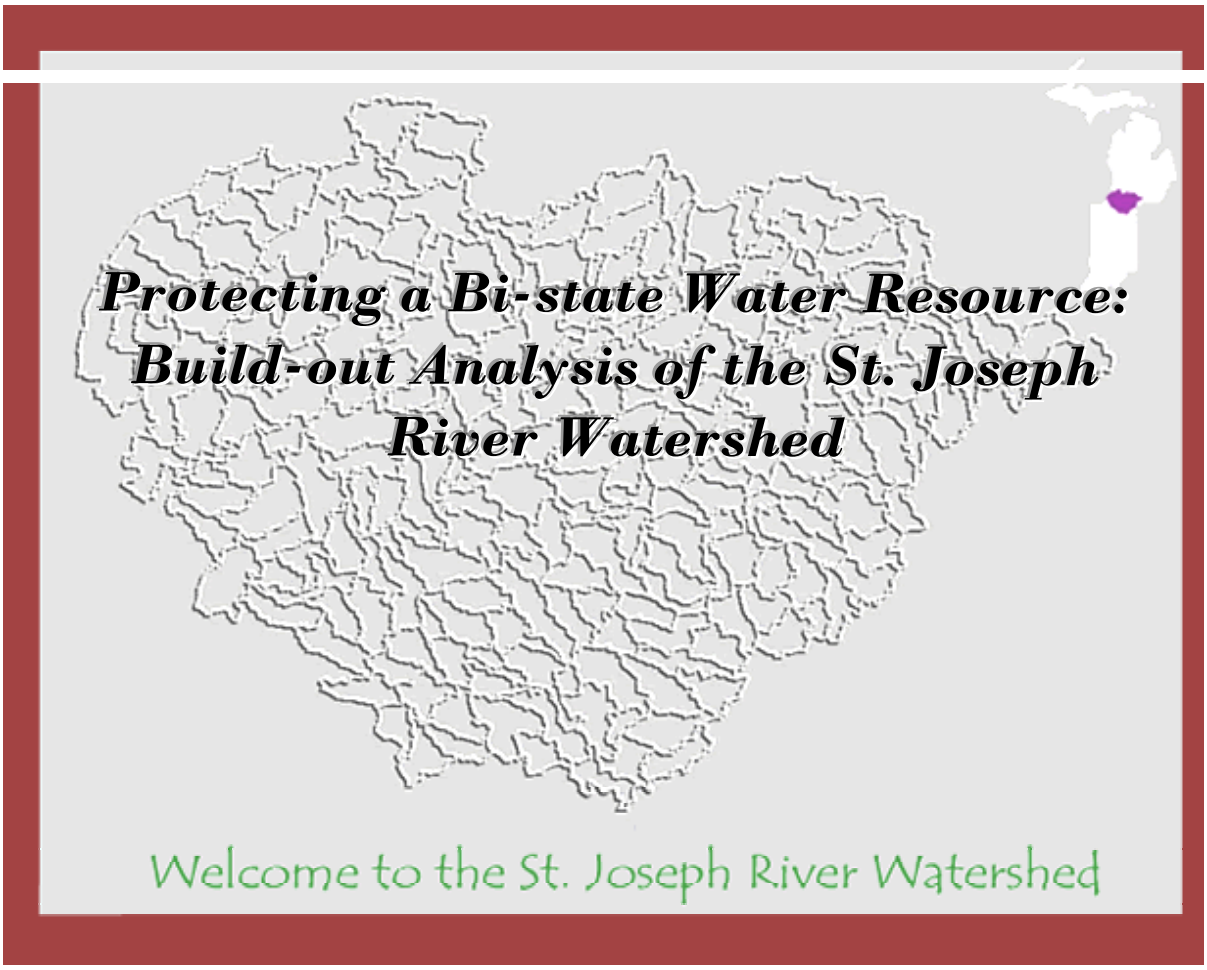
appendix d

protecting a bi-state water resources: build-out analysis of the st. joseph river watershed



Protecting a Bi-state Water Resource: Build-out Analysis of the St. Joseph River Watershed

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Project Background

The U.S. Environmental Protection Agency (USEPA) issued new requirements for watershed management plans funded through Section 319 grant monies in late 2003. All watershed management plans must meet the new requirements (known as the Nine Elements) to be eligible for implementation funds through the Section 319 grant program. These requirements call for additional quantification of sources of nonpoint source pollutants and expected reductions in pollutants with recommended Best Management Practices. The St. Joseph River Watershed Management Planning Project was initiated in December 2002. New efforts are being completed to quantify sources of impact in the basin including nonpoint source modeling of agricultural and urban land covers. This report addresses the latter.

The St. Joseph River Watershed is a large (4,685 square miles), bi-state watershed (Figure 1). Field scale data collection and analysis are not feasible at such a large scale. Therefore, GIS-based models are necessary to understand current nonpoint source loading conditions and to characterize pollutant sources. Predictive tools are necessary to model watershed changes and the associated water quality threats. The Great Lakes Commission awarded a $6,000 grant to the Friends of the St. Joe River Association, Inc. to conduct limited build-out analyses using the ArcView extension, Landscape Analyst as a tool to help the Watershed Management Plan (currently in development) meet the Nine Elements. Under contract to the Friends of the St. Joe River Association, Kieser & Associates (K&A) used Landscape Analyst to project future development in the watershed and to model potential threats to existing open space. Identification of threats to open space and loss of farmland is used here to signal the need for preservation and smart growth, as well as implementing the Watershed Management Plan. This effort was also designed to illustrate the impacts on water quality from unplanned growth with no stormwater management. A nonpoint source loading model for sediment and phosphorus was used to estimate loads to the St. Joseph River from future potential development in these regards. It is envisioned that these exercises will also underscore the importance of ongoing land use planning efforts.

Model Overview

Landscape Analyst, developed by the Canaan Valley Institute (West Virginia), is an ArcView 3.2 GIS extension designed for watershed simulations. The development model within the extension, was used to simulate potential future changes to the landscape. The model identified areas where future development can occur in the watershed based on physical constraints such as topography. These results were used to identify where preservation may be needed and where increased stormwater runoff may be expected. Those new areas of potential development identified by Landscape Analyst were used as inputs to adjust the empirical nonpoint source load model run for current land cover conditions for the Watershed Management Planning Project (K&A, 2003). The adjusted nonpoint source load model predicted associated changes in stormwater runoff and loading of sediments and phosphorus to the St. Joseph River with new development assuming no stormwater management practices are applied.

Landscape Analyst also includes many indicators of watershed conditions. Indicators were used to identify forested areas to confirm preservation priorities developed through subwatershed scoring in the Watershed Management Planning Project.

In addition to modeling potential threats to the watershed, a goal of this effort was to assess the use of Landscape Analyst as a tool for watershed planning and analysis in the St. Joseph River Watershed. The Watershed Management Planning Project is unique in the fact that it encompasses a large geographic unit

that includes two states. This modeling project therefore presents an innovative method for identifying and quantifying potential watershed threats at a large scale.

Methods

This section discusses the approach used by K&A to use the Landscape Analyst model for projecting future development and the associated water quality impacts in the St. Joseph River Watershed. Documentation of the Landscape Analyst extension is included in Attachment A. In this section, we discuss:

- predicted watershed level development
- model limitations
- county-scale analysis of future development
- nonpoint source loading
- indicators of forested land use

Predicted Watershed Level Development

Future development in the St. Joseph River Watershed was predicted with the development model within Landscape Analyst. The development model utilizes land cover, roads, streams and elevation spatial data in a fuzzy logic technique with GIS to identify areas where development can occur. A 30-meter digital elevation model from the U.S. Geological Survey (USGS, 1999) and 2000 land cover data (Figure 2a) from the National Oceanic and Atmospheric Association (NOAA, 2000) were used in the model. The stream network from the USGS National Hydrography Dataset (USGS, 1997) was also utilized, while road data were derived from U.S. Census TIGER files (U.S. Census, 1995). The geographic extent of the modeling was defined by a watershed delineation completed for the Watershed Management Planning Project (K&A, 2003).

The development model allows users to define maximum thresholds for locations of development and a minimum suitability for development. User defined inputs are detailed in Table 1.

Table 1. User-defined input parameters for Landscape Analyst.

Input Parameter	**Value**
Distance from roads (miles)	10.9
Distance from current development (miles)	10.9
Slope threshold (%)	2.5
Minimum suitability (range 0-1, 1 is most suitable)	0.75

The minimum threshold values allowed by the model were 10.9 miles for both distance from roads and distance from current development. This is due to the fact that the model adjusts the available user inputs based on the size of the geographic area. Because the study area, i.e., the St. Joseph River Watershed, is so large, the model did not allow smaller user inputs. In order to verify this, the model was also run for Elkhart County alone to refine predictions and to evaluate the utility of the model at a smaller scale for possible use

by land use planners. A minium threshold of 2.2 miles was allowed by the model at this refined geographic scale.

Model Limitations

The model allows users to define the current land cover type on which development can occur. Two scenarios were attempted: one in which agricultural lands were developed, and one in which forested lands were developed. However, a visual review of the grid file output of the model revealed that both scenarios resulted in the same areas being predicted for development. This was confirmed by an area analysis in which the 2000 land cover grid file was intersected with each development prediction scenario. The two scenarios projected development on the same absolute areas and ratios of land cover type, regardless of the user input. The model also predicted development on all land cover types, including wetlands, open water and currently developed lands, even though the user input specified only forest land or only agricultural lands to be developed. This type of issue was identified by another user of the model (Fongers, personal communication, 2004). Assistance from the Canaan Valley Institute did not result in a correction of this issue. Assistance was limited due to a lack of funding support for the extension (Kemlage, personal communication, 2004). Therefore development projected on wetlands, open water and currently developed lands (i.e., approximately 25% of the total) was disregarded, and the following data analysis was applied to the model output to produce representative results for this exercise.

County-scale Analysis of Future Development

Landscape Analyst simply identifies areas in which development is expected based on physical constraints within the watershed. Further analysis is therefore necessary to place that projection in the context of actual population growth. This section discusses the application of U.S. Census data and land development patterns within jurisdictional units, i.e., counties, to the development model output.

For each county in the St. Joseph River Watershed, the areas of projected development (output of the development model) on each current land cover type were tabulated using the Spatial Analyst extension in ArcView 3.2 (for example, the acres of forested land cover expected to be developed in Branch County). The areas in which development was projected on currently developed lands, wetlands and open water were disregarded, as discussed above in the Model Limitations section. The areas in which development was projected on cultivated land and grassland were summed as agricultural land, and the areas projected on forested and scrub-shrub land were summed as forest land. Those areas projected for these two land use categories were used as future development in further calculations.

The total acreage of projected developed land (agricultural and forested land) in each county was compared to the acreage of currently developed land identified by the 2000 land cover. The projected acreage to be developed in each county was reported as a percentage of that county's current (2000) development. To gauge the time to reach the projected development build-out at current trends, the population growth rate (from 1990 to 2000) was identified for each county from U.S. Census data (U.S. Census, 2000, Attachment B). The relationship of land development to population growth was derived from a study of sprawl by the Brookings Institution (2001). The average Midwest urban area develops land at a rate 4.5 times that of population growth. The publication also identified these sprawl factors for metropolitan areas in the watershed including Kalamazoo, MI; South Bend-Mishawaka, IN; and Elkhart-Goshen, IN. Specific rates were applied to the counties containing these metropolitan areas (see Table 2).

Table 2. Sprawl factors (rate of change in urbanized land area/rate of population growth, 1982 - 1997) for metropolitan areas (Brookings Institution, 2001).

Metropolitan Area	Sprawl Factor
Elkhart-Goshen, IN	1.37
Kalamazoo, MI	3.11
South Bend-Mishawaka, IN	4.03

Benton Harbor, MI was also included in the report. However, it reported a decrease in population from 1982 to 1997. Therefore, the average rate (4.5) was applied to Berrien County.

The following formula was used to calculate the time, in years, for each county to reach full development as predicted by the development model:

$$\text{Time to reach development (years)} = \frac{\text{percent development projected} * 10 \text{ years}}{\text{sprawl factor} * \text{percent population growth from 1990-2000}} \qquad \textit{Equation 1}$$

Based on the current (2000) and projected development from Landscape Analyst, the percentage of total future developed land as a portion of total land area was also calculated for each county by:

$$\text{Total future developed land (\%)} = 100 * \frac{\text{current developed acreage} + \text{projected developed acreage}}{\text{total acreage of portion of county within the watershed}} \qquad \textit{Equation 2}$$

Nonpoint Source Loading

An empirical nonpoint source phosphorus and sediment loading model using USGS 1992 land cover data was run in 2003 for the Watershed Management Planning Project to identify critical subwatersheds (K&A, 2003). The model output identified annual runoff volumes, annual sediment loading and annual phosphorus loading from each geographic unit (subwatershed). A rudimentary calibration to published loading data for the basin in the 1990s was completed for this empirical model.

For this report, the load model was updated using the 2000 land cover data and run at the subwatershed and county levels to be consistent with the Landscape Analyst model run. The area of expected urban land development in each subwatershed and in each county was calculated in GIS. These land areas were used to adjust the land cover input in the nonpoint source load model. The area of projected developed land in each unit was used to increase the area of residential land cover (by 75% of future developed land) and the area of the commercial/industrial/transportation (referred to as commercial) land cover (by 25% of the future developed land) in the model (Equations 3 and 4, respectively). These percentages were based on a Brookings Institution (2004) study that indicates that the majority of new development from 2000 to 2030 will be residential. The projected developed land in each county was used to decrease the agricultural and forested land uses in the loading model (Equations 5 and 6, respectively).

$$\text{Future residential land area} = \text{projected development area} * 0.75 + \text{current residential land area} \qquad \textit{Equation 3}$$

$$\text{Future commercial land area} = \text{projected development area} * 0.25 + \text{current commercial land area} \qquad \textit{Equation 4}$$

$$\text{Future agricultural land area} = \text{current agricultural land area} - \text{projected development area (ag/grassland)} \qquad \textit{Equation 5}$$

Future forested land area = current forested land area - projected development area (forest/shrub) *Equation 6*

At the subwatershed level, the total acres of projected development were subtracted from the current forest and agricultural land area at an average watershed percentage of 10% and 90%, respectively. That is, 10% of the new development was projected to occur in forested areas, and 90% was projected to occur in agricultural areas. These percentages were derived from the county level analysis as the average distribution of land types in which development was projected to occur. The new runoff volumes and loads were calculated for each county and each subwatershed. For planning purposes, the county each subwatershed is predominantly located within was also determined using GIS.

Indicators of Forested Land Use

Indicators in the Landscape Analyst extension were used to identify areas of interior forest land, percentage of forested areas, forest edge habitat, forested land uses along riparian areas and agricultural land uses along riparian areas using 2000 land cover data. The extension identified these areas by the production of a new GIS grid file and by reporting a total watershed percentage. The work plan for this project also called for an identification of the largest forest patch in the watershed. However, the Landscape Analyst extension failed to run this indicator.

Results and Discussion

The predicted areas of development and estimated times to reach development for each county are discussed in this section. Times to reach full build-out levels, as predicted by the Landscape Analyst, vary from 26.4 years to 2,197 years. The greatest time was calculated for counties with little development in the watershed and a large land area of predicted development. These larger values present crude projections which should be updated with year 2010 census data, as population growth trends are not expected to remain constant. The predicted changes in runoff and nonpoint source loading by county and subwatersheds are also discussed and represent the potential water quality impacts of uncontrolled development with no stormwater management.

Development Model by County

The build-out analysis (future acres developed and time to reach development) was conducted for each county in the St. Joseph River Watershed (i.e., the portion of those counties within the watershed). The counties predicted to have the most future development within the shortest time period are discussed in this section.

St. Joseph, IN; St. Joseph, MI; Kalamazoo, MI; Kosciusko, IN and Elkhart, IN counties were predicted to have the most future developed land (as a percentage of total land area). Of these counties, St. Joseph, IN and Elkhart County were projected to reach this level of development in the shortest period of time (26.4 and 66.3 years, respectively). St. Joseph County (IN) also has the greatest current developed area, at 30%, and a sprawl rate of 4.03. Elkhart County is expected to reach its future level of development based on a 17% population growth rate from 1990 to 2000 and a land development rate at 1.37 times the population growth rate. Of those counties with the greatest future developed land, Kalamazoo County has the potential to increase its developed land by the greatest percentage (959%) from current development. However, it is

expected to take the longest time to reach this level of development (1,400 years) due to its relatively low population growth (6.8%) and rate of sprawl (3.1) below the Midwest average (4.5). St. Joseph County (MI) is predicted to have the greatest number of acres developed (104,507). This development is predicted to be reached in 300 years, based on current population growth rates.

Figure 2b illustrates the projected land cover with the future developed areas as predicted by the Landscape Analyst development model. Table 3 identifies the expected development within the watershed by county in relation to developed land in 2000. It also identifies from which land uses the development is expected to occur. VanBuren County was projected to have the greatest percentage of new development in forested areas (19.32% of 57,916 acres or 11,178 acres). Kosciusko County was predicted to have the greatest percentage of new development on agricultural lands (95.9% of 17,201 acres or 16,341 acres).

Development by Subwatersheds

In order to identify future build-out and water quality impacts at the subwatershed scale, the acres expected to be developed in each of 217 St. Joseph River subwatersheds were calculated from the watershed scale model run (see the table and figure in Attachment C). For planning purposes, the county in which each subwatershed predominantly falls was identified. Two subwatersheds, #42 in VanBuren County (a 32,900-acre subwatershed in the Dowagiac River drainage) and #65 in St. Joseph County, MI (a 23,500-acre subwatershed at the mouth of Portage River) each have over 9,000 acres of projected development.

For the Watershed Management Planning Project, subwatersheds were scored for preservation based on mapped attributes (K&A, 2004). Those subwatersheds were grouped into larger subwatershed units, and the scores were averaged. Two units scored the highest for preservation (primarily because they were small drainages in which the preservation score was not averaged over many units). They drain directly to the St. Joseph River in St. Joseph, MI, and Cass Counties and are known as Mill Creek (Subwatersheds #89 and #104) and Trout Creek (Subwatershed #124). These subwatersheds are shaded in the Attachment C table. The model did not predict much development in these units, compared with development predicted in other subwatersheds. It did, however, identify over 1,200 acres in each that could be developed based on the model constraints.

The scoring procedure conducted for the Watershed Management Planning Project also identified the eight drainage units (in bold in Attachment C) which scored highest for preservation at the individual subwatershed level. A high preservation score means that the watershed has a high percentage of forested and wetland land cover, according to the USGS 1992 land cover dataset used for the nonpoint source model and the subwatershed scoring. Two of these subwatersheds have over 4,700 acres projected for development (#51 in Cass County, Dowagiac Creek and #12 in Kalamazoo County, Gourdneck Creek).

Development in Elkhart County

The development model was also run on Elkhart County alone because it is almost entirely within the St. Joseph River Watershed and it was projected to have one of the greatest percentages of future developed land. With the smaller geographic scope, the model allowed for a distance threshold of 2.2 miles from current development and roads. The model was again attempted with two different user inputs: forested land as developed and agricultural land as being developed. The outputs (acres of future land developed on all current land cover types) were quite different between the two scenarios (approximately 50,000 acres vs.

Table 3. Projected development within the St. Joseph River Watershed by county using the 2000 land cover data.

County	Acres to be Developed	Acres Currently Developed	% Developed	% Development Change	% Population Change 1990-2000	Estimated Time to Reach Development (years)	Future % Developed	% of Development Occurring in Each Land Use	
								forest	agriculture
Berrien	22,338	27,650	11.1	80.8	0.7	253.9	20.0	15.0	83.9
Branch	86,956	8,951	2.7	971.5	10.3	207.5	29.1	11.5	87.9
Calhoun	39,393	2,630	1.8	1498.0	1.5	2197.0	29.3	12.5	87.1
Cass	51,382	13,857	4.3	370.8	3.3	247.2	20.2	12.8	86.9
DeKalb	908	146	2.1	622.1	14	**97.8**	15.0	8.9	91.1
Elkhart	52,335	33,899	11.6	154.4	17	**66.3**	**29.6**	9.9	89.6
Hillsdale	13,363	3,699	3.5	361.3	7.1	111.9	16.1	13.6	85.8
Kalamazoo	47,088	4,912	3.0	958.6	6.8	1409.8	**31.8**	11.1	87.9
Kosciusko	17,201	2,937	4.8	585.6	13.4	451.1	**33.2**	4.0	**95.9**
LaGrange	61,436	4,751	1.9	1293.3	18.4	**96.1**	26.7	10.0	89.9
Noble	28,597	5,542	2.8	516.0	22.2	**51.1**	17.1	9.5	90.4
St. Joseph, IN	25,513	32,185	**29.7**	79.3	7.5	**26.4**	**53.2**	13.6	86.1
St. Joseph, MI	**104,807**	12,885	3.9	813.4	6	298.3	**35.5**	8.8	90.6
Stueben	18,888	5,911	3.8	319.6	21	**33.5**	15.9	13.6	86.3
VanBuren	57,916	10,074	4.0	574.9	8.9	142.1	27.3	**19.3**	79.5

Bold figures are the highest or lowest values for those categories, depending on category.

Elkhart County and St. Joseph, IN County figures are shaded because they have the greatest predicted future development in the smallest amount of time.

61,000, respectively). When the model was run at the whole watershed level, approximately 78,000 acres were predicted to be developed in Elkhart County on all land cover types. [The model predicted 52,335 acres to be developed on the appropriate land cover types, as discussed in the Model Limitations section (see Table 3).] However, the county-scale model run also projected future development in wetland areas, open water areas and areas where development is currently located, as did the watershed scale run.

The county level run of the model with forested land selected for future development projected 3,800 acres to be developed on forested and shrub lands. The scenario in which agricultural land was selected to be developed predicted 36,000 acres of agricultural land to be developed. Therefore, 39,800 acres are projected to be developed (95% of which is on agricultural land) when the distance threshold is 2.2 miles in contrast to 10.9 miles with the watershed-scale model run. Table 3 illustrates that when the model was run at the whole watershed level, 90% of the 52,335 acres of new development were predicted to occur in agricultural areas. This exercise illustrates that running the model on a smaller geographic scale allows smaller distance thresholds to be used. However, the model outputs must still be carefully considered because development is projected in more places than on the specified land uses.

Nonpoint Source Load Model

The nonpoint source load model run for the Watershed Management Planning Project (K&A, 2003) was updated with the NOAA 2000 land cover data. The new development predicted by the Landscape Analyst based on 2000 land cover data was used to adjust the model to calculate associated increases in stormwater runoff and nonpoint source loading of sediments and phosphorus at the county level (Table 4).

Table 4. Increases in stormwater runoff and nonpoint source loads by county related to projected development.

County	Increase from Baseline Loads (2000)		
	Runoff	TP	TSS
Berrien	12.5%	20.6%	6.3%
Branch	35.1%	69.7%	18.7%
Calhoun	32.3%	73.5%	21.0%
Cass	21.3%	42.4%	11.9%
DeKalb	20.2%	35.3%	8.4%
Elkhart	23.6%	37.9%	10.9%
Hillsdale	17.7%	33.6%	9.1%
Kalamazoo	36.1%	77.3%	21.9%
Kosciusko	35.4%	67.9%	17.3%
LaGrange	33.1%	65.8%	16.9%
Noble	18.7%	37.6%	9.9%
St. Joseph, IN	25.0%	36.9%	13.9%
St. Joseph, MI	**43.6%**	**82.5%**	**21.6%**
Stueben	13.3%	30.2%	9.2%
VanBuren	30.4%	63.8%	19.7%

TP = total phosphorus
TSS = total suspended solids

St. Joseph County (MI) is expected to increase in stormwater runoff and pollutant loading by the greatest percentages. This is due to the fact that it is largely undeveloped and was predicted to have 104,807

acres of additional development. Only 3.9% of the county land area, all of which lies within the St. Joseph River Watershed, is currently developed. It is also expected to have the greatest percentage of future developed area (35.5%) after St. Joseph County, IN, which is currently 30% developed. However, it is predicted to take almost 300 years to reach this level of development.

Expected changes in runoff and loading by subwatershed are tabulated in Attachment C for the 217 drainage units used in the empirical loading model. The attachment includes the percent change from current levels to projected levels. These projections can be used with planning tools by municipalities and county governments to identify areas threatened by development (based on topography and distance to roads and current development).

Table 5 lists the total St. Joseph River Watershed calculated runoff volume and nonpoint source loads in relation to the original values (2000). The future development increases signal impacts to the watershed from future development. The increase in phosphorus loading is the greatest because the future predicted development is primarily residential (75%), which produces the highest concentration of phosphorus in runoff of all land cover types, according the estimated mean concentrations.

Table 5. Annual watershed runoff and loads with projected development.

	2000 Land Cover (baseline)	**Future Development**	**Increase from Baseline**
Runoff (acre-feet/year)	13,424,289	17,071,834	27%
Sediment (tons/year)	131,712	151,088	15%
Phosphorus (tons/year)	318	483	52%

Land cover data available from the USGS (1992) was used in the nonpoint source model conducted during the Watershed Management Planning project (K&A, 2003). More current land cover data (2000) has since become available (from NOAA) and was used to update the nonpoint source model and as a baseline for the development predictions. A 1995 land cover dataset was also available from NOAA. The land cover changes seen among these datasets and the associated watershed nonpoint source loading are discussed in Attachment D.

Forest Indicators

The model indicated that the watershed contains 11.3% upland forest and that 9.9% of this forested land is edge habitat. It also identified 8% of the watershed as forest interior, based on a 52-hectare moving window which identified areas that are at least 50% forested. Figures 3 and 4 illustrate forested areas within the watershed. Riparian areas (lands bordering streams) were found to border agricultural land on 40% of the stream length and to border forests on 35% of that length. By visual observation of the maps, the majority of forested land uses and forest interiors were identified in the northwest portion of the watershed. A large area of interior forest land was also identified in northeast LaGrange County.

Conclusions

The Landscape Analyst ArcView extension was used to conduct a build-out analysis of the St. Joseph River Watershed. This analysis predicted areas where future development can occur based on topography, distance to roads and distance to current development. The model results were used with U.S. Census data to predict the rate at which each county could be developed. The extension and other modeling tools were also used to determine on which current land use types development is predicted to occur. Changes in land cover were then used to examine potential stormwater load increases.

The Landscape Analyst model was developed by the Canaan Valley Institute through a federal grant, but is not supported nor updated through any continual funding. It is offered at no charge through an online download of the extension. Available technical assistance and help documents are limited. The institute was contacted regarding several model issues, though the large distance threshold (10.9 miles) allowed as a minimum and the placement of projected development on areas not specified by the user were of primary concern. The distance threshold could be corrected by running the model at a smaller geographic scale, as evidenced by the Elkhart County level run. Therefore, the whole watershed level run could be considered a screening tool by which Elkhart County was identified as a critical county (Table 3). The projection of future development on areas not specified by the user could not be corrected in the model. Those land areas were simply ignored and only the development projected on agricultural land and forested areas is reported. However, the future land cover map (Figure 2b) shows all development predicted by the model. Further, the largest forest patch indicator could not be executed. Though visual observation of the forest interior indicator (Figure 4) produced a similar outcome for the project. Despite these shortcomings, output from the Landscape Analyst extension has provided useful information to illustrate the potential impacts of future development in the watershed.

Elkhart County was identified as a critical county because it was predicted to have one of the greatest percentages of future developed land (29.6%), as a proportion of total land area, in a relatively short period of time (66.3) years. This is based on a 17% growth rate from 1990 to 2000. However, the relatively low sprawl rate of 1.37 (identified in Table 2) extends the time frame needed to reach the future predicted development (from the Midwest average sprawl rate of 4.5). This sprawl rate indicates the development in the Elkhart-Goshen metropolitan area is much more dense than most Midwest areas. Therefore, less land is used for development. Denser development requires innovative stormwater management techniques, such as permeable pavement and other Low Impact Development techniques. It is desirable because it actually results in less watershed imperviousness due to less extensive road and driveway networks to access sprawl development. During the Watershed Management Planning Project, subwatersheds were scored for BMP implementation priority based on the presence of identified impaired water bodies [inclusion on the 303(d) list] and the percentage of developed land uses (urban and agriculture). Of the six major subwatersheds scoring highest in this analysis, five fell partly or wholly in Elkhart County. (A higher score means the area is more impacted.) Three of these drainage units are parts of the Elkhart River Watershed. Analysis of USGS water quality monitoring data revealed the Elkhart River to be a large contributor of suspended solids and phosphorus to the St. Joseph River Watershed (analysis conducted for the Watershed Management Planning Project).

St. Joseph County (IN) was also identified as a critical county due to a high potential for future developed land (53.2% of the land in the watershed). However, the portion of this county in the watershed is already 29.7% developed. It also has the highest sprawl factor of the three metropolitan areas (4.03) in

the watershed. (This value is below the Midwest average of 4.5.) This analysis indicates that the county is currently largely developed, but has the potential to add even more developed land. This is supported by current growth trends in areas spanning South Bend and Mishawaka. A watershed group in this area, the Juday Creek Task Force, is active in encouraging stormwater management at new developments. St. Joseph County (IN) and Elkhart County are the most developed counties in the watershed and are both continuing to grow, based on Census data. Therefore, they are assigned the greatest priority for stormwater management and land use planning. Berrien County is the third most developed county in the watershed, but has the lowest growth rate of any county in the watershed. Therefore, Berrien County is assigned the lowest priority in the watershed, based on this analysis.

During the Watershed Management Planning Project, subwatersheds were also scored on mapped attributes for preservation potential (K&A, 2004). Scoring was based on forested and wetland land cover, and on the presence of identified trout streams. The preservation scoring identified major drainage units and individual subwatersheds having the greatest amount of natural resources, based on current land cover. It was rationalized that those with large areas of intact, undisturbed lands should be preserved. The development model in Landscape Analyst was used to determine which of these areas with the greatest remaining natural resources have the potential to be developed and, thus, have threatened resources. It also addressed the consequences of doing nothing (a "no-action scenario for land use planning) to protect these natural resources.

St. Joseph County, MI, which scored highly for preservation due to its forested land, was actually predicted to have over 90% of its development occur in agricultural lands. VanBuren County, also prioritized for preservation, was predicted to have the greatest percentage of development in forested areas (19.3%). Subwatersheds in the Dowagiac River Watershed (which lies in VanBuren, Cass and Berrien Counties) were identified as having the most potential for development (#42, VanBuren County) of all of the subwatersheds and as having the one of the greatest acres of potential development of those prioritized for preservation (#51, Cass County). (Subwatershed 12 in Kalamazoo County was predicted to the have the greatest number of acres developed, of those subwatersheds prioritized for preservation. However, Subwatersheds 12 and 11 contain the Gourdneck State Game Area, which is protected by the MI Department of Natural Resources.)

Further, VanBuren County is predicted to have most of its new development on forested land. This points to the need for preservation and strengthens the importance of the ongoing efforts in the Dowagiac River Watershed. This particular watershed was the subject of a 2002 watershed management planning project and is undergoing hydraulic restoration activities by the Army Corp of Engineers. VanBuren County is also drained by the PawPaw River Watershed, which contains rare prairie fen habitats (Friends, 2002-2004). Subwatershed #2 in the PawPaw River Watershed was also prioritized for preservation. The development model predicted that 3,624 acres in this subwatershed could be developed. The PawPaw River joins the St. Joseph River in Berrien County. Although Berrien County was assigned the lowest priority in this analysis, the portions of that county drained by the PawPaw River Watershed should remain a priority. The PawPaw River Watershed is a critical area based on preservation scoring and prioritization of VanBuren County.

The development model predicts future development based on physical constraints, i.e., topography and location in relation to current development and roads. It does not account for economic and social impacts on development, nor for land use planning policies. The model simply identifies areas that could

be developed at some time in the future. Further, the nonpoint source load model assumed that no stormwater BMPs are installed with the future development. It simply predicts the runoff and load based on rainfall depth and land use types. It also does not account for transport to and within the stream network. These values are meant to be used for comparison purposes to illustrate the potential impacts of unplanned development and to compare geographic units within the watershed. Based on this analysis at the county level, Elkhart County is prioritized for urban BMP implementation and VanBuren County is prioritized for land use planning related to preservation.

Landscape Analyst is a powerful tool that was developed with limited funding. Therefore, resources are currently not available to update or debug the program or to provide technical support. However, the development model outputs could be manipulated and utilized with published data on land development patterns and population growth to predict potential future impacts to the St. Joseph River Watershed. When the outputs are carefully considered, they provide useful insights into future land use pressures and potential water quality threats. The development model is also applicable at a smaller geographic, such as the county or subwatershed levels, for land use planning efforts.

Landscape Analyst is useful for future watershed management planning efforts in light of the quantitative requirements associated with USEPA's Nine Elements. Additional refinements, as noted here, would be useful. Funding for updates to the extension and technical support should be a priority to aid watershed planning efforts using this tool. Calibrating the development model output with U.S. Census data and sprawl factors further supports the utility of the model at the local level. A linkage between the model and population statistic databases could result in a powerful land use planning tool. Further, use of the extension indicators to identify agricultural land in riparian areas could be useful for targeting appropriate BMPs such as buffers, livestock exclusion and drainage protection. Although there were issues encountered using this tool, we believe the results to be reasonable and reliable for the purposes of this effort. When coupled with Census data, the development model is useful for predicting watershed threats.

Lastly, the model works with ArcView 3.2 only. This version, however, is no longer supported by ESRI, the software developer. New GIS software, ArcGIS, is now available for mapping. Ideally, two versions of the extension software could be updated/developed to allow compatibility with ArcGIS and ArcView 3.2.

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ATTACHMENT A

Landscape Analyst Documentation

Community Assistance

How can we help you?
Highlighted Projects
Watershed News
CVI Grant Program
Other Grant Opportunities
Community Tools
Online Mapping
Highlands Profiler
Watershed Calculators
Landscape Analyst
- Landscape_Analyst
- Flow Chart
- Developers
- Functionality
- Screen Shots
- Secure Login

Landscape Analyst

Description

The **Landscape Analyst** is an ArcView GIS (version 3.x) 3rd party extension. ArcView extensions add more functionality to the core software.

The **Landscape Analyst** allows users to assess the current conditions of watersheds, counties and/or regions both visually and quantitatively. It also allows users to simulate potential impacts of future changes to the **landscape**. The **Landscape Analyst** depends on users of ArcView having the ESRI created Spatial **Analyst** Extension loaded on their system.

Many of the tools, models and processes in the **Landscape Analyst** can be performed using the core ArcView software with the Spatial **Analyst** extension alone but the expertise, time and complexity required to perform such actions would be prohibitive. The **Landscape Analyst** simplifies and organizes such specialized functions into an interface that can be used by the intermediate ArcView users to make policy decisions regarding the Earth's **landscape**.

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Community Tools
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Highlands Profiler
Watershed Calculators
Landscape Analyst
- Landscape_Analyst
- Flow Chart
- Developers
- Functionality
- Screen Shots
- Secure Login

Developers:

The Landscape Analyst was developed as a cooperative agreement between the Canaan Valley Institute and the Natural Resource Analysis Center at West Virginia University.

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www.nrac.wvu.edu

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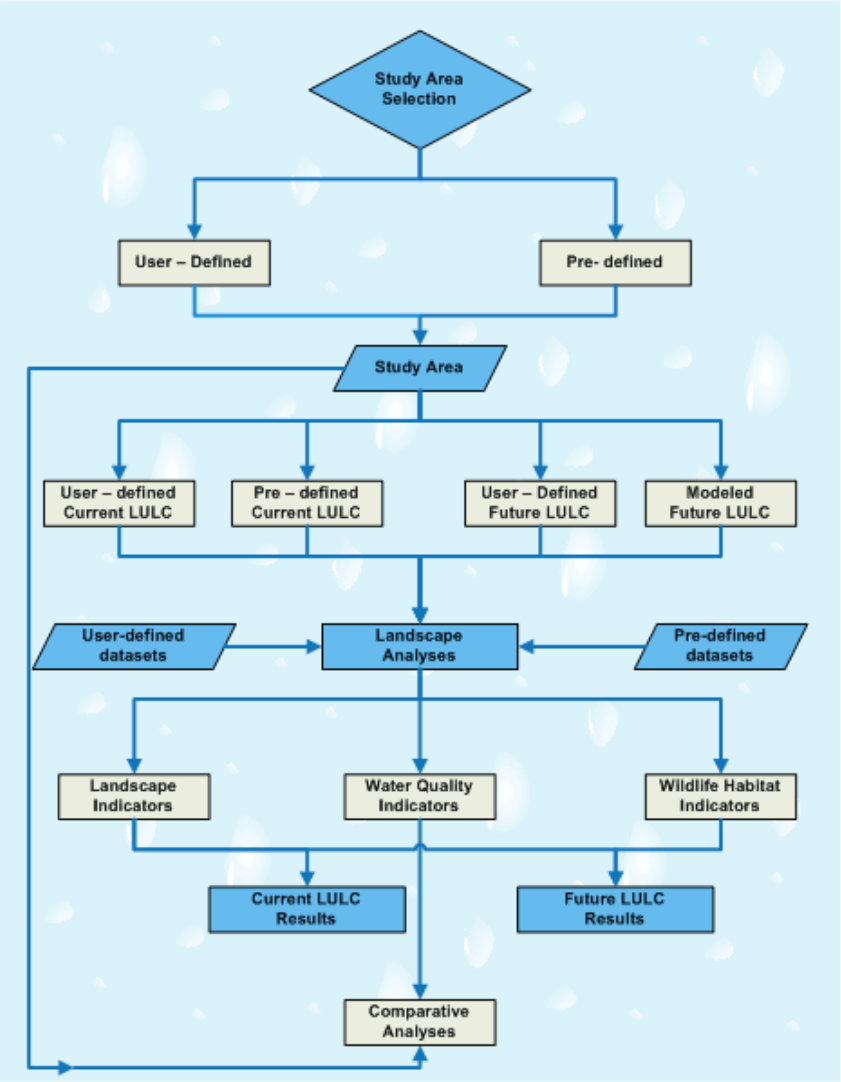
Landscape Analyst Flow Chart



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Some of the Landscape Analyst functions include:

Expected mean concentration - Estimate concentrations and loadings in the stream based on expected mean concentrations from land use/cover classes.

Fate transport - Estimate pollutant concentrations and loadings based on changing flow conditions using a weighted mass balance approach.

Potentially affected streams - Potential stream locations can be found where pollution may flow during a precipitation event.

Delineate watersheds - Automatically create watersheds at set sizes.

Erosion model - Estimate how land use changes influence the amount of runoff in a watershed.

Trace raindrop path - Trace the path of steepest descent across the landscape.

Estimate drainage area - Query a stream location and report back an estimate of the drainage area.

Stream flow query tool - Estimate the Cubic Feet Per Second of water flowing through a stream at a specified point.

Riparian forest - Estimate the percentage of stream length with adjacent forested land cover.

Agriculture near streams - Estimate the proportion of total stream length with adjacent agricultural land cover.

Stream/road intersections - List the number of stream/road intersections and the number of intersections per unit stream length.

Development model - Identify areas that are more likely to be developed in the future based on a fuzzy logic approach.

Tabulate Land Use/Land Cover Area - Compute the total area in square meters, hectares, acres, and square miles for different land cover types.

Land Use/Land Cover Histogram - Computes a histogram depicting the total area of different land cover types.

Derive slope - Calculate the higher elevation, lower elevation, elevation change, length, percent slope, and slope for a line.

Report elevation - Elevation is returned in meters and feet.

Percent forested - Estimate the percentage forested land cover.

Forest edge habitat - Estimate approximate amount of forest edge habitat.

Largest forest patch - Estimate the single largest contiguous forested patch.

Forest interior - Estimate the proportion of the study area above a user-specified percent forested threshold.

Road density - Compute the total length of roads per unit area.

Relative Road density - Compute the relative road density.

Human use index - Estimate the percentage of human-influenced land uses.

Agriculture on steep slopes - Estimate the proportion of agricultural areas that are found on steep slopes.

Cropland on steep slopes - Estimate the proportion of cropland that is found on steep slopes.

Bird community index - Estimate the overall ecological condition by relating the types of birds inhabiting an area with the surrounding land cover.

Louisiana Waterthrush - Estimate the amount of suitable and less suitable riparian habitat available for Louisiana Waterthrush (Seiurus motacilla).

Select Study Area - Define a study area based on the spatial coordinates of a center point, a graphical point, line, or polygon, or a dataset feature.

Clip GRID to polygon - Clips a GRID theme with a polygon theme.

GRID Re-class - Change the land cover GRID cells interactively.

Measure distance - Measure distance in Feet, Meters and Miles.

Report polygon area - Report the area of a polygon.

Coordinate display - Report the UTM coordinates of a point.

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ATTACHMENT B

1990-2000 Population Growth Rates

County Level Population Growth Rates (1990-2000), as identified by the U.S. Census
(http://www.census.gov)

County	Growth Rate (%)
Berrien	0.7
Branch	10.3
Calhoun	1.5
Cass	3.3
DeKalb	14.0
Elkhart	17.0
Hillsdale	7.1
Kalamazoo	6.8
Kosciusko	13.4
LaGrange	18.4
Noble	22.2
St. Joseph, IN	7.5
St. Joseph, MI	6.0
Stueben	21.0
VanBuren	8.9

ATTACHMENT C

Projected Development and Associated Nonpoint Source Loading Increases by Subwatershed

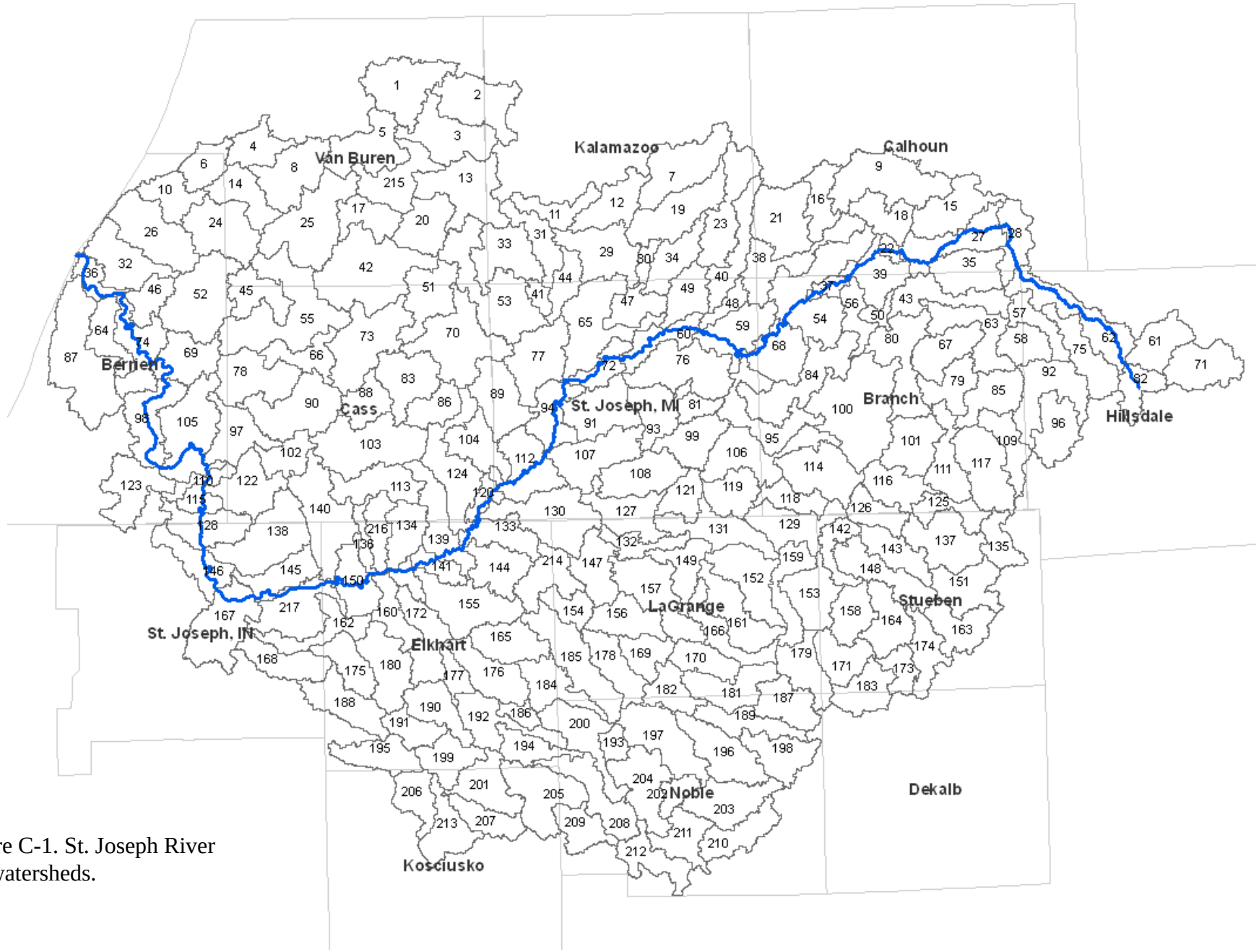

Figure C-1. St. Joseph River Subwatersheds.

Number	County	Acres to be Developed	Annual Runoff (acre-feet/year)			Annual TSS Loading (tons/year)			Annual TP Loading (tons/year)		
			Baseline	Projected	Percent Increase	Baseline	Projected	Percent Increase	Baseline	Projected	Percent Increase
1	VanBuren	3,240	92,939	113,265	21.87	894	999	11.70	2.08	3.00	43.92
2	**VanBuren**	**3,624**	**102,066**	**124,278**	**21.76**	**631**	**745**	**18.11**	**1.75**	**2.75**	**56.98**
3	VanBuren	3,185	83,781	103,456	23.48	710	811	14.25	1.72	2.60	51.50
4	VanBuren	2,142	52,302	66,513	27.17	446	520	16.38	1.08	1.72	59.38
5	VanBuren	4,173	100,627	127,221	26.43	680	817	20.13	1.78	2.97	67.31
6	Berrien	1,098	62,006	69,431	11.97	384	422	9.94	1.17	1.51	28.43
7	Kalamazoo	6,095	92,276	127,366	38.03	829	1010	21.78	1.94	3.52	81.37
8	VanBuren	2,087	93,024	106,729	14.73	810	881	8.70	2.02	2.64	30.47
9	Calhoun	7,248	117,510	157,113	33.70	906	1110	22.49	2.23	4.01	79.84
10	Berrien	604	54,676	58,816	7.57	532	553	4.00	1.44	1.63	12.91
11	Kalamazoo	2,636	48,247	63,968	32.58	334	415	24.22	0.98	1.69	72.29
12	**Kalamazoo**	**4,777**	**80,591**	**108,467**	**34.59**	**446**	**589**	**32.20**	**1.39**	**2.64**	**90.32**
13	VanBuren	4,118	91,114	116,364	27.71	896	1026	14.49	2.18	3.31	52.18
14	VanBuren	2,196	65,915	80,637	22.33	624	700	12.14	1.55	2.21	42.66
15	Calhoun	4,008	64,265	85,920	33.70	637	748	17.50	1.42	2.40	68.38
16	Calhoun	1,043	48,840	54,735	12.07	336	366	9.04	0.86	1.13	30.74
17	VanBuren	2,581	42,388	58,827	38.78	487	572	17.37	1.04	1.78	70.82
18	Calhoun	2,032	54,888	65,992	20.23	347	404	16.48	0.93	1.43	53.84
19	Kalamazoo	4,997	100,206	128,923	28.66	757	905	19.52	1.91	3.20	67.76
20	VanBuren	3,350	60,668	81,486	34.31	584	692	18.33	1.39	2.33	67.37
21	Calhoun	2,746	97,982	113,569	15.91	719	799	11.15	1.82	2.52	38.48
22	Calhoun	714	9,662	13,583	40.58	92	112	21.88	0.21	0.39	82.99
23	Kalamazoo	3,295	72,466	91,285	25.97	785	882	12.33	1.70	2.55	49.69
24	VanBuren	2,800	85,114	104,120	22.33	1039	1136	9.42	2.29	3.14	37.39
25	VanBuren	4,942	131,225	163,517	24.61	1278	1444	13.00	2.99	4.44	48.63
26	Berrien	1,043	98,544	105,768	7.33	1114	1151	3.34	2.59	2.92	12.53
27	Calhoun	5,985	77,845	110,123	41.46	649	815	25.58	1.60	3.06	90.55
28	Calhoun	4,173	53,755	76,101	41.57	386	501	29.81	1.00	2.01	100.27
29	Kalamazoo	5,766	93,134	126,888	36.24	738	912	23.53	1.90	3.42	80.01
30	Kalamazoo	1,647	14,342	23,844	66.26	136	185	35.92	0.32	0.74	135.35
31	Kalamazoo	4,777	31,599	60,165	90.41	529	676	27.81	1.04	2.32	123.64
32	Berrien	1,922	98,265	111,702	13.68	1067	1136	6.48	3.15	3.76	19.19
33	Kalamazoo	4,612	72,907	100,691	38.11	700	843	20.43	1.59	2.84	78.65
34	Kalamazoo	2,416	52,884	66,750	26.22	459	530	15.54	1.08	1.70	57.89
35	Calhoun	2,636	60,355	74,553	23.52	525	598	13.93	1.23	1.86	52.12
36	**Berrien**	**769**	**50,276**	**55,677**	**10.74**	**354**	**382**	**7.85**	**1.43**	**1.67**	**17.01**
37	Branch	988	18,800	24,278	29.14	126	154	22.38	0.37	0.62	66.28
38	Calhoun	4,612	75,988	101,887	34.08	674	808	19.76	1.59	2.75	73.32
39	Calhoun	2,910	48,538	64,530	32.95	522	604	15.77	1.15	1.87	62.34
40	Kalamazoo	1,977	56,914	68,153	19.75	532	589	10.88	1.21	1.72	41.75
41	St. Joseph MI	933	10,665	16,209	51.98	146	175	19.53	0.30	0.55	82.73
42	VanBuren	9,829	124,221	186,659	50.26	1601	1922	20.07	3.36	6.17	83.71
43	Branch	4,558	58,675	83,312	41.99	582	709	21.77	1.31	2.42	84.60
44	Kalamazoo	2,965	36,681	54,216	47.80	338	428	26.70	0.82	1.61	96.57
45	Cass	2,636	76,098	93,831	23.30	529	620	17.24	1.50	2.30	53.11
46	Berrien	494	30,420	33,888	11.40	440	458	4.06	0.92	1.07	17.02
47	St. Joseph MI	3,075	38,314	56,061	46.32	391	482	23.37	0.88	1.67	91.19
48	St. Joseph MI	1,702	17,311	26,976	55.83	206	255	24.17	0.44	0.88	97.91
49	St. Joseph MI	1,812	33,682	44,040	30.75	486	539	10.97	0.97	1.44	47.90
50	Branch	879	12,152	16,968	39.64	125	150	19.76	0.27	0.49	79.01
51	**Cass**	**4,173**	**91,952**	**117,671**	**27.97**	**592**	**724**	**22.35**	**1.62**	**2.78**	**71.24**
52	Berrien	1,702	111,408	123,178	10.57	1275	1335	4.75	2.79	3.32	19.00
53	St. Joseph MI	5,326	136,742	168,830	23.47	1141	1306	14.47	2.76	4.20	52.34
54	Branch	8,456	115,138	162,251	40.92	1203	1446	20.15	2.65	4.77	79.97
55	Cass	8,895	203,214	262,250	29.05	1593	1897	19.07	4.16	6.82	63.78
56	Branch	1,592	30,647	39,430	28.66	295	340	15.34	0.67	1.06	59.19

			Annual Runoff (acre-feet/year)			Annual TSS Loading (tons/year)			Annual TP Loading (tons/year)		
Number	**County**	**Acres to be Developed**	**Baseline**	**Projected**	**Percent Increase**	**Baseline**	**Projected**	**Percent Increase**	**Baseline**	**Projected**	**Percent Increase**
57	Hillsdale	1,647	26,749	35,578	33.00	351	397	12.93	0.72	1.11	55.35
58	Branch	1,153	36,282	42,463	17.04	348	379	9.15	0.78	1.06	35.43
59	St. Joseph MI	4,063	67,378	90,387	34.15	639	757	18.53	1.47	2.50	70.51
60	St. Joseph MI	3,404	39,402	58,905	49.50	451	552	22.24	0.99	1.87	88.23
61	Hillsdale	1,373	46,251	53,664	16.03	458	496	8.34	1.02	1.36	32.58
62	Hillsdale	3,020	79,750	96,015	20.40	865	949	9.68	2.00	2.73	36.65
63	Branch	4,063	59,373	81,289	36.91	634	747	17.79	1.42	2.40	69.62
64	Berrien	1,098	40,457	48,236	19.23	601	641	6.66	1.26	1.61	27.82
65	St. Joseph MI	9,829	94,367	151,663	60.72	1087	1382	27.13	2.42	5.00	106.44
66	Cass	1,318	50,802	59,394	16.91	461	505	9.59	1.21	1.60	31.90
67	Branch	2,196	53,315	65,243	22.37	578	639	10.62	1.50	2.04	35.77
68	Branch	2,581	59,123	73,608	24.50	604	679	12.33	1.34	1.99	48.76
69	Berrien	494	65,887	69,364	5.28	745	763	2.40	1.76	1.92	8.89
70	Cass	2,691	124,016	140,278	13.11	1021	1105	8.20	2.50	3.23	29.24
71	Hillsdale	1,647	59,003	67,914	15.10	595	641	7.70	1.34	1.74	29.99
72	St. Joseph MI	2,471	34,671	48,960	41.21	323	397	22.73	0.79	1.43	81.72
73	Cass	3,185	91,648	111,704	21.88	1095	1198	9.42	2.33	3.24	38.67
74	Berrien	988	80,953	87,961	8.66	910	946	3.96	2.15	2.46	14.69
75	Hillsdale	1,263	49,969	56,785	13.64	515	550	6.81	1.14	1.44	27.00
76	St. Joseph MI	5,875	74,773	108,220	44.73	994	1166	17.31	2.03	3.53	74.30
77	St. Joseph MI	3,350	75,854	95,541	25.95	759	860	13.34	1.82	2.71	48.57
78	Cass	3,075	96,435	117,228	21.56	864	971	12.38	2.09	3.03	44.72
79	Branch	1,922	42,610	53,085	24.58	462	516	11.68	1.08	1.56	43.46
80	Branch	3,789	91,172	111,910	22.75	778	884	13.72	1.94	2.87	48.16
81	St. Joseph MI	1,373	15,117	22,893	51.44	230	270	17.39	0.46	0.81	76.52
82	Hillsdale	329	34,617	36,402	5.16	351	361	2.61	0.95	1.03	8.49
83	Cass	1,483	68,309	77,378	13.28	684	731	6.82	1.56	1.97	26.19
84	Branch	4,393	76,245	100,676	32.04	916	1041	13.73	1.91	3.01	57.49
85	Branch	3,185	52,516	69,684	32.69	493	582	17.91	1.16	1.93	66.54
86	**Cass**	**439**	**45,364**	**47,998**	**5.81**	**340**	**354**	**3.99**	**0.90**	**1.02**	**13.17**
87	**Berrien**	**2,800**	**139,355**	**159,197**	**14.24**	**1918**	**2020**	**5.32**	**4.62**	**5.51**	**19.34**
88	Cass	1,922	46,430	58,354	25.68	473	535	12.97	1.16	1.70	46.16
89	**St. Joseph MI**	**1,373**	**80,931**	**89,026**	**10.00**	**558**	**600**	**7.46**	**1.49**	**1.85**	**24.47**
90	Cass	2,361	86,069	101,386	17.80	1078	1157	7.31	2.31	3.00	29.78
91	St. Joseph MI	5,216	53,632	83,685	56.04	777	932	19.90	1.58	2.93	85.59
92	Hillsdale	2,306	68,470	80,847	18.08	740	804	8.60	1.61	2.17	34.63
93	St. Joseph MI	2,636	58,108	73,126	25.85	485	562	15.95	1.20	1.87	56.42
94	St. Joseph MI	3,679	53,101	74,490	40.28	585	695	18.83	1.38	2.34	69.72
95	St. Joseph MI	4,283	79,219	103,190	30.26	675	798	18.27	1.64	2.72	65.87
96	Hillsdale	879	49,308	54,035	9.59	515	539	4.72	1.14	1.36	18.61
97	Cass	2,636	59,151	77,273	30.64	715	808	13.04	1.63	2.45	49.88
98	Berrien	1,153	87,500	95,755	9.43	805	848	5.27	2.07	2.44	17.98
99	St. Joseph MI	2,526	59,835	74,103	23.85	429	503	17.10	1.12	1.76	57.52
100	Branch	8,182	143,978	189,009	31.28	1466	1697	15.81	3.29	5.32	61.57
101	Branch	4,173	67,547	90,396	33.83	564	681	20.86	1.39	2.42	73.89
102	Cass	714	39,950	44,522	11.44	386	410	6.09	0.92	1.13	22.27
103	Cass	4,503	126,505	153,989	21.73	1079	1220	13.11	2.62	3.86	47.20
104	Cass	1,208	48,776	55,879	14.56	523	559	6.99	1.15	1.47	27.77
105	Berrien	1,537	109,876	120,852	9.99	1391	1448	4.06	3.24	3.73	15.25
106	St. Joseph MI	6,370	66,952	102,511	53.11	878	1061	20.85	1.85	3.45	86.55
107	St. Joseph MI	6,315	65,417	101,613	55.33	808	994	23.06	1.69	3.32	96.19
108	St. Joseph MI	3,404	68,061	87,372	28.37	591	691	16.81	1.44	2.31	60.31
109	Branch	1,208	32,878	39,402	19.84	426	459	7.89	0.87	1.16	33.86
110	Berrien	494	28,405	31,915	12.36	300	318	6.02	0.96	1.12	16.43
111	Branch	3,185	76,331	93,690	22.74	412	501	21.68	1.24	2.02	62.96
112	St. Joseph MI	5,216	69,005	99,249	43.83	789	944	19.73	1.77	3.13	76.90

			Annual Runoff (acre-feet/year)			Annual TSS Loading (tons/year)			Annual TP Loading (tons/year)		
Number	County	Acres to be Developed	Baseline	Projected	Percent Increase	Baseline	Projected	Percent Increase	Baseline	Projected	Percent Increase
113	Cass	2,142	62,321	75,166	20.61	577	643	11.45	1.37	1.95	42.13
114	Branch	6,425	63,545	98,962	55.74	792	974	23.01	1.64	3.23	97.34
115	Berrien	604	24,286	28,551	17.56	245	267	8.94	0.65	0.84	29.43
116	Branch	3,185	50,940	68,364	34.21	417	507	21.49	1.00	1.78	78.66
117	Branch	4,283	65,034	88,316	35.80	752	872	15.93	1.58	2.63	66.21
118	Branch	2,526	27,300	41,263	51.15	315	387	22.82	0.66	1.29	94.86
119	St. Joseph MI	1,428	39,588	47,559	20.13	424	465	9.68	0.92	1.28	38.87
120	Cass	714	17,014	21,163	24.39	163	184	13.13	0.37	0.56	50.27
121	St. Joseph MI	2,910	30,789	47,153	53.15	443	527	19.01	1.20	1.93	61.51
122	Cass	2,581	64,110	81,091	26.49	744	832	11.74	1.80	2.57	42.40
123	Berrien	384	72,673	75,400	3.75	773	787	1.82	1.87	1.99	6.56
124	**Cass**	**1,757**	**97,514**	**107,864**	**10.61**	**701**	**754**	**7.60**	**1.85**	**2.31**	**25.19**
125	Branch	1,537	42,809	51,187	19.57	268	311	16.07	0.77	1.15	48.79
126	Branch	1,318	35,500	42,714	20.32	364	401	10.20	0.83	1.15	39.28
127	St. Joseph MI	4,063	53,526	76,520	42.96	624	743	18.95	1.33	2.37	77.68
128	St. Joseph IN	1,702	99,017	110,539	11.64	610	669	9.72	2.17	2.69	23.89
129	LaGrange	3,185	67,360	84,943	26.10	607	697	14.91	1.43	2.22	55.41
130	St. Joseph MI	5,985	104,010	138,274	32.94	960	1137	18.36	2.34	3.88	65.89
131	LaGrange	4,448	59,024	83,832	42.03	703	830	18.17	1.51	2.63	73.77
132	LaGrange	1,977	34,599	45,722	32.15	279	336	20.54	0.68	1.18	73.68
133	Elkhart	1,318	56,797	64,382	13.35	420	459	9.29	1.09	1.43	31.37
134	Elkhart	4,338	53,276	78,737	47.79	494	625	26.51	1.34	2.49	85.40
135	Steuben	2,142	31,029	42,716	37.66	327	387	18.39	0.72	1.25	72.87
136	Elkhart	1,318	26,928	34,733	28.98	224	265	17.90	0.71	1.06	49.22
137	Steuben	2,306	108,235	120,807	11.62	640	705	10.11	1.96	2.52	28.89
138	St. Joseph IN	5,820	126,410	162,207	28.32	1261	1446	14.60	4.02	5.63	40.10
139	Elkhart	3,514	55,598	76,146	36.96	733	838	14.43	1.63	2.55	56.84
140	Elkhart	7,303	101,018	145,193	43.73	1087	1314	20.91	2.76	4.75	72.05
141	Elkhart	1,043	28,204	34,240	21.40	244	275	12.73	0.67	0.95	40.28
142	Steuben	1,812	30,539	40,474	32.53	322	373	15.90	0.72	1.17	61.95
143	Steuben	1,428	79,370	87,159	9.81	344	384	11.65	1.18	1.53	29.66
144	Elkhart	439	70,760	73,276	3.56	484	497	2.67	1.32	1.43	8.59
145	St. Joseph IN	5,985	69,220	105,260	52.07	675	861	27.46	2.16	3.79	74.94
146	St. Joseph IN	2,581	97,417	114,577	17.62	921	1009	9.59	3.26	4.03	23.70
147	LaGrange	2,471	52,830	66,773	26.39	559	630	12.84	1.27	1.90	49.23
148	Steuben	2,471	96,941	110,429	13.91	578	647	12.02	1.74	2.34	34.92
149	LaGrange	3,404	41,097	60,095	46.23	475	573	20.58	1.07	1.92	80.01
150	Elkhart	5,107	93,998	123,945	31.86	854	1008	18.04	3.08	4.42	43.81
151	Steuben	1,977	54,149	64,941	19.93	567	622	9.80	1.24	1.73	39.03
152	LaGrange	3,240	89,432	107,342	20.03	610	702	15.11	1.56	2.37	51.52
153	LaGrange	1,922	73,343	83,870	14.35	493	548	10.98	1.28	1.75	37.05
154	LaGrange	659	21,824	25,536	17.01	320	339	5.97	0.63	0.79	26.65
155	Elkhart	1,153	80,539	87,135	8.19	890	924	3.81	2.04	2.34	14.52
156	LaGrange	3,350	36,011	54,718	51.95	571	667	16.86	1.09	1.94	76.89
157	LaGrange	4,118	67,411	90,407	34.11	868	987	13.63	1.76	2.79	58.83
158	Steuben	549	45,604	48,597	6.56	417	433	3.69	0.95	1.08	14.18
159	LaGrange	1,483	51,147	59,290	15.92	440	482	9.52	1.02	1.39	35.82
160	Elkhart	2,471	53,191	67,475	26.85	490	563	15.01	1.60	2.25	40.10
161	LaGrange	2,581	72,532	86,782	19.65	624	698	11.74	1.46	2.10	43.95
162	St. Joseph IN	1,867	44,289	55,277	24.81	574	630	9.85	1.29	1.78	38.44
163	Steuben	1,153	54,207	60,506	11.62	505	538	6.42	1.26	1.54	22.54
164	Steuben	879	72,635	77,422	6.59	437	462	5.63	1.22	1.43	17.71
165	Elkhart	1,318	38,159	45,607	19.52	621	660	6.17	1.19	1.53	28.13
166	LaGrange	1,757	40,371	50,070	24.03	506	556	9.86	1.12	1.56	38.93
167	St. Joseph IN	3,240	138,334	158,590	14.64	1261	1365	8.27	4.45	5.36	20.48
168	St. Joseph IN	3,404	37,808	58,063	53.57	631	735	16.52	1.21	2.12	75.50

			Annual Runoff (acre-feet/year)			Annual TSS Loading (tons/year)			Annual TP Loading (tons/year)		
Number	**County**	**Acres to be Developed**	**Baseline**	**Projected**	**Percent Increase**	**Baseline**	**Projected**	**Percent Increase**	**Baseline**	**Projected**	**Percent Increase**
169	LaGrange	2,361	25,166	38,280	52.11	415	483	16.24	0.78	1.37	75.43
170	LaGrange	1,592	46,538	55,324	18.88	356	401	12.71	0.87	1.27	45.25
171	Steuben	1,098	47,229	53,209	12.66	422	453	7.28	0.99	1.26	27.17
172	Elkhart	2,855	64,416	80,767	25.38	681	765	12.35	1.88	2.61	39.22
173	Steuben	769	22,303	26,492	18.78	305	327	7.06	0.65	0.84	28.81
174	Steuben	1,428	48,809	56,596	15.95	396	436	10.13	0.98	1.33	35.86
175	Elkhart	1,263	32,489	39,805	22.52	538	575	7.00	1.07	1.40	30.76
176	Elkhart	2,361	61,368	74,692	21.71	789	858	8.69	1.97	2.57	30.42
177	Elkhart	1,812	32,942	43,210	31.17	265	317	19.96	0.92	1.38	50.36
178	LaGrange	4,503	35,268	60,320	71.04	598	727	21.54	1.18	2.31	95.40
179	LaGrange	1,153	61,451	67,735	10.23	455	487	7.11	1.14	1.42	24.85
180	Elkhart	1,647	48,075	57,533	19.67	770	818	6.32	1.51	1.94	28.15
181	LaGrange	2,416	77,974	91,227	17.00	507	575	13.45	1.38	1.97	43.31
182	LaGrange	1,428	42,997	50,878	18.33	362	402	11.21	0.85	1.20	41.72
183	Dekalb	988	38,199	43,576	14.08	495	523	5.59	1.02	1.26	23.73
184	Elkhart	1,757	37,720	47,543	26.04	585	635	8.64	1.17	1.61	37.91
185	LaGrange	4,832	58,363	85,399	46.32	997	1136	13.95	1.88	3.09	64.79
186	Elkhart	659	14,320	18,006	25.74	168	187	11.30	0.35	0.52	46.79
187	Noble	769	52,239	56,426	8.02	468	490	4.60	1.08	1.27	17.41
188	Elkhart	3,514	43,409	63,699	46.74	764	869	13.66	1.54	2.45	59.28
189	Noble	1,428	57,503	65,297	13.55	401	441	10.00	1.05	1.40	33.35
190	Elkhart	1,153	40,048	46,574	16.30	551	584	6.10	1.16	1.45	25.30
191	Elkhart	933	21,071	26,361	25.11	393	420	6.93	0.73	0.97	32.43
192	Elkhart	3,789	52,082	73,322	40.78	624	733	17.52	1.35	2.30	70.82
193	Noble	220	15,358	16,572	7.90	172	178	3.63	0.37	0.42	14.83
194	Elkhart	3,514	25,941	45,518	75.47	412	513	24.42	0.79	1.67	111.05
195	Elkhart	2,087	37,460	49,323	31.67	601	662	10.16	1.33	1.86	40.17
196	Noble	1,867	73,166	83,357	13.93	667	719	7.86	1.54	2.00	29.83
197	Noble	3,899	67,025	88,458	31.98	847	957	13.02	1.73	2.70	55.65
198	Noble	1,098	66,395	72,364	8.99	560	591	5.48	1.66	1.93	16.21
199	Elkhart	659	35,550	39,251	10.41	536	555	3.55	1.11	1.28	15.00
200	Noble	2,581	55,154	69,468	25.95	747	821	9.86	1.62	2.27	39.65
201	Kosciusko	604	49,860	53,229	6.76	608	625	2.85	1.35	1.50	11.21
202	Noble	220	25,565	26,765	4.69	166	172	3.73	0.44	0.50	12.20
203	Noble	1,153	61,659	67,935	10.18	652	685	4.95	1.47	1.76	19.15
204	Noble	2,032	83,762	94,914	13.31	616	673	9.32	1.53	2.03	32.85
205	Kosciusko	5,052	130,408	158,426	21.49	688	832	20.96	2.24	3.50	56.29
206	Kosciusko	3,350	23,951	42,778	78.60	485	582	19.97	0.88	1.72	96.79
207	Kosciusko	1,098	42,826	48,939	14.27	372	403	8.46	0.90	1.17	30.59
208	Noble	4,118	46,115	68,829	49.26	727	844	16.07	1.40	2.42	72.86
209	Noble	769	38,973	43,215	10.88	397	419	5.49	0.88	1.07	21.79
210	Noble	1,098	58,116	64,083	10.27	371	402	8.27	0.97	1.24	27.58
211	Noble	604	50,964	54,259	6.46	397	414	4.27	0.97	1.11	15.36
212	Noble	1,428	50,922	58,728	15.33	448	488	8.97	1.05	1.41	33.31
213	Kosciusko	4,887	33,055	60,346	82.56	634	774	22.16	1.18	2.41	103.86
214	Elkhart	439	59,687	62,179	4.18	586	599	2.19	1.45	1.57	7.72
215	VanBuren	4,667	83,486	112,897	35.23	689	840	21.97	1.82	3.14	72.80
216	Elkhart	4,667	77,625	105,047	35.32	682	823	20.70	2.26	3.49	54.67
217	St. Joseph IN	5,711	96,170	130,098	35.28	897	1072	19.46	2.75	4.28	55.49

Bold subwatersheds were prioritized for preservation.
Shaded subwatersheds were parts of major subwatershed units prioritized for preservation.
Subwatershed numbers 89 and 124 fit both criteria.

Berrien, Branch, Calhoun, Cass, Hillsdale, Kalamazoo, St. Joseph (MI) and VanBuren Counties are in Michigan.
DeKalb, Elkhart, Kosciusko, LaGrange, Noble, St. Joseph (IN) and Stueben Counties are in Indiana.

ATTACHMENT D

Comparison of 1992 USGS Land Cover Data to 2000 NOAA Land Cover Data

KIESER & ASSOCIATES

Comparison of 1992 USGS Land Cover Data to NOAA Land Cover Data Sets

The 1992 USGS land cover data are available for the entire United States for download from the USGS website (http://edc.usgs.gov/products/landcover/nlcd.html). Those data were used in 2003 for the nonpoint source load model conducted for the St. Joseph River Watershed Planning Project (K&A, 2003). Since that time, 1995 and 2000 land cover data became available from the NOAA Coastal Change Analysis Program. These data cover the United State coastal areas, including land draining to the Great Lakes. The 2000 data were used to update the nonpoint source load model from 1992 data and as a baseline for the Landscape Analyst development model.

Although NOAA and USGS use the same type of satellite image data for land cover classification, and the classification process is also similar between the two agencies, they have different purposes for such data and hence, differing final classifications. NOAA's Coastal Change Analysis Program is interested in coastal habitat change, and its land cover classification reflects this by giving more detailed sub-classes for wetlands and coastal lands but less for human-influenced land uses (developed lands and agricultural lands) compared to 1992 USGS data.

For the nonpoint source modeling, the land cover types were grouped into classes, as show in Table D-1. It can be seen from the table that the NOAA data contain several divisions for wetland and shoreline land uses, while the USGS data contain more distinctions for human-influenced land uses. The USGS land cover data used for the 2003 nonpoint source loading were calibrated to loading data from a USGS study of major tributaries to Lake Michigan and Lake Superior (Robertson, 1997). Thus loading values generated from 1992 land cover data are considered representative of the watershed loading because USGS data define human-influenced land uses (which affect runoff) more distinctly than the NOAA data. The NOAA data were still considered adequate to use as a baseline for the Landscape Analyst development model which simply needed the general land cover divisions of: developed, forest, agriculture and wetlands. The nonpoint source loading model was updated with the 2000 land cover data to serve as a new loading baseline. It was then refined with the output of the build-out analysis to illustrate potential increases in runoff from future development. The validity of using the nonpoint source loading estimates calculated with the NOAA data stems from the desire to obtain a comparison of future loading from predicted development to baseline loading (i.e., the percentages reported in Tables 4 and 5 of the report text).

Table D-1. Grouping of land cover classes.

Major Land Cover Groups	NOAA Land Cover Classes (2000)	USGS Land Cover Classes (1992)
Water and Wetland	Open water, palustrine forest, palustrine scrub/shrub, palustrine emergent, unconsolidated shore, palustrine aquatic bed	Open water, woody wetlands, emergent herbaceous wetlands
Forest and Open Space	Deciduous forest, evergreen forest, mixed forest, scrub/shrub	Deciduous forest, evergreen forest, mixed forest, shrubland, grassland
Agriculture	Cultivated land, grassland	Pasture/hay, row crops, small grains
Residential	Low intensity development	Low intensity residential, high intensity residential, urban/ recreational grasses
Commercial, Industrial and Transportation	High intensity development	Commercial/industrial/ transportation

The land cover distribution and associated nonpoint source loading of sediments and phosphorus were compared among the 1992, 1995 and 2000 land cover data sets (see Table D-2). This comparison highlights significant discrepancies among the data sets for open water and wetland land cover types which seem to infer these are increasing in area over time. This is not considered realistic and thus, suggests incompatibility for comparing loading estimates between USGS and NOAA data. Therefore, forest lands and agricultural lands, though shown to be decreasing over time resulting in a decrease in sediment loading from 1992 to 2000, cannot be rationalized.

Other differences or discrepencies included the following:

- For the NOAA data, grassland and cultivated lands were summed as agricultural lands because the acreage of cultivated lands alone was much lower than the agricultural land in the USGS data set.
- With the USGS data, row crops, pasture/hay and small grains formed the agricultural land grouping. A separate grassland land cover type was grouped into the forest/open space grouping.
- Residential land increased sharply from 1992 to 1995 and then dropped in 2000. Only one land cover type in the NOAA data was available for the residential grouping, while three land cover types were delineated with the USGS data.
- The residential and agricultural land cover types signal that the USGS data are more refined for human-influenced land cover types which is more useful for nonpoint source load estimates.
- From the 1992 USGS data to the 2000 NOAA data, commercial land rose sharply over time. This may be because the NOAA grouping for high intensity development may include both commercial and residential land uses.

There are irreconcilable changes even within the 1995 and 2000 NOAA land cover data sets. For example, total acreage for the residential and commercial/industrial/transportation land cover groupings decreased from 172,667 acres in the 1995 NOAA data set to 170,147 acres with the 2000 NOAA data. This is not considered representative of the watershed, as it is known that development has increased over time. This may be partially explained by the limitations of the ArcView data processing capabilities. The NOAA data were made available as one large grid file encompassing all of the area of Michigan and Indiana draining to Lake Michigan in an Albers Conical Equal Area projection. These data needed to be reprojected to Universal Transverse Mercator Zone 16 to be compatible with the other GIS files used in this modeling exercise. However, the file was too large for ArcView to reproject in one step. It had to be cut into smaller pieces, which were reprojected individually. The pieces in the new coordinate system were then “mosaiced” back together. This data processing may have resulted in the loss or alteration of some “grids” from the original file. The USGS data did not have to manipulated in this way.

Regardless of these data discrepancies, the 2000 NOAA data set was considered valid to serve as a baseline for the development model to project future development and to calculate percent changes in stormwater runoff and nonpoint source loading associated with such development.

Reference

Robertson, Dale M. 1997. Regionalized Loads of Sediment and Phosphorus to Lakes Michigan and Superior: High Flow and Long-term Average. J. Great Lakes Res 23(4):416-439.

1992 USGS

	Water + Wetland	Forest/open	Agricultural	Residential	Com/ind/transp	Total
acres	248,191	495,175	2,109,499	87,699	29,450	2,970,014
% total	8.36	16.67	71.03	2.95	0.99	
TP (lbs/yr)	69,074	28,187	395,552	55,114	31,046	578,973
TSS (lbs/yr)	5,180,572	13,068,344	230,916,857	10,125,600	9,701,937	268,993,310

1995 NOAA

	Water + Wetland	Forest/open	Agricultural	Residential	Com/ind/transp	Total
acres	352,861	467,349	1,979,133	128,155	44,512	2,972,011
% total	11.87	15.73	66.59	4.31	1.50	
TP (lbs/yr)	98,780	26,210	371,965	79,167	46,961	623,083
TSS (lbs/yr)	7,408,521	12,152,086	217,147,003	14,544,668	14,675,202	265,927,480

2000 NOAA

	Water + Wetland	Forest/open	Agricultural	Residential	Com/ind/transp	Total
acres	438,765	394,619	1,968,416	121,634	48,513	2,971,946
% total	14.76	13.28	66.23	4.09	1.63	
TP (lbs/yr)	121,354	22,396	369,848	75,608	51,210	640,416
TSS (lbs/yr)	9,101,554	10,383,661	215,911,376	13,890,719	16,003,014	265,290,324

FIGURES

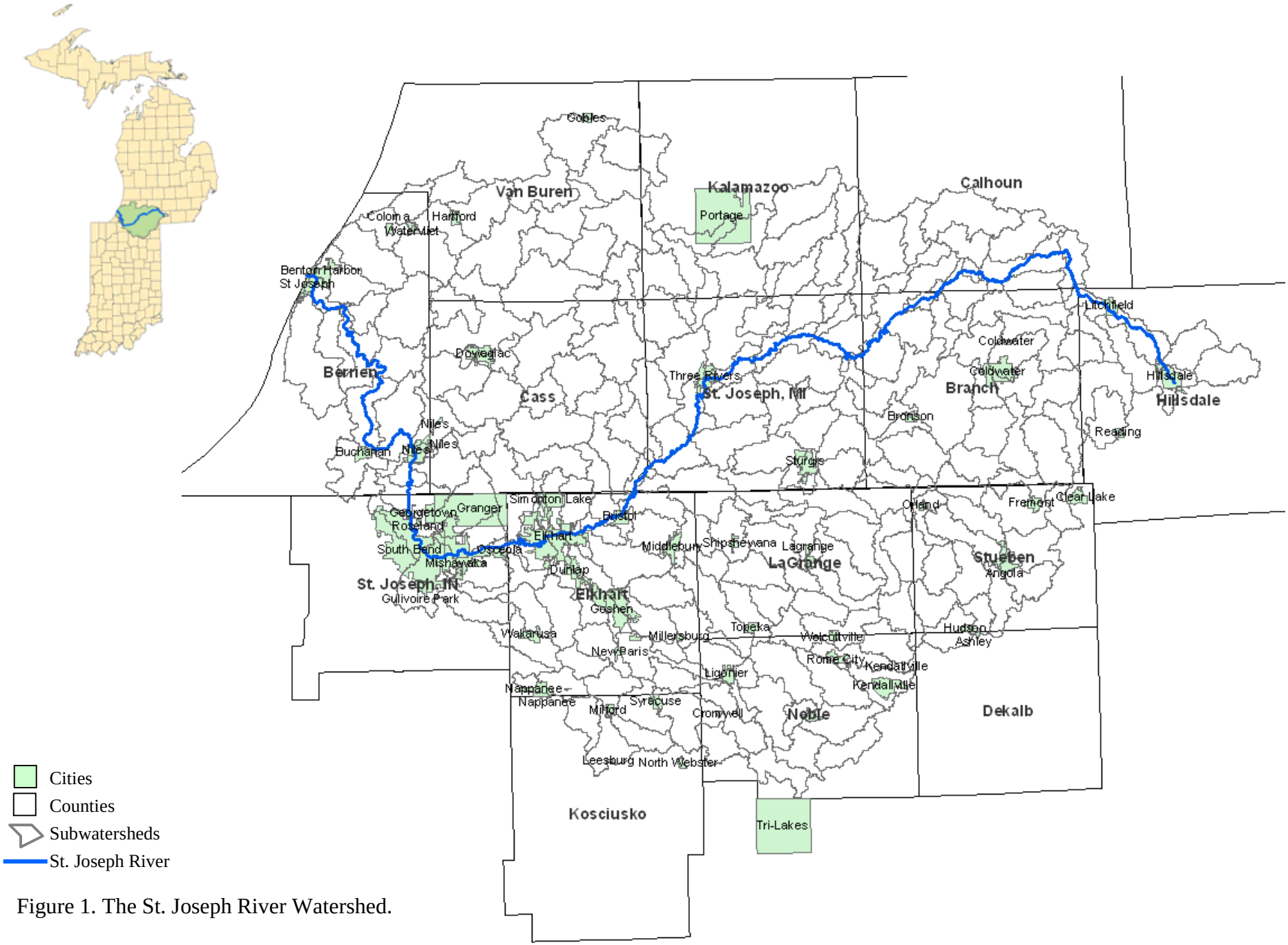

Figure 1. The St. Joseph River Watershed.

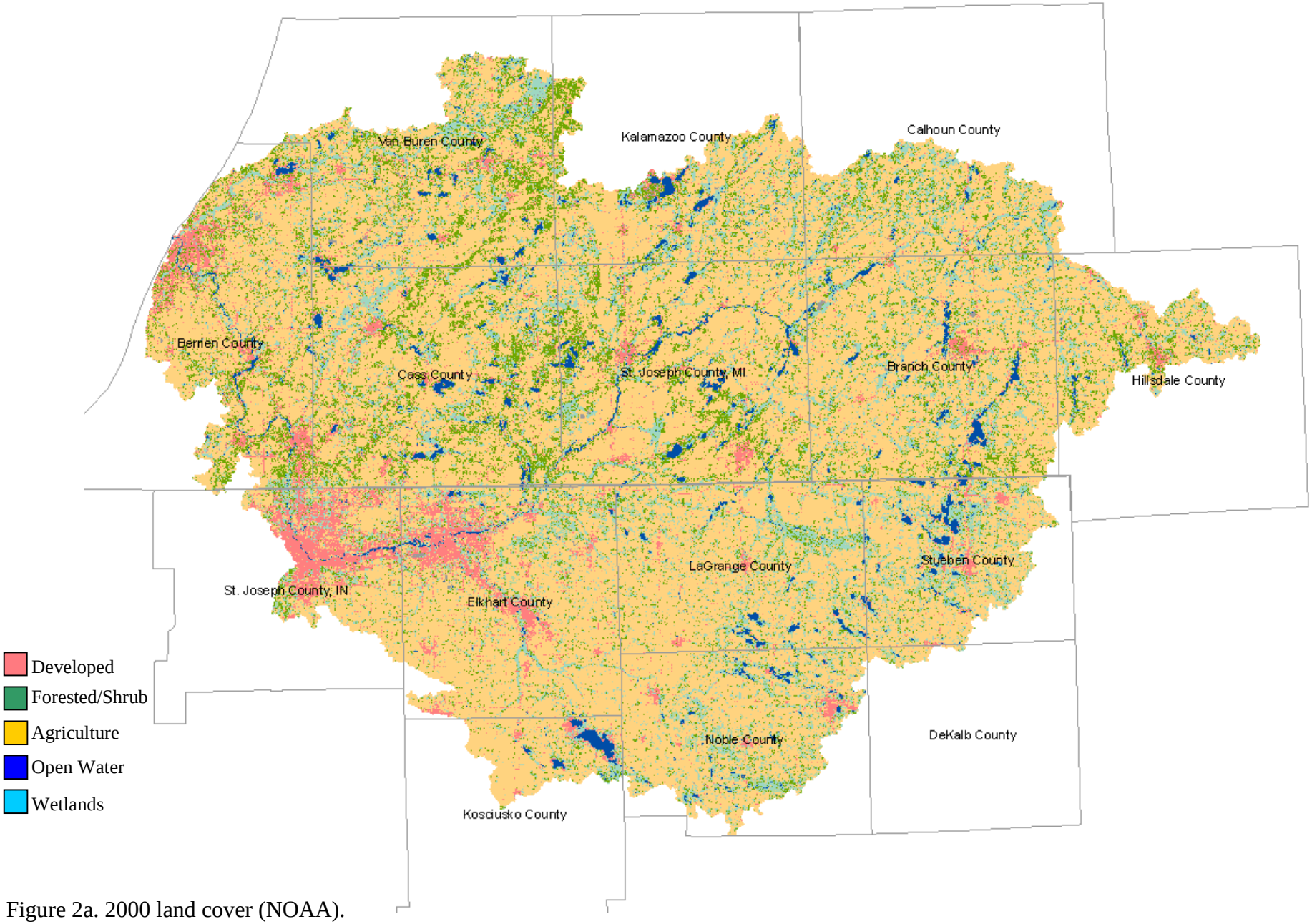

Figure 2a. 2000 land cover (NOAA).

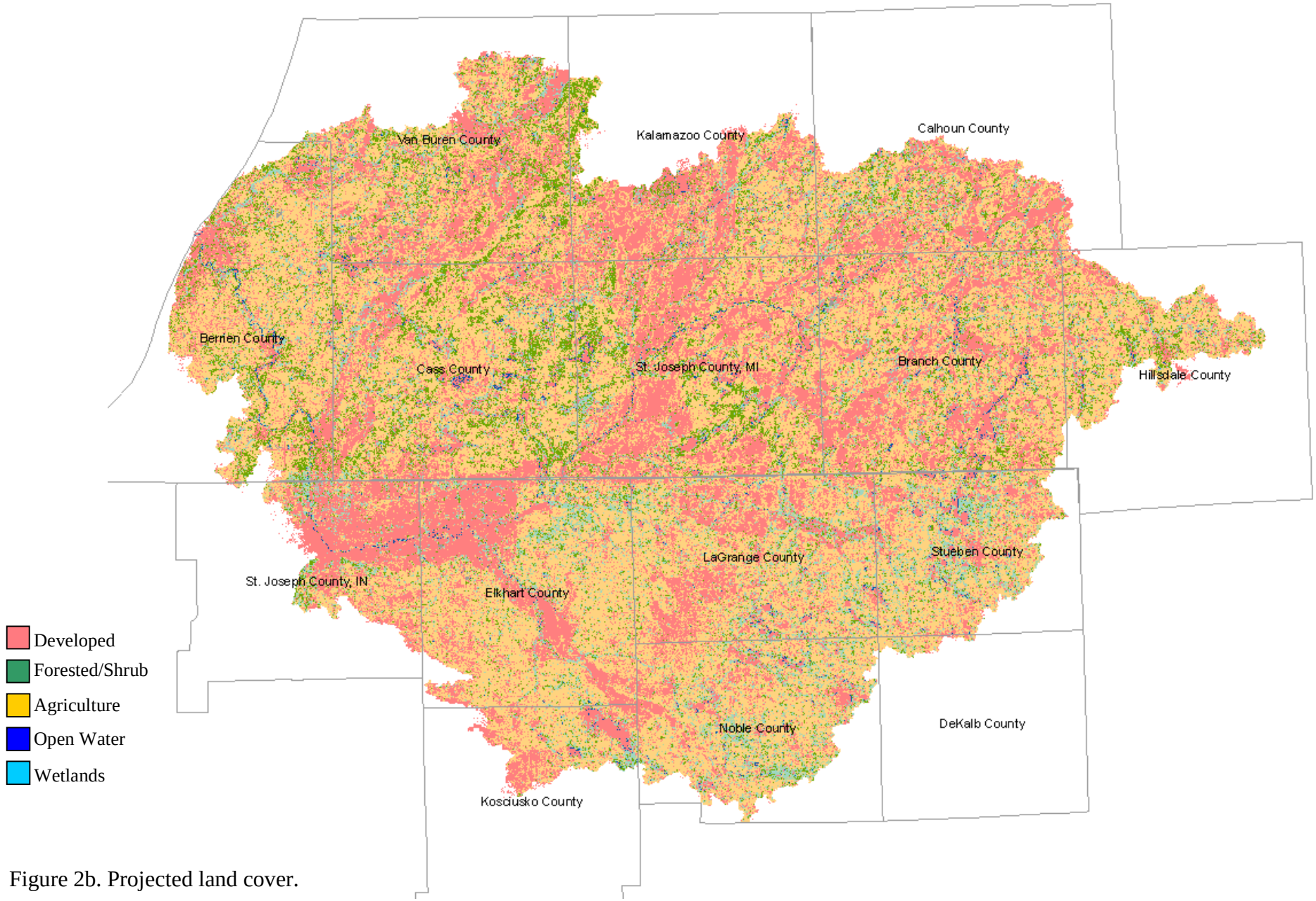

Figure 2b. Projected land cover.

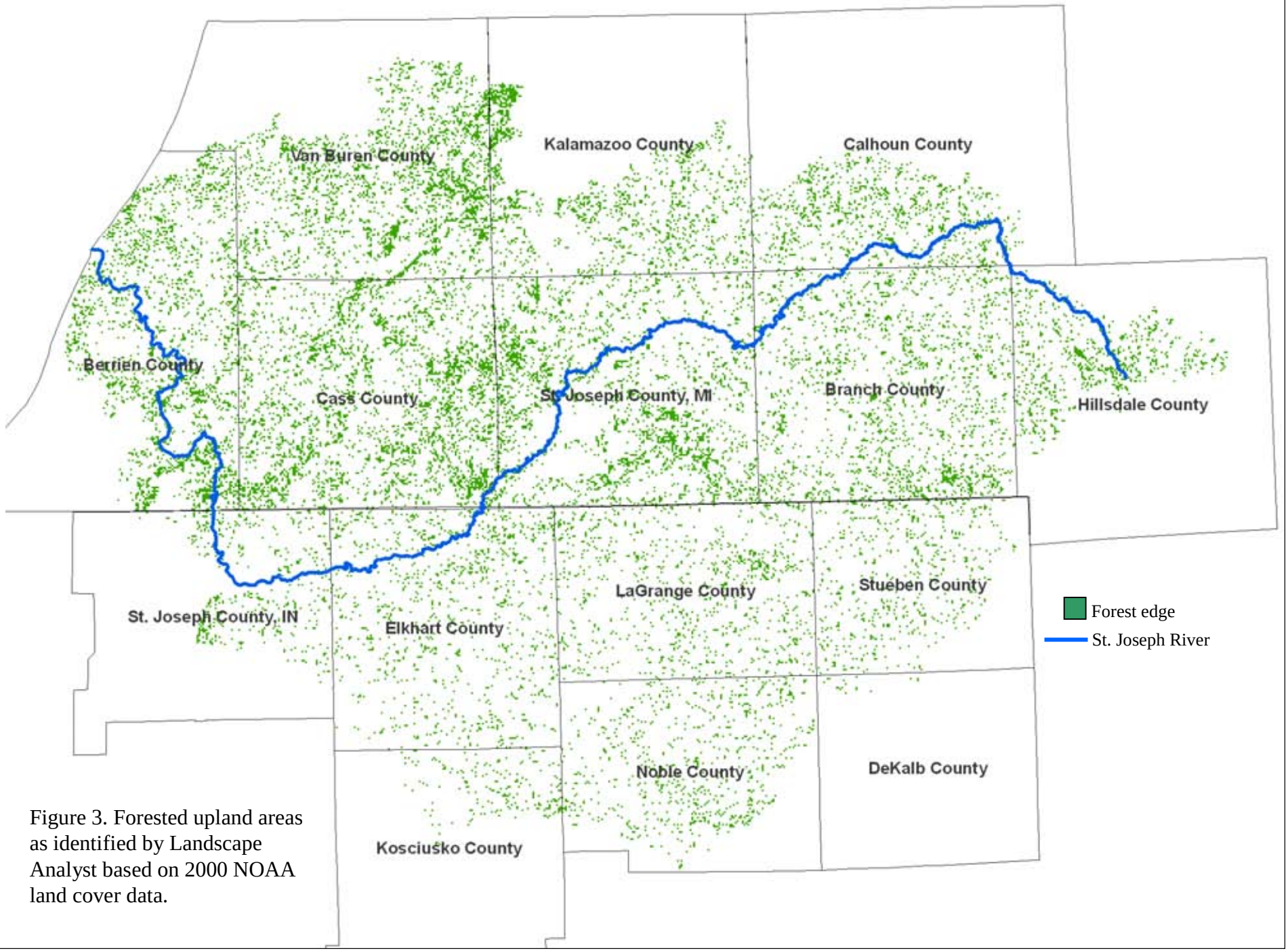

Figure 3. Forested upland areas as identified by Landscape Analyst based on 2000 NOAA land cover data.

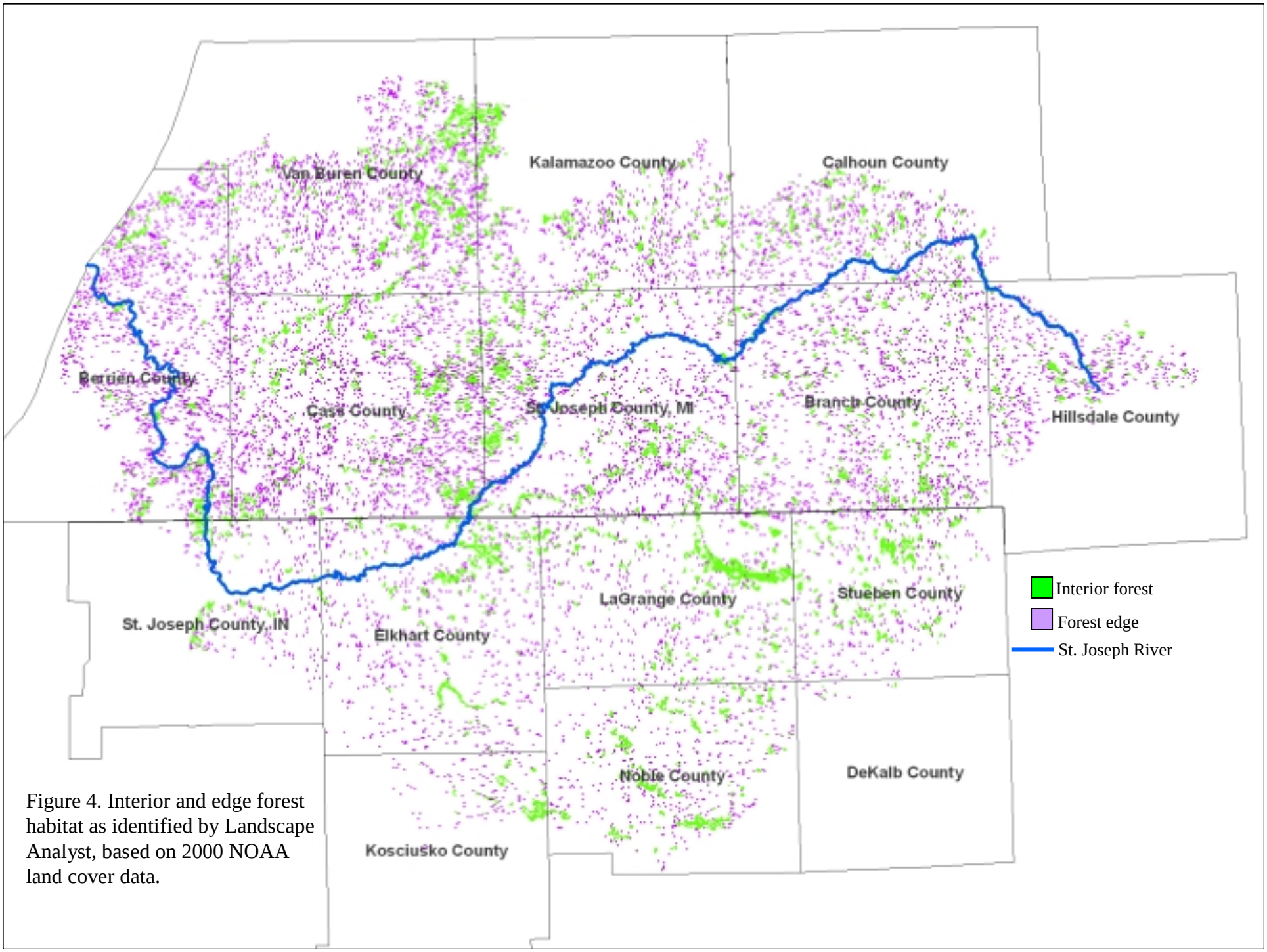

Figure 4. Interior and edge forest habitat as identified by Landscape Analyst, based on 2000 NOAA land cover data.