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Agricultural & Biological

Great Lakes Basin Water Quality Analysis Using L-THIA Model in Desktop GIS

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Abstract

The objective of this project is to provide a scientific estimate of the surface runoff and water quality within the Great Lakes watershed. A "Big Data" Long-term Hydrologic Impact (L-THIA) model was used for the analysis inside an ArcMAP user interface. The entire Great Lakes basin was analyzed, in addition, the Great Lakes Areas of Concern (GLAOC) were individually analyzed to highlight remedial efforts in this area. The model used national land coverage data (NLCD) for the years 2001, 2006 and 2011 to give a comparison over a 10 year period. The general observation was an increase in urbanization between 2001 and 2006 which resulted in an increase in runoff and decrease in water quality. A similar trend existed from 2006 to 2011, however, the rate of water quality degradation had decreased.

Introduction

The aim of this project is to estimate changes in runoff, and nonpoint source (NPS) pollution resulting from past land use changes in the Great Lakes Area. The problem is that there has been a trend in a decrease in water quality that threatens to damage marine ecosystems. In addition, the Great Lakes significance to the US economy is highlighted by its use in fisheries, tourism, shipping, recreation and as a freshwater supply.

In 1972 the Great Lakes Water Quality Agreement was established between the US and Canada, and Areas of Concern(AOC) were identified within respective country boundaries. The US government has invested heavily in remedial action within these areas and this is expected to be reflected by improved land use policy making. Therefore, it is expected that although there is to be an overall degradation in water quality, in these areas signs of improvement should be evident.

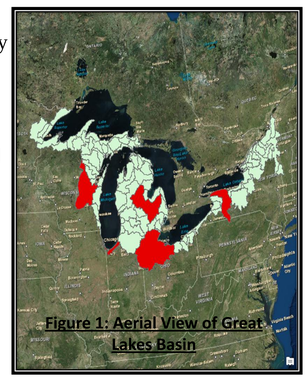

Figure 1: Aerial View of Great Lakes Basin

Constraints

- Land Use data for Canadian territories is inaccessible
- Focuses on average long term impact, rather than storm event
- L-THIA produces an estimate so results are qualitative in nature
- Climate/ Rainfall (CLIGEN) data statistically generated
- Point source pollution is not within the scope

Method

I. The java tool is used to generate average annual runoff based on SCS CN Number runoff equations
II. Land use and soil maps are used to generate CN maps for 2001, 2006 and 2011
III. A java tool is used to generate average annual runoff from daily CLIGEN precipitation data
IV. Surface runoff and non-point source concentrations reports are generated based on event mean concentration (EMC) table for study areas.

ArcMAP User Interface

- Tools that allowed geoprocessing on raster layers and shape files
- Platform for L-THIA Python Tool
- Allowed for easy data visualization
- Instrumental in spatial referencing

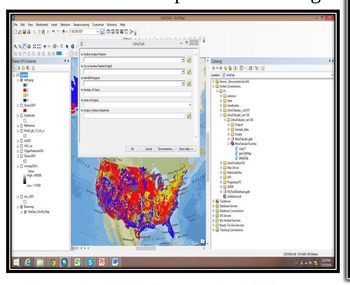

Figure 2: L-THIA Tool and ArcMAP Interface

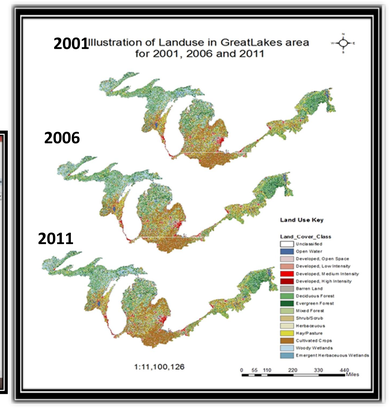

Figure 3: Land Use Change in Great Lakes Basin

Results

Figure 4: Line Chart Highlighting Percent Change in Land Use

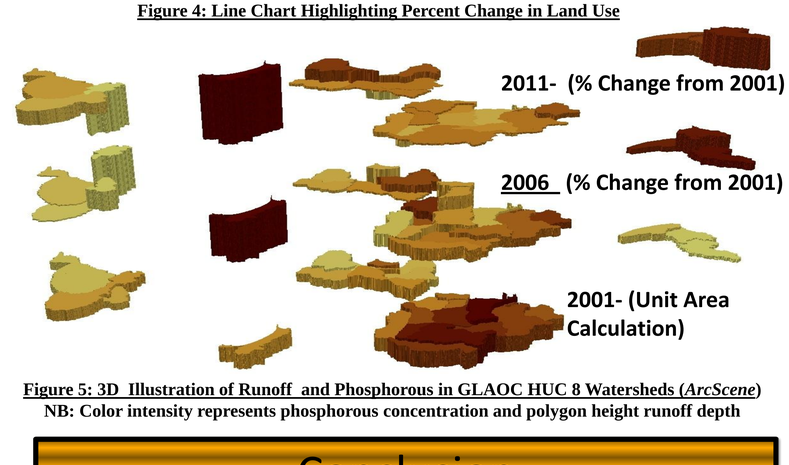

Figure 5: 3D Illustration of Runoff and Phosphorous in GLAOC HUC 8 Watersheds (*ArcScene*)
NB: Color intensity represents phosphorous concentration and polygon height runoff depth

Table 1: Estimates of Runoff and Non-point Source (NPS) pollution in the Great Lakes Basin

Year	Runoff depth (ft.)	Runoff Volume (ac-ft)	TSS Tonnes	P Tonnes	Ni Tonnes	Pb Pounds	Cu Pounds	Zn Pounds	E-coli MPN/100ml
2001	0.1243	9656621	378854	5953	22443	81587	213342	677507	1118
2006	0.1248	9693243	382225	5966	22503	83416	215102	703704	1133
2011	0.1251	9716449	384611	5973	22538	84785	216343	723433	1146

Table 2: Estimates of Runoff and Non-point Source (NPS) pollution in the Great Lakes Areas of Concern

Year	Runoff depth (ft)	Runoff Volume (ac-ft)	TSS Tonnes	P Tonnes	Ni Tonnes	Pb Pounds	Cu Pounds	Zn Pounds	E-coli MPN/100ml
2001	0.1568	2900077	199854	3320	11039	20434	43626	209770	1235
2006	0.1573	2910329	200624	3318	11040	21062	44262	218524	1260
2011	0.1578	2919557	201376	3317	11044	21621	44808	226346	1279

Conclusion

In essence, in the entire Great lakes Basin there has been a decrease in water quality due to non-point source pollution in the period 2001 to 2011. It must be highlighted that in the latter five years of this period the rate of this degradation had decelerated. Furthermore, in the Areas of concern, in which remedial action was heavily invested, many water quality parameters indicated in 2011 have shown signs of significant improvements .

References

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