FINAL REPORT

SEP 12 2001

1999 Project Abstract
For the Period Ending June 30, 2001

Title: W35 Erosion Impacts on the Cannon Valley Big Woods
Project Manager: Brad Carlson
Organization: Big Woods Project
Address: U of M Extension, 320 NW 3rd Street, Suite 7
Faribault, MN 55021
Web site address: http://www.soils.umn.edu/research/bigwoods
Fund: Environment and Natural Resources Trust Fund
Legal Citation: ML 99, Ch. 231 Sec. 16, Subd. 006(g)

Appropriation amount: $150,000

Overall project outcomes and results.

This project determined the historical and contemporary soil erosion trends across the big woods ecosystem in Rice County in order to develop effective land management tools for future natural resources planning. Our study found, through the use of GIS databases and 512 field observations, that a large amount of sediment (30,000,000 m^3 or 1,100,000,000 ft^3) is held within the valleys of eastern Rice County. The areas containing these sediments were commonly associated with high agricultural land-use, steep valleys, and increasing watershed area. Large stream flows through these sediment-rich areas have the potential to lower the water quality in the Cannon River.

Subsurface agricultural tile drainage has been suggested as a soil conservation strategy in eastern Rice County, where permeable soils overlie a dense glacial till. We monitored a partially tile-drained hillslope where we observed waterlevels lowered on the tile-drained side of the hill by 80 cm when compared to the undrained side. This suggests that tile drainage could increase the ability of the upland soils to absorb rainfall and decrease runoff thereby decreasing soil erosion locally. While tile drainage may provide site-specific benefits, there are likely disadvantages related to potential increases in stream peak flows causing erosion and rapid stream dissection.

Project results use and dissemination.

Delivery of information to the general public and land-use managers has taken several forms. The Big Woods Project has coordinated several tours to educate local groups (25-30 participants). The University of Minnesota has had up to 15 students and staff working on different aspects of this project; used sites on course field trips (~50 students); developed customized products for the Nerstrand Big Woods State Park; worked with local colleges; and established a website documenting research activities. Project data and information has been used by county and regional land resource managers to assist in long-range planning and addressing water quality concerns in the Cannon River Watershed.

SEP 12 2001

Date of Report: July 1, 2001
Project Completion Date: June 30, 2001

LCMR Final Work Program Report

A. Legal Citation: ML 99, Ch. 231 Sec. 16, Subd. 006(g)

I. PROJECT TITLE: W35 Erosion Impacts on the Cannon Valley Big Woods

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Total Biennial Project Budget:

$LCMR	$150,000	$Match:	0
-$LCMR Amount Spent:	**$150,000**	-$Match Amount Spent:	0
=$LCMR Balance:	**$ 0**		0

Appropriation Language: This appropriation is from the Environment and Natural Resources Trust Fund to the University of Minnesota in cooperation with the Big Woods Project to determine historical soil erosion levels, predict future effects of land practices and develop land management tools in the big wood ecosystem in Rice County.

NOTE: The Big Woods Project is currently led by a Board of Directors of which Brad Carlson, Project Manager is a member. The current project originated in the Water Committee chaired by Brad Carlson. The Water Committee is the direct connection between the U of M researchers and the Big Woods Project, reporting to the Board of Directors.

B. Status of Match Requirement: Not applicable.

II. and III. FINAL PROJECT SUMMARY

This project had three main objectives: (i) estimate quantities of post-settlement alluvium in dissected valleys of the Cannon River watershed, (ii) produce soil erosion potential maps for Rice County, and (iii) establish a monitoring site to determine the effects of tile drainage on soil moisture storage. The soils of eastern Rice County are unique because dense till is mantled by less than a few meters of silty sediments, ideal conditions for soil erosion. Our 511 field observations confirmed the presence of large volumes (30,000,000 m^3 or 1,100,000,000 ft^3) of post-settlement alluvium (PSA) in valleys of the Cannon River watershed. PSA is associated with areas of high agricultural land-use, steep valleys, and generally increasing catchment area.

The erosion potential of the landscape of Rice County was estimated using a combination of soil survey and landform data derived from a digital elevation model (DEM). Scattered areas of steep slopes in close proximity to waterways with high soil erodibility pose substantial risk for accelerated soil erosion without proper land use or use of vegetative buffer strips.

The tile drainage study supported our original hypothesis that the greatest lowering of water tables occurred on the backslope where soil water perches above the dense till. While only minor differences exist (10-20 cm) between drained and undrained landscapes in the depressions, up to 80 cm of difference was noted on the backslope. This suggests that tile drainage has beneficial effects on soils on backslopes in the spring. Increasing the ability of the upland soils to absorb rainfall and decrease runoff could decrease soil erosion locally. Automated monitoring of water levels will continue in order to formulate more conclusive results. While tile drainage may provide site-specific benefits, there are likely disadvantages related to potential increases in stream peak flows potentially causing streambank erosion and rapid stream dissection.

IV. OUTLINE OF PROJECT RESULTS:

Result 1: Estimation of the amount of post settlement erosion that has occurred on upland landscapes and the amount of post-settlement alluvium and glacial sediments retained in stream valleys in the Cannon Valley Big Woods.

Products: 1. A predictive model to map the spatial distribution of post-settlement sediment from a digital elevation model. 2. Estimation of the spatial distribution and volumes of post-settlement sediment in the stream valleys for eastern Rice County. 3. General survey of stream bank erosion in 3 to 5 minor watersheds. 4. Interpretation of results to identify areas of potentially high rates of stream bank erosion and points of headward erosion along stream channels. 5. Knowledge gained of the location of the pre-settlement land surface layer would also aid in the discovery and protection of archaeological artifacts.

Results 1 and 2 Budget: ***$69,000*** **Balance:** ***$0***

Result 1-Project Results

BACKGROUND

Following European settlement, much of the land was cleared in Southeastern Minnesota for agriculture and lumber products. The silty soils in the region are highly erodible and the clearing resulted in significant quantities of sediment being eroded from the uplands and deposited in the wide, gently sloping, stream valleys. This sediment has recently become an issue due to accelerated streambank erosion. This erosion occurs in areas where significant sediment was deposited and contemporary streams are attempting to reestablish the base level that existed prior to the onset of erosion. Developing a methodology to reliably identify these areas of post-settlement alluvium provides a valuable planning tool. Areas of significant sediment can be targeted as sensitive areas of the landscape and appropriate land management practices can be directed at these areas. Some of the areas containing post settlement alluvium area also habitats for endangered plant species. The results from this study will help identify which of those areas are at risk. Other applications include archeological studies, fishery studies, and an improvement of our understanding of geomorphic processes in this region.

METHODS

The Cannon River Watershed consists of approximately 94,300 hectares, primarily within Rice County, with portions extending into Goodhue, Dakota, and Scott Counties (Fig. 1). The watershed is composed of 36 minor watersheds. The soils within the watershed are generally comprised of thin loess (silt), less than 1 m thick, overlaying dense, clayey, and fractured pre-Wisconsinan glacial till. The Wisconsinan-age loess is highly erodible and was deposited with the retreat of glacial ice associated with the Des Moines Lobe advance (Wright 1972). The landscape in the northwestern third of the watershed is comprised largely of high relief, morainal topography with a deranged (poorly defined) natural drainage system (Fig. 2). A high density of lakes and closed depressions characterizes this area. The landscape in the remainder of the watershed consists of level uplands dissected by the well-developed, dendritic stream networks of the Cannon River and its tributaries. This area has locally steep slopes along the channels as a result of stream downcutting. Warm, moist summers and cold winters characterize the climate of southeastern Minnesota. The average temperature for June, July, and August is 21° C and –8.2° C during December, January, and February. Mean annual precipitation is 780 mm, 75% of which falls during the summer months. Prior to European settlement the watershed was primarily covered by a mixture of deciduous hardwoods (known as the Big Woods ecosystem) and prairie vegetation. The forest-prairie boundary has migrated across this area in response to climate change during the past 12,000 years. Present land use is predominantly agricultural (corn, soybeans, and alfalfa). Most of the remaining areas are forest and grassland with small areas in urban land use.

Field Sampling

We identified areas likely to contain post-settlement alluvium (PSA) based on available digital geographic data. Slope gradient, curvatures, and catchment areas were calculated from a 30-m (horizontal resolution) digital elevation model (DEM) obtained from the U.S. Geological Survey. Minor watersheds with differences in elevation of less than 200 meters were removed from consideration for sampling (Fig 3). Digital USDA-NRCS National Cooperative Soil Survey maps were used to identify areas that were likely to contain thickened surface horizons near streams. The theory was that these areas of the landscape would be susceptible to alluvial deposition (Fig. 4). Areas with deranged surface drainage were also removed from consideration since local sediment would be deposited in the closed depressions and would not be transported to stream valleys. These areas were primarily in the northwestern portion of the watershed. Using this approach, we hoped to select minor watershed with a high probability of containing substantial quantities of post-settlement alluvium. Four minor watersheds were randomly selected by numbering each watershed and using a random number generator. The selected minor watersheds were used for detailed field sampling (Fig 5).

We sampled 511 individual points, with observations beginning at the watershed's outlet and working back upstream at 100-meter intervals to the head of the channel. At confluences, we randomly selected the channel to continue sampling. We collected information on landscape features, stream channel characteristics and soil profile morphology at each sampling point. Stream valley data included floodplain width and slope (lateral to the sample point). Channel information included channel depth, channel width, channel gradient (slope within the channel, upstream from the point), activity (water flow), and a cross section sketch to provide a visual reference of the channel at the sampling point. Land use and land cover was noted. Primary and secondary (if applicable) vegetative cover was noted as was other features such as rock outcroppings, roads and culverts, dwellings, or other factors that may have influenced the soil or water characteristics at that particular point. Soil profile characteristics observed in core samples taken by a hand probe to a depth of at least 40-cm were recorded including soil color (in Munsell notation), soil texture, mottling (color, size, and abundance of), depth to water table, and depth to carbonates. Deeper samples were described in areas where post-settlement alluvium was thicker than 40 cm. The depth of PSA was determined primarily by changes in soil color and texture. The original, buried surface layer is usually significantly darker and higher in organic matter content than the overlying PSA. The original surface tends to be black, in Munsell notation a benchmark of 10YR $^3/_1$ (very dark gray) or darker was assigned to aid in expediency for field identification, whereas the PSA deposits were much lighter- tending to be light to medium grayish brown.

As data was collected for each minor watershed it was entered as point data into a GIS database for analysis. Other pertinent features including surface water, current land use/cover, pre-settlement vegetation, soil survey data, and terrain attributes calculated from the DEM were also added to the database. A statistical software program (SYSTAT 7.0) was used to create scatterplots to assess general relationships among variables. Simple statistics were calculated on the variables from each watershed to aid in identifying variables that may be related to the depth of post settlement alluvium.

RESULTS

The preliminary GIS screening of each minor watershed allowed for the identification of areas not likely contributing to the sedimentation of the Cannon River. This enabled us to narrow the study area and more thoroughly cover the areas that were sampled. The minor watersheds sampled in the study exhibited differences in land use percentages and average slope. The amounts of post-settlement alluvium found within each minor watershed tended to vary, although the relative locations of high and low amounts of PSA followed similar patterns. PSA depth was the result of a combination of slope, catchment area, and land use. The individual channel characteristics (depth, width, and gradient) did not affect the variability of PSA depth and location.

Stream valleys with a high catchment area, under forested or grassed vegetation tended to have higher amounts of PSA, especially in locations with steep slopes leading to agricultural land use in the upland areas. A combination of steep slopes and highly erodible soils leads to significant upland erosion and deposition of PSA on the relatively level flood plains. Deep areas of PSA were frequently associated with dense vegetation. Presumably, the vegetation helped prevent secondary erosion once the PSA was deposited on the floodplain. Shallow depths of PSA were observed in the gently sloping, upper reaches of the incised stream valleys. As stream incision became less prominent, agricultural production tended to occur within a short distance of the stream channels. As such, higher sources of PSA were present in these upland areas and were transported to more gently sloping stream reaches where sediment could be deposited and/or transported into the Cannon River.

Efforts to produce quantitative, statistical models to predict depth of PSA were not successful. This was due, in part, to the numerous interacting factors affecting depth of PSA. However, a definite inverse trend was found in depth of PSA and distance from the Cannon River as well as qualitative relationships with land use, stream valley gradient, and floodplain width. In other words, depth of PSA increased the further one traveled from the head of the minor watershed. This trend was moderated by the characteristics of the stream valley with relatively deep (50-100 cm) depths of PSA in wide reaches of the stream valley. PSA was not present as the streams incised into bedrock creating narrow stream channels that acted to transport PSA rather than have it accumulate. Bedrock incisions were often found closer to the confluence with the Cannon River since incision increases with catchment area.

In summary, large volume of PSA were found in the four minor watersheds that were sampled. Significant streambank erosion was present in all minor watersheds indicating the PSA had increased rates of stream incision and consequent transport of sediment into the Cannon River. Somewhat consistent relationships were found among depth of PSA and landscape characteristics. PSA was less in areas with a high percentage of forested land cover and where the streams were incised into the bedrock. PSA was deepest in watersheds of high agricultural land use, steep stream valleys, and broad, relatively flat floodplains. As such, areas of the stream valleys subject to excessive rates of streambank erosion can be consistently identified for the purposes of land management and planning. Additionally, the first approximation of PSA location based on the location of soils with overthickened surface horizons provided a reasonable prediction of PSA location.

A geographic information system (GIS) database was created containing the digital geographic datalayers used in this part of the project. Data include the digital elevation model and derived terrain attributes, minor watershed locations, streams and lakes, soil survey, land cover, and predicted areas of PSA. Selected images can be viewed at the web site for the Soil and Landscape Analysis Laboratory at http://www.soils.umn.edu/slal. The entire database can be obtained by contacting the Soil and Landscape Analysis Laboratory at 612-624-1788 or Dr. Jay Bell at 612-625-6703. The results and data of this portion of the project will be shared with the Rice County Soil and Water Conservation District, the Big Woods Project, and the University of Minnesota Extension Service for distribution and use in local watershed planning.

Figure 1. Location of the Cannon River Watershed

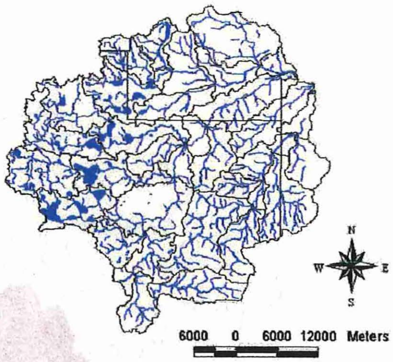

Figure 2. Lakes and Streams within the Cannon River Watershed

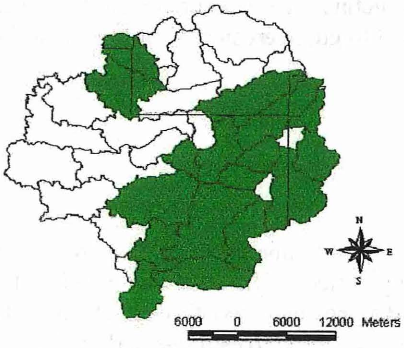

Figure 3. Minor watersheds with high (>200 m) topographic relief

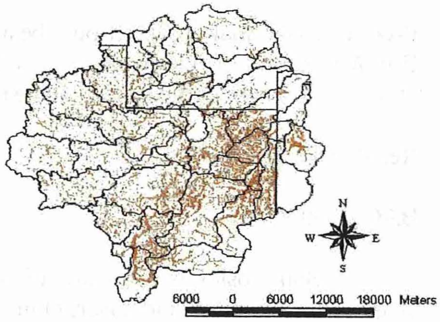

Figure 4. Predicted areas of post-settlement alluvium based on interpretation of the soil survey.

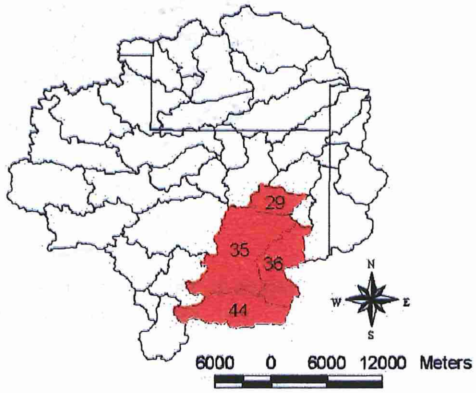

Figure 5. Minor watersheds where field sampling was conducted.

Result 2: Estimate areas susceptible to overland soil erosion based on terrain analysis of digital elevation models, and digital soil survey data.

Products: The final product would be a series of digital maps depicting the erosion potential for the entire Big Woods Project Area (eastern Rice County) and could be used to guide erosion management and control practices throughout the larger southeast Minnesota region.

Result 2-Project Results

BACKGROUND

Soil erosion is a function of many different aspects of the landscape including soil characteristics, slope characteristics, land cover, climate, and land management practices. The inherent potential of the land for erosion can be estimated from a combination of soil and slope characteristics and climate. The digital geographic database assembled for Result 1 of this project was used to estimate soil erosion potential at scales of approximately 1:24,000 based on analysis of the digital (SSURGO) USDA-NRCS National Cooperative Soil Survey for Rice County, MN, and terrain attributes derived from a 30-m (horizontal resolution) digital elevation model.

RESULTS

The analysis of soil and topographic data for Rice County was used to produce erosion potential maps. The maps rate the relative susceptibility to erosion based on soil and topographic characteristics using the general framework of the Universal Soil Loss Equation. The maps do not include the current effects of land-use and conservation practices because the purpose of these products is to highlight portions of the landscape with inherent susceptibility regardless of current land use. The images below represent the elevation (Fig. 1) and erosion potential (Fig. 2) for a minor watershed in Rice County as an example.

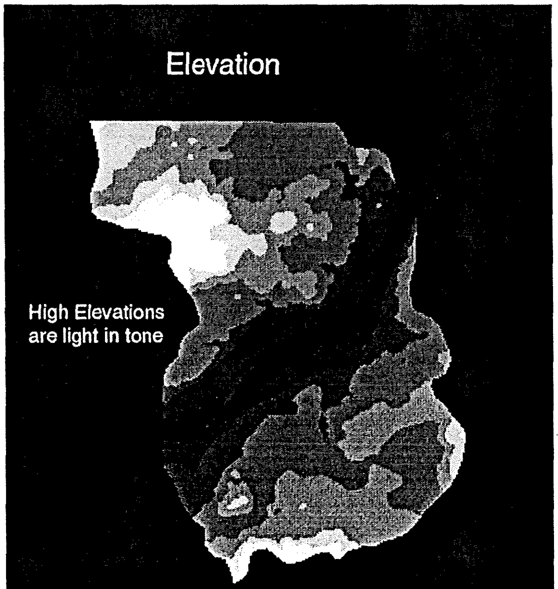

Figure 1. Digital Elevation Model for Minor Watershed #17 in Rice County

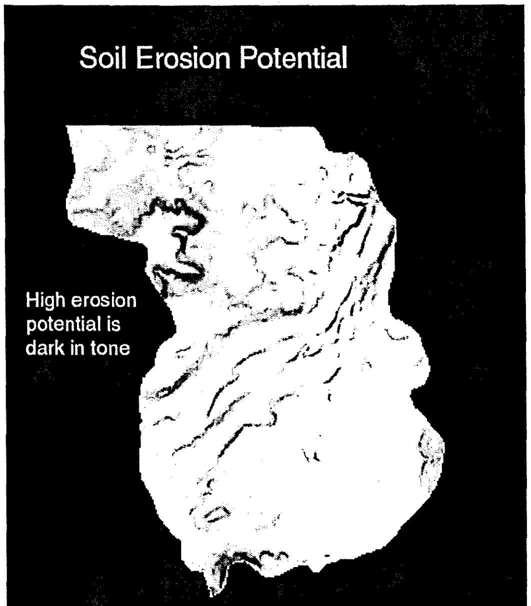

Figure 2. Soil Erosion Potential for Minor Watershed #17 in Rice County

Result 3: Determine the dynamic effect of tile drainage on soil moisture storage and potential surface runoff; and the potential contribution of tile line outlets to increased peak stream flow volumes by comparing tiled and non-tiled fields.

Products: 1. Comparison of annual, shallow water table fluctuations along two hillslopes to evaluate the potential effects of tile drainage on seasonal patterns of surface runoff and soil moisture storage. 2. Comparison of seasonal patterns of flow rates from tile outlets and the flow characteristics of the stream at the minor watershed outlet. 3. Interpretation of results with regard to implications for soil erosion and recommended management practices to minimize soil erosion.

Result 3 Budget: *$81,000* **Balance:** *$0*

Result 3-Project Results

BACKGROUND

Seasonal wetness across all landscape positions (top of hill, side hill, lowlands) is a common complaint throughout Eastern Rice County. The reason for this wetness is due to the unique stratigraphy present in the soils where we have a relatively thin (1-2 feet) and permeable material (windblown silt) overlying a dense older till material that serves as a restriction for vertical movement of water. As moisture penetrates the silty materials at the surface, it infiltrates readily until it encounters the dense till below. Once the water reaches this lithologic discontinuity, the water will stop moving down and begin to accumulate or move laterally in the soil. This type of situation results in many of the areas, even those high in the landscape, remaining wet for portions of the year especially after spring snowmelt. Not only is this an issue for timely spring planting of crops, but saturated soils are also likely to experience significant soil erosion due to the amount of water running off the land at the soil surface. Lowering water levels in these landscapes may provide the answer farmers are looking for to allow opportune planting dates while also minimizing the loss of valuable topsoil via soil erosion.

Tile lines were installed in a herringbone pattern in the Fall of 1999 across a portion of a hillslope on the Willard Tripp farm just to the west of Cannon City, Minnesota (tile drainage layout). Research staff worked with Rice County staff, the farmer, and the tile installer to assure the layout was acceptable. We also were present to measure the amount of tile line installed and get the exact GPS coordinates of each line. The remaining portion of the hillslope remained in its natural state (undrained). Careful examination of the soils and stratigraphy were completed across the two areas of the hillslope to assure common soils and landscapes existed for hydrologic comparison. Field installation was completed in fall 1999 after the tile lines were installed. We implemented five stations on each the drained portion of the hillslope and the undrained portion for a total of ten monitoring stations (location of nested piezometers). Each station has a set of nested piezometers (1/2-inch diameter PVC pipe with perforations at a discrete depth) that allow us to measure water levels and water movement. During the spring of 2000 we also installed four automated water level recorders at the two lowest landscape stations on each side of the hillslope. Due to abnormally dry conditions during spring and summer 2000, water levels were too low to get readings in the upper 200-cm, so only spring and early summer 2001 data are presented and summarized here. Automated and manual data collection of annual, shallow water table fluctuations along a hillslope to evaluate the potential effects of tile drainage on seasonal patterns of surface runoff and soil moisture storage continues at this site. Electronic water level recorders are constantly collecting and storing fluctuations in water levels. This data is periodically downloaded into a comprehensive database for soil hydrology analyses at this site. The monitoring data collection for this result of the project will require greater than the two-year period to produce reliable interpretations due to seasonal and annual variability in weather patterns. Data will continue to be monitored using the electronic automated recorders and manual (hand) monitoring for data quality assurance.

RESULTS & DISCUSSION

After weekly monitoring of the newly installed tile outlet during the Spring of 2000 and monthly monitoring throughout the year 2000 growing season, there has been no recorded water discharged from the tile drain outlet into the surface stream. After further discussions with the tile installer and experts at the University of Minnesota's Southern Research and Outreach Center in Waseca, we have surmised that the lack of flow from this tile line may be due to the interception of the water by a sand layer in contact with the tile line. This sand layer would act as a conduit for water movement and could preclude the tile drainage water from reaching the surface tile drain outlet. After mentioning the problem to the tile installer, he recalled hitting a sandier textured soil when digging the trenches. This finding impacts the conclusions that may be drawn from this result. Due to these unforeseen issues with the installed tile line, the comparison of seasonal patterns of flow rates from tile outlets and the flow characteristics of the stream at the minor watershed outlet cannot be addressed in this report.

The relationship of hydrologic responses among the hillslope positions on the undrained transect explains the natural or control conditions to be expected on this hillslope. Monitoring data from spring 2001 indicate that the toeslope is the wettest portion of the slope followed by the footslope (Fig. 1). This is expected as these are the two positions in the landscape that are the lowest elevation-wise and receive more water than those positions upslope. The next wettest position was the backslope. Initially it had water above the soil surface, but decreased very rapidly likely due to its high slope. The next position is the shoulder where water levels did not start out as high as on the backslope, but remained saturated within 50 cm (20 inches) of the soil surface until early June 2001. In most landscapes in Minnesota, this may be unexpected due to the high position of the shoulder in the landscape and low contributing area, however because of the unique stratigraphy of dense glacial till underlying coarse silty surface water will perch above this restrictive layer. Especially in very wet springs such as spring 2001 this position will stay quite wet provided a consistent source of precipitation. The summit position showed signs of wetness early in the spring but tended to dry out earlier than other landscape positions due to its high landscape position.

The hydrologic response for the drained portion of the hillslope looks somewhat different than the undrained hillslope (Fig. 2). The pattern of landscape positions from wetter to drier follows the same order as in the undrained transect, with one notable exception. The footslope position on the drained transect has the lowest water level recorded of all landscape positions for the initial reading in early April 2001. This should be the second wettest portion of the landscape under natural conditions. This lowering of the water levels at the drained footslope average 86 cm (34 inches) lower than the corresponding water levels at the undrained footslope. The drained toeslope position also had water levels lower than the undrained toeslope, but differences were between 10-15 cm (4-6 inches).

In comparing the backslope, footslope and toeslope positions between the undrained and the drained transect; we can better understand the effect of tile drainage on the hydrologic responses on this hillslope (Fig. 3). The toeslope position data from the undrained station shows water levels at all depths at or above 15cm until late June 2001 with water levels at or above the surface in early April. By comparison, the drained toeslope has levels reaching down to 34cm below the surface and did not experience saturated conditions to the soil surface. The drained toeslope hydrologic response also appears to experience less dramatic changes in water levels when compared to the undrained toeslope data. The undrained footslope position has water levels similar to the toeslope stations, but significantly closer to the soil surface than the drained footslope position. During early April, there was already a 70cm lowering of the water level in the drained portion of the hillslope due to tile drainage. The tile drainage planed off the hydrologic response of the footslope position through most of the spring. The undrained footslope also displays a more rapid drop in water levels during the months of June and July when compared to the toeslope positions. Although brief, the lowering of the water levels by 70 cm at the backslope position on the drained portion of the hillslope during the early spring probably is the most significant hydrologic response induced by tile drainage with respect to soil erosion. Due to its steep slopes and higher position on the landscape, the backslope is one of the most susceptible positions to soil erosion by water. By lowering its water level by a 70 cm, this greatly minimizes the risk of experiencing soil erosion on this portion of the hillslope. While the footslope and toeslope water levels were also lowered by the installation of tile drainage, these positions are located on areas of the landscape that do not have steep slopes and are therefore not as susceptible to soil erosion.

Anecdotal field observations confer with the collected data. Early spring visits to the site saw standing water along several of the landscape positions on the undrained portion of the hillslope, while the soil surface appeared drier on the drained side. The soil surface was "spongy" feeling to walk on at the undrained side and often afforded the water level recorder muddy boots as the drained side felt solid and no mud at the surface. Along with saturation to the surface, there was evidence that significant soil erosion is taking place on the undrained portion of the field. In almost every inter-row space, 2-5 cm (1-2 inches) deep by 7-10 cm (3-4 inches) wide rills were formed and evident. Crop residue and soil movements were both readily observed at and near the backslope and footslope positions. The drained side of the field has much less evidence of this type of erosion. This is what would be expected after investigating the data collected because no portion of the drained hillslope experienced saturated soil conditions to the surface during spring and early summer 2001 while the undrained hillslope had both the backslope and toeslope possessing saturation at or above the soil surface.

CONCLUSIONS

Seasonal variations in soil hydrologic responses to precipitation in this eastern Rice County agricultural field closely follow our initial hypothesis in that lower landscape positions are wet and remain wet in response to contributions from precipitation and upslope contributions. The steeper backslope position has the largest range in water levels throughout spring and summer 2001. This type of hydrologic response is expected in this portion of the county and is responsible for significant erosional events during seasonally wet periods due to saturated conditions and subsequent runoff at the soil surface along the hillslope.

The installation of tile drainage to these landscapes is a proposed method for minimizing the upland soil erosion. Soil erosion may be curtailed by lowering water levels throughout a hillslope allowing more water to infiltrate into the soil and not runoff at the soil surface. Comparisons between the undrained and the drained portions of the hillslope monitored suggest that tile drainage installed along hillslopes can dramatically lower soil water levels during wetter periods of the year. The water level drops were most noticeable at the backslope and footslope positions. We also saw lowered water levels in the toeslope position (depression), but not to the extent observed in the backslope and footslope positions.

Soil erosion is more likely to occur in areas of the landscape were there is (i) susceptible soils (silty soils); (ii) high soil water levels; and (iii) steep slopes. Since most of eastern Rice County meets criteria one and two, all that is needed for soil erosion to occur is a steep slope. This is the reason that lowering the water level on the backslope position of the hillslope is so important. Our data and anecdotal evidence suggest that while the backslope soil surface may not be saturated for a long period of time during the year, timely precipitation events while the soil is saturated can cause significant soil erosion events. Subsurface tile drainage in eastern Rice County does appear to be an effective means of controlling upland soil erosion.

Minimizing upland soil erosion via subsurface tile drainage may present increased risks down drainage. Risks including increased flooding frequency, flood height, stream bank erosion, and decreased water quality can all be associated with focusing flow from a large upland area to a single tile drain outlet. Unfortunately due to circumstances out of our control, flow from the tile outlet was not monitored due to the interception of all tile waters by a sandy textured soil that intersected the tile line before its outlet. It is our opinion that installing tile drainage on a few hillslopes will not adversely impact down drainage areas, but installing tile drainage across large portions of a watershed may contribute significantly to down drainage problems. Further research may be useful in order to identify the optimal percentages of the watershed to tile drain in order to minimize upland soil erosion without impacting down drainage erosion and flooding. Placing tile outlets into streams with bedrock bottoms may be another way to minimize down drainage erosional problems. The other effect that tile drainage can have on a down drainage area is lowering its water quality. Tile drainage effluent does have the potential to carry environmental contaminants such as pesticides, excess nutrients, and sediment. Due to the efficiency of the drainage system these contaminants are not as likely to be filtered by the soil and can readily be transported to surface waters. Therefore any recommended increase the use of subsurface tile drainage to decrease upland soil erosion in eastern Rice County should not progress without a closer examination of the tile drainage's' water quality and flow at the surface water outlet.

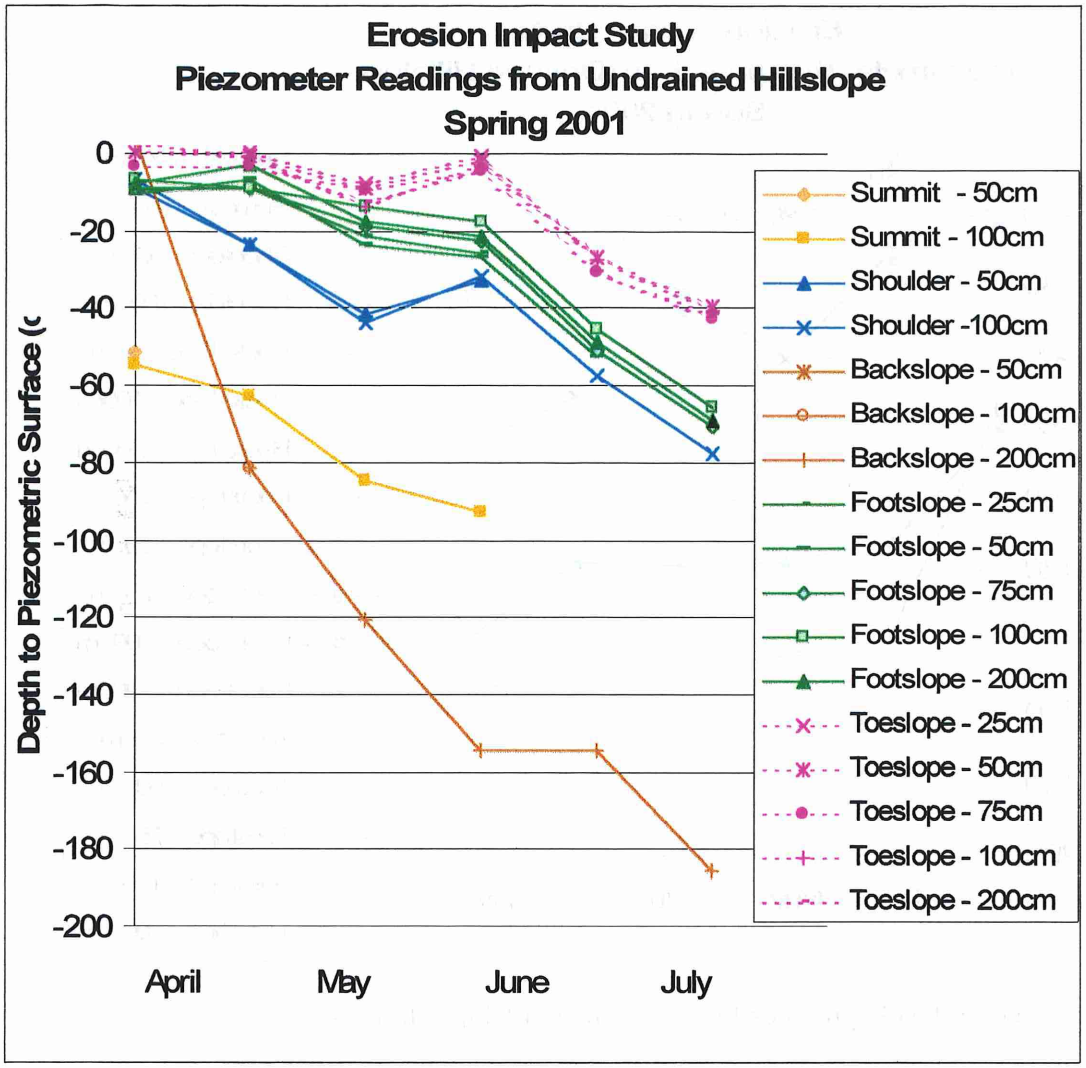

Figure 1. Water level dynamics for the undrained hillslope stations.

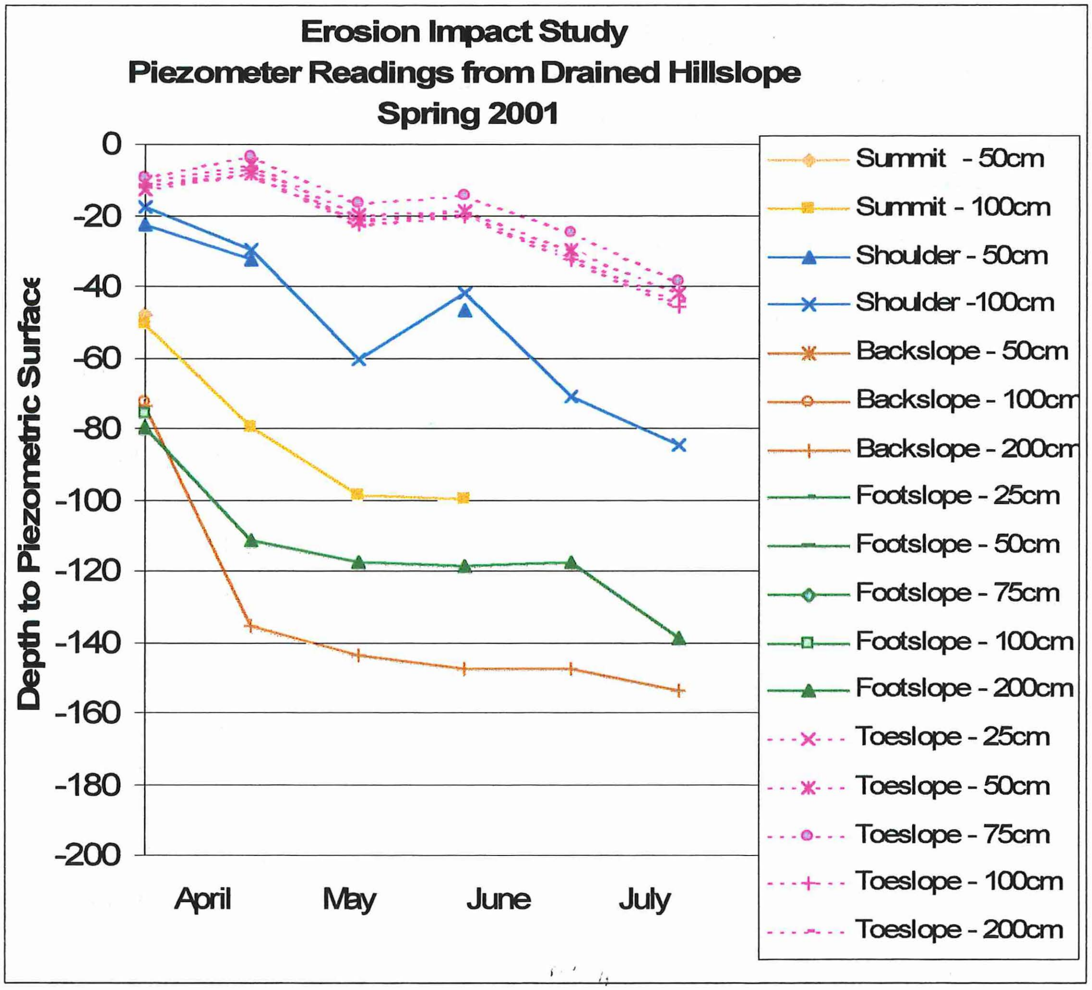

Figure 2. Water level dynamics for the drained hillslope stations.

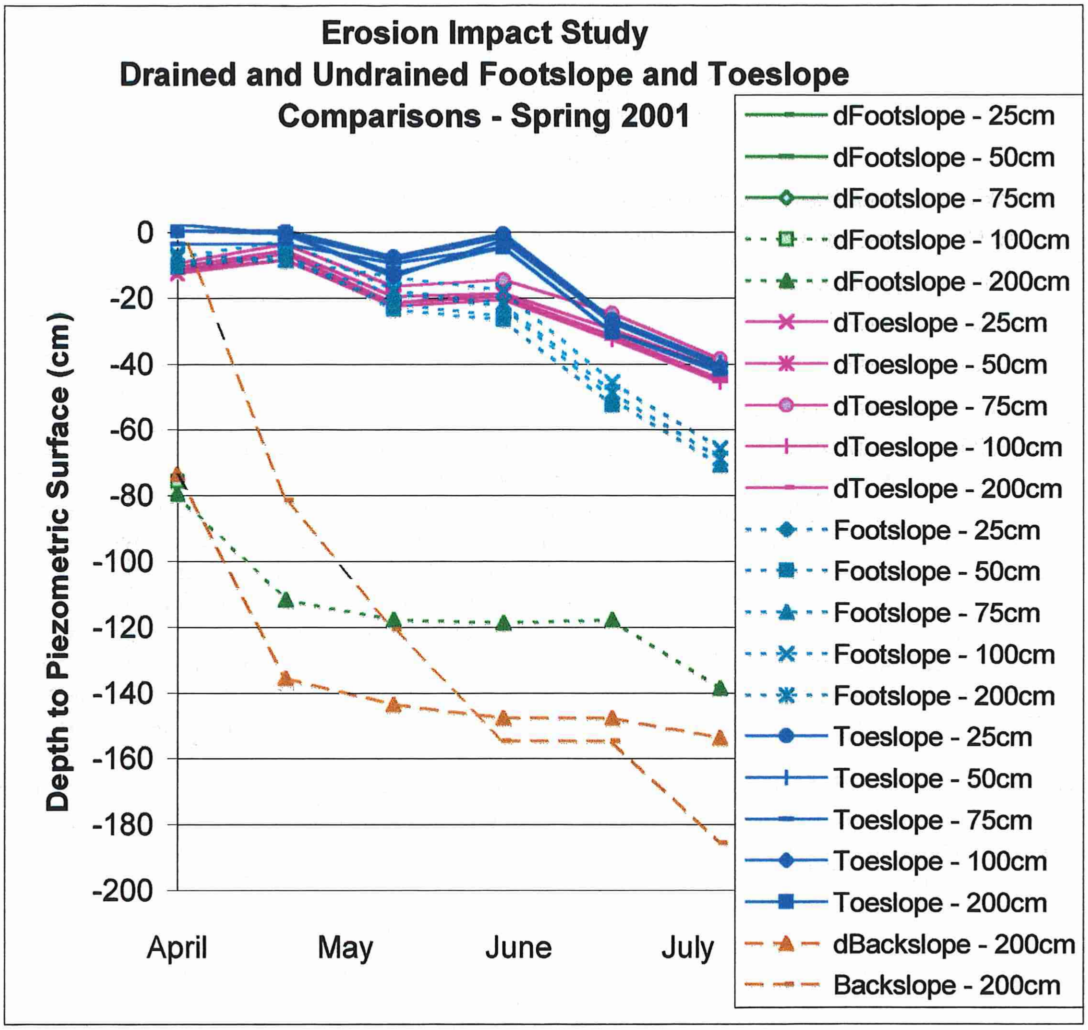

Figure 3. Water level comparisons between the undrained and drained stations for the footslope and toeslope stations.

V. DISSEMINATION:

Dissemination of final products will occur in print form, public forums hosted by the Big Woods Project and through personal contact with all land managers in the study area. Project personnel will conduct a series of workshops in the final months of the project for land managers and county officials explaining the results of the project, implications for land management, and the use and access of the GIS database created as part of this project. An interactive version of the GIS database will be available over the Internet using software tools already developed at the University of Minnesota. As such, potential users will not be required to have any specialized software to access the database, only a modem and Internet browser.

Dissemination-Progress Summary

(06/30/00) GIS data has been used extensively throughout the course of the project to complete analysis, but also to summarize preliminary findings. We have developed a web site (http://www.soils.agri.umn.edu/research/bigwoods/) where those interested in the project may find relevant resources to each facet of this project. Currently, static maps similar to those produced for many presentations are available for viewing and printing. We are also continuing research on the most effective ways to present on-line interactive GIS data to land managers and county officials.

Our soil and GIS information was also used extensively for the DNR Surficial Geology Mapping Project completed during the summer 1999 for the Nerstrand Big Woods State Park.

We have also continued to make progress on related Project activities including:

1. *Collecting soil hydrology data within the Nerstrand Big Woods State Park to study water movement through typical Eastern Rice County landscapes,*
2. *Collecting soil hydrology data within the Nerstrand Big Woods State Park to assess the effects of soil compaction (due to trail placement) on restricting water movement (Graph 1), and*
3. *Completed preliminary investigations of temperature and precipitation patterns that may provide further explanation for the various types of erosion observed in the Cannon Valley Big Woods Region.*

(01/17/01) Dissemination of the preliminary findings of the Erosion Impacts on the Cannon Valley Big Woods Project have continued to be shared with other researchers, land managers, county officials, and local residents via a variety of media. Throughout the duration of the project, we have been updating a project website (http://www.soils.umn.edu/research/bigwoods) with information regarding each of the three project results and associated information. We also update the website to include preliminary data from each result of the projects. This information is accessible to anyone capable of using web browser. GIS data layers used for post-settlement alluvium analysis have been provided to land managers via CD-ROM and via the Internet for their internal and extension activities. Data collected within the Nerstrand Big Woods State Park was shared with county officials and DNR staff at a presentation at the Rice County Government Services Building during the summer of 2000. Field trips to one or more of the research sites have also been provided to local officials and other interested parties in order to illustrate the need for this project and its' anticipated results. Several University of Minnesota classes have utilized one or more of these research sites for a field trip experience where students investigate how the soils and landscapes found in eastern Rice County might play a role in soil erosion and sedimentation and then view some of the locations where the results of erosion and sedimentation are exemplified. We have also presented poster summaries from results 1 and 2 at the 2000 Soil Science Society of America's Annual meeting held in Minneapolis, MN in November (see two posters, reformatted for 8 ½ x 11 paper, attached).

VI. CONTEXT:

A. Significance: Since its formation in 1992, the Big Woods Project has been working to protect and improve the unique cluster of Big Woods remnants found in eastern Rice County. Intensifying land use - both urban and agricultural - increasingly threaten the Big Woods remnants. Soil erosion resulting from overland flow, gully formation, and stream bank erosion are critically important for land management. The unique soils and landscapes of the region present unique land management challenges and make the extrapolation of information from other geomorphic regions within the state of questionable use. Several parks and preserves, containing rare natural features including populations of the endangered Minnesota dwarf trout lily, are located on steep slopes surrounded by farmland or urban development. These areas are experiencing severe erosion. Local advisors require knowledge of soil geomorphic processes in order to make sound recommendations to private and public landowners.

B. Time: Two years, with possible extension of Result 3 if rainfall is extremely atypical.

C. Budget Context: 1. LCMR Budget History: $0. 2. Non-LCMR Budget History: $25,000/yr. NRCS, etc: MN Wet Soil Monitoring Project near Epsom. This study (now ended) provides some background context from the same geomorphic region. 3. TOTAL: $100,000, 1994-1997

1. BUDGET:

Personnel	Researchers: Ed Nater, Professor, and Jay Bell, Associate Professor, University of Minnesota, Department of Soil, Water, and Climate.	In-Kind
	Big Woods Project Steering Committee (Project Manager Brad Carlson, etc.)	In-Kind
	Big Woods Project Water Committee (Chair Harriet Mason, etc.)	In-Kind

	Graduate Student 1 (Results 1&2)	$37,000
	Graduate Student 2 (Result 3)	$37,000
	Undergraduate Assistants (Results 1&2)	$15,000
	Undergraduate Assistants (Result 3)	$10,000
Equipment	Mass Storage, printer, PC (Results 1&2)	$ 5,000
	Monitoring instruments, laptop computer, etc. (Result 3)	$18,000
Acquisition	None	$ 0
Development	None	$ 0
Other	GIS Laboratory Support (Results 1,2&3)	$15,000
	Supplies, Travel and Lodging (Results 1&2)	$ 7,000
	Supplies, Travel and Lodging (Result 3)	$ 6,000
TOTAL		$150,000

2. Submit a budget detail with all the specifics as attached as Attachment A.
   See attachment A.

VII. COOPERATION:
Researchers: Ed Nater, Professor, and Jay Bell, Associate Professor, University of Minnesota, Department of Soil, Water, and Climate. Approximately 5% of their time will be given to this project.

VIII. LOCATION:
The Big Woods Project area of eastern Rice County. (See attached map.)