# Effects of Historic and Current Land Covers on Water Budget and Water Quality in Agricultural Regions of Michigan and Wisconsin:

# SWAT Model Report 040303 (Lake Michigan)

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## 1.0 General Information

The Lake Michigan Basin lies on the East edge of Wisconsin. The basin has a mild topography with minimum elevation of 176m and the maximum elevation reading 381m, with a mean of 276m. The catchment has a total area of 861 thousand hectares (or 2.13 million acres). A relief map is shown in figure 1.

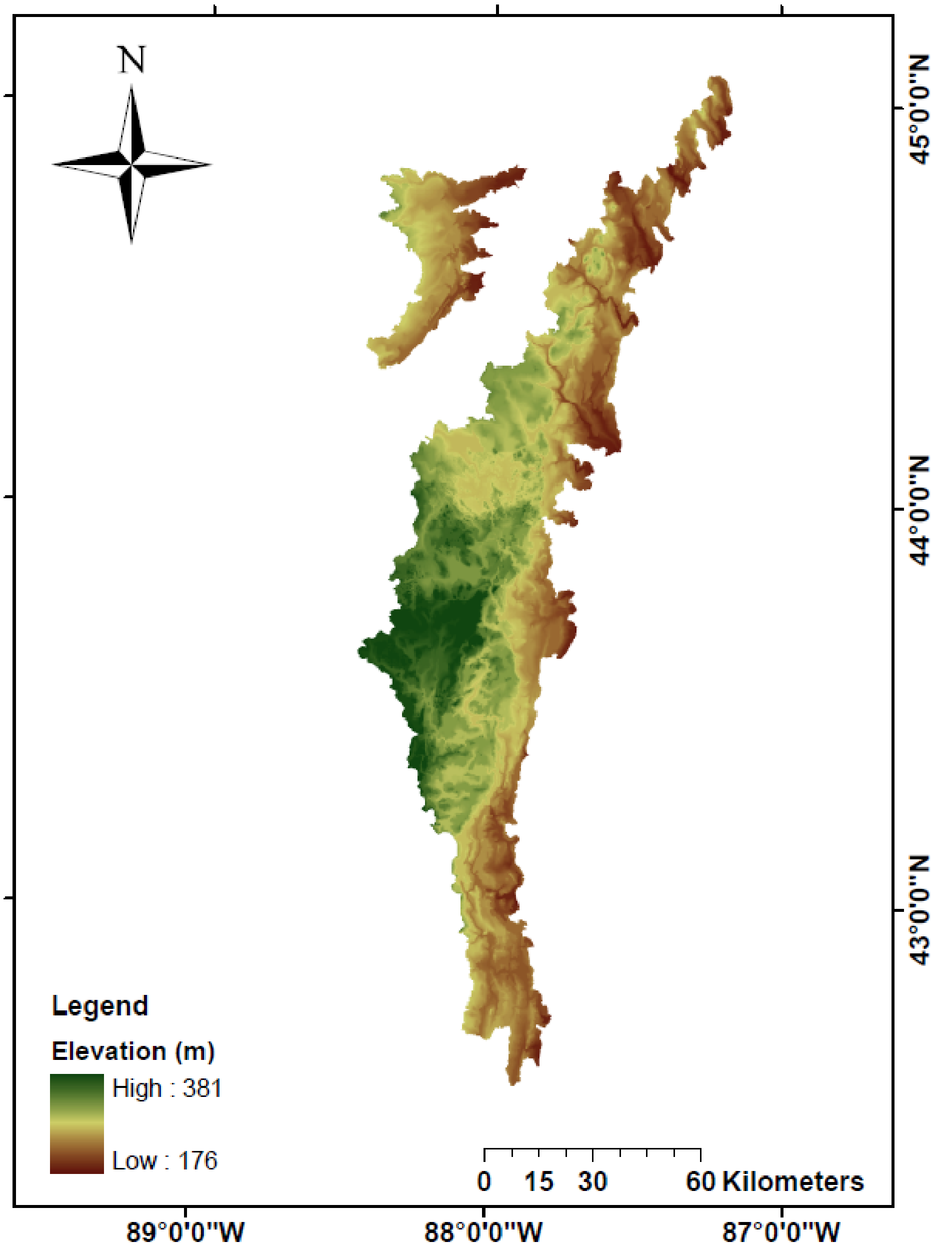



Figure 1. Relief map of the Lake Michigan Basin

## 2.0 River Network

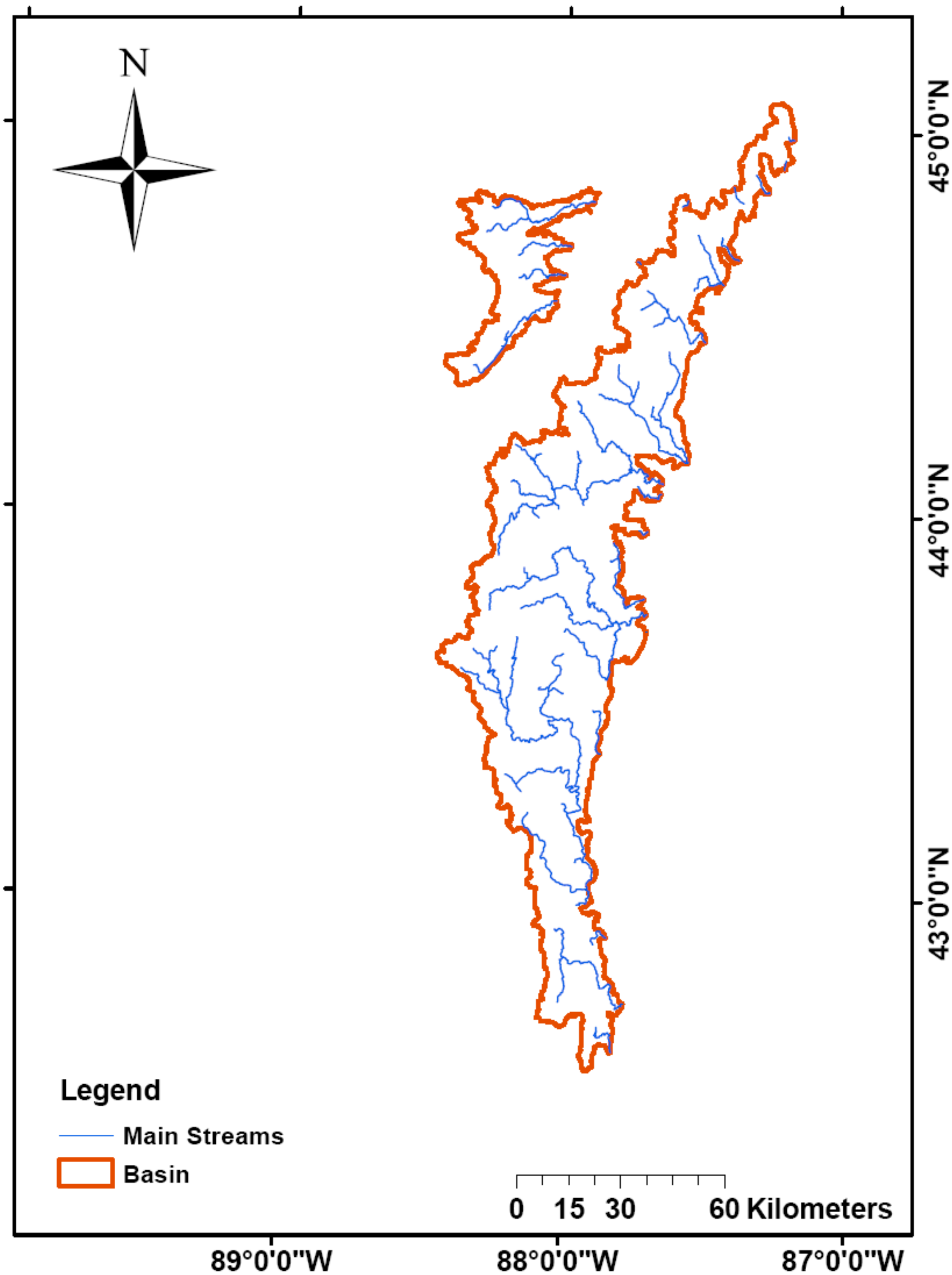



Figure 2. Major streams of the Wolf Basin

# 3.0 Landuse/Land Cover map

Two set of maps were used in this study.
1) 2001 National Land Cover Dataset (NLCD 2001)
2) Landuse Circa 1800 County Base (LU1800) Edition: 1.

Based on the 2001 National Land Cover Dataset, cropland in the Lake Michigan Basin Watershed is the predominant land usage covering 59 percent of land area. Urban land covers 15 percent of the watershed area. Forest, wetlands, rangelands, and water constitute the remaining 26 percent of land cover (Tables 1a and 1b). In the Lake Michigan Basin, large urban development is found along the coast, with agriculture and other landuses inland (Figure 3).

Table 1a. Landuse of the Lake Michigan Basin ranked by area (NLCD 2001)

| LANDUSE: | AREA (ha) | PERCENTAGE |
|---|---|---|
| Agricultural Land-Row Crops | 295613.8 | 34.3 |
| Hay | 212825.6 | 24.7 |
| Forest-Deciduous | 94001.3 | 10.9 |
| Wetlands-Forested | 74788.2 | 8.7 |
| Residential-Medium Density | 55070.1 | 6.4 |
| Residential-Low Density | 39634.7 | 4.6 |
| Residential-High Density | 24638.9 | 2.9 |
| Wetlands-Non-Forested | 17989.6 | 2.1 |
| Range-Grasses | 15227.1 | 1.8 |
| Industrial | 9086.8 | 1.1 |
| Range-Brush | 8380.6 | 1.0 |
| Water | 5770.8 | 0.7 |
| Forest-Evergreen | 5102.8 | 0.6 |
| Range-Other | 1021.5 | 0.1 |
| Forest-Mixed | 1045.8 | 0.1 |

Table 1b. Landuse of the Lake Michigan Basin given by coarse classification (NLCD 2001)

| | |
|---|---|
| Agriculture | 59.1% |
| Urban | 14.9% |
| Forest | 11.6% |
| Wetland | 10.8% |
| Range | 2.9% |
| Water | 0.7% |

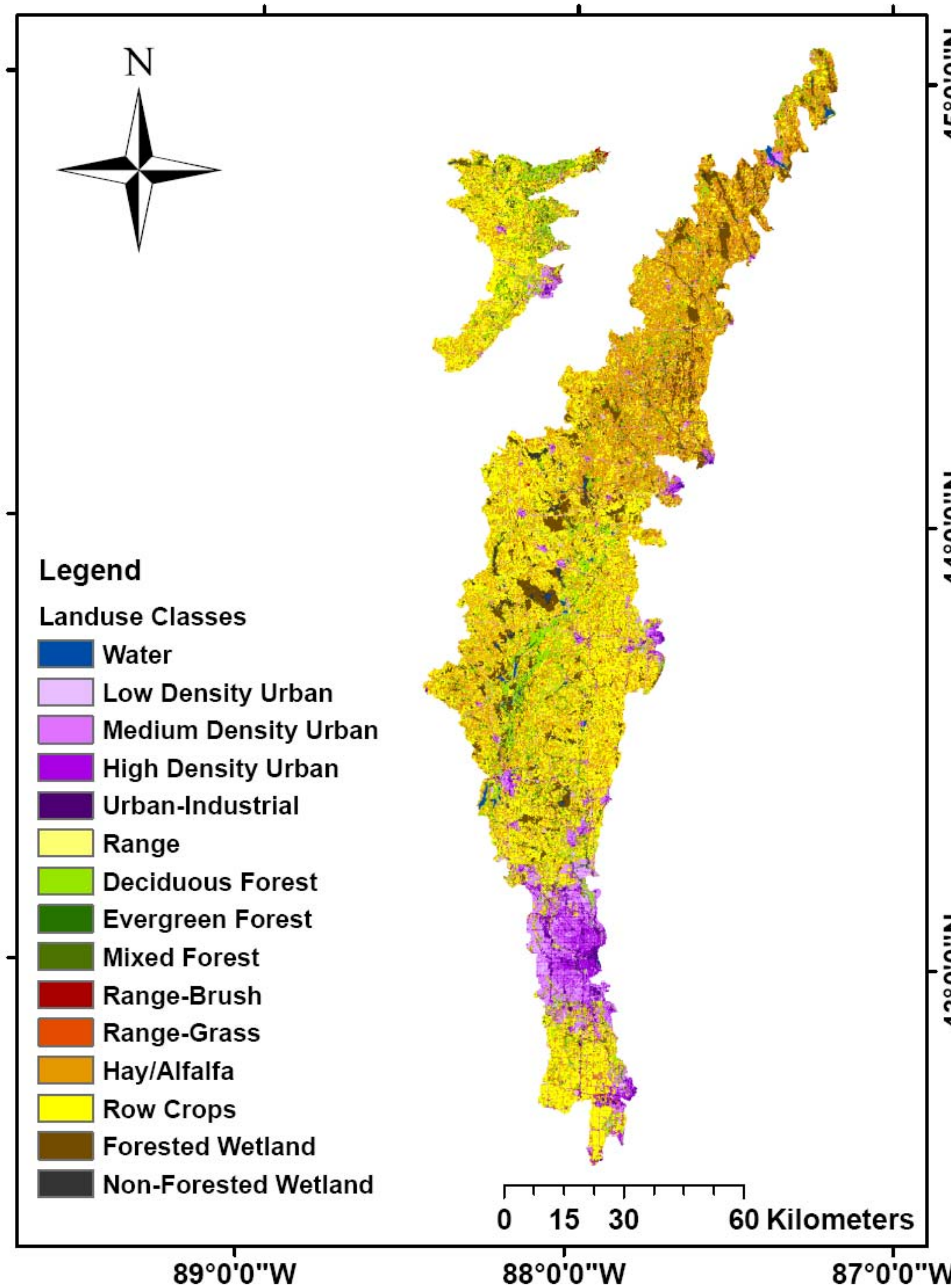



Figure 3. Current landuse map of the Lake Michigan Basin

Based on the Landuse circa 1800 county base (LU1800), forest was the predominant land usage in the Lake Michigan Basin covering 82 percent of land area. Wetlands covered 13 percent of the land area. Rangeland and water constitute the remaining 5 percent of land cover (Tables 2a and 2b). In the Lake Michigan Basin, mixed forest dominates its northern upland and deciduous forest dominates the southern area (Figure 4). Range and wetlands are scattered throughout the basin.

Table 2a. Landuse of the Lake Michigan Basin ranked by area (LU1800)

| LANDUSE: | AREA (ha) | PERCENTAGE |
|---|---|---|
| Forest-Deciduous | 563651.1 | 65.5 |
| Forest-Mixed | 140063.8 | 16.3 |
| Wetlands-Forested | 102377.0 | 11.9 |
| Range-Grasses | 32245.8 | 3.8 |
| Wetlands-Non-Forested | 8938.9 | 1.0 |
| Range-Brush | 6304.2 | 0.7 |
| Water | 5167.4 | 0.6 |
| Forest-Evergreen | 1366.0 | 0.2 |

Table 2b. Landuse of the Lake Michigan Basin given by coarse classification (LU1800)

| | |
|---|---|
| Forest | 81.9% |
| Wetlands | 12.9% |
| Rangeland | 4.5% |
| Water | 0.6% |
| Urban | 0.0% |
| Agriculture | 0.0% |

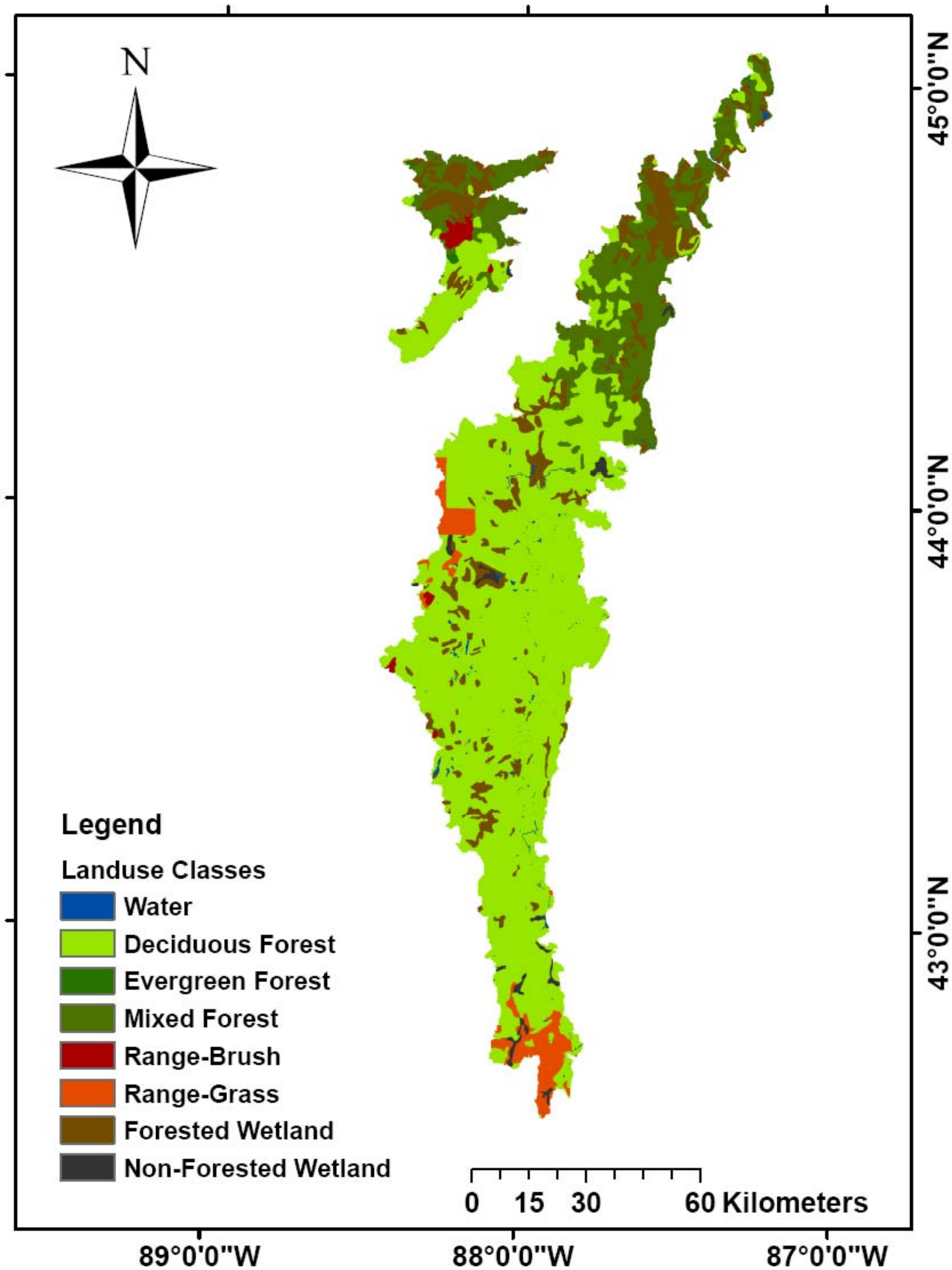



Figure 4. Pre-Settlement landuse map of the Lake Michigan Basin

## 4.0 Hydrologic Soil Groups

The Natural Resources Conservation Service (NRCS) - National Cartography and Geospatial Center (NCGC) developed the State Soil Geographic (STATSGO) Database. Figure 5 shows the hydrologic soil group for the Lake Michigan Basin.

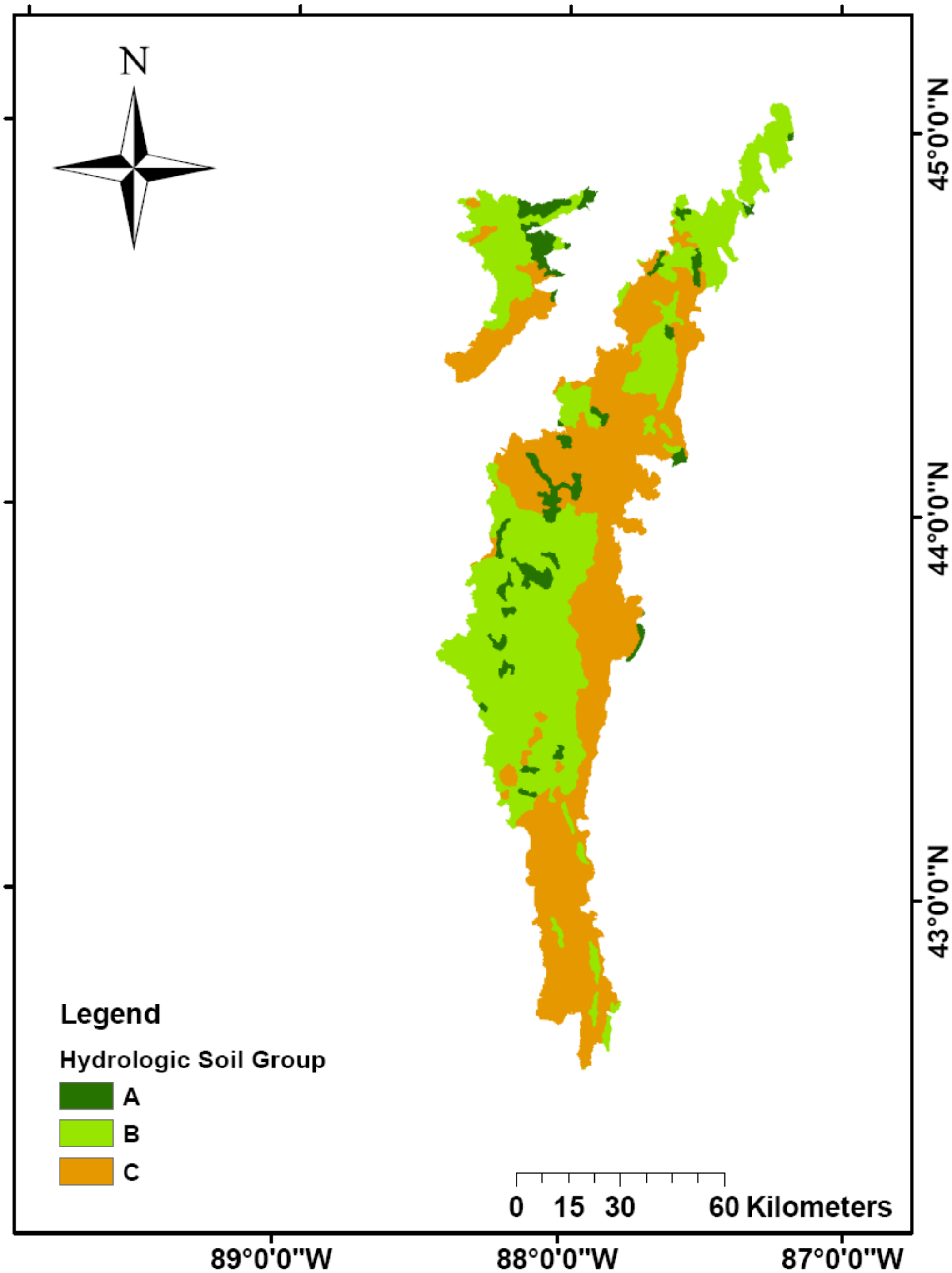



Figure 5. Hydrologic Soil Groups for the Lake Michigan Basin

## 5.0 Climate data

Daily records of precipitation along with minimum and maximum temperatures are obtained from National Climatic Data Center (NCDC). However, relative humidity, wind speed and solar radiation were estimated by the weather generator in the SWAT model. Figure 6 shows the locations of precipitation and temperature gages used for this watershed. As a default approach, the climatic data of a watershed is assigned from the nearest climatic station.

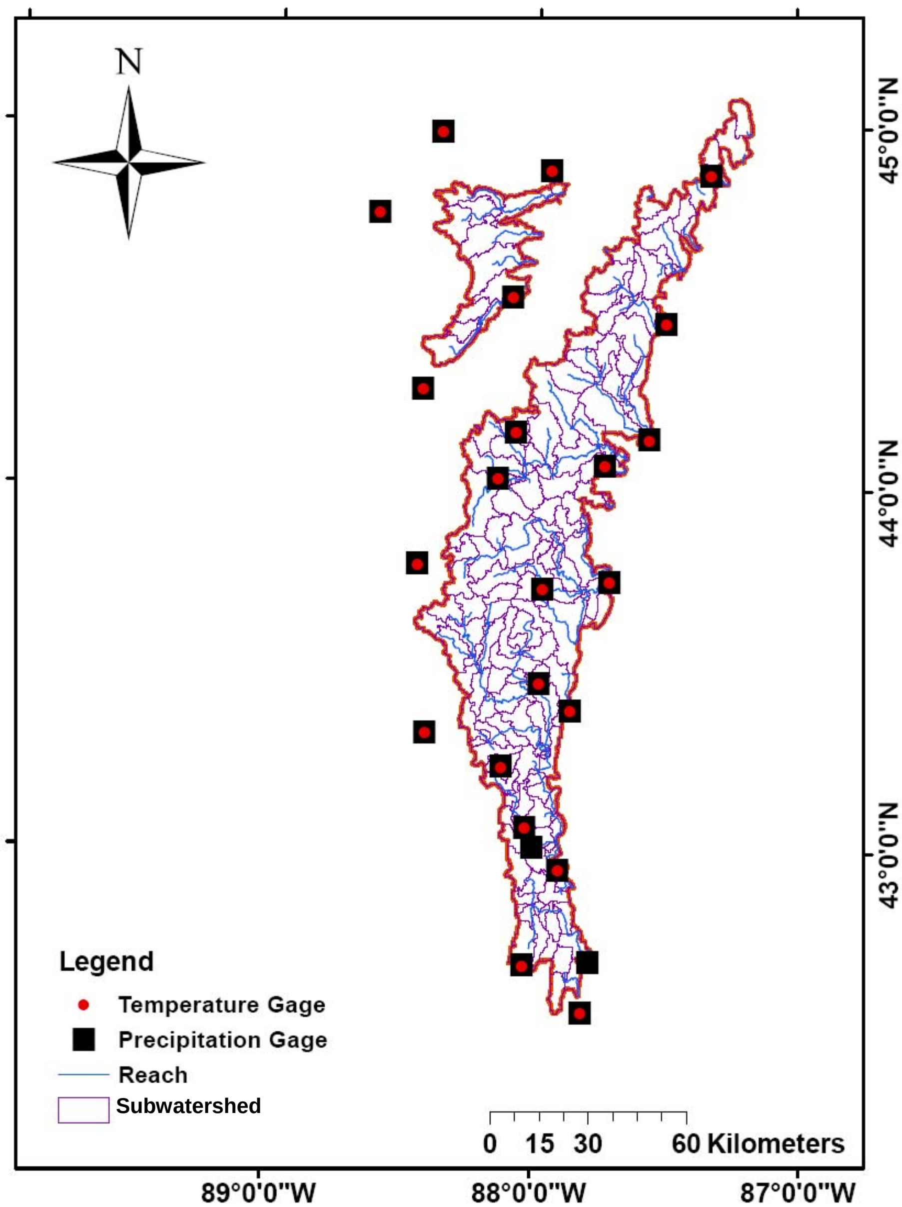



Figure 6. Temperature and precipitation gages in the Lake Michigan Basin

## 6.0 SWAT Model

In this project ArcSWAT 2.1.5a for ArcGIS 9.2 SP6 was used. This version of the SWAT model was released on 7/20/2009. We also used Better Assessment Science Integrating point & Non-point Sources (BASINS v. 4.0 released on 03/2009) to obtain model inputs. Nineteen years of daily precipitation and temperature data (1990 to 2008) were used to setup the model.

## 6.1 Watershed Delineation

The Digital Elevation Model (DEM 90 m) and USGS National Hydrography Dataset (NHD) were used to delineate the study area. In the case of observing cuts in the stream networks, finer resolution elevation data set (National Elevation Dataset-NED) was employed to correct the inconsistencies within the stream networks. The study area was divided to 197 subwatersheds. Figure 7 shows the boundary and the locations of subwatersheds in the Lake Michigan Basin.

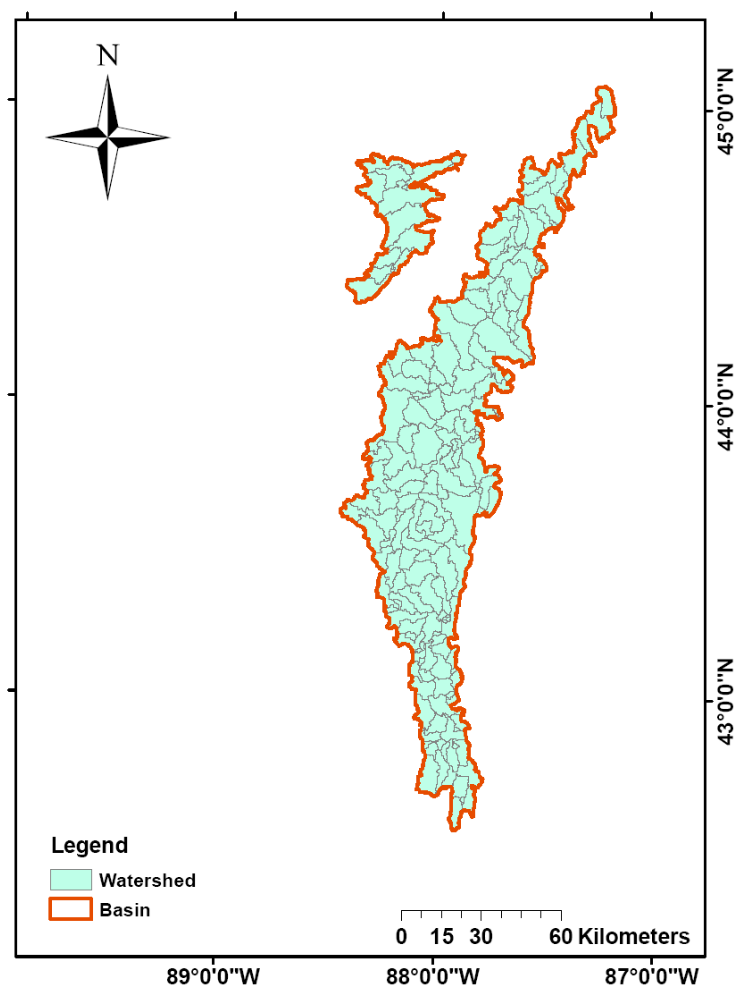



Figure 7. Delineated watersheds of the Lake Michigan Basin

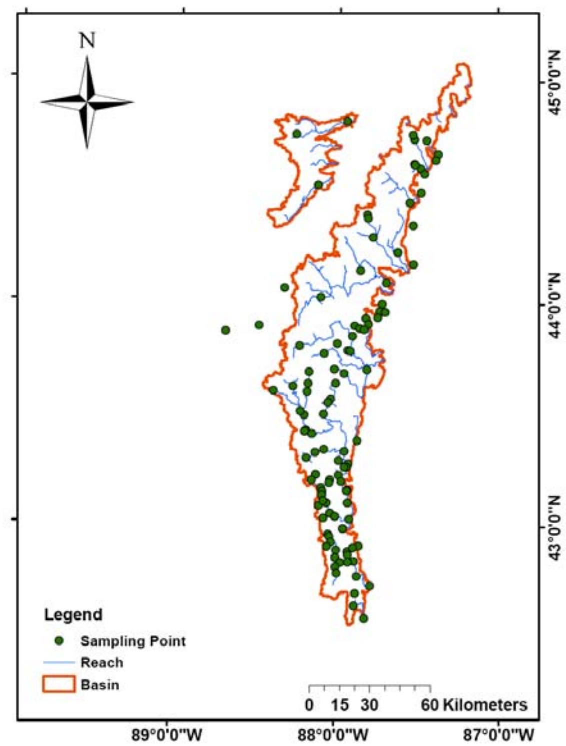
The SWAT model generates results on the outlets of subwatersheds. Since our goal is to obtain the model results on the locations of fish sampling points, these points were introduced to the model. In some cases, the fish sampling points lie on small creeks, which are too small for the model to recognize. In those cases, fish sampling points are snapped to the nearest stream network. Therefore, the location of the outlet sometimes is different from the original location of the fish sampling point (Table 3). Figures 8a and 8b show the locations of the original fish sampling points and the model.

Table 3. Coordinates of the original and snapped fish sampling points

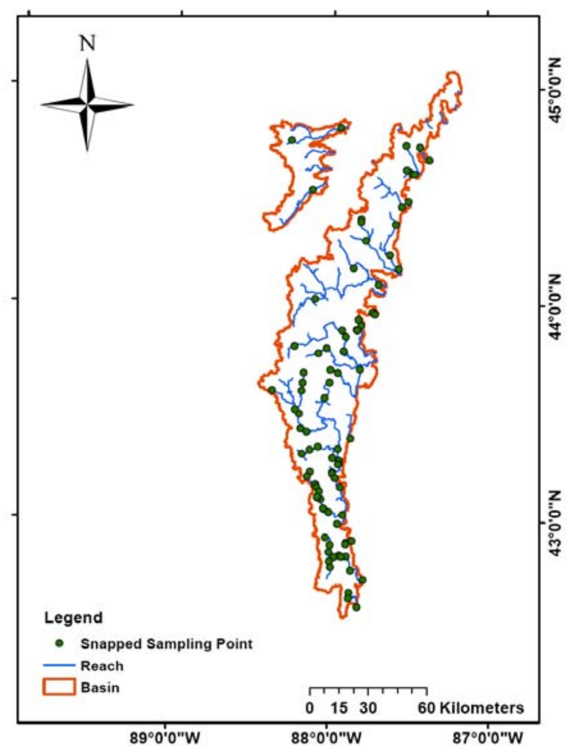
| Original | LAT | LONG | Snapped | LAT | LONG |
|---|---|---|---|---|---|
| 1 | 44.7407 | -87.5262 | 1 | 44.5331 | -88.0978 |
| 2 | 44.7364 | -87.4506 | 2 | 44.4628 | -87.5050 |
| 3 | 44.7616 | -87.5358 | 3 | 44.2786 | -88.4386 |
| 4 | 44.6734 | -87.3769 | 4 | 44.1617 | -88.0803 |
| 5 | 44.6471 | -87.3907 | 5 | 44.1428 | -87.5686 |
| 6 | 44.6301 | -87.5251 | 6 | 44.0692 | -87.7386 |
| 7 | 44.6085 | -87.4863 | 7 | 44.0328 | -88.1469 |
| 8 | 44.5854 | -87.4627 | 8 | 43.7500 | -87.7167 |
| 9 | 44.6265 | -87.5225 | 9 | 43.7300 | -87.9714 |
| 10 | 44.5010 | -87.4837 | 10 | 43.7961 | -88.4506 |
| 11 | 44.4556 | -87.5529 | 11 | 43.4703 | -87.9836 |
| 12 | 44.0703 | -88.3292 | 12 | 43.3311 | -88.4114 |
| 13 | 43.8734 | -88.6913 | 13 | 43.3944 | -87.8636 |
| 14 | 43.9001 | -88.4848 | 14 | 43.2389 | -88.1222 |
| 15 | 43.6938 | -88.1709 | 15 | 43.0719 | -88.0294 |
| 16 | 43.6437 | -88.0054 | 16 | 43.0175 | -88.0017 |
| 17 | 43.6416 | -88.1765 | 17 | 42.9550 | -87.9044 |
| 18 | 43.6290 | -88.2701 | 18 | 42.7022 | -87.7861 |
| 19 | 43.6084 | -88.3903 | 19 | 42.6903 | -88.0336 |
| 20 | 43.6045 | -88.1823 | 20 | 42.5608 | -87.8156 |
| 21 | 43.5733 | -88.0362 | 21 | 44.8722 | -87.3353 |
| 22 | 43.5561 | -88.0527 | 22 | 44.8836 | -87.9539 |
| 23 | 43.4996 | -88.1974 | 23 | 44.9878 | -88.3769 |
| 24 | 43.5042 | -88.0793 | 24 | 44.7642 | -88.6181 |
| 25 | 43.5175 | -88.2229 | 25 | 44.5331 | -88.0978 |
| 26 | 43.4326 | -88.1861 | 26 | 44.4628 | -87.5050 |
| 27 | 43.4266 | -88.1934 | 27 | 44.2786 | -88.4386 |
| 28 | 43.4266 | -88.1934 | 28 | 44.1617 | -88.0803 |
| 29 | 43.4163 | -88.1490 | 29 | 44.1428 | -87.5686 |
| 30 | 43.3467 | -88.0745 | 30 | 44.0692 | -87.7386 |
| 31 | 43.3375 | -87.9485 | 31 | 44.0328 | -88.1469 |
| 32 | 43.3328 | -88.1275 | 32 | 43.7500 | -87.7167 |
| 33 | 43.3080 | -88.1824 | 33 | 43.7300 | -87.9714 |

| | | | | | |
|---|---|---|---|---|---|
| 34 | 43.2962 | -87.9830 | 34 | 43.7961 | -88.4506 |
| 35 | 43.2820 | -87.9237 | 35 | 43.4703 | -87.9836 |
| 36 | 43.2662 | -87.9322 | 36 | 43.3311 | -88.4114 |
| 37 | 43.2665 | -87.9473 | 37 | 43.3944 | -87.8636 |
| 38 | 43.2331 | -88.1219 | 38 | 43.2389 | -88.1222 |
| 39 | 43.2330 | -88.1221 | 39 | 43.0719 | -88.0294 |
| 40 | 43.2299 | -87.9825 | 40 | 42.9550 | -87.9044 |
| 41 | 43.2101 | -88.0356 | 41 | 42.6903 | -88.0336 |
| 42 | 43.2094 | -88.1476 | 42 | 42.5608 | -87.8156 |
| 43 | 43.2031 | -87.9660 | 43 | 44.8722 | -87.3353 |
| 44 | 43.1970 | -88.0403 | 44 | 44.8836 | -87.9539 |
| 45 | 43.1745 | -88.0892 | 45 | 44.9878 | -88.3769 |
| 46 | 43.1645 | -87.9276 | 46 | 44.7642 | -88.6181 |
| 47 | 43.1610 | -87.9329 | | | |
| 48 | 43.1587 | -88.0813 | | | |
| 49 | 43.1414 | -88.0831 | | | |
| 50 | 43.1056 | -88.0548 | | | |
| 51 | 43.1059 | -87.9259 | | | |
| 52 | 43.0946 | -88.1024 | | | |
| 53 | 43.1157 | -88.0765 | | | |
| 54 | 43.0593 | -88.0334 | | | |
| 55 | 43.0448 | -88.0025 | | | |
| 56 | 43.0379 | -88.0731 | | | |
| 57 | 43.0593 | -88.0334 | | | |
| 58 | 43.0327 | -87.9149 | | | |
| 59 | 42.9905 | -87.9530 | | | |
| 60 | 42.9905 | -87.9530 | | | |
| 61 | 43.0448 | -88.0025 | | | |
| 62 | 44.8212 | -87.9500 | | | |
| 63 | 44.7608 | -88.2687 | | | |
| 64 | 44.5343 | -88.1280 | | | |
| 65 | 44.5343 | -88.1280 | | | |
| 66 | 42.9647 | -88.0439 | | | |
| 67 | 42.9548 | -88.0358 | | | |
| 68 | 42.9299 | -88.0266 | | | |
| 69 | 42.9106 | -88.0501 | | | |
| 70 | 42.9051 | -87.8913 | | | |
| 71 | 42.9134 | -87.8556 | | | |
| 72 | 42.8936 | -87.9930 | | | |
| 73 | 42.8864 | -87.9246 | | | |
| 74 | 42.8864 | -87.9246 | | | |
| 75 | 42.9051 | -87.8913 | | | |
| 76 | 42.8726 | -87.9219 | | | |

| | | | | | |
|---|---|---|---|---|---|
| 77 | 42.8609 | -87.9985 | | | |
| 78 | 42.8609 | -87.9985 | | | |
| 79 | 42.8436 | -87.8840 | | | |
| 80 | 42.8383 | -87.9669 | | | |
| 81 | 42.8397 | -87.9217 | | | |
| 82 | 42.8177 | -87.9965 | | | |
| 83 | 42.7903 | -87.9887 | | | |
| 84 | 42.7760 | -87.8659 | | | |
| 85 | 42.7336 | -87.7840 | | | |
| 86 | 42.7002 | -87.8753 | | | |
| 87 | 42.6439 | -87.8819 | | | |
| 88 | 42.5877 | -87.8183 | | | |
| 89 | 44.4027 | -87.8178 | | | |
| 90 | 44.3856 | -87.8138 | | | |
| 91 | 44.3534 | -87.5322 | | | |
| 92 | 44.2998 | -87.7820 | | | |
| 93 | 44.2335 | -87.6267 | | | |
| 94 | 44.2335 | -87.6267 | | | |
| 95 | 44.1788 | -87.5289 | | | |
| 96 | 44.1507 | -87.8588 | | | |
| 97 | 44.0954 | -87.6974 | | | |
| 98 | 44.0301 | -88.1040 | | | |
| 99 | 44.0011 | -87.7223 | | | |
| 100 | 43.9683 | -87.7373 | | | |
| 101 | 43.9647 | -87.7037 | | | |
| 102 | 43.9392 | -87.7496 | | | |
| 103 | 43.9353 | -87.8234 | | | |
| 104 | 43.9087 | -87.8064 | | | |
| 105 | 43.9019 | -87.8915 | | | |
| 106 | 43.8909 | -87.8607 | | | |
| 107 | 43.8852 | -87.8323 | | | |
| 108 | 43.8558 | -87.9052 | | | |
| 109 | 43.8218 | -87.9976 | | | |
| 110 | 43.8104 | -88.2317 | | | |
| 111 | 43.7910 | -87.9336 | | | |
| 112 | 43.7884 | -87.9177 | | | |
| 113 | 43.7774 | -88.0785 | | | |
| 114 | 43.7066 | -88.0152 | | | |
| 115 | 43.6872 | -87.9539 | | | |
| 116 | 43.7050 | -87.8139 | | | |
| 117 | 43.3866 | -87.8698 | | | |




(a)




(b)

Figure 8. Maps of the original fish sampling points (a) and the model's outlets (b).

## 6.2 Monitoring Stations

The model was calibrated on a monthly basis for flow, sediment, total nitrogen, and total phosphorus. Five years of data were used for calibration, including 255 observations for sediment, 160 observations for total nitrogen, and 221 observations for total phosphorus.

The most downstream USGS gaging station on the Milwaukee River (Station No. 04087000) was used to calibrate the model for flow and water quality (Figure 9). Daily water quality data were input to the USGS Load Estimator model (LOADEST) in order to generate monthly average values.

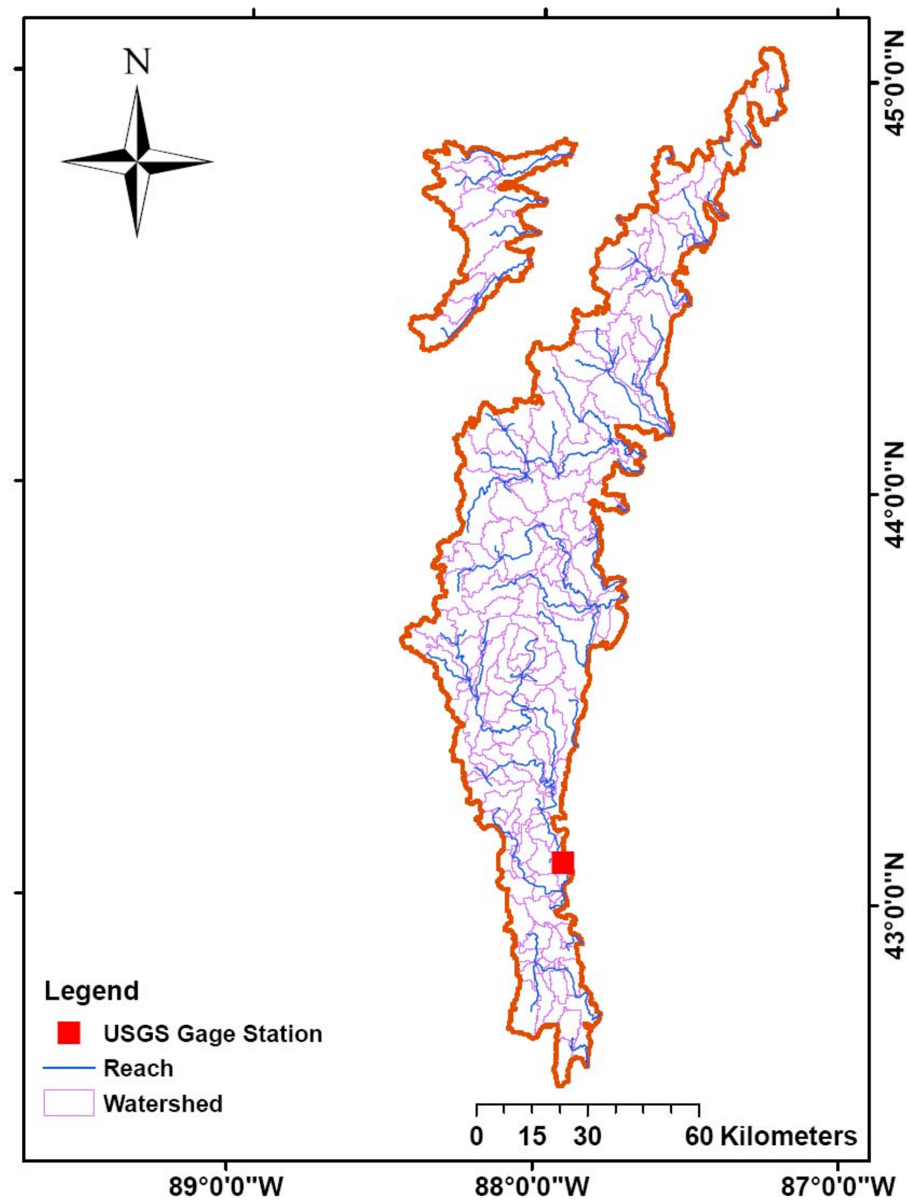



Figure 9. The delineated watersheds and selected USGS station.

## 6.3 Model Calibration

In the next step, the sensitivity analysis was performed. The Latin- Hypercube One-At-a-Time (LH-OAT) method was employed using observed flow, sediment, total nitrogen, and total phosphorus data (van Griensven, Meixner et al. 2006). The sensitivity ranking of 42 parameters for this watershed is given in Table 4.

Table 4: Rank-Based Sensitivity Analysis*

| | Flow | Sed | TotalN | TotalP |
|---|---|---|---|---|
| Cn2 | 1 | 1 | 1 | 1 |
| Alpha_Bf | 2 | 4 | 2 | 2 |
| Sol_Z | 3 | 5 | 3 | 6 |
| Esco | 4 | 6 | 4 | 4 |
| Timp | 5 | 11 | 8 | 8 |
| Sol_Awc | 6 | 12 | 7 | 10 |
| Ch_K2 | 7 | 10 | 9 | 7 |
| Rchrg_Dp | 8 | 14 | 13 | 15 |
| Canmx | 9 | 16 | 10 | 9 |
| Blai | 10 | 13 | 6 | 5 |
| Surlag | 11 | 8 | 5 | 3 |
| Ch_N2 | 12 | 3 | 17 | 16 |
| Biomix | 13 | 15 | 15 | 13 |
| Epco | 14 | 22 | 22 | 21 |
| Smtmp | 15 | 19 | 14 | 14 |
| Gw_Delay | 16 | 21 | 21 | 24 |
| Sol_K | 17 | 23 | 16 | 12 |
| Slsubbsn | 18 | 20 | 19 | 17 |
| Slope | 19 | 17 | 20 | 18 |
| Sol_Alb | 20 | 25 | 18 | 19 |
| Nperco | 21 | 24 | 12 | 20 |
| Spcon | 42 | 2 | 42 | 42 |
| Spexp | 42 | 7 | 42 | 42 |
| Usle_P | 42 | 9 | 11 | 11 |
| Usle_C | 42 | 18 | 23 | 23 |
| Phoskd | 42 | 42 | 24 | 22 |
| Pperco | 42 | 42 | 25 | 25 |
| Ch_Cov | 42 | 42 | 42 | 42 |
| Ch_Erod | 42 | 42 | 42 | 42 |
| Gw_Revap | 42 | 42 | 42 | 42 |
| Gwqmn | 42 | 42 | 42 | 42 |
| Revapmn | 42 | 42 | 42 | 42 |
| Sftmp | 42 | 42 | 42 | 42 |
| Shallst_N | 42 | 42 | 42 | 42 |
| Smfmn | 42 | 42 | 42 | 42 |
| Smfmx | 42 | 42 | 42 | 42 |
| Sol_Labp | 42 | 42 | 42 | 42 |
| Sol_No3 | 42 | 42 | 42 | 42 |
| Sol_Orgn | 42 | 42 | 42 | 42 |
| Sol_Orgp | 42 | 42 | 42 | 42 |
| Tlaps | 42 | 42 | 42 | 42 |

* Each number represents the relative important of each parameter for a given objective, with 1 being most important and 42 being virtually no impact.

In the next step, the model was calibrated based on the results obtained from the sensitivity analysis and observed values from the monitoring stations. The Nash and Sutcliffe coefficient of efficiency, along with the root mean square error (RMSE), and the coefficient of determination ($R^2$) were used for the model evaluation. The results of this section are presented in Table 5, 6 and figures 10 to 17.

The calibrated model has achieved excellent comparisons with observed flow and sediment. The comparisons of sediment were not as good because the observed data did not provide enough information. However, the model is still able to give proper predictions on the same magnitude with the observed data.

Table 5. Statistics of model calibration

| | Nash-Sutcliffe | RMSE | $R^2$ |
|---|---|---|---|
| Flow | 0.744 | 1.223 | 0.769 |
| Total Suspended Solids (TSS) | 0.793 | 5.562 | 0.833 |
| Total N | 0.452 | 367.767 | 0.562 |
| Total P | 0.463 | 38.551 | 0.631 |

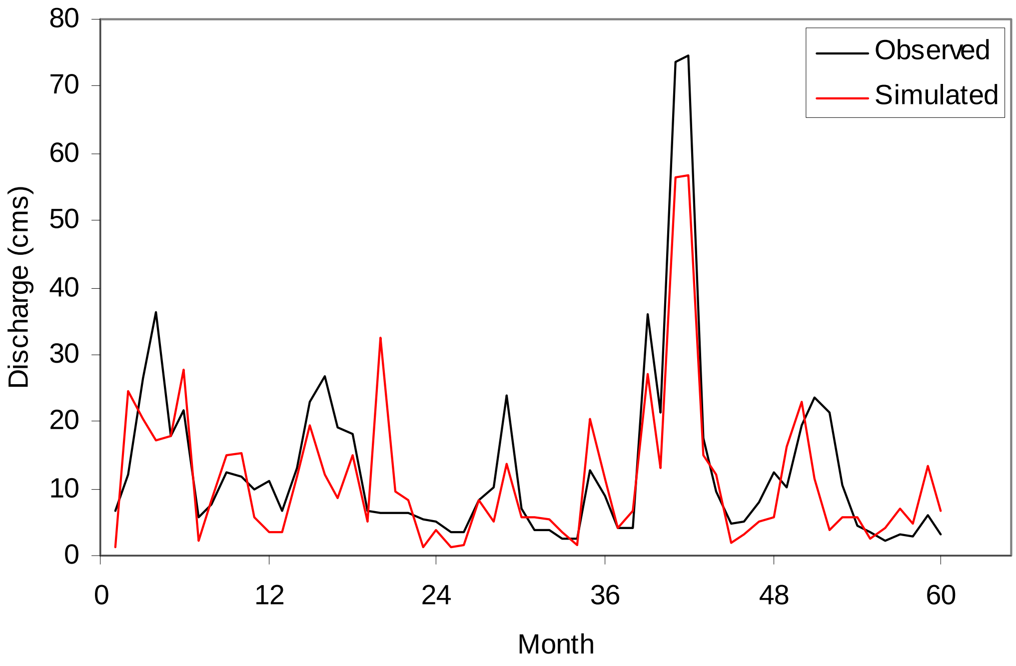



Figure 10. Model simulated results vs. USGS measurements at USGS 04087000 station

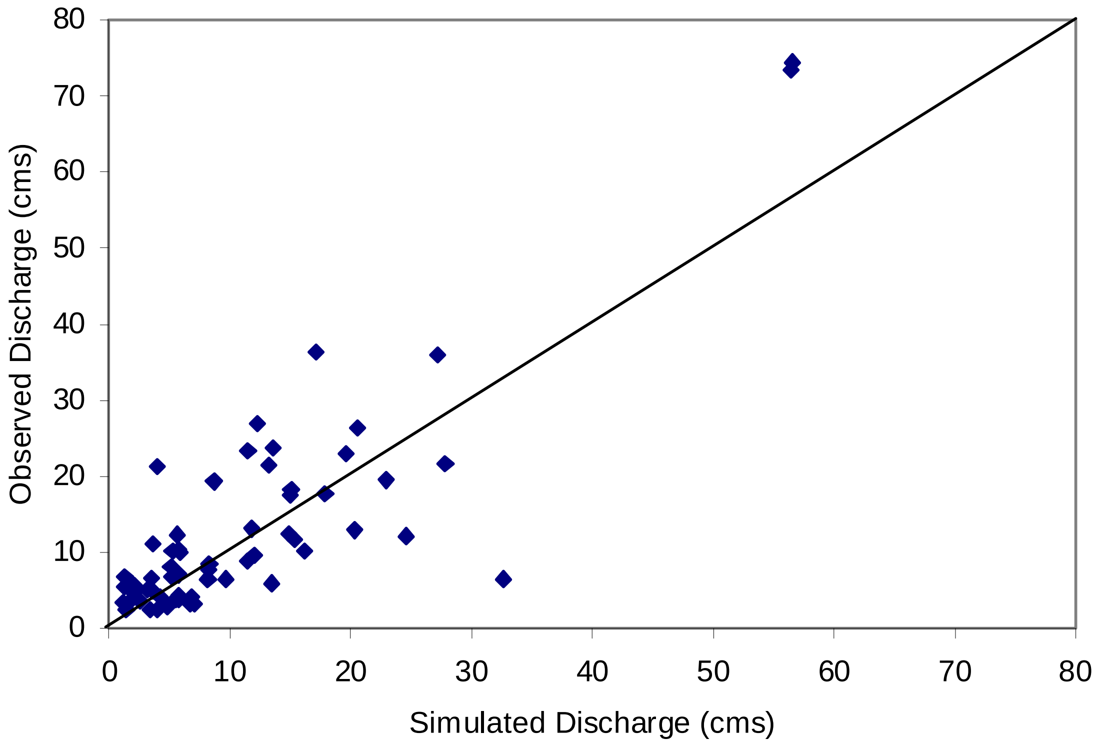



Figure 11. Simulated vs observed flow at USGS 04087000 station

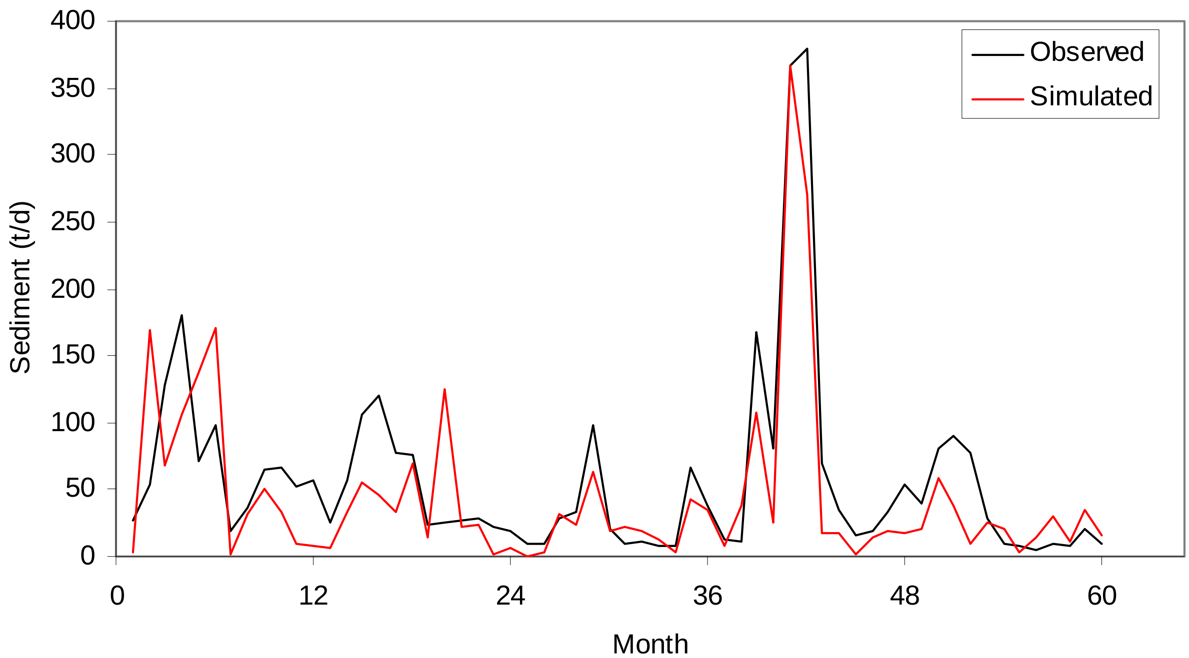



Figure 12. Time series of simulated vs observed TSS

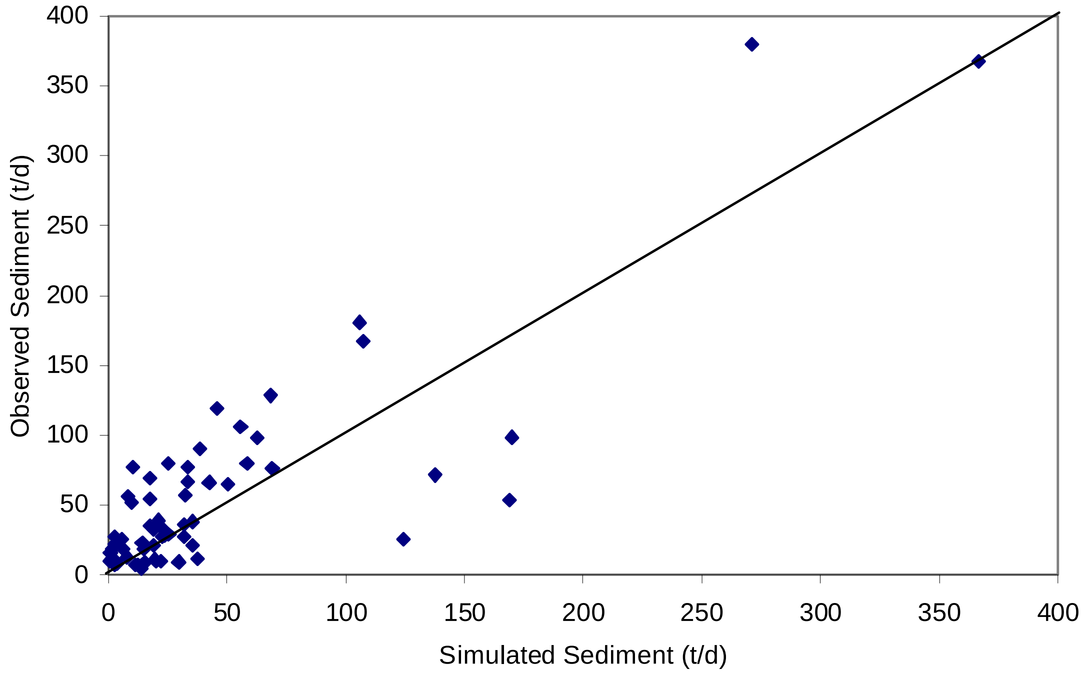



Figure 13. Simulated vs observed TSS

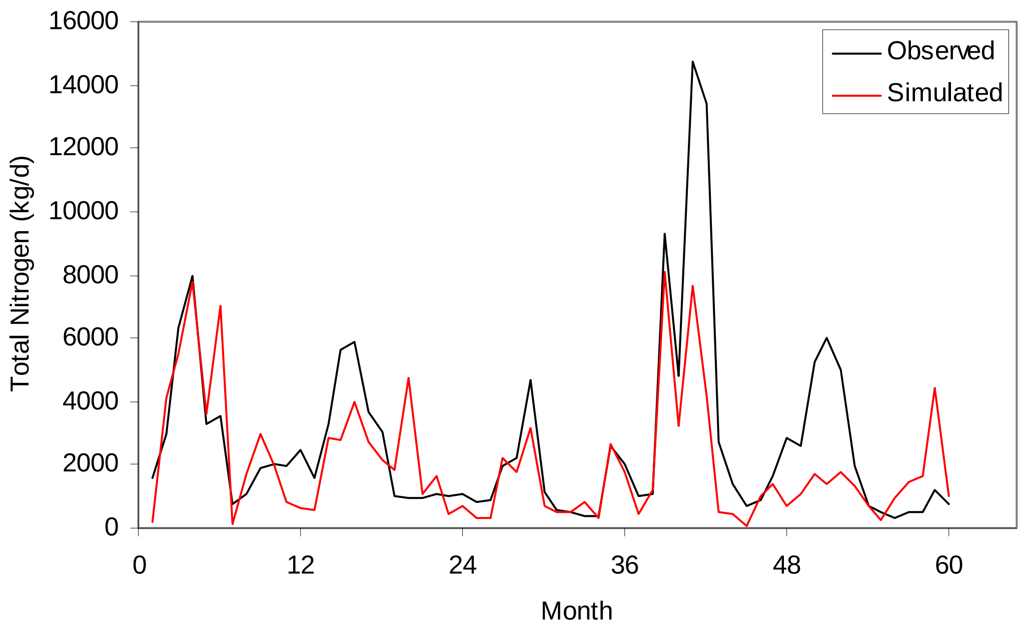



Figure 14. Time series of simulated vs observed Total Nitrogen

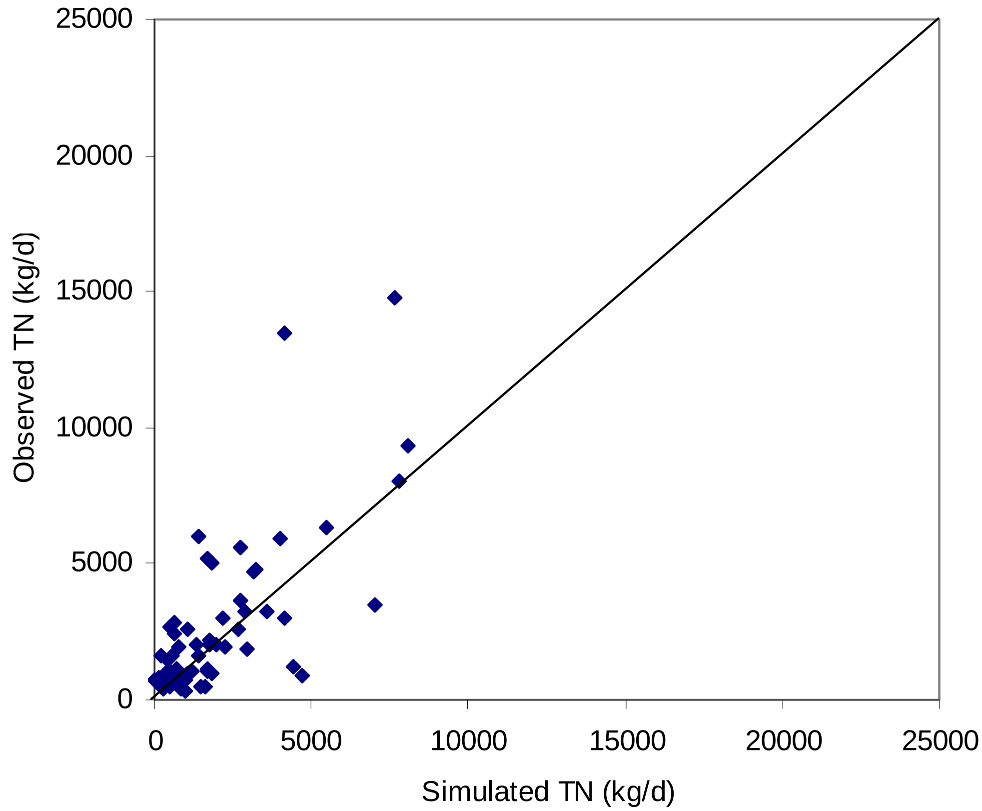



Figure 15. Simulated vs observed Total Nitrogen

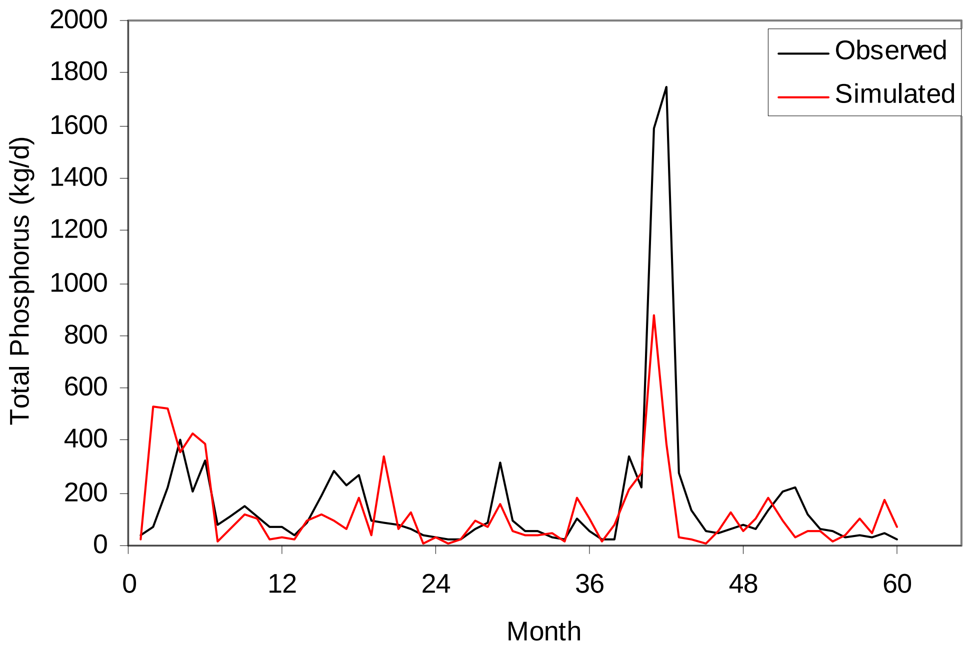



Figure 16. Time series of simulated vs. observed total phosphorus

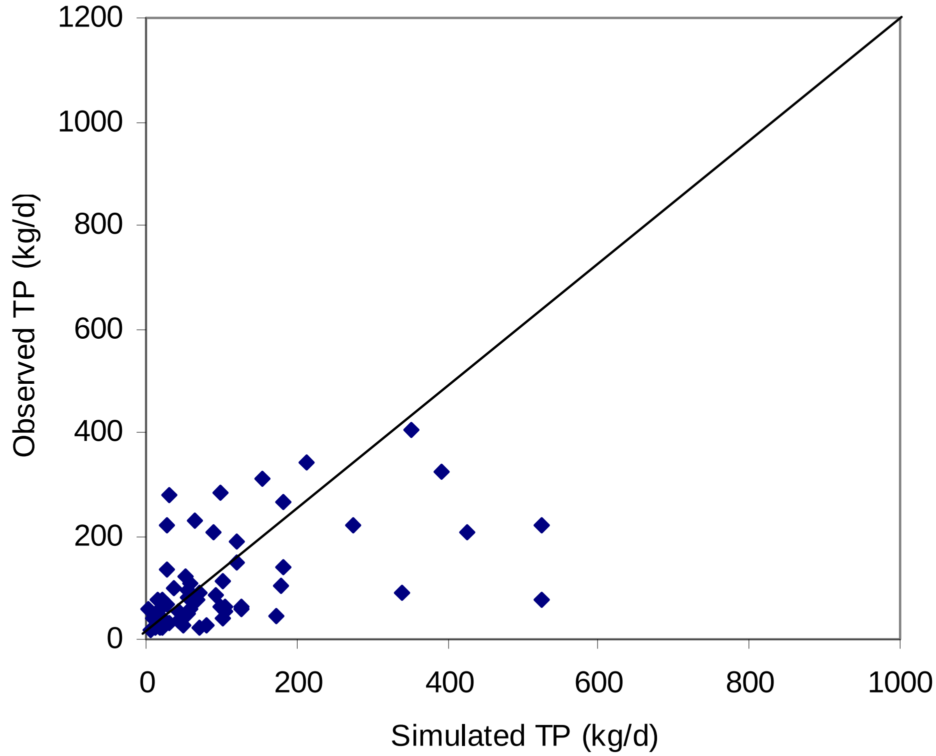



Figure 17. Simulated vs. observed total phosphorus

Table 6. Monthly and annual hydrologic budget from the Lake Michigan Basin

| Month | Rain | Snowfall | Surface Runoff | Lateral Flow | Total Water Yield | ET | Sediment Yield | PET |
|---|---|---|---|---|---|---|---|---|
| | (mm) | (mm) | (mm) | (mm) | (mm) | (mm) | (t/ha) | (mm) |
| 1 | 43.23 | 32.68 | 14.61 | 0.01 | 15.4 | 10.1 | 0.03 | 19.74 |
| 2 | 34.38 | 24.11 | 23.79 | 0.01 | 24.14 | 13.24 | 0.05 | 24.37 |
| 3 | 45.9 | 16.15 | 32.77 | 0.03 | 33.92 | 31.35 | 0.08 | 55.74 |
| 4 | 80.48 | 5.8 | 24.46 | 0.08 | 28.76 | 50.27 | 0.08 | 93.04 |
| 5 | 94.29 | 0 | 27.63 | 0.07 | 33.07 | 64.99 | 0.12 | 129.14 |
| 6 | 110.65 | 0 | 36.93 | 0.09 | 43.31 | 79.15 | 0.13 | 148.3 |
| 7 | 92.52 | 0 | 18.53 | 0.05 | 22.98 | 87.36 | 0.04 | 162.88 |
| 8 | 95.2 | 0 | 22.36 | 0.05 | 24.81 | 68.59 | 0.05 | 141.37 |
| 9 | 77.65 | 0 | 20.09 | 0.04 | 21.7 | 49.79 | 0.05 | 114.23 |
| 10 | 62.06 | 0.53 | 14.73 | 0.04 | 16.07 | 38.53 | 0.04 | 69.79 |
| 11 | 56.11 | 7.26 | 14.93 | 0.04 | 16.38 | 26.14 | 0.03 | 44.18 |
| 12 | 42.02 | 26.46 | 12.74 | 0.02 | 14.01 | 14.71 | 0.02 | 24.55 |
| Annual Average | 834.49 | 112.99 | 263.57 | 0.53 | 294.55 | 534.2 | 0.72 | 1027.3 |

## 6.4 Impacts of Landuse Changes (Pre-Settlement vs. Current) on Water Budget and Water Quality

In this stage of study, the landuse circa 1800 county base (LU1800) was used to setup the SWAT model for the pre-settlement (PS) scenario. Then the model was run for the period of 1990-2008 and the results were compared with the model results obtained based on the current landuse map (NLCD 2001). Results are presented in figures 18 to 27 and Table 7. In addition, in order to compare the results from two different scenarios, percent change and percent difference were calculated. Percent change is the numerical interpretation of comparing one value with another (Equation 1). The equation for determining the percent difference is used to compare the change to the average of the two values (Equation 2).

$$\text{Percent change} = \frac{(x_1 - x_2)}{x_2} \times 100 \qquad (1)$$

$$\text{Percent difference} = \frac{(x_1 - x_2)}{(x_1 + x_2)/2} \times 100 \qquad (2)$$

The results are presented based on the average annual simulated values for the period of study (1990-2008).

Table 7. Annual average percent changes (1800 vs. current) for the Wolf Basin

| Calibrated | Current | Pre-Settlement | Percent Change | Percent Different |
|---|---|---|---|---|
| Recharge (mm) | 33.09 | 23.93 | 38.24% | 32.10% |
| Surface Runoff (mm) | 259.82 | 217.77 | 19.31% | 17.61% |
| Baseflow (mm) | 33.79 | 25.40 | 33.02% | 28.34% |
| Water Yield (mm) | 294.15 | 243.69 | 20.71% | 18.77% |
| Sediment Yield (t/ha) | 0.72 | 0.07 | 903.09% | 163.74% |
| Total N Output (t/ha) | 9.07 | 1.56 | 481.22% | 141.28% |
| Total P Output (t/ha) | 0.63 | 0.06 | 990.46% | 166.40% |

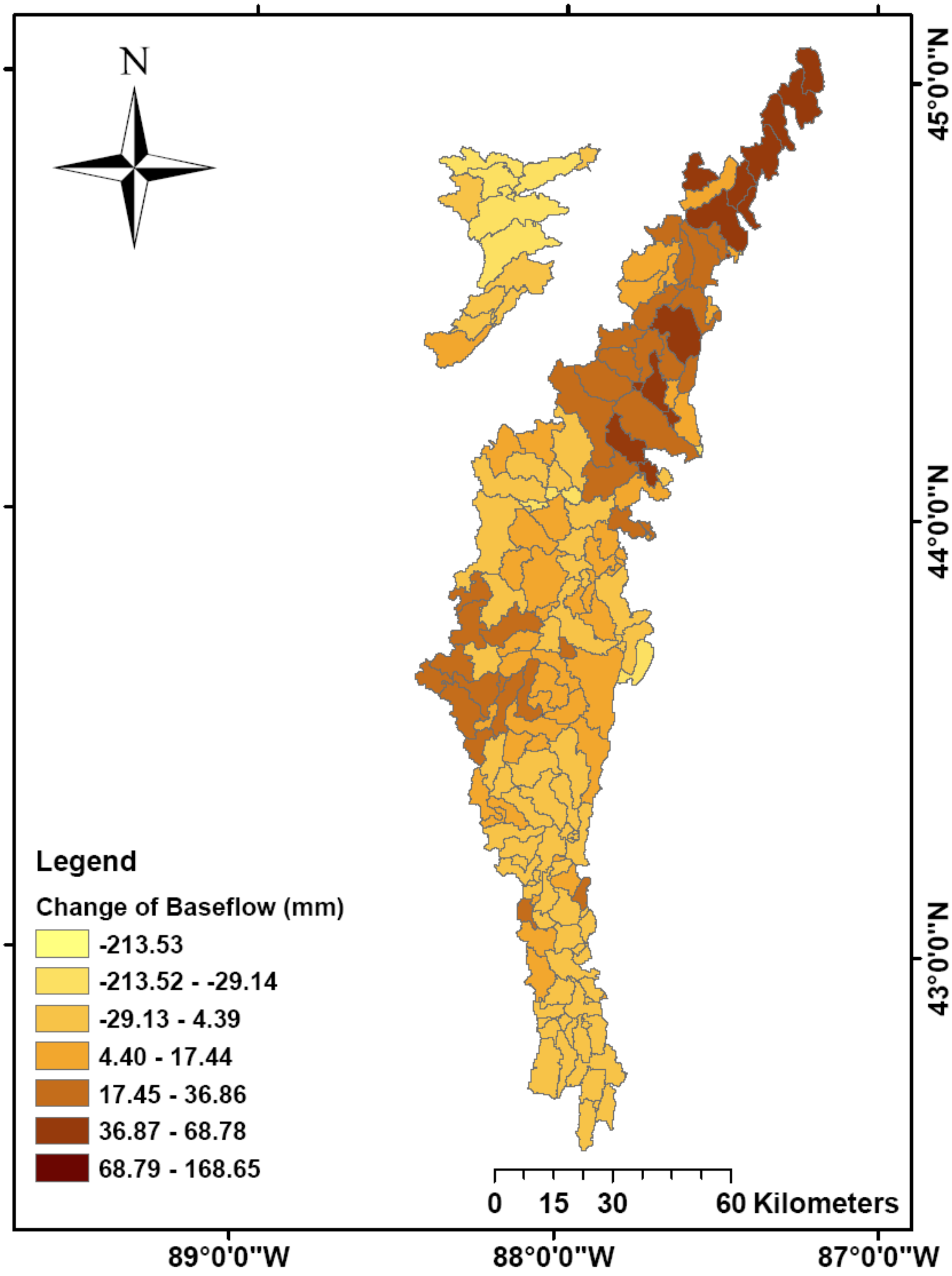



Figure 18. Change of baseflow values resulted from landuse changes (mm)

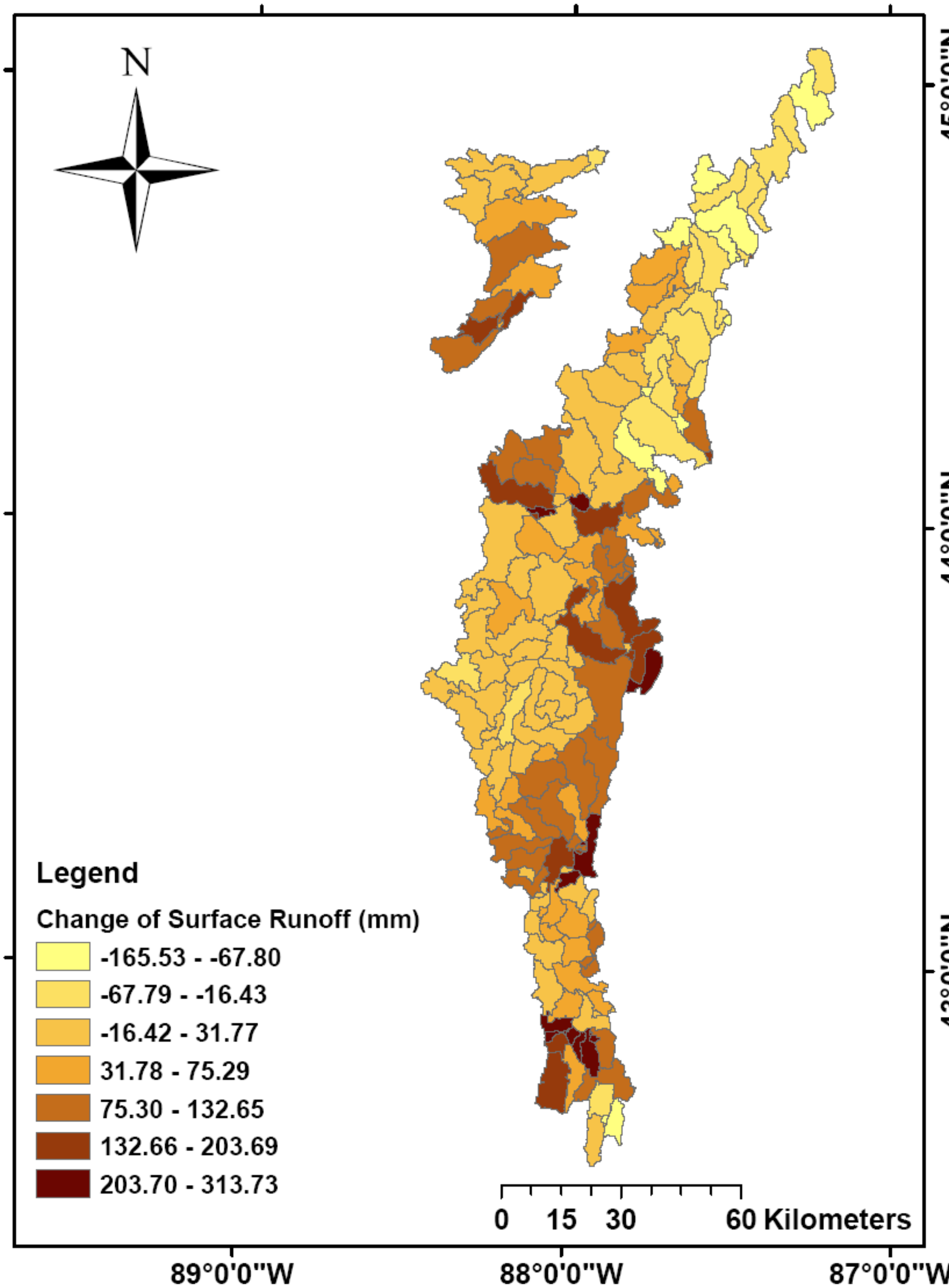



Figure 19. Change of surface runoff values resulted from landuse changes (mm)

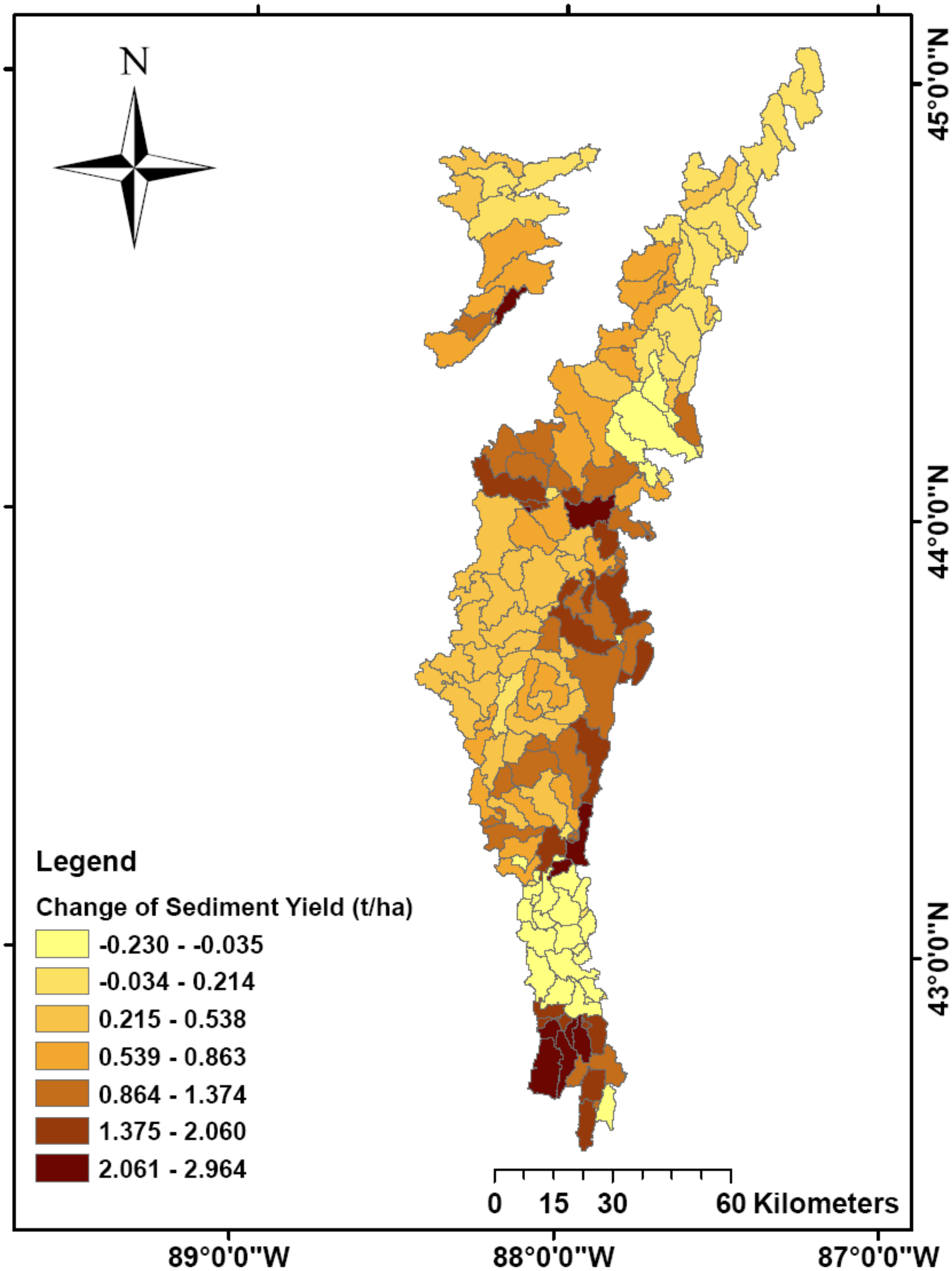



Figure 180. Change of sediment yields resulted from landuse changes (t/ha)

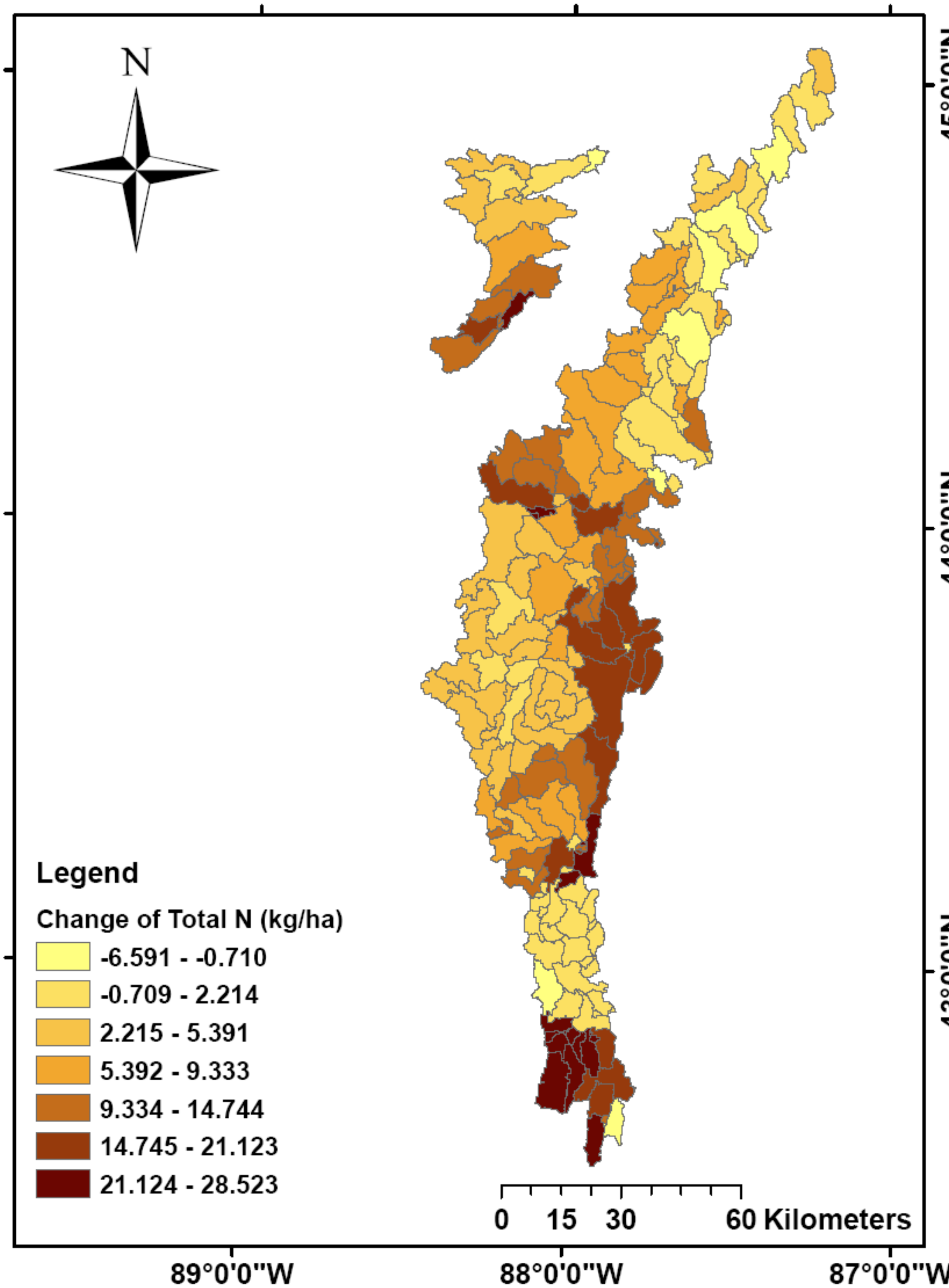



Figure 191. Change of total N output values resulted from landuse changes (kg/ha)

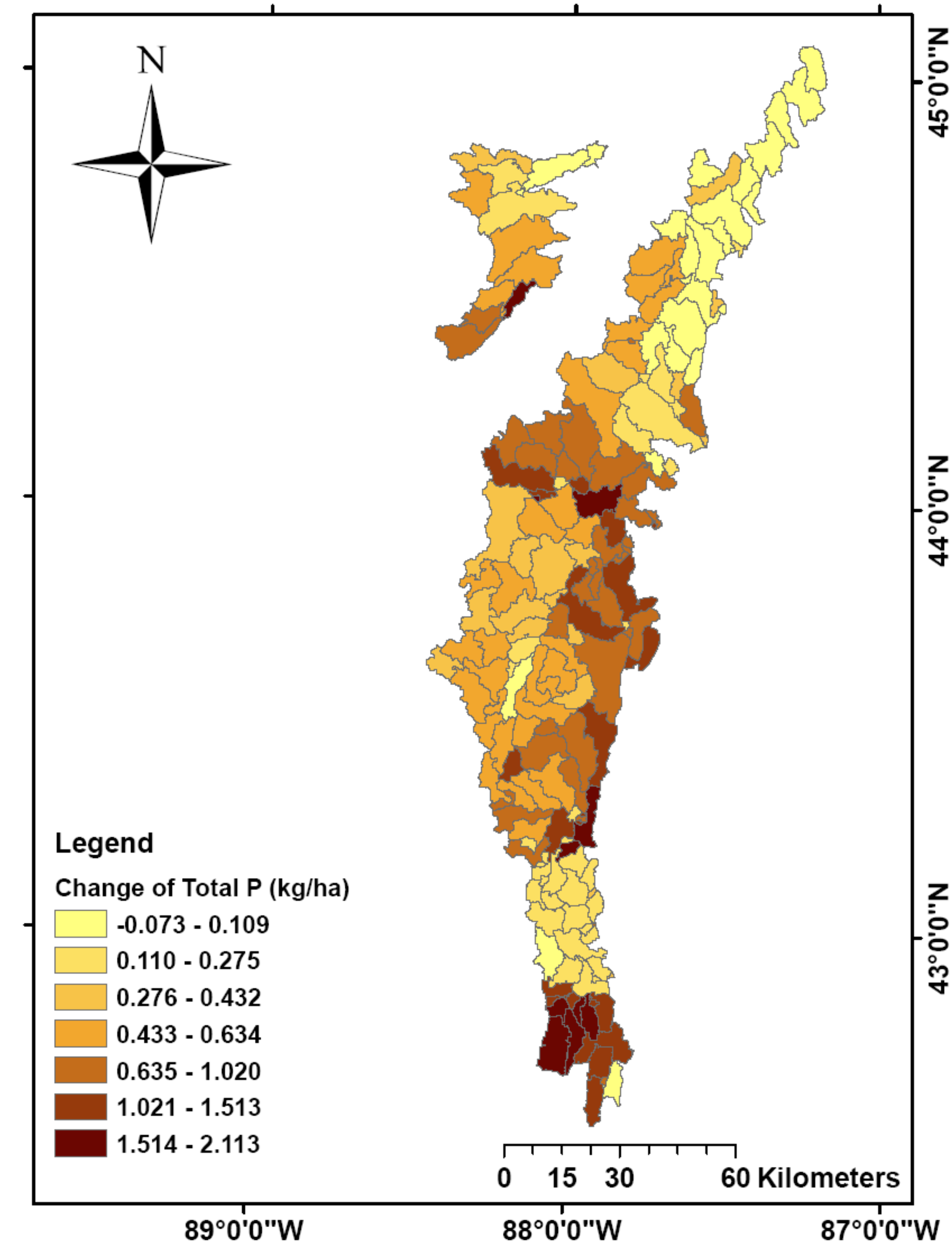


Figure 202. Change of total P output values resulted from landuse changes (kg/ha)

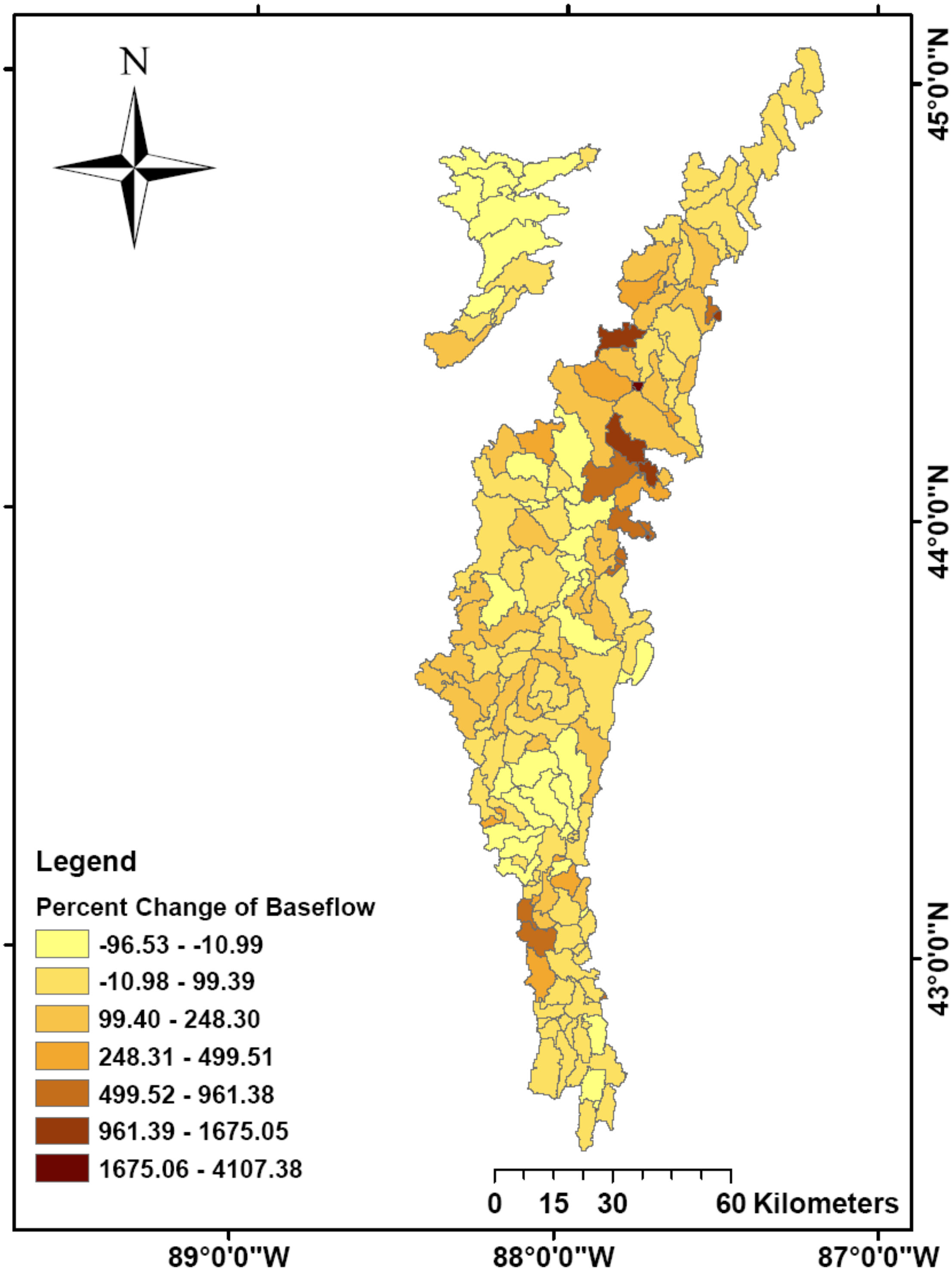


Figure 23. Percent change of baseflow values resulted from landuse changes

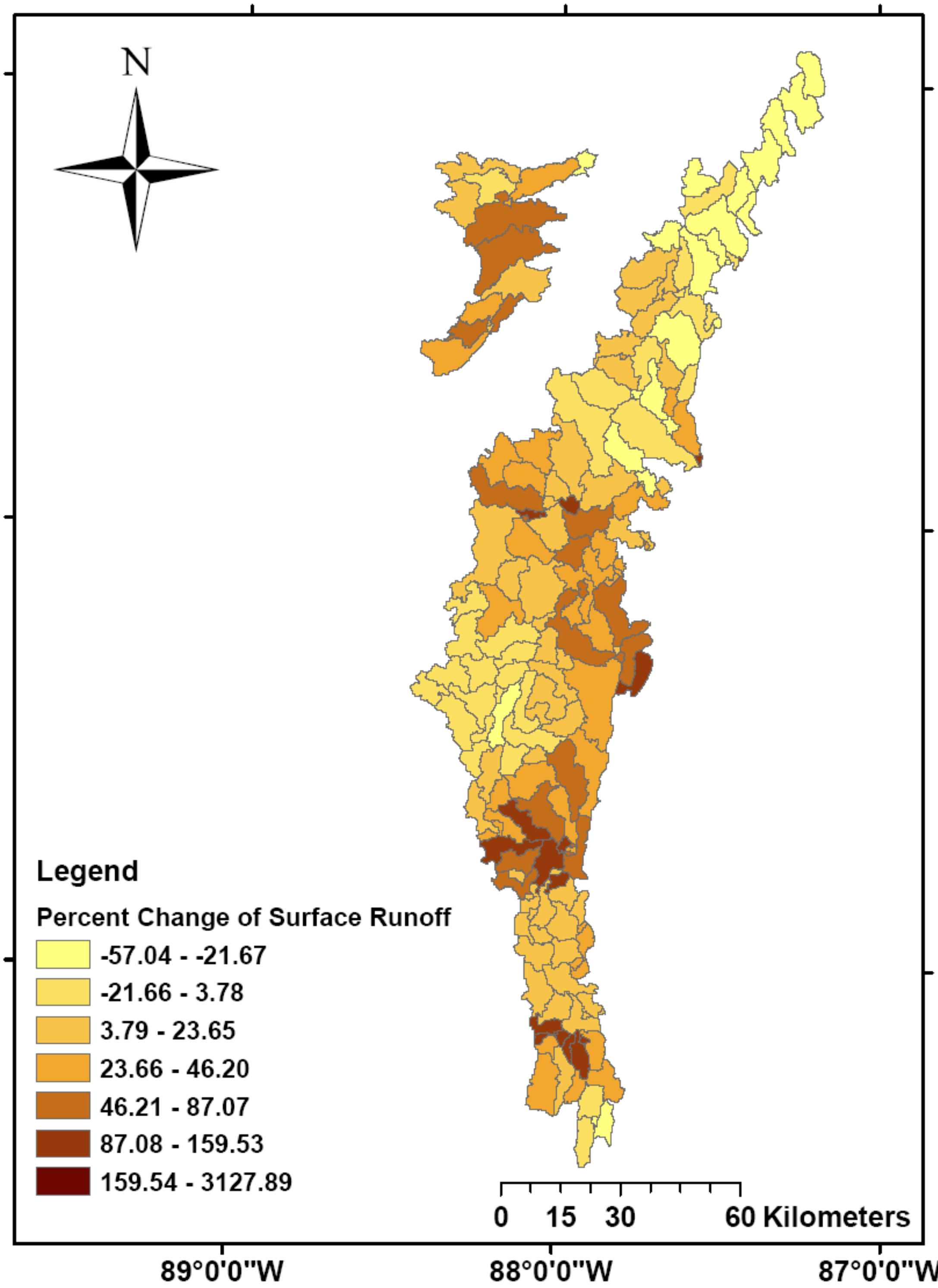



Figure24. Percent change of surface runoff values resulted from landuse changes

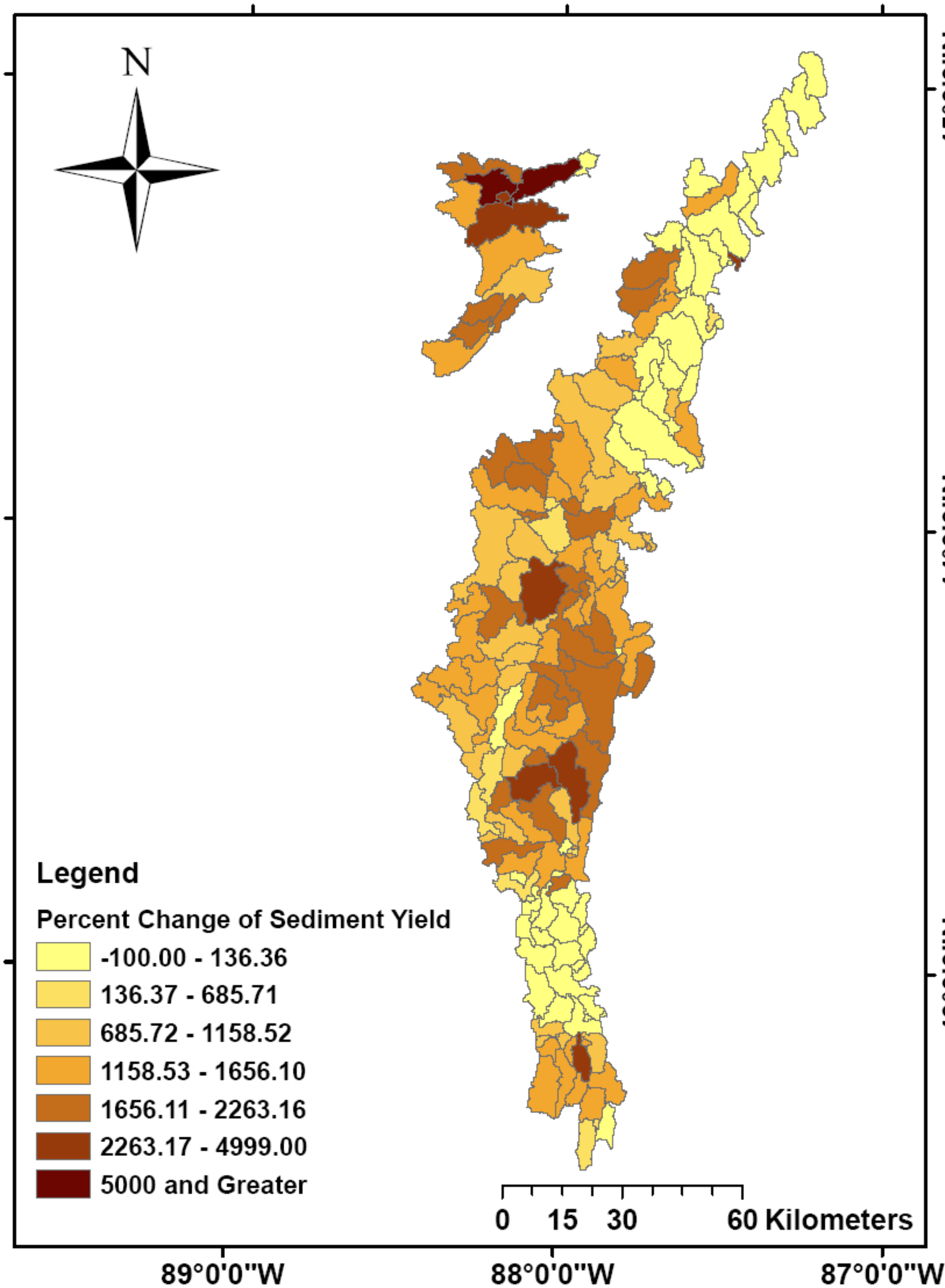



Figure25. Percent change of sediment yield resulted from landuse changes

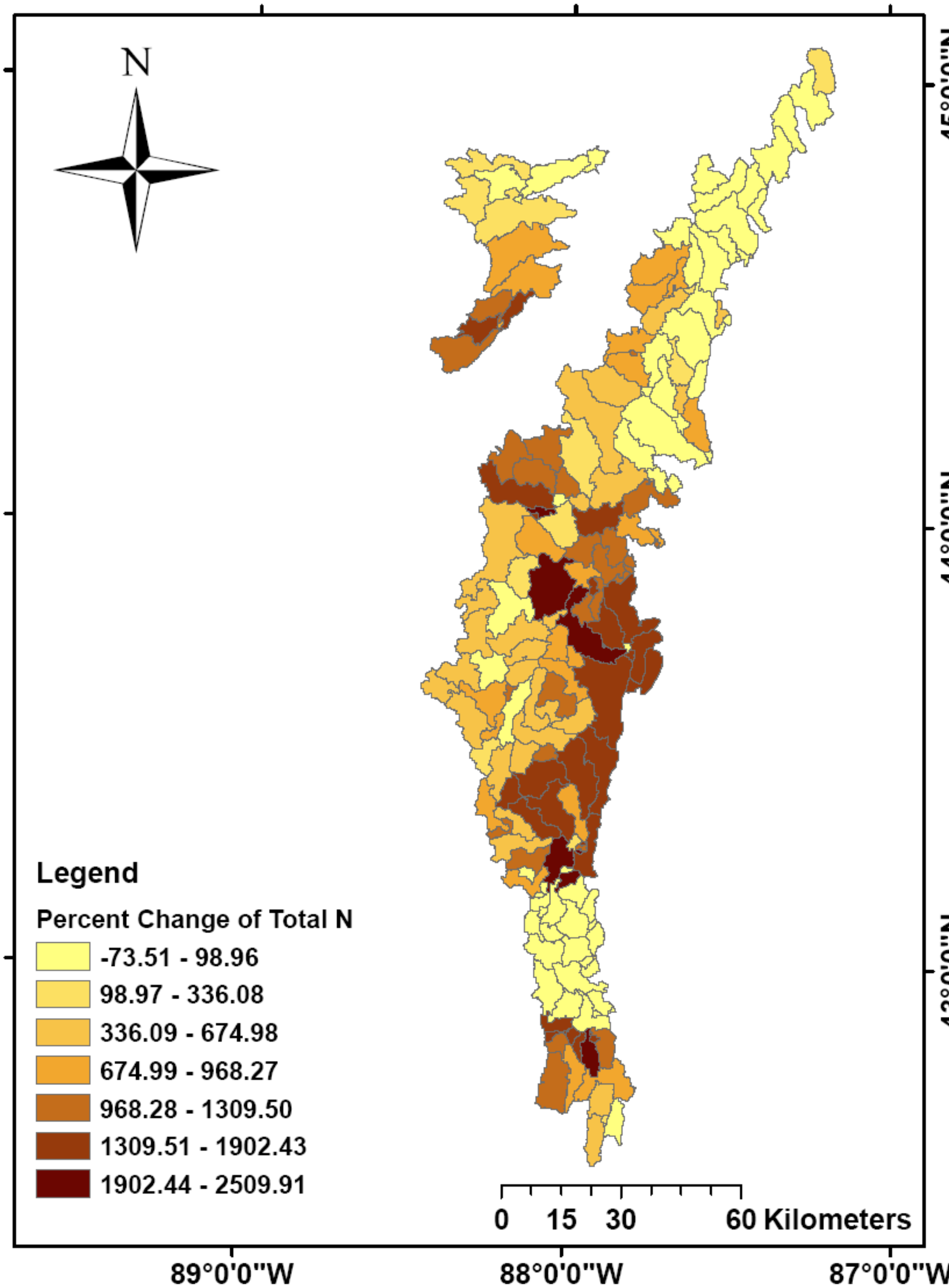


Figure 26. Percent change of total N output values resulted from landuse changes

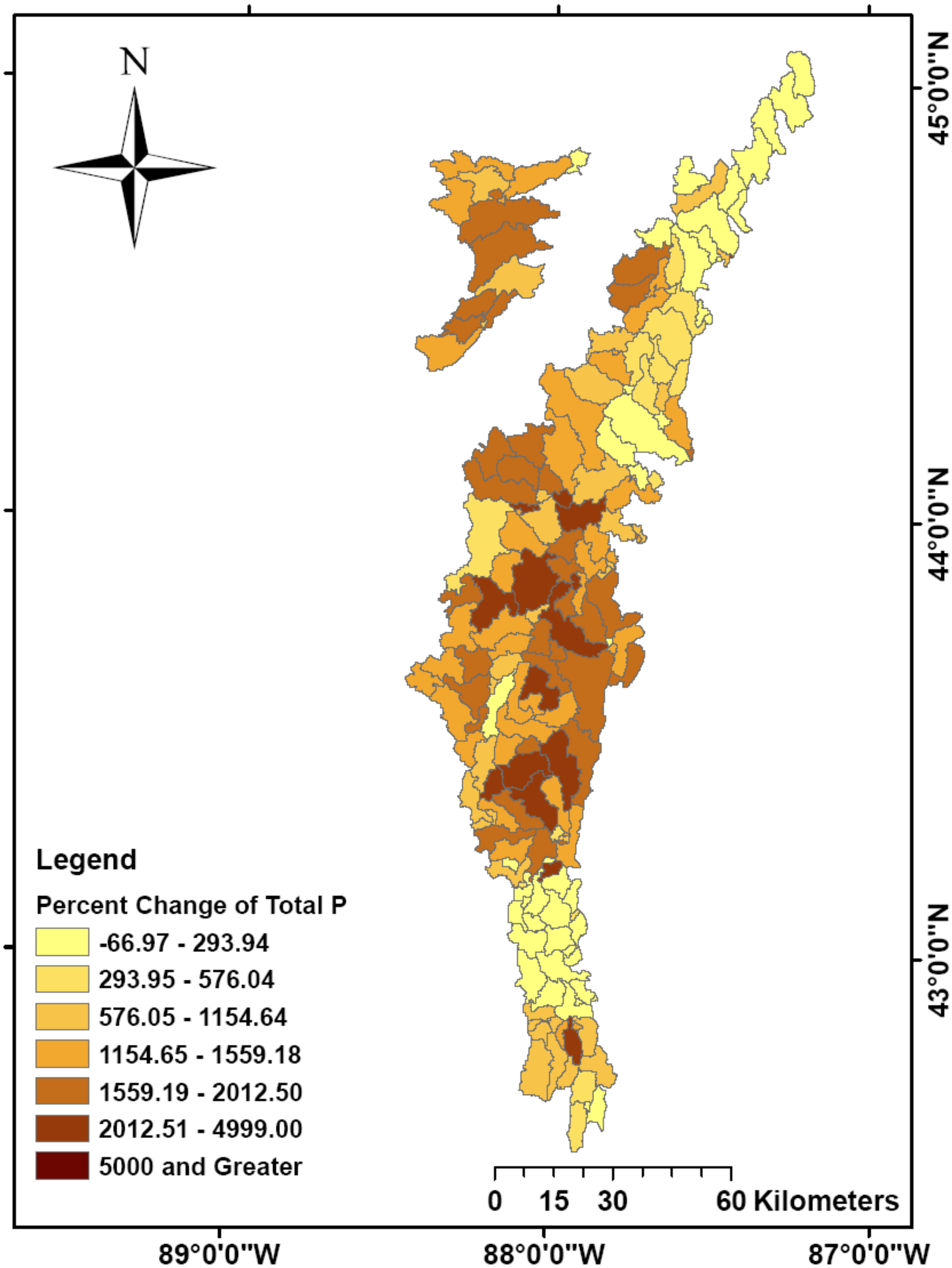



Figure 27. Percent change of total P output values resulted from landuse changes

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## 7.0 References

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