (69%)	0 (0%)
Forest	5.43 (15%)	9.626 (25%)	41.82 (97%)
Farmstead Property	4.73 (13%)	0 (0%)	0 (0%)
Stream Margins/Misc.	1.47 (4%)	2.33 (6%)	1.26 (3%)

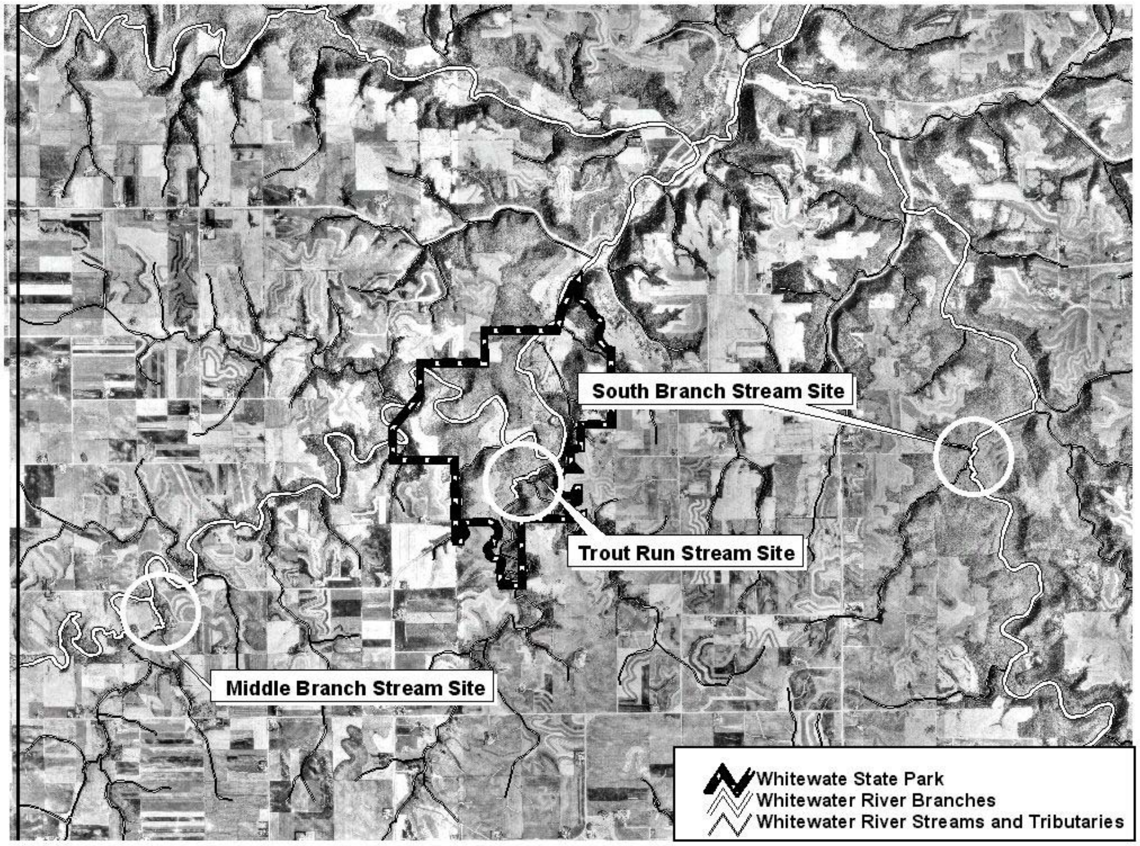

Figure 2. Overall sample area showing landscape, land cover, sample stream sections and various other features through the use of DOQQ

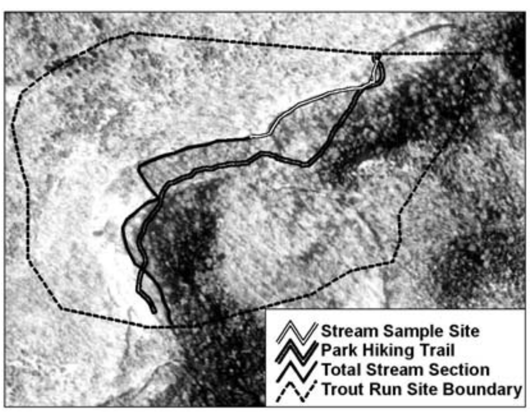

Figure 3. DOQQ image of Trout Run land cover showing the sample river section, hiking trail and 150 m trout data sample section.

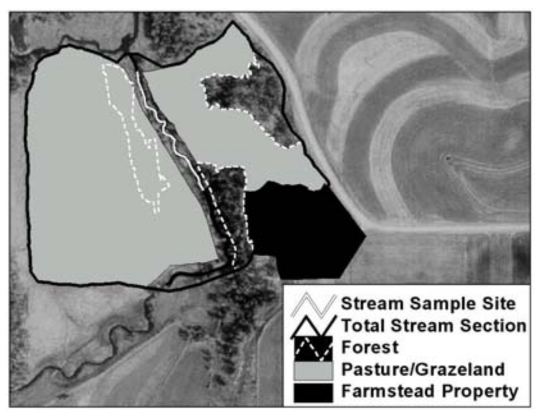

Figure 4. DOQQ image of the Middle Branch sample site showing land cover/land use types and the 150 m trout data stream sample section.

Trout Run contained only upland forest and a narrow, dirt hiking trial (Figure 3). The Middle Branch site had a large proportion of the area covered by pasture/grazing land (Figure 4), but this site also contained fenced buffers on each side of the stream. The South Branch site land cover/ land use was mostly pasture/grazing and very little upland forest (Figure 5). This site did not contain any type of buffer or grazing control measure.

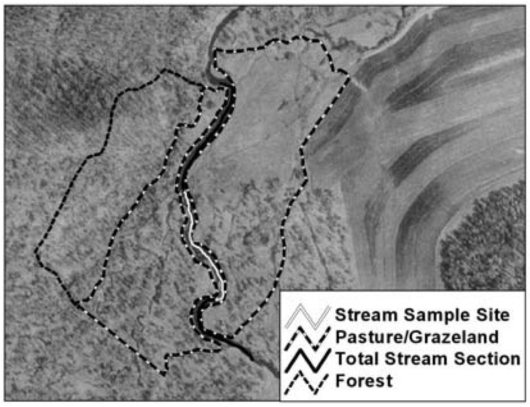

Figure 5. DOQQ image of the South Branch sample site showing land cover/land use types adjacent to the stream banks and the 150 m trout data stream sample section.

DEM Elevation Analysis

Through the use of Digital Elevation Models of Altura and Elba, precise elevations were obtained and analyzed for the entire project area. Each of the three sample sections was overlayed on the corresponding DEM to show the various changes in elevation of the landscape.

The project area was present in the Mississippi River Valley, with portions of the watershed covering flat, plateau-like, agricultural land and other parts covered with bluffs and forest. This led to a very dynamic landscape. The three sample sites were within valleys that spread throughout the entire river and its tributaries. The western and southeastern portions of the project area did not have as much variation in overall elevation (Figure 6), as noted by the increase in agricultural and pasturelands in these areas. The northern portion of the project area had significant elevation changes, with the river valleys in these areas being more distinct.

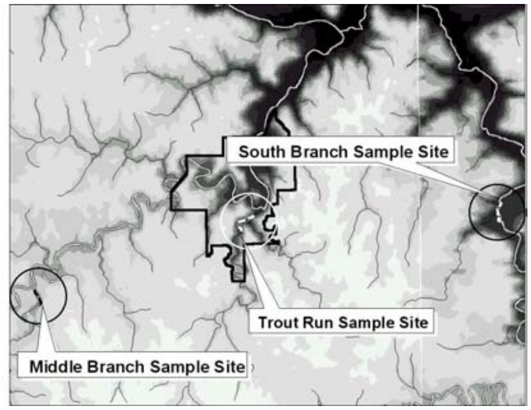

Figure 6. Total sample area DEM elevation analysis. Elevation ranges from high (light color) too low (dark colors).

Trout Run had the highest variation in elevation, with much of the river present within a deep valley and very steep slopes on both sides (Figure 7).

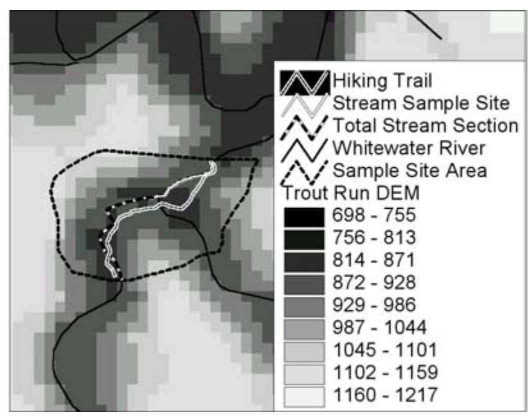

Figure 7. The Trout Run sample site DEM elevation analysis.

Agricultural lands and areas with relatively little slope dominated the landscape of the Middle Branch sample area. Areas that had the highest elevation changes were those adjacent to the river. This was evident in the southeastern portion of the Middle Branch sample site area, which had a high elevation change (Figure 8). The stream banks showed no elevation change (Figure 8).

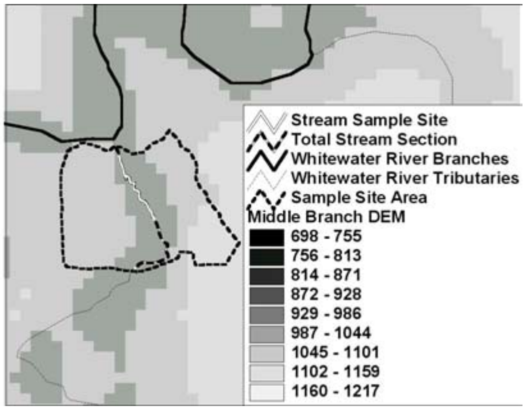

Figure 8. Middle Branch sample area and adjacent lands showing DEM elevation analysis.

The South Branch sample area and adjacent lands showed high variability in elevation (Figure 9). Portions of the sample area directly adjacent to the stream site showed no elevation changes.

The eastern portion of the South Branch sample area consists entirely of pasture/grazing land. The sudden elevation changes are found on the western side of the stream section (Figure 9).

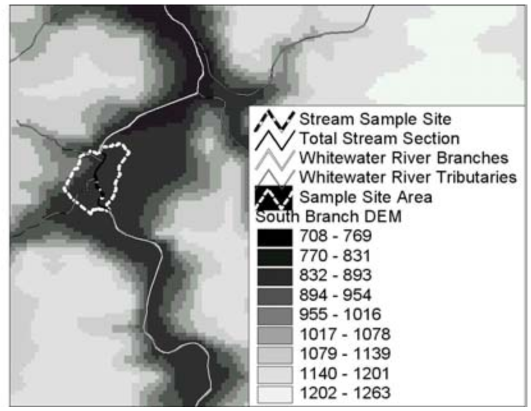

Figure 9. South Branch sample area and adjacent land DEM elevation analysis.

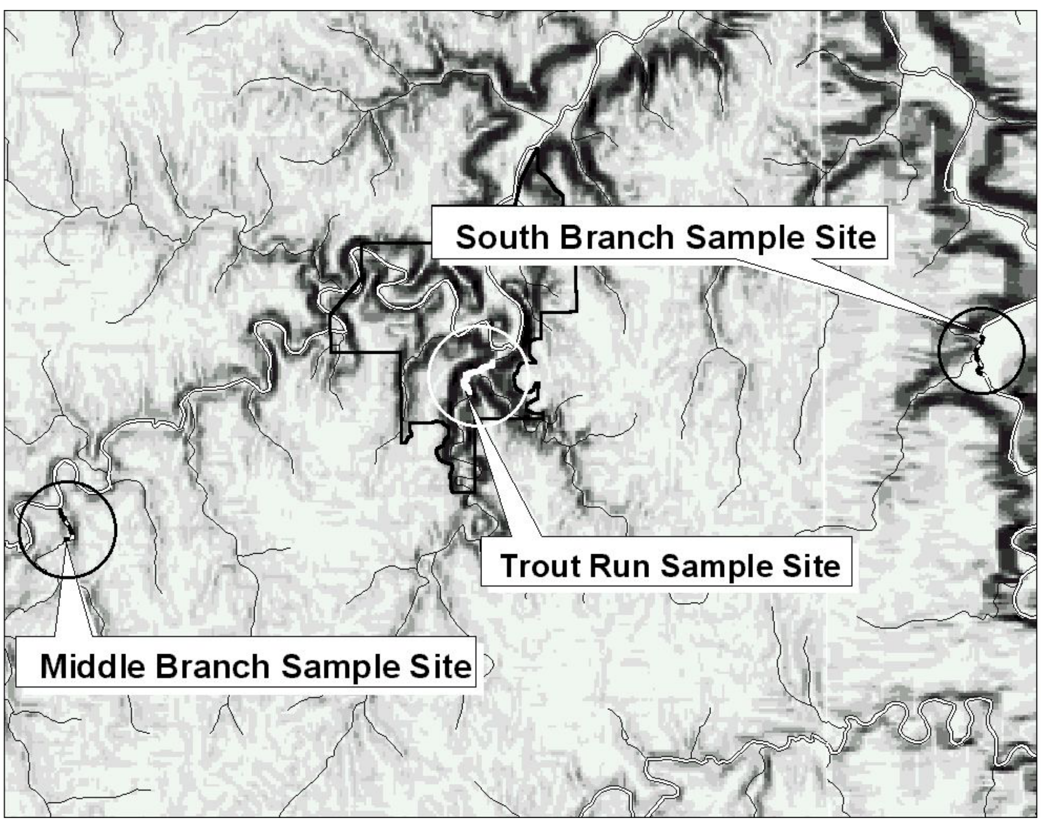

Figure 10. Overall sample area showing slope using DEM areas for landscape analysis. Areas in black have high slope values.

DEM Slope Analysis

The use of a DEM to analyze slope allowed for a better understanding of the landscape. The project area contained many areas of very high slope (Figure 10). Steep slopes dominated the entire river system valley, with areas in between consisting mainly of flat lands. The riverbanks and adjacent lands show an extremely high slope. The river system itself rests in a valley, allowing for high levels of run-off from the flat lands above.

The Middle Branch sample site and areas in the vicinity showed relatively little slope. The only areas with significant slope variation were within the river boundaries. The southeastern portion of the sample site area showed the steepest slope. The western side of the Middle Branch sample section consisted of flat land with little slope (Figure 11). The fenced buffer area on either side of the river section had no slope between the fence and the river bank. This allowed for a natural vegetation buffer for the stream, which helped to control erosion.

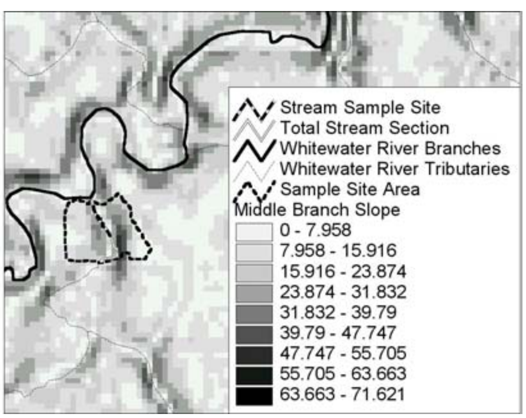

Figure 11. Slope analysis using a DEM for the Middle Branch sample site and adjacent lands.

Trout Run and Whitewater State Park showed little variation in slope except within the river and stream valleys themselves (Figure 12). This is especially evident adjacent to the Trout Run sample area. Both areas abutting the banks of the sample stream section showed significant slope, causing significantly high runoff potential.

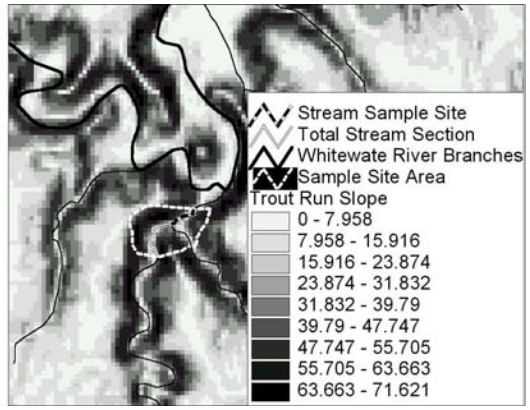

Figure 12.The Trout Run sample area, Whitewater State Park and adjacent lands DEM elevation slope analysis.

Steep banks were found at the South Branch sample site (Figure 13). The northwestern corner of the sample area displayed the steepest slope. The eastern side of the sample site and the areas adjacent to it were relatively flat with very little slope.

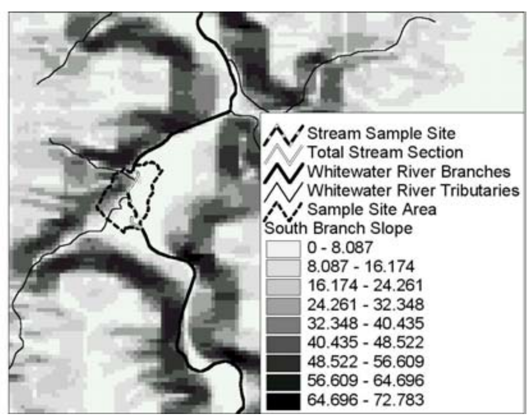

Figure 13. Slope analysis using DEM elevation data for the South Branch sample site and adjacent lands.

The northwest portion of the sample section had agricultural lands that surrounded the stream banks and ran directly to the edge of the stream. This area did not have any buffers between the runoff from the agricultural land and the stream itself.

Trout Population Analysis

Trout populations in the Whitewater River varied greatly between sections (Figure 14). Trout Run during 1996 had the highest number of trout, with numbers the following years being relatively similar with those of the Middle Branch. The South Branch consistently exhibited the lowest total trout population for each year (Figure 14). The three stream sections used for this study had very different physical characteristics that directly impacted the trout population.

Trout Run, located within Whitewater State Park, had a relatively steady population of trout. The sample site within Trout Run had a high number of trout. The Middle Branch site was an area where dramatic habitat improvement took place in the early 1990's. This allowed the severely degraded stream section, with a dangerously low trout population to rebound and show a healthy population. The South Branch sample site exhibited a dangerously degraded stream habitat with a very low trout population. Trout Run had the highest average number of adults, adults >30cm, and total trout during the four-year sample period (Figure 15). The South Branch section had the lowest average numbers of adults, adults >30cm, and the lowest overall total. The Middle Branch section had the highest young-of-the-year average. This showed that the Middle Branch has a reestablished reproduction within the stream section due to the habitat improvements made (Figure 15).

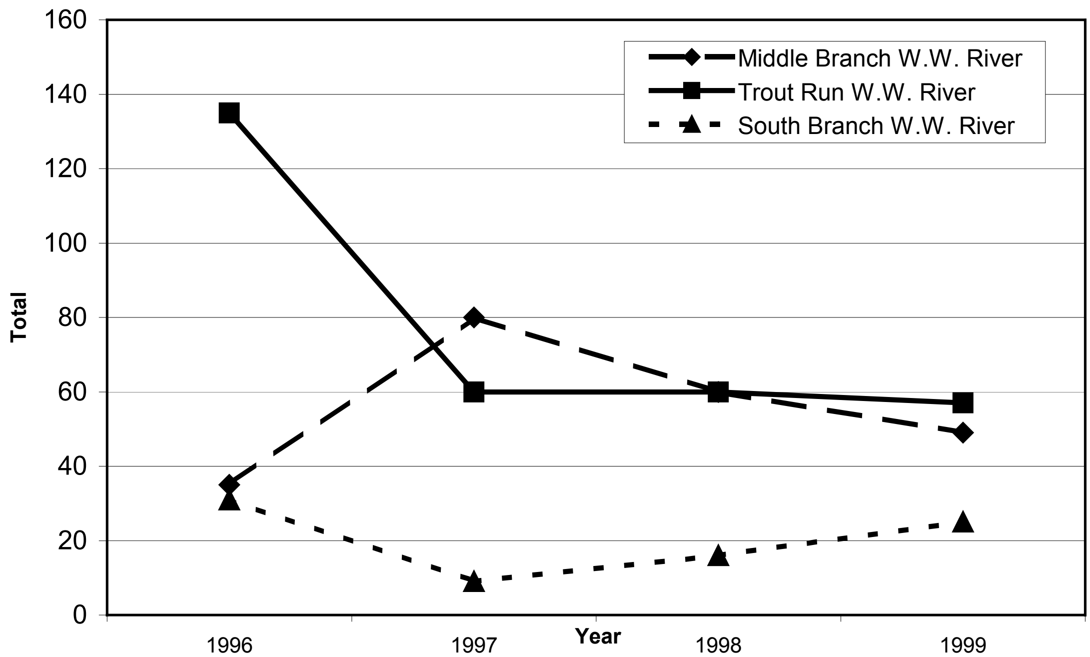

Figure 14. Total trout population (all size classes combined) at each sample site from 1996 to 1999.

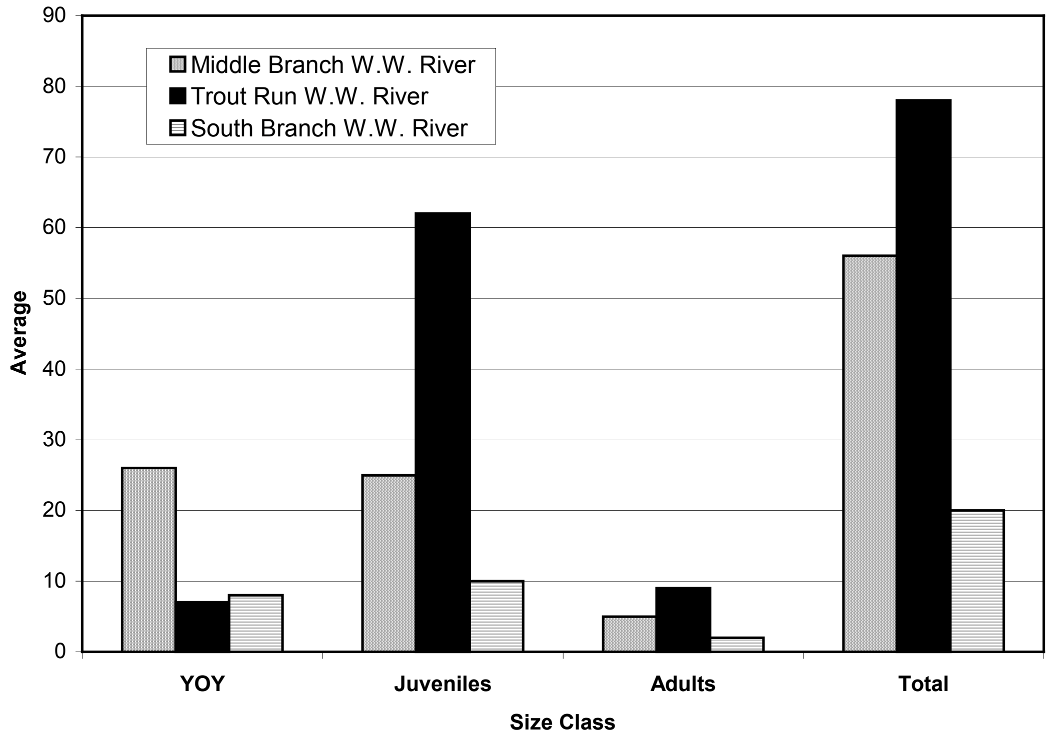

Figure 15. Average number of trout per size class at each sample site over a four-year span from 1996 – 1999

Discussion

The Whitewater River is located within the Whitewater Watershed. The watershed spreads across a vast array of both natural and manmade ecosystems that range from bluff lands to row crops. According to the Minnesota Pollution Control Agency (1995), land use in the watershed consists of approximately 46 percent cropland, 25 percent pastureland, 24 percent woodland, and 5 percent in other categories. The Whitewater River consists of three branches that split into numerous tributaries. Trout angling is a mainstay in Southeastern Minnesota, and with its picturesque landscape and abundant trout populations, the Whitewater River is the premier fishery. The riparian vegetation within the river margins and the structural stability of the bank lands directly affect the health and survival of the trout populations. The most severely degraded stream site within this study was the section within the South Branch. The main cause of bank erosion and overall habitat degradation within the South Branch site is due to extreme cattle grazing along the river margins and access to the river channel. Excessive livestock use can cause breakage or other physical damage to streamside vegetation (FISRWG, 1998).

Increasing the habitat quality of individual stream sections within a watershed will also improve the overall ecosystem of the entire watershed. Maintaining a healthy, ecologically diverse stream section is something that will increase the fitness of the entire watershed. The extensive use of bank lands for grazing has a profound impact on not only the trout population, but also the stream margins and instream ecosystem. Loss of bankholding plant species and undercut banks can reduce habitat for fish and other aquatic species (FISRWG, 1998). However, the effects caused by severe and sustained grazing within the stream can be overcome and corrected through habitat improvement methods that not only will protect the bank stability and reduce erosion, but will also improve the instream habitat. The addition of large woody debris, such as fallen trees and rootwads, to streams can raise fish abundance by increasing cover and streambank stability (Culp et. al., 1996).

Habitat improvement in areas most affected by grazing can not only benefit the areas directly related to the improved areas, but they will also help trout populations and stream habitats downstream of the improved site. This, in turn, is something that can prove essential for the further development of stream sections lacking in sustainable trout populations. Increasing the vegetative habitat and water quality of the stream section can do this, thus creating a larger fishery with abundant trout populations.

The severely degraded South Branch section is a prime area for habitat improvement. This section has severely eroding and cut banks with virtually no riparian vegetation. The stream itself has very little riffle, cow-stomped substrate, and a severe loss of instream vegetation. To improve this stream section, some basic structures need to be installed. The stream margins need a fenced buffer that would allow the riparian vegetation to reestablish itself. This would also prevent cattle access to the stream channel itself, which would protect the stream substrate. Riffle structures need to be installed within the stream channel, as well as making the channel narrower and deeper. The installment of LUNKER structures and woody debris also would benefit the instream cover and habitat for trout. These structures enhance the traditional riprap stabilization by simulating a natural undercut bank (Stuber, 1996).

Even though this particular stream section has been severely degraded for a long time, habitat improvement will benefit the surrounding ecosystem and trout population almost immediately. This occurred at the Middle Branch stream site. Severe degradation had occurred at the Middle Branch stream site, resulting in a very similar landscape to the South Branch site. Eroding banks and a severe loss of riparian vegetation were the most severe issues facing the trout population at the Middle Branch site. The Middle Branch site underwent a complete habitat improvement. The improvements that took place were a fenced buffer that has led to complete re-growth of the native vegetation along the stream margins. Instream LUNKER structures were installed, as well as riffle structures and woody debris. Through these improvement measures, the Middle Branch site is now competing with the natural Trout Run stream site for trout abundance.

Conclusion

This study has provided many useful tools that will help inform the landowners adjacent to the Whitewater River of the impacts occurring. Through the use of GIS data and maps landowners can better understand the impacts of their land use practices on the stream ecosystem. DEM analysis can demonstrate an area’s slope and runoff potential, a potential which can lead to eroding banks and complete loss of stability in the stream habitat.

The GIS can only function in conjunction with stream sampling data. The fish sampling data help to support the original hypothesis that an increase in grazing pressure on the stream ecosystem will directly impact the trout population within this site.

This study outlines the degraded condition of one section of the Whitewater River and the recovery effort at another, through comparison of three stream sections that vary in habitat quality from natural and undisturbed to severely degraded. It was determined that the South Branch site's habitat is in serious need of drastic improvement measures. Because of the loss of essential habitat in and surrounding the stream site, the South Branch study section contains a depleted trout population. Through the efforts of improvement within the Middle Branch stream section, it was possible to improve a degraded habitat enough to restore the trout population and the overall quality of the entire sample site.

Further study of the impacts of grazing on trout populations and overall ecosystem quality of streams is recommended. This study could include sample sites larger than 150 meters, as well as water quality studies that could trace levels of nitrates and fecal coliform that are present in cow waste. These chemical levels could also be tested in individual trout present at each location.

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