GIS Assessment of the Lower Minnesota Watershed

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Abstract

Analysis was conducted for forest change over time within the Lower Minnesota Watershed. Areas at high risk for erosion and 1977 forested areas were then compared. Finally, these areas were associated with respect to soil type. Analyses were performed in EPPL7 using EPIC data layers. Results showed an 80% reduction in forest cover within the watershed from 1977 to 1993. In 1977, forested areas were concentrated in the eastern portion of the watershed. In 1993, they were concentrated in the western portion of the watershed. Ninety six percent of areas at high risk for erosion were within one mile of 1977 forested areas. Loam and Sandy Loam made up the greatest proportion of soil type in both 1977 forested areas and areas at high risk for erosion. Although land cover/use data used to create the model of areas at high risk for erosion was from 1969, some broad conclusions are possible. The extensive loss of forest, in the eastern portion of the watershed, will make this area more susceptible to erosion in the future. Loam and Sandy Loam soils are contributing factors to erosion. The high percentage of Loam and Sandy Loam soil types in this area will also contribute to the future risk of erosion.

Introduction

The Resource Analysis Department at Saint Mary's University of Minnesota has taken the opportunity to work with a new Geographic Information System (GIS). Minnesota's Land Management Information Center (LMIC) created the new software. It provides a user interface to LMIC's current Environmental Planning and Programming Language (EPPL7) Geographic Information System. The name of the new software is Environmental Planning Interface Consortium (EPIC). The software includes a CD-ROM with hundreds of thematic layers for the state of Minnesota. These layers allow users the ability to do an unlimited number of spatial analyses.

This paper describes the process used for performing land change analysis on existing thematic layers available from Minnesota's Land Management Information Center. The layers were assembled for licensed Environmental Planning and Programming Language and Environmental Planning Interface Consortium users. EPIC for Windows is a recently released Geographic Information System custom application written for the EPPL Interface Consortium by LMIC. EPIC for Windows was written using an intuitive menu-driven selection system to permit easy access, analysis, display, and file management functions for digital geographic data. It was designed to be as user friendly as possible in order to allow non-typical and casual GIS users to access geoprocessing and GIS related commands without extensive training or capital investment. In all, over four hundred Minnesota "statewide" thematic layers have been assembled for EPIC users and are available on CD-ROM. The data sets are extensive in the natural resource arena. They currently include climatology (temperature, rainfall, hydrology, etc.), forest resources (cover type, forest health, etc.), soil information (type, pH, erosion), ecology (native ranges, ecological zones), geology (elevation, landforms, glacial history, etc.) and administrative data (counties, zip codes, communities, etc.). The layers originated from a variety of sources including the Minnesota Pollution Control Agency, the United States Geological Survey and the University of Minnesota's Soils Department.

This project began with the selection of a study area from the EPIC set of thematic data layers available from LMIC and developing a land change analysis within that area. The study area originally included twelve major watersheds located in southern Minnesota. These twelve watersheds make up the greater Minnesota River Basin. Due to the large area of the combined watersheds the study area was reduced to include only a single watershed. The Lower Minnesota Watershed was chosen because it included a large section of the Minnesota River (Figure 1). The watershed covers an area of 1,164,901 acres in southeastern Minnesota. The Lower Minnesota Watershed lies within Renville, McLeod, Carver, Hennepin, Sibley, Scott, Dakota, Le Sueur, Nicollet, and Rice counties.

Analyses were based upon the data obtainable from individual EPIC layers. Over fifty layers covering the study area were evaluated according to their ability to be used for analysis. The selection was narrowed to layers that provided the

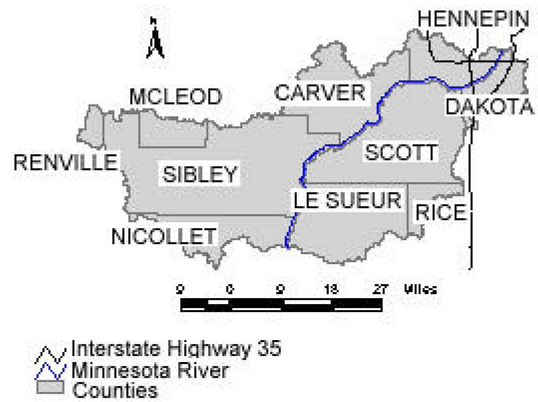

Figure 1. Study area location: Lower Minnesota Watershed.

change analysis. The decision was made to do a comparison of forest change over time using forest data layers for 1977 and 1993 (Figure 2).

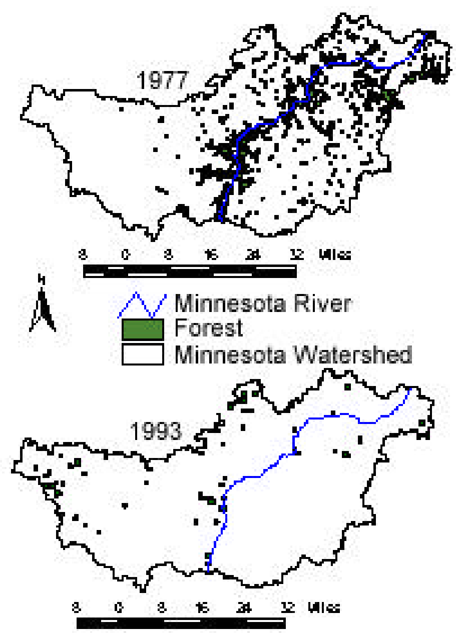

Figure 2. Forest cover within the Lower Minnesota Watershed in 1977 and 1993.

The analysis would be performed in EPPL7 using GIS software, produced by LMIC. After conducting analysis in EPPL7, results were imported to ArcView because of EPPL7 and EPIC's limited display capabilities. After comparing the forest change from 1977 to 1993 and finding a reduction in total forest cover, it was decided to look for a correlation between forest cover loss and areas at high risk for erosion (Figure 3).

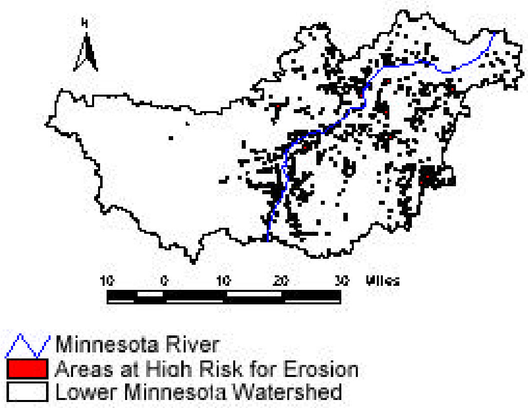

Figure 3. Areas at high risk for erosion in the Lower Minnesota Watershed.

Areas of forest cover loss and high risk for erosion tended to be concentrated within the same general area. The analysis showed a large occurrence of areas at high risk for erosion within one mile of areas covered by forest in 1977. Soil type was brought into the analysis to confirm if the areas at high risk for erosion and 1977 forest consisted of similar soil types. Five EPIC data layers were used in analysis: 1995 major watersheds, 1977 forest cover, 1993 forest cover, areas at high risk for erosion, and soil types. The actual EPIC and EPPL7 naming convention for these covers are listed in Table 1.

All five covers were projected in the North American Datum 1983 (NAD83) with the coordinate system Universal Transverse Mercator (UTM) and the units in meters. The file types were RASTER/POLYGON with cell resolutions of 2.471 acres or 10,000 m^2. All five covers had 100 meter cell sizes. The 1977 forest cover was created with data from DNR Forestry Phase I Survey in cooperation with the United States Forest Service (USFS). The 1993 forest cover was created from Advanced Very High Resolution Radiometer (AVHRR) satellite and FIA data by the USFS in Starkville, MS. The soil types cover was created by modeling 1989 Ground Water Contamination Susceptibility data from the Minnesota Pollution Control Agency (MPCA). The areas at high risk for erosion were created with the Universal Soil Loss Equation (USLE) and LMIC's Minnesota Soil Atlas data. The USLE is briefly explained below:

$$\text{Estimated Soil Loss (tons/acre/year)} = R * K * C * LS$$

Where R = rainfall intensity factor, K = soil erodibility factor, C = land cover factor, and LS = topographic factor (Mellerowicz et. al., 1994). In the creation of the areas at high risk for erosion cover, R was derived from the SCS Technical Guide, K was derived from Surface K Factor data, 1969 Land Use/Cover data was used for C, and LS was derived from slope lengths obtained from the U.S.D.A. Agricultural Research Service (ARS) and slope steepness from USGS 1:250,000 topographic maps.

Methods

The initial steps of the project involved becoming familiar with the capabilities of the recently released EPPL7 and EPIC for Windows software. The Minnesota data layers were loaded into the program after the installation of EPIC for Windows version 1.2. Learning how to use EPIC for

Table 1. Naming conventions for data layers used in analyses.

"Assigned Name"	EPIC Name	EPPL7 Name
1995 major watersheds	Hydro, DNR watersheds, major, 1995	
1977 forest cover	FIA, Forest Cover, 1977	4FORT
1993 forest cover	FIA, Forest Cover, AVHRR, 1993	MNAFTA
soil types	PCA, Soil Material	
areas at high risk for erosion	Soil, High Priority Water Erosion	WATREROS

Windows was achieved with the help of LMIC's EPPL7 Geographic Information System user manual version 3.0 (Anonymous, 1997). The manual included an introduction and tutorial section on EPIC for Windows. Since EPIC for Windows is a new software program, it still has a few errors that are being fixed by LMIC. An update and solutions for these errors was available on LMIC's Internet site. The Minnesota data layers were previously known to include a coverage of major watersheds. A flow chart representing the methods of analysis can be seen in Figure 4. With this information it was decided to select a study area using watershed boundaries and then choose layers that would provide data for this site. A complementary metadata booklet from LMIC was used to gain detailed information about the description, data source, coding procedure, and legend of each individual thematic layer (Anonymous, 1998). The layers were chosen for their ability to provide adequate data in doing an analysis of the study area. The selection of layers meeting this requirement was limited to those that provided forest, geological, climate, hydrology, and soils data. From this list of layers, the type of analysis could be determined based on the specific information provided by those layers. The analysis for this project involved comparing forest cover change over time with areas at high risk for erosion.

A study area was created for analysis in EPIC with the 1995 major watersheds data layer. The statewide data were selected after opening EPIC and the 1995 major watershed data were loaded. After choosing Display from the File menu, Build New Area was chosen from the File menu, followed by Pick Polygons. The polygon representing the Lower Minnesota Watershed was selected from the 1995 major watersheds data layer. Additional data layers were added to the study area by highlighting each layer and pressing the > button to add them to the set in the resulting dialog box. A folder and filename were then specified for the new study area and data layers. Build was then selected from the File menu to create the study area. The data layers were then clipped to the extent of the Lower Minnesota Watershed polygon.

Frequency counts for 1977 and 1993 forest covers were then created in EPPL to identify total numbers of forested cells in each cover, numbers of cells for each forest cover type, and the respective areas and percents of each. This was done with the COUNT command in EPPL. After typing the COUNT command, a Number of Files, Old File, Legend File, and New File were specified. Number of Files referred to the number of files that would be used to generate frequency counts. Old File was the original file that would be used to create a frequency count. Legend File was the associated legend file

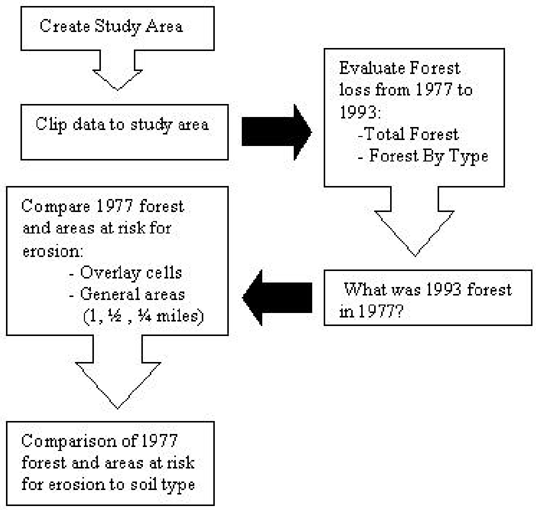

Figure 4. Flow chart representing methods for analysis.

for the Old File. New File referred to the name for the resulting frequency count file.

Forest loss from 1977 to 1993 was then evaluated by selecting areas of forest in 1977 that were also forest in 1993. This was accomplished with the CLIP command in EPPL. Because the CLIP command will only allow one cell class, or value, to be used to clip another cover with, the CLIP process was repeated with each forest class from the 1993 forest cover. After typing the CLIP command, a Clip File, Old File, New File, Description, and Clip Value were supplied. The Clip File was the file used to clip another file (the 1993 forested cover). The Old File referred to the file that would be clipped (the 1977 forested cover). The New File was the name of the resulting clipped 1977 forest cover. The Description referred to an identification for the new clipped file that could be no more than 32 characters long. The Clip Value specified the class, or value, used from the 1993 forested cover to clip the same areas of the 1977 forested cover. The values 8 (Elm-Ash-Cottonwood), 9 (Maple-Beech-Birch), and 6 (Oak-Hickory) were used to perform three clips on the 1977 forest cover. The fourth value, 1, which was equal to Pine in 1993 was not used because the total area was so small it was considered insignificant. The resulting clipped covers showed what areas of the different forest types in 1993 were in 1977. The COUNT command was then used to generate frequency counts of these clipped covers.

Forest cover for 1977 was then compared with areas at high risk for erosion in the watershed. The CLIP command in EPPL was again used to select areas at high risk for erosion that coincided with areas of forest in the 1977 forest cover. Before this could be done it was necessary to reclassify both the 1977 forest cover and areas at high risk for erosion. The different forest cover types in the 1977 forest cover were combined to create one value (Class 1) equal to forest, representing all the forest cover types. Both erosion types in the areas at high risk for erosion cover were also combined to create one value (Class 1) of high risk erosion areas. This was necessary because the CLIP command will allow only one class to be used for clipping. The RECLASS command in EPPL was used to accomplish this task. After typing the RECLASS command, a Number of Files, Old File, New File, and Evaluation Expression were specified.

The Evaluation Expression: 1=3:5 1 was used to reclassify the different 1977 forest types to Class 1, which represented all forest types in 1977. A textual representation of the expression would be: New Class = Class 3 through 5 and Class 1 (from the original 1977 forest cover). This process was then repeated for the areas at high risk for erosion cover using the expression: 1=1:2, where 1:2 represented the two erosion classes from the original cover of areas at high risk for erosion. The resulting reclassed areas at high risk for erosion cover was then used to clip the coinciding areas of the reclassed total 1977 forest. The CLIP command was used in EPPL again for this purpose. A frequency count of the clipped cover was created with the COUNT command to show areas of forest coinciding with areas at high risk for erosion.

The actual number of cells identified in the above frequency count was relatively low (12%), even though both 1977 forest and areas at high risk for erosion were concentrated in the same area when visually comparing the covers. A buffer of the reclassed 1977 forest was then created to identify the number of cells for areas at high risk for erosion within the general surroundings of the 1977 forested areas. A buffer distance of one mile was chosen to represent those general surroundings. Buffer distances of 1/2 mile and 1/4 mile were also used to clip the cover and were found to contain fewer areas at high risk for erosion as the distance decreased. This was accomplished by first buffering the reclassed 1977 forest cover and then clipping the reclassed areas at high risk for erosion cover to that buffered 1977 forest cover.

The BUFFER command in EPPL was typed and an Old File, New File, Description, Radius, and Direction were then supplied. The Radius specified the buffer width in cells. Because the covers contained 100 meter cells, 16 was supplied as the Radius in cells. Sixteen was chosen for the radius because one mile is equal to 1,609.34 meters and 16 cells at a cell width of 100 meters is equal to 1,600 meters, or about one mile. Direction referred to the angles at which the reclassed 1977 forest would be buffered. The default Direction, 4, in EPPL was used to buffer the 1977 forest cells in all angles. The default direction is the most accurate buffer option because it buffers a cell in a circle, not just to the top, bottom, and sides. The buffered 1977 forest cover was then used to clip the reclassed areas at high risk for erosion cover. The process was then repeated using buffer distances of 1/2 mile (Radius = 8), and 1/4 mile (Radius = 4).

After finding a strong inverse correlation between 1977 forested areas and areas at high risk for erosion in the watershed, both areas were compared to soil type for any further potential correlation. The reclassed 1977 forest cover and reclassed areas at high risk for erosion were then used to clip the soils type cover to the same areas of both covers. This was again done with the CLIP command in EPPL, and frequency counts of the results were generated with the COUNT command.

Results were exported from EPPL7 to ArcView for display with the EXPORT command in EPPL. Raster covers were exported by typing EXPORT, selecting EPP from the EPPL7 File Type menu, navigating to the EPPL file, navigating to the EPPL LEGEND file, and then choosing SHAPE for the Export File Type. Vector covers were exported by typing EXPORT, selecting DGT from the EPPL7 File Type menu, navigating to the vector file, and choosing SHAPE as the Export File Type.

Results and Discussion

Analysis

Descriptions of forest cover types, cell classes, counts, area, and percent area are shown for 1977 forest and 1993 forest in Table 2. Because forest cover type categories are different for the 1977 forest and 1993 forest covers, only general comparisons can be made between the covers. Total forested areas decreased from 92,791 acres in 1977 to 18,318 acres in 1993. In other words, there was a loss of 80% of the total overall forested areas in the watershed from 1977 to 1993. Total area of Elm-Ash-Cottonwood decreased from 60,626 to 5,179.22 acres from 1977 to 1993. Pine decreased from 118.61 to 34.59 acres. Total areas of Oak in 1977 were 26, 822.71 acres while the total area of Oak-Hickory in 1993 was 2,727.98 acres. Although the categories changed from Oak to Oak-Hickory, it is still evident that Oak decreased significantly. Similarly, the categories including Maple also changed from Maple-Basswood in 1977 to Maple-Beech-Birch in 1993. A general observation can still be made that these areas increased from 5,223.69 acres in 1977 to 10,375.73 acres in 1993.

The results of identifying what 1993 forest cover types were in 1977 can be seen in Table 3. Areas of Elm-Ash-

Table 2. Forest cover for 1977 and 1993 in the Lower Minnesota Watershed.

Year	Class	Count	% Area	Area (acres)	Legend
1977	1	48	0.01	118.61	Pine
	3	10855	2.30	26822.71	Oak
	4	24535	5.20	60625.99	Elm-Ash-Cottonwood
	5	2114	0.45	5223.69	Maple-Basswood
	9	433877	92.03	1072110.07	Undefined
1993	1	14	0.00	34.59	Pine
	6	1104	0.23	2727.98	Oak-Hickory
	8	2096	0.44	5179.22	Elm-Ash-Cottonwood
	9	4199	0.89	10375.73	Maple-Beech-Birch
	23	463683	98.36	1145760.69	Non-forest Area
	24	333	0.07	822.84	Water

Table 3. What 1993 forest cover types were in 1977 in the Lower Minnesota Watershed.

What Class 8: Elm-Ash-Cottonwood in 1993 was in 1977

Class	Count	% Area	Area (acres)	Legend
3	433	20.66	1069.94	Oak
4	175	8.35	432.43	Elm-Ash-Cottonwood
5	18	0.86	44.48	Maple-Basswood
9	1470	70.13	3632.37	Undefined

What Class 9: Maple-Beech-Birch in 1993 was in 1977

Class	Count	% Area	Area (acres)	Legend
3	42	1.00	103.78	Oak
4	71	1.69	175.44	Elm-Ash-Cottonwood
5	20	0.48	49.42	Maple-Basswood
9	4066	96.83	10047.09	Undefined

What Class 6: Oak-Hickory in 1993 was in 1977

Class	Count	% Area	Area (acres)	Legend
3	193	17.48	476.90	Oak
4	176	15.94	434.90	Elm-Ash-Cottonwood
9	735	66.58	1816.19	Undefined

Cottonwood in 1993 were predominantly (70%) Undefined (non forested area) in 1977. Of the Elm-Ash-Cottonwood in 1993, Oak consisted of 21% of the total area of the watershed in 1977. Areas of Maple-Beech-Birch in 1993 consisted of mostly (97%) Undefined (non forested area) in 1977. Areas of Oak-Hickory in 1993 were 67% Undefined, 17% Oak, and 16% Elm-Ash-Cottonwood in 1977. This would suggest that areas of forest in 1993 were in different places than areas of forest in 1977, because most 1993 forest was Undefined (non forested area) in 1977. Figure 1 supports this idea because it shows that in 1977 forested areas were concentrated in the eastern portion of the watershed while they were concentrated in the western portion of the watershed in 1993. This also suggests that the majority of forest in 1993 was young forest because it developed sometime after 1977.

When comparing 1977 forest to areas at high risk for erosion, it is evident that both are concentrated in the eastern portion of the watershed. Of the 37, 552 total 1977 forest cover cells, 4,438 coincided exactly with cells at high risk for erosion. This translates into about 12%. After buffering the 1977 forested cells by 1/4 mile, 1/2 mile, and 1 mile, it was found that 9,192 cells, 15,369 cells, and 26,620 cells coincided with areas at high risk for erosion, respectively. These totals would translate into percentages of 33 at 1/4 mile, 55 at 1/2 mile, and 96 at 1 mile.

Soil type was then compared to areas of 1977 forest and areas at high risk for erosion to find possible similarities in soil type between them. Soil types within the 1977 forested areas and areas at high risk for erosion can be seen in Table 4 and Figure 4. The most predominant soil type within 1977 forested areas was Loam (52%), followed by Sandy Loam (19%), and Sand (15%). Similarly, the most predominant soil type within areas at high risk for erosion was Loam (60%), followed by Sandy Loam (17%), and Sand (7%). This would suggest a strong correlation between soil types of Loam and Sand with areas at high risk for erosion.

Because land cover/use data used to create the areas at high risk for erosion model was from 1969, direct correlation between the model and 1977 forested areas would not be entirely accurate. Attributing the areas at high risk for erosion to the loss of 1977 forest would be incorrect since the model used forest data from the 1969 land cover/use cover. Investigation of another erosion risk model using the USLE in the Lower Minnesota Watershed created by the University of Minnesota Soils Department revealed areas at risk for erosion to be even more extensive than the EPIC model reflected (Anonymous, 1998). Because of this, general conclusions can still be made since there was such an extensive loss of forest in the area from 1977 to 1993. Although areas of forest in 1977 and coinciding areas at high risk for erosion were found to be low (12%), areas at high risk for erosion within one mile of 1977 forested areas were high (95.5%). This would be expected because as the area of 1977 forest increased, which was no longer present in 1993, the total area at risk for erosion also increased.

According to Smith (1992), soil becomes vulnerable to erosion when stripped of its vegetative cover. The removal of that vegetation results in the loss of soil integrity and increased surface water runoff. Agriculture is the predominant land use within the watershed, which is also a strong factor of erosion. County land cover/use statistics from the Minnesota Agricultural Statistics Service for 1996 reported percentages of cropland for Nicollet of 76%, 67% for Le Sueur, 55% for Carver, 47% for Scott, and 78% for Sibley counties (Anonymous, 1998). These five counties account for most of the total area of the watershed. It has been found that natural forest and agroforesty are the land uses most conducive to soil conservation (Rai, 1998). The continued loss of forest in the watershed, which is predominantly agricultural, will inhibit soil conservation in the future. Both areas of forest in 1977 and areas at high risk for erosion had high percentages of the same soil types. This would support the conclusion that areas suffering forest loss with loam and sandy loam soil types are more susceptible to erosion.

Table 4. Soil types for 1977 forest and areas at high risk for erosion in the Lower Minnesota Watershed.

1977 Forest

Class	Count	% Area	Area (acres)	Legend
1	1016	2.71	2510.54	Water
3	2068	5.51	5110.03	Clay Loam
4	692	1.84	1709.93	Silt Loam
5	19619	52.24	48478.55	Loam
6	6991	18.62	17274.76	Sandy Loam
7	1216	3.24	3004.74	Peat
8	5491	14.62	13568.26	Sand
9	459	1.22	1134.19	Thin or Absent

Areas at High Risk for Erosion

Class	Count	% Area	Area (acres)	Legend
1	508	1.82	1255.27	Water
3	1613	5.79	3985.72	Clay Loam
4	780	2.80	1927.38	Silt Loam
5	16822	60.34	41567.16	Loam
6	4867	17.46	12026.36	Sandy Loam
7	1090	3.91	2693.39	Peat
8	1830	6.56	4521.93	Sand
9	367	1.32	906.86	Thin or Absent

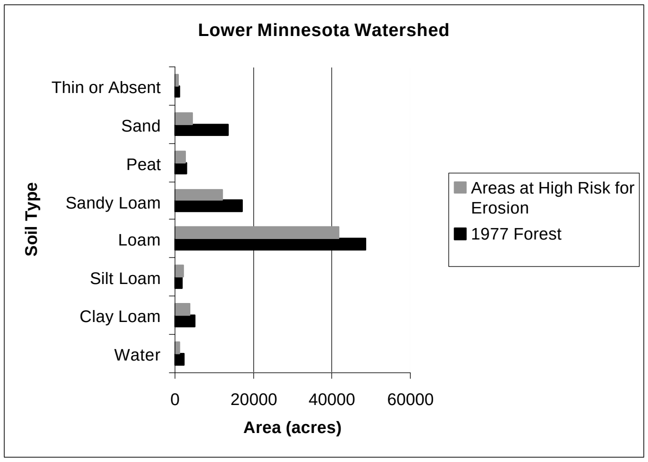

Figure 4. Soil types for areas at high risk for erosion and 1977 forest within the Lower Minnesota Watershed.

Potential Error

Although a significant loss in total forested areas from 1977 to 1993 was found in the Lower Minnesota Watershed, the fact that the 1977 forest cover and 1993 forest covers were created from different types of data must be taken into account. Classification of forest cover and type probably varied between survey procedures for the DNR Forestry Phase I Survey, which was used to create 1977 forest data, and classification procedures of forest cover in the AVHRR data used for the 1993 forest cover. Another issue of potential error is rectification. Most of the statewide 100 meter covers included with EPIC were originally encoded at a 40 acre cell resolution. These covers were then projected to North American Datum 1927 (NAD27) and rescaled to 100 meters. In 1998, LMIC then shifted the statewide data to NAD83, resulting in an actual Y shift of approximately 214 meters. The introduction of potential error into data from projecting covers to NAD27, rescaling to 100 meter cells, and then shifting to NAD83 must be taken into consideration when looking at the results.

EPPL7/EPIC

EPPL7 is an inexpensive and effective GIS with a number of analytical and display tools. It is simple to use and easily understood when using the comprehensive manual supplied with the software. An online help system is also contained within EPPL7 for a quick reference guide. Although EPPL7 works in Microsoft DOS and is command line oriented, which adds some user unfriendliness, file navigation can be done with a mouse. This is very helpful if one forgets their file tier. EPIC is a user friendly window's interface for EPPL7 which allows a user to see data very quickly by clicking a few buttons. EPIC allows a user with no knowledge of EPPL7 to conduct simple analysis with EPPL7 through EPIC. A user can perform reclasses, buffers, and interpolations, create new study areas and generate frequency reports of data layers. EPIC comes with an extensive natural resources data set for the state of Minnesota and the seven county metro region.

For this analysis EPIC and EPPL7 were probably not the best GIS's available. The statewide covers used were represented by 100 meter cells, which is extremely coarse, resulting in a poor resolution for analysis. The 1977 and 1993 forest data were taken from different sources, which may have affected the results. The variation of categories for forest cover types also made direct comparisons impossible. While becoming familiar with EPPL7 and EPIC it was found that they have limited display capabilities which were undesirable for displaying this analysis. When trying to bring the results into ArcView for enhanced display difficulties were encountered. After trying to export data from EPPL7 to ArcView for better display, runtime errors were often encountered, revealing EPPL7 and EPIC's poor ability to be interfaced with ArcView.

Conclusion

Areas of forest were found to have changed in forest type from 1977 to 1993. Further analysis could be performed to determine why these areas changed in forest cover type. Changes in cover type could be related to insect pests, weather conditions, or land use patterns. Most forest cover in 1993 was also found to have developed after 1977, meaning it is predominantly young forest. After finding almost all 1977 forested areas were no longer present in the eastern portion of the watershed in 1993, and a concentration of areas at high risk for erosion in this area, it can be concluded that forest loss is a contributing factor to erosion in the watershed. Loam and sandy loam were found to be the prevalent soil types in this area, suggesting a correlation between 1977 forest and areas at high risk for erosion.

Potential errors with EPPL7/EPIC data must be taken into consideration when using the data. The statewide EPPL7 and EPIC data sets should only be used for general understandings and at broad levels. EPPL7 is an inexpensive GIS with many powerful capabilities which is suitable for beginning GIS users. The EPIC interface provides novice users quick and relatively easy access to an extensive Minnesota data set with some limited analysis capabilities.

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References

Anonymous. 1997. *The EPPL7 Geographic Information System, User Manual, Version 3.0.* The Land Management Information Center. St. Paul, MN.

Anonymous. 1998. County Land Use Statistics. Internet. Minnesota River Agricultural Basin Web's Home Page. Dept. Soil, Water, and Climate. Univ. MN. http://solum.soils.umn.edu/research/mn-river/doc/lanuse.html

Anonymous. 1998. Lower Minnesota Watershed, Potential Risk for Soil Erosion by Water. Internet. Minnesota River Agricultural Basin Web's Home Page. Dept. Soil, Water, and Climate. Univ. MN. http://solum.soils.umn.edu/research/mn-river/images/images2/lo_rkls.gif

Anonymous. 1998. *MGC 100 Data Documentation*. The Land Management Information Center. St. Paul, MN.

Mellerowicz, K.T., H.W. Rees, and I. Ghanem. 1994. Soil conservation planning at the watershed level using the Universal Soil Loss Equation with GIS and microcomputer technologies: A case study. *J. Soil and Water Conservation*. 49:194-200.

Rai, S. C. 1998. Hydrology and nutrient flux in an agrarian watershed of the Sikkim Himalayas. *J. Soil and Water Conservation*. 53:125-132.

Smith, R. L. 1992. Soil erosion, pp. 150-152. In *Elements of Ecology*, Third Ed. HarperCollins, New York.