# A GIS Based Approach to Green Infrastructure

## A Partnership through COA Funding

Presented by: Chris Menary

October 2022

Long Point Region Conservation Authority

Catfish Creek Conservation Authority

Kettle Creek Conservation Authority

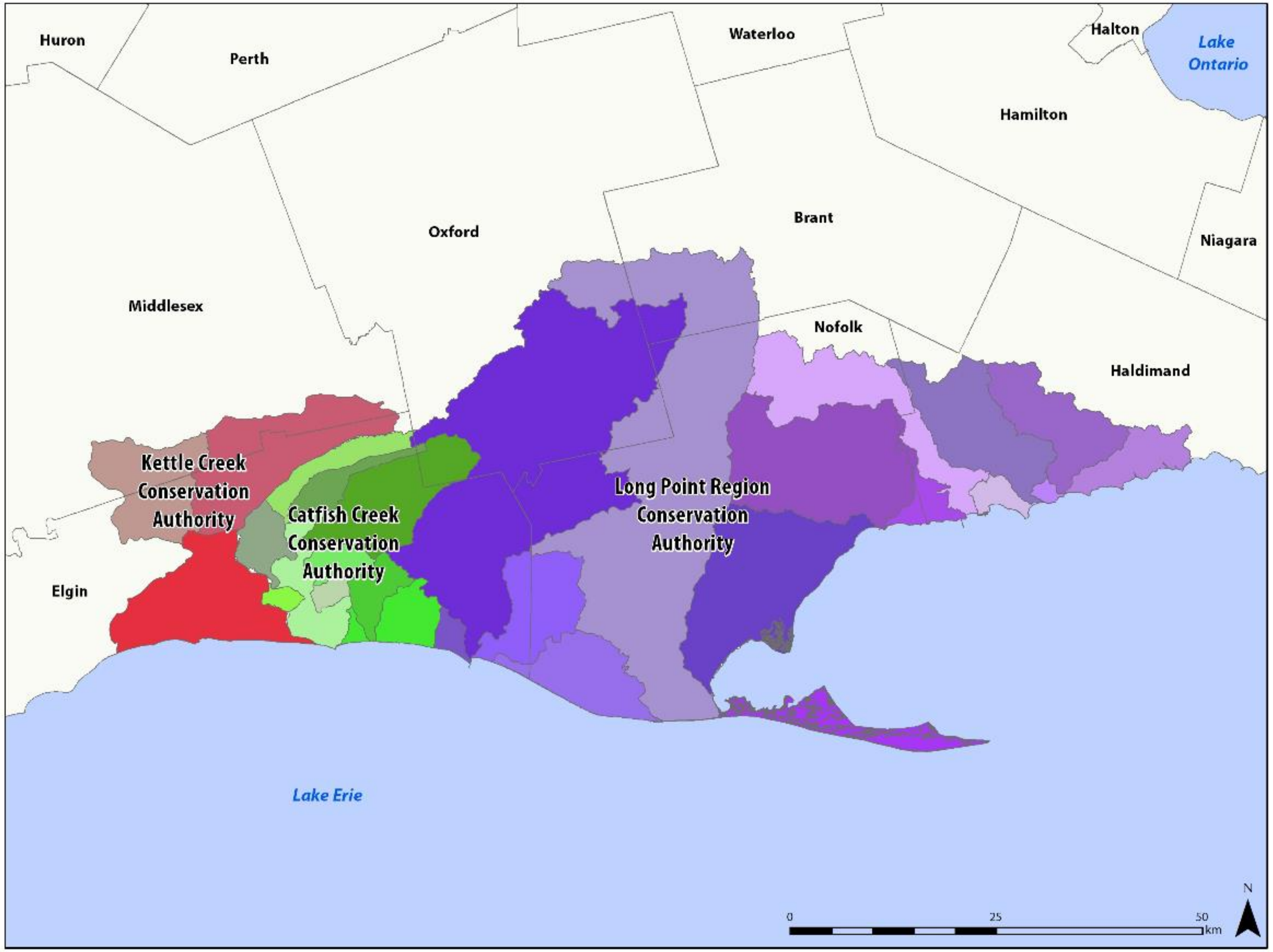
Toronto and Region Conservation Authority

# Outline

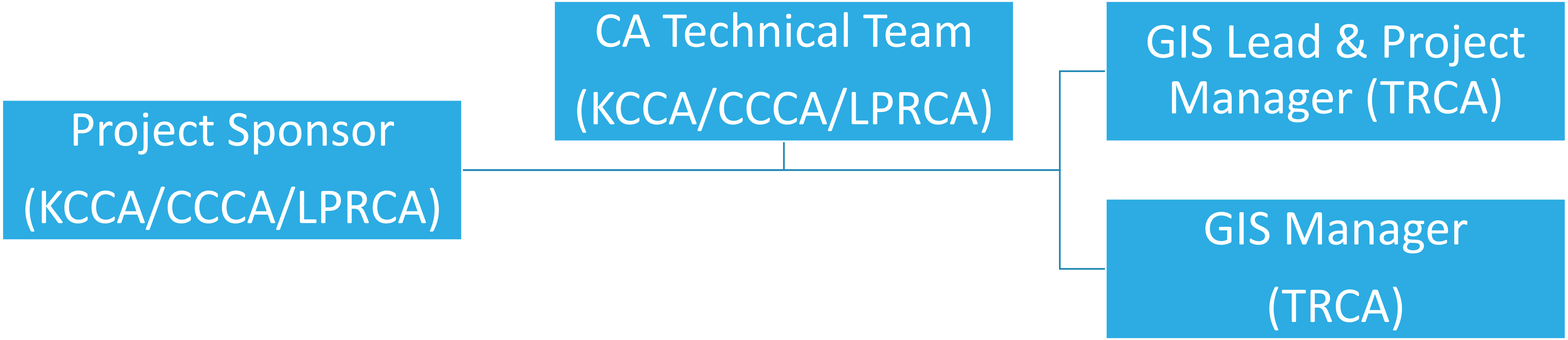
- Project Collaboration
- Methodology and Data Selection
- Data Production and Analysis
- How Data is Used

# Project Overview

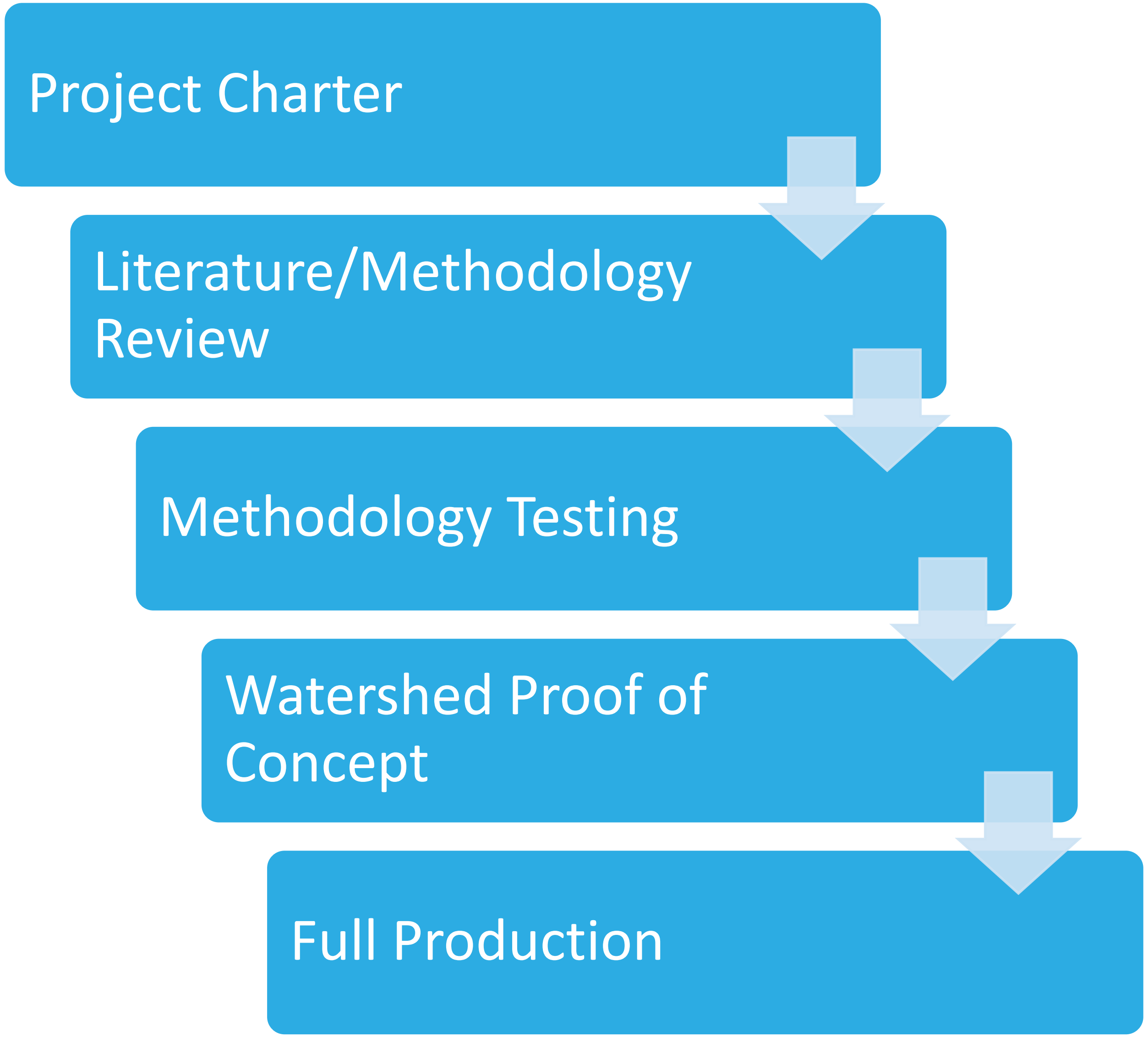
- OMAFRA initiative to prevent phosphorus run-off from entering Lake Erie
- Development of a mapping tool and/or a methodology for identifying potential sites for green infrastructure on agricultural lands
- TRCA partnered with KCCA, CCCA, and LPRCA as technical lead
- Project Area covers over 3900 $km^2$ and 15 Municipalities



# Project Team



# Project Workflow



# Initial Steps

1. Conduct a literature review of studies and methodologies to determine the current trends and methodologies in determining agricultural best practices.
2. Once complete, determine the most applicable studies/methodologies using the available data in the project study area.
3. Conduct a proof-of-concept test to determine the validity of the methodologies.
4. Select a test subwatershed and run the same methodologies to see whether they are scalable.
5. Analyze results of subwatershed test against original studies to determine if results are similar
6. Once complete, gain approval of selected methodology and process the remaining extend of the project study area.

# Literature & Methodology Review

Akturk, E., Post, C. & Mikhailova, E.A. Modeling and monitoring riparian buffer zones using LiDAR data in South Carolina. Environ Monit Assess 192, 350 (2020).

Rody Nigel, Karem Chokmani, Julio Novoa, Alain N. Rousseau & Anas El Alem (2014) An extended riparian buffer strip concept for soil conservation and stream protection in an agricultural riverine area of the La Chevrotière River watershed, Québec, Canada, using remote sensing and GIS techniques, Canadian Water Resources Journal / Revue canadienne des ressources hydriques, 39:3, 285-301

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McPherson, T., Veliz, M. The use of GIS in the Gully Creek Watershed to Identify Suitable Locations for Agricultural Best Management Practices. Ausable Bayfield Conservatoin Authority, 2016.

Yang, W., Lio, Y., Shen, H. Evaluation of Multiple Best Management Practices in Fairchild Creek Watershed. University of Guelph, 2011.

Daggupati, Naga. GIS Methods to Implement Sediment Best Management Practices and Locate Ephemeral Gullies. Doctor of Philosophy dissertation abstract. Kansas State University, 2012.

Tomer, M., Porter, S., James, D., Boomer, K., Kostel, J., McLellan, E. Combining precision conservation technologies into a flexible framework to facilitate agricultural watershed planning. Journal of Soil and Water Conservation, Sept/Oct 2013. Vol 68, No. 5.

Galdin et al. Large-Scale Modeling of Soil Erosion with RUSLE for Conservationist Planning of Degraded Cultivated Brazilian Pastures. Land Degradation & Development, 2015.

# Data Availability

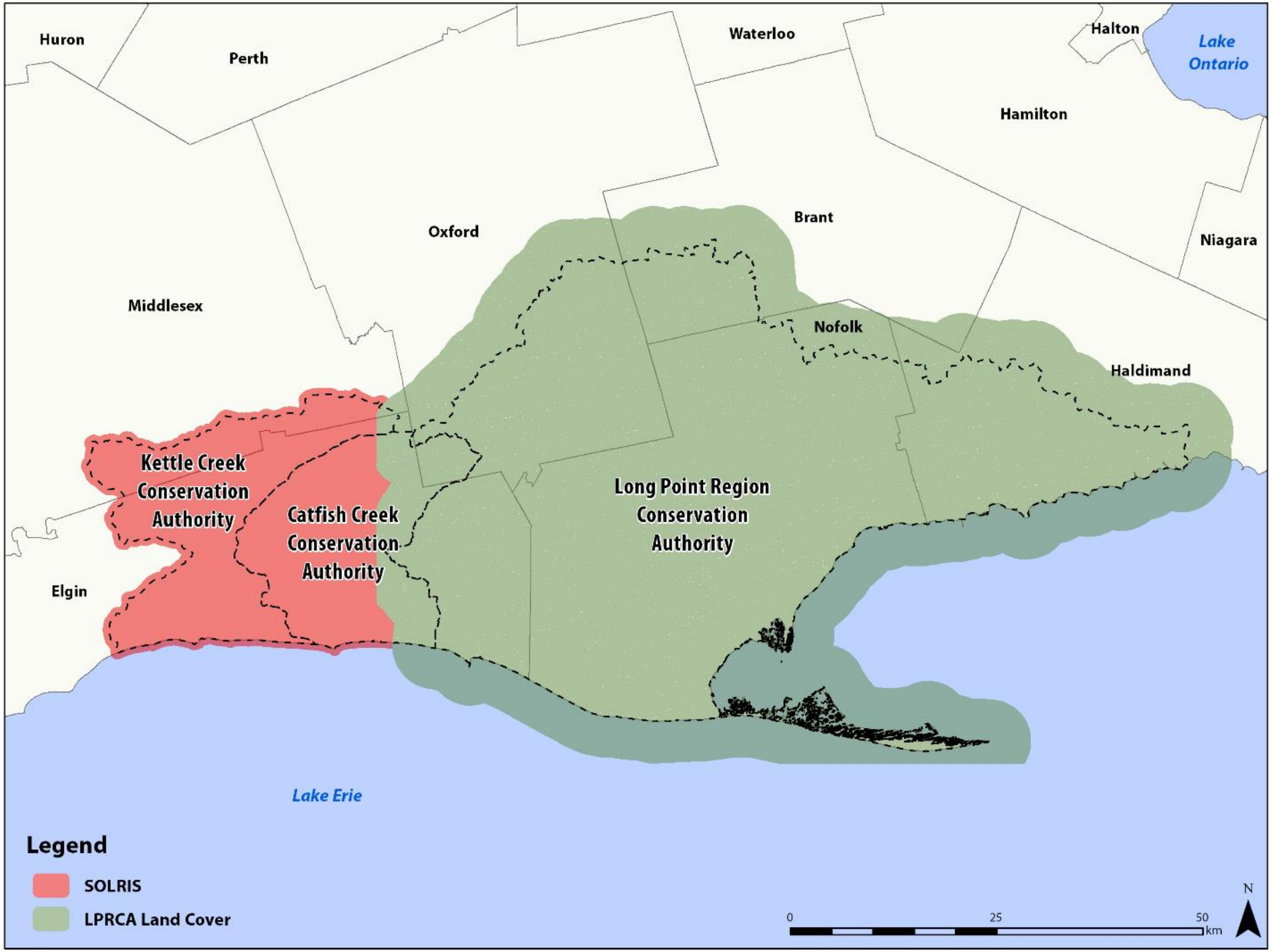
| | CCRA | KCCA | LPRCA | Province | |
|---|---|---|---|---|---|
| **Watercourse** | x | x | x | x | |
| **Culverts** | x | x | | | Elgin County coverage |
| **Watreshed Boundary** | x | x | x | | |
| **Subwatershed Boundary** | x | x | x | | |
| **Imagery** | x | x | x | x | SWOOP 2010/15 /20 |
| **Engineered Floodway** | | x | | | |
| **Lake Erie Flood Uprush** | | x | | | |
| **Land Cover** | x | x | x | x | SOLRIS & LPRCA |
| **Generic Regulation Limit** | x | | | | |
| **Natural Heritage** | x | | | | |
| **Tile Drainage Area** | x | | | x | |
| **Floodplain** | | | x | | |
| **Agricultural Resource Inventory** | | | | x | Limited coverage |
| **Lot Fabric** | | | | x | |
| **Soils** | | | | x | |
| **Constructed Drains** | | | | x | |
| **Lidar DSM** | | | | x | |
| **Lidar DTM** | | | | x | |

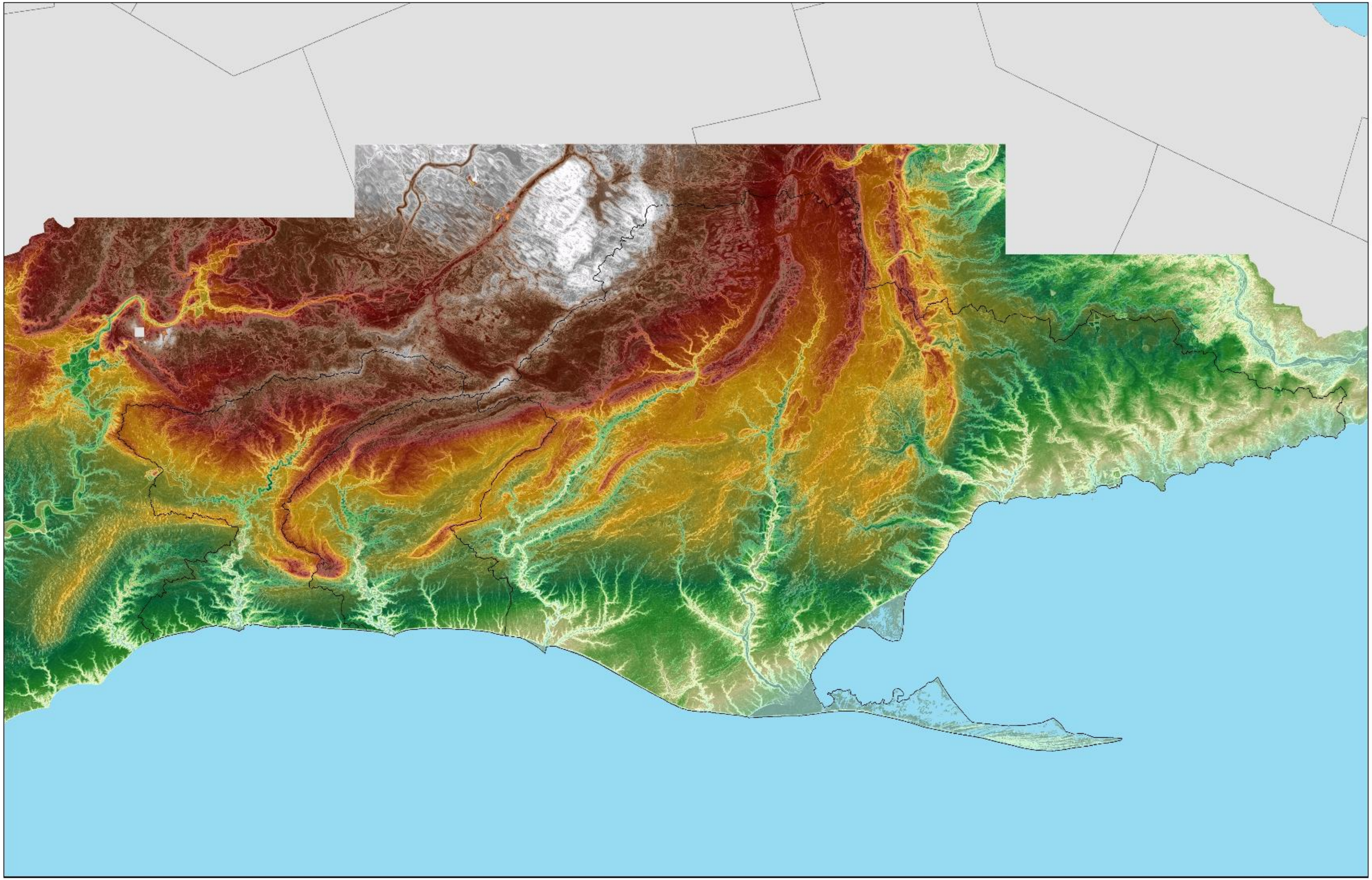
# Methodologies Selected

- Riparian Buffer Vegetation Analysis
- Agricultural Field Run-Off Assessment (Erosion Potential Model)
- Depressions within the Riparian Buffer

# Data Used in Project

- Lidar DSM Mosaic (MNRF)
- Lidar DTM Mosaic (MNRF)
  - Lidar-derived Slope
  - Lidar-derived Absolute Height
  - Lidar-derived Flow Accumulation
- Watercourse (CA)
- Watershed Boundary (CA)
- Landcover (SOLRIS & CA)
- Soils (MNRF)
- Municipal Drains (CA & MNRF)


Huron
Perth
Waterloo
Halton
Lake Ontario
Hamilton
Oxford
Brant
Niagara
Middlesex
Nofolk
Haldimand
Kettle Creek Conservation Authority
Catfish Creek Conservation Authority
Long Point Region Conservation Authority
Elgin
Lake Erie
Legend
SOLRIS
LPRCA Land Cover
0
25
50
km
N



# Riparian Buffer Analysis

- Calculate mean slope on a 30 m buffer of watercourse segment
- Four classes of RBZs based on slope (12/24/36/48m)
- Clip DSM/DTM, subtract to create Absolute Height of vegetation with buffer
- Extract values to predetermined classes (3 in study, 4 in project)

Environ Monit Assess (2020) 192: 350
https://doi.org/10.1007/s10661-020-08301-6

Check for updates

## Modeling and monitoring riparian buffer zones using LiDAR data in South Carolina

**Emre Akturk · Christopher Post · Elena A. Mikhailova**

Received: 27 November 2019 / Accepted: 15 April 2020 / Published online: 9 May 2020


**Abstract** Functional riparian areas protect water quality and conserve aquatic systems, plants, and wildlife. Laser-based remote sensing technology offers a high-resolution approach to both characterize and document changes in riparian buffer zones (RBZs). The objectives of this study were to demonstrate a rapid method and model to calculate riparian buffer widths on both sides of a stream using a LiDAR-derived slope variable, to classify riparian buffers and determine their quality, and to evaluate the appropriateness of using LiDAR in riparian buffer assessment. For this purpose, RBZs were delineated for Hunnicutt and King Creek, which are located in Oconee and Pickens counties, in South Carolina. Results show that LiDAR was effective in delineating required riparian buffer widths based on the topography slope of upstream areas, and in calculating the ratio of tree cover. This LiDAR-based assessment methodology could be applied to a wide-range of environments.

**Keywords** Riparian buffer · GIS · LiDAR · Water quality · Remote sensing

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### Introduction

It is critical to protect water quality and aquatic resources with appropriate riparian buffer zones. Urban, agricultural, and forestry activities change the structure of the landscape and can cause an increase in the quantity of sediments which reduce water quality and inhibit presence of aquatic organism (Robinson and Blyth 1982; Salomons 1985; Pimentel et al. 1987; Walker et al. 1999; Anbumozhi et al. 2005). Establishing or restoring functional riparian areas can be a solution to conserve and protect aquatic systems, plants, and wildlife. Riparian buffer zones (RBZs) can be defined as the neighboring areas to streams, lakes, and other surface waters (Narumalani et al. 1997). The word "buffer" is used to define zones or barriers to stop runoff and pollutants before they enter water sources via infiltration, absorption, filtering, and uptake (Narumalani et al. 1997). Riparian buffer zones have many important functions, such as improving surface water quality by reducing the amount of sediment, nutrients, and other environmental pollutants (Hession et al. 2000; Anbumozhi et al., 2004); stabilizing stream banks and helping to remove nitrogen fluxes from uplands (Sabater et al. 2003); storing water to prevent floods; and protecting habitat areas by enabling shade, shelter, and access to food for fish, birds, and other wildlife (Lathrop and Haag 2007). For instance, Lowrance and Sheridan (2005) found riparian forest buffers were effective in reducing non-point source pollution reporting reductions from 27% for total Kjeldahl N to 63% for P. In another study, 20 sites were differentiated by buffer

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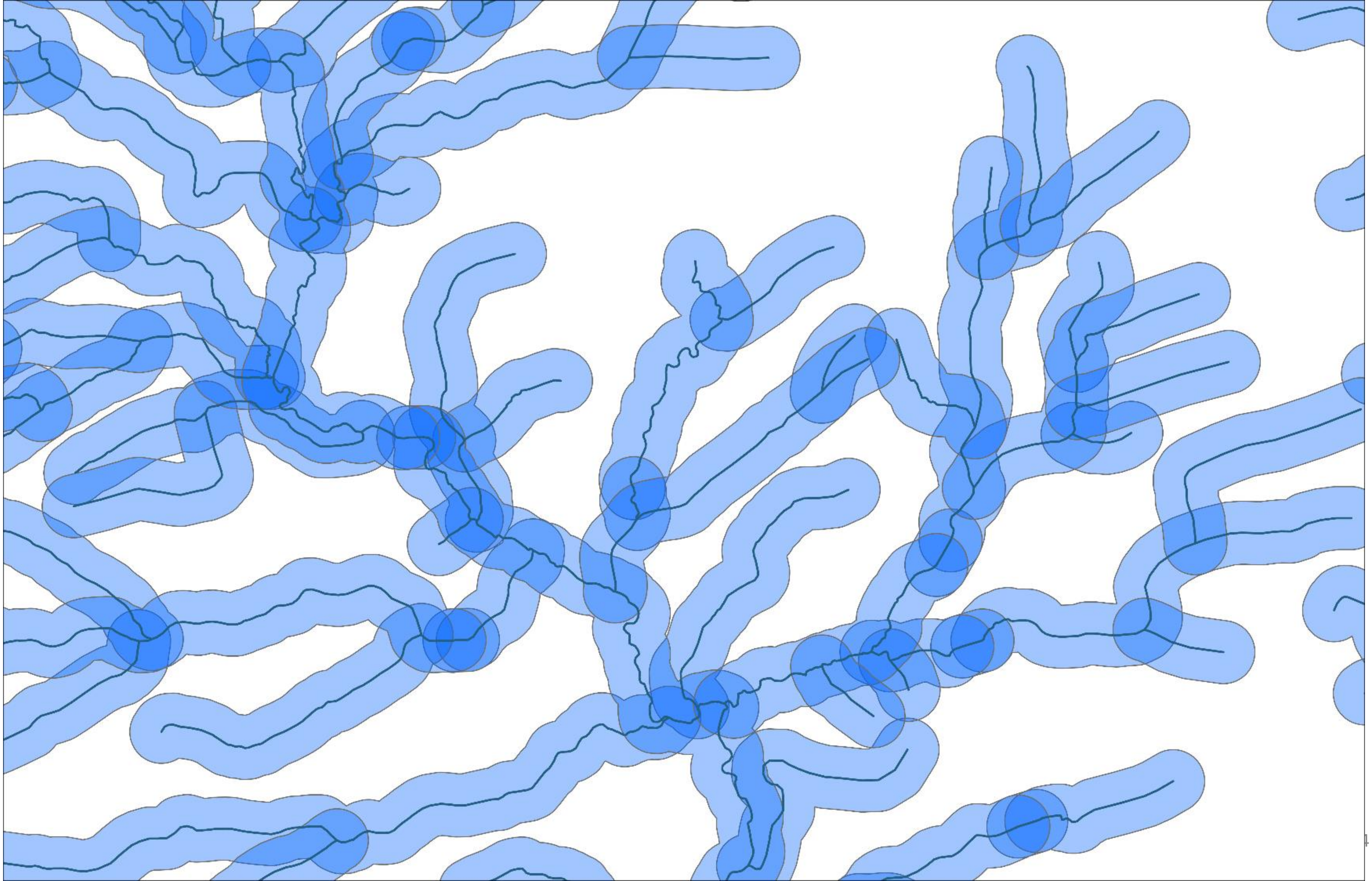
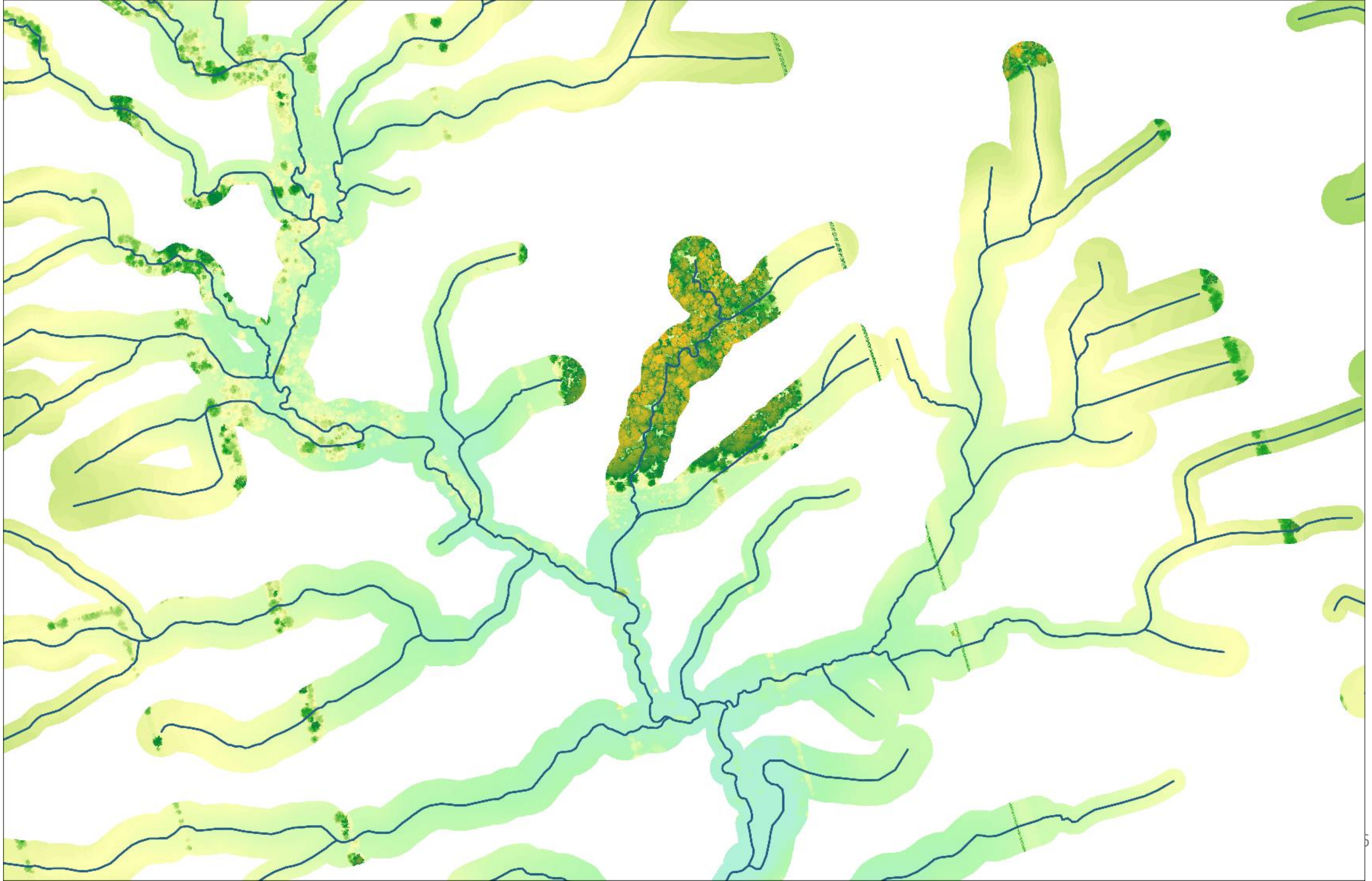
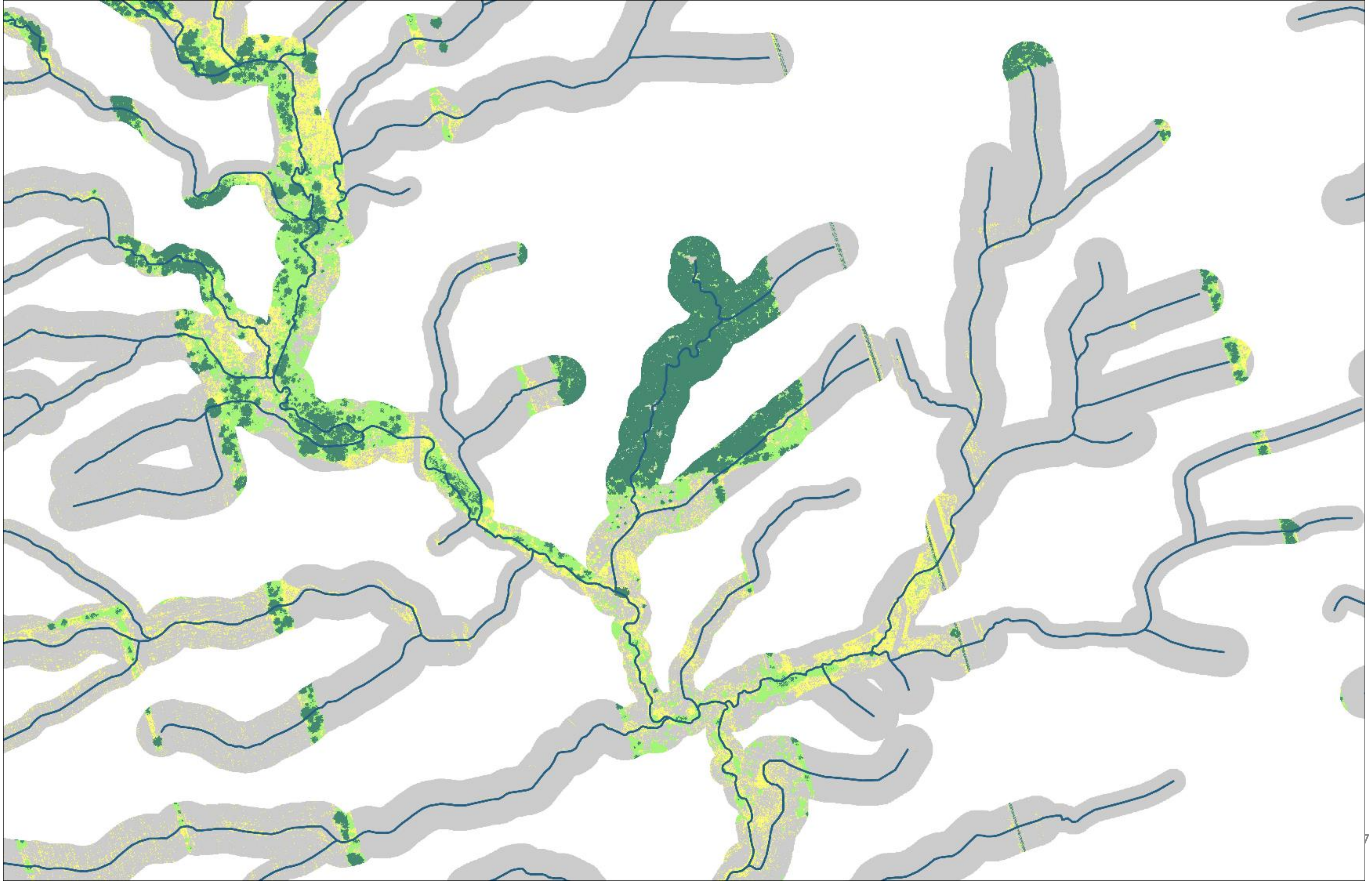
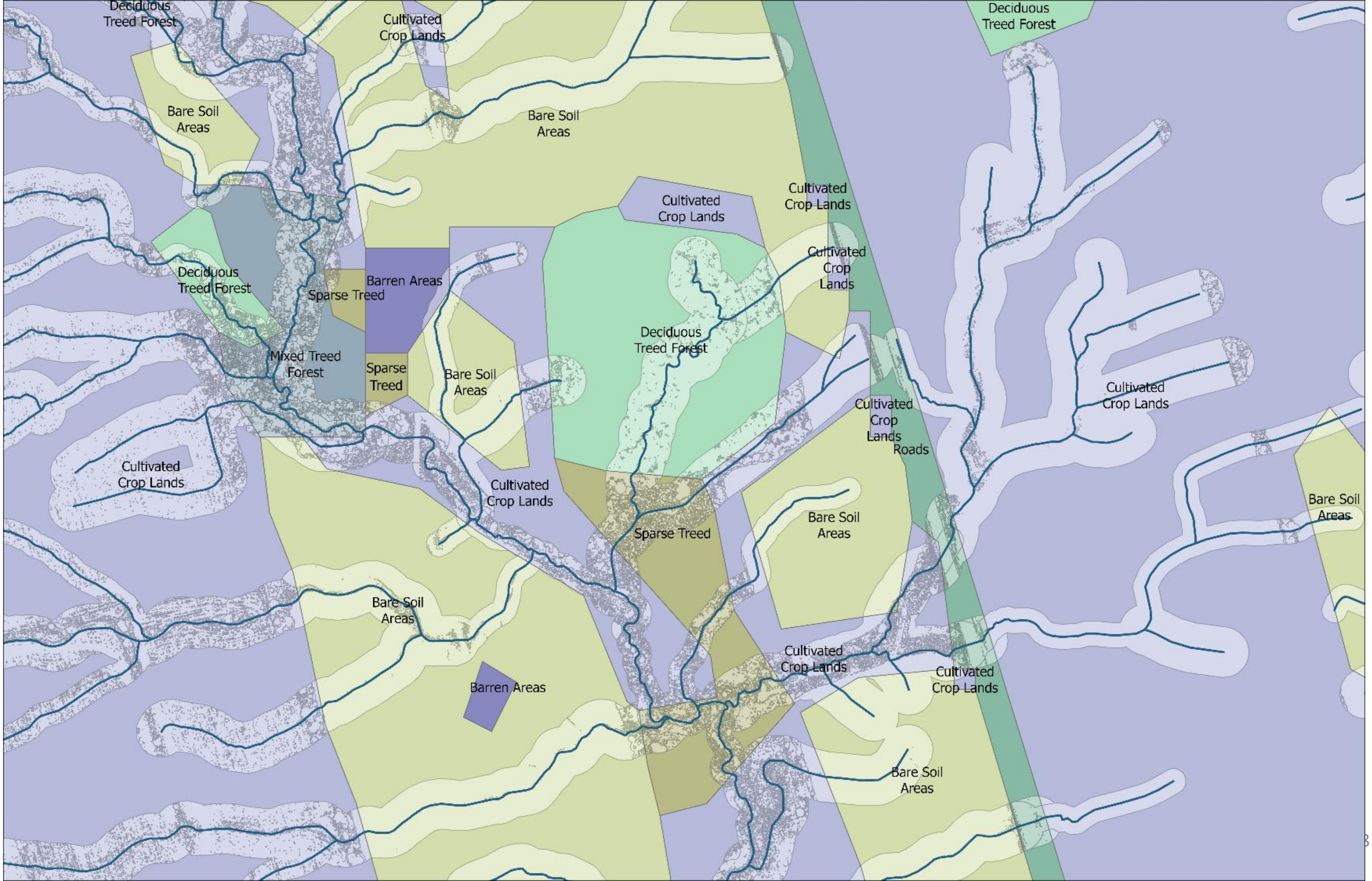


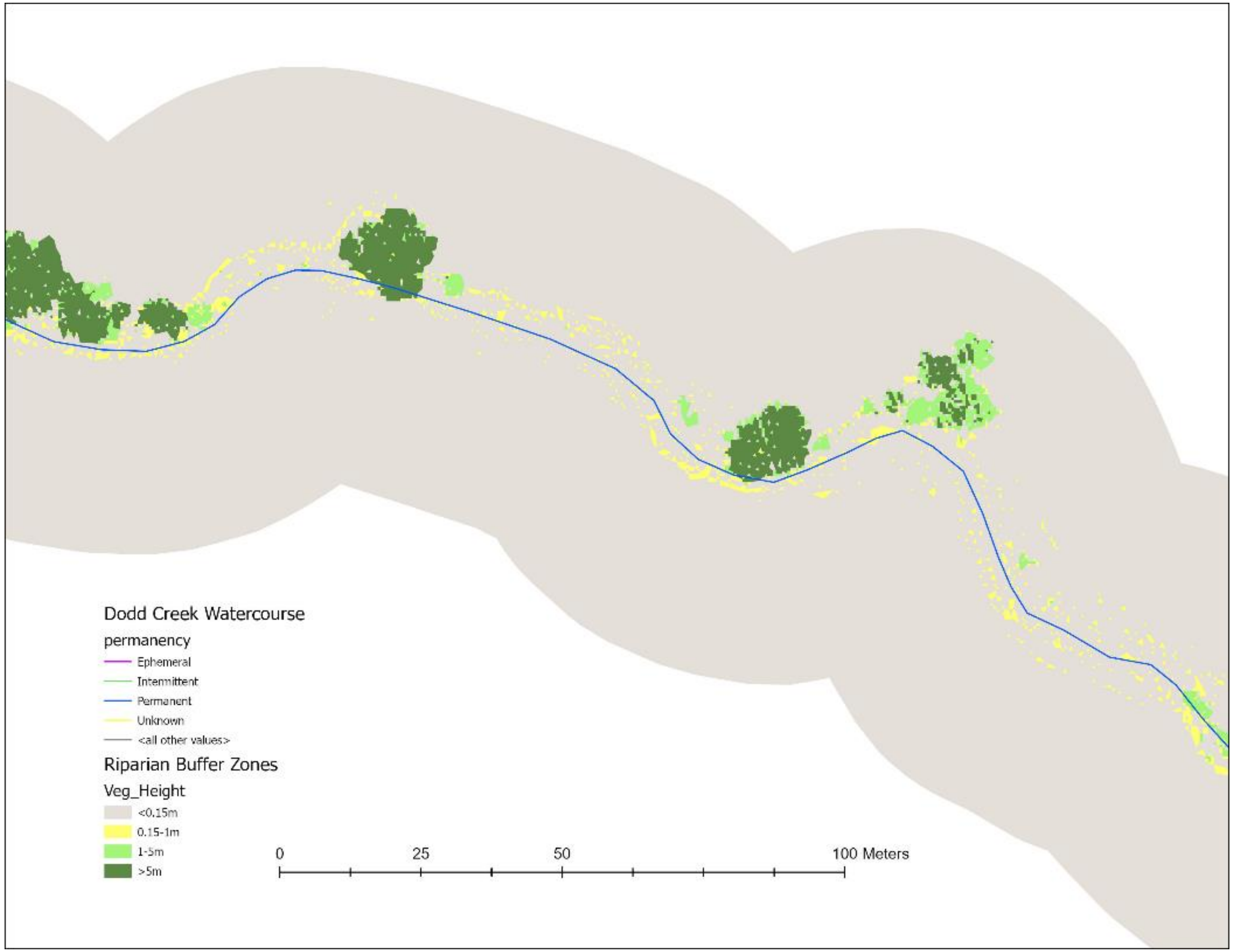





Deciduous Treed Forest
Cultivated Crop Lands
Deciduous Treed Forest
Bare Soil Areas
Bare Soil Areas
Cultivated Crop Lands
Cultivated Crop Lands
Cultivated Crop Lands
Deciduous Treed Forest
Sparse Treed
Barren Areas
Deciduous Treed Forest
Mixed Treed Forest
Sparse Treed
Bare Soil Areas
Cultivated Crop Lands
Cultivated Crop Lands
Roads
Cultivated Crop Lands
Cultivated Crop Lands
Bare Soil Areas
Sparse Treed
Bare Soil Areas
Bare Soil Areas
Barren Areas
Cultivated Crop Lands
Cultivated Crop Lands
Bare Soil Areas

# Riparian Buffer Analysis

- Vegetation Classes:
  1. None (<0.15m)
  2. Low (0.15 – 1m)
  3. Thicket (1 – 5m)
  4. Trees (>5m)
- Additional Data:
  - Watercourse Type
  - Watercourse Permanency
  - Land Cover
  - Municipal Drain (y/n)
  - Depression in RBZ (y/n)



# Agricultural Field Run-Off Assessment

- **Potential for Sheet Erosion**
- **Potential for Gully Erosion**

The use of GIS in the Gully Creek Watershed to Identify Suitable Locations for Agricultural Best Management Practices

**A report prepared for Agricultural Research Institute of Ontario**
**July 25, 2016**

**Prepared by: Tracey McPherson and Mari Veliz, Ausable Bayfield Conservation Authority**

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**Acknowledgements:** The authors would like to acknowledge Brynn Upsdell of the Ausable Bayfield Conservation Authority, Kevin McKague and Gabrielle Ferguson of the Ontario Ministry of Agriculture and Food, Pradeep Goel from the Ministry of the Environment and Climate Change and Ramesh Rudra and Trevor Dickinson from the University of Guelph for their advisory support. Funding for this project was provided by the Ontario Ministry of Agriculture and Food and the Ministry of Rural Affairs through a New Directions Grant. The views expressed in this report are the views of the authors and do not necessarily reflect those of the Ontario Ministry of Agriculture, Food and Rural Affairs.

AUSABLE BAYFIELD CONSERVATION

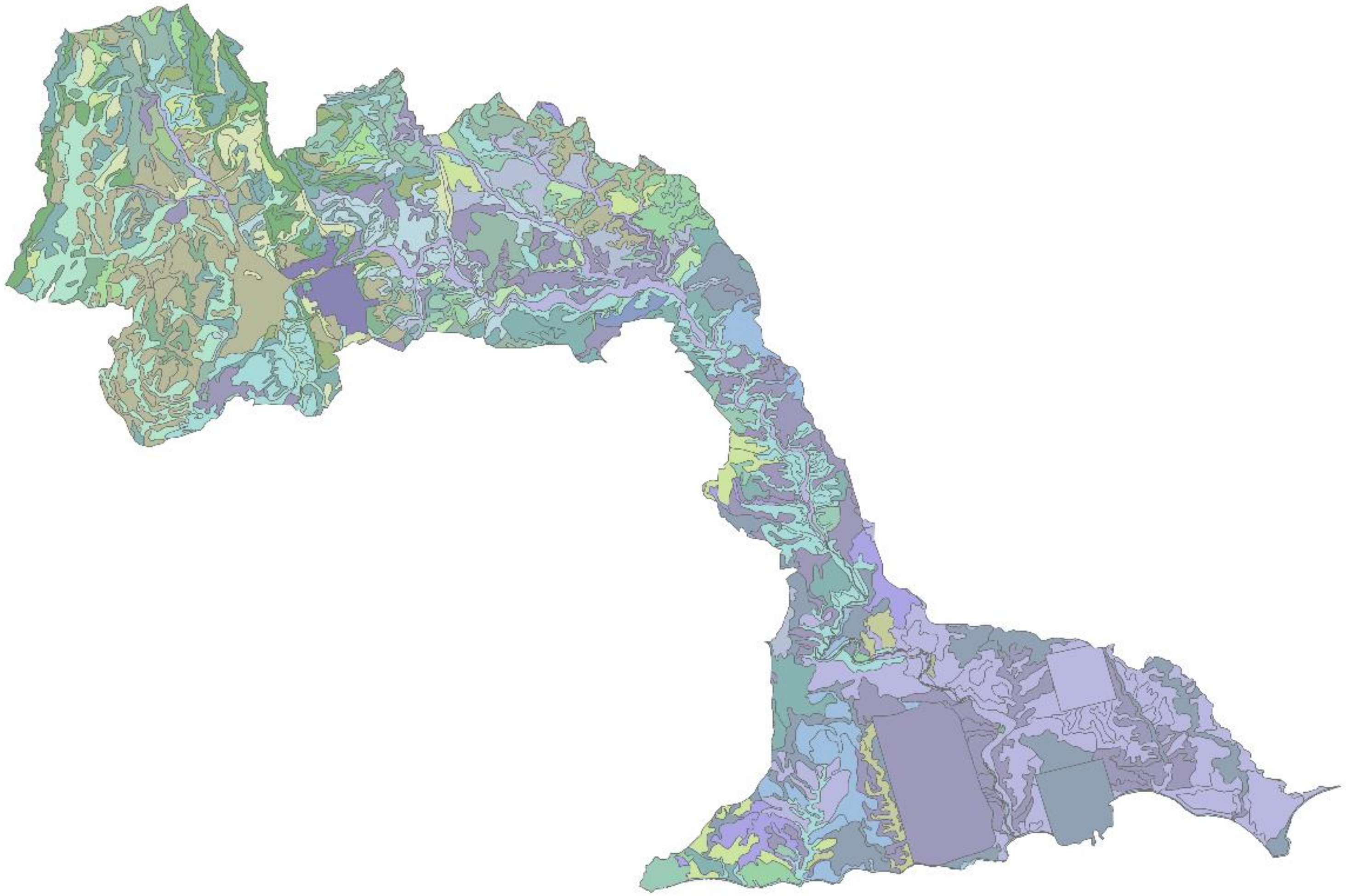
The photographs on this page demonstrate the variability in flow conditions in Gully Creek, with low-flow conditions on the left and high-flow conditions on the right.

# Potential for Sheet Erosion

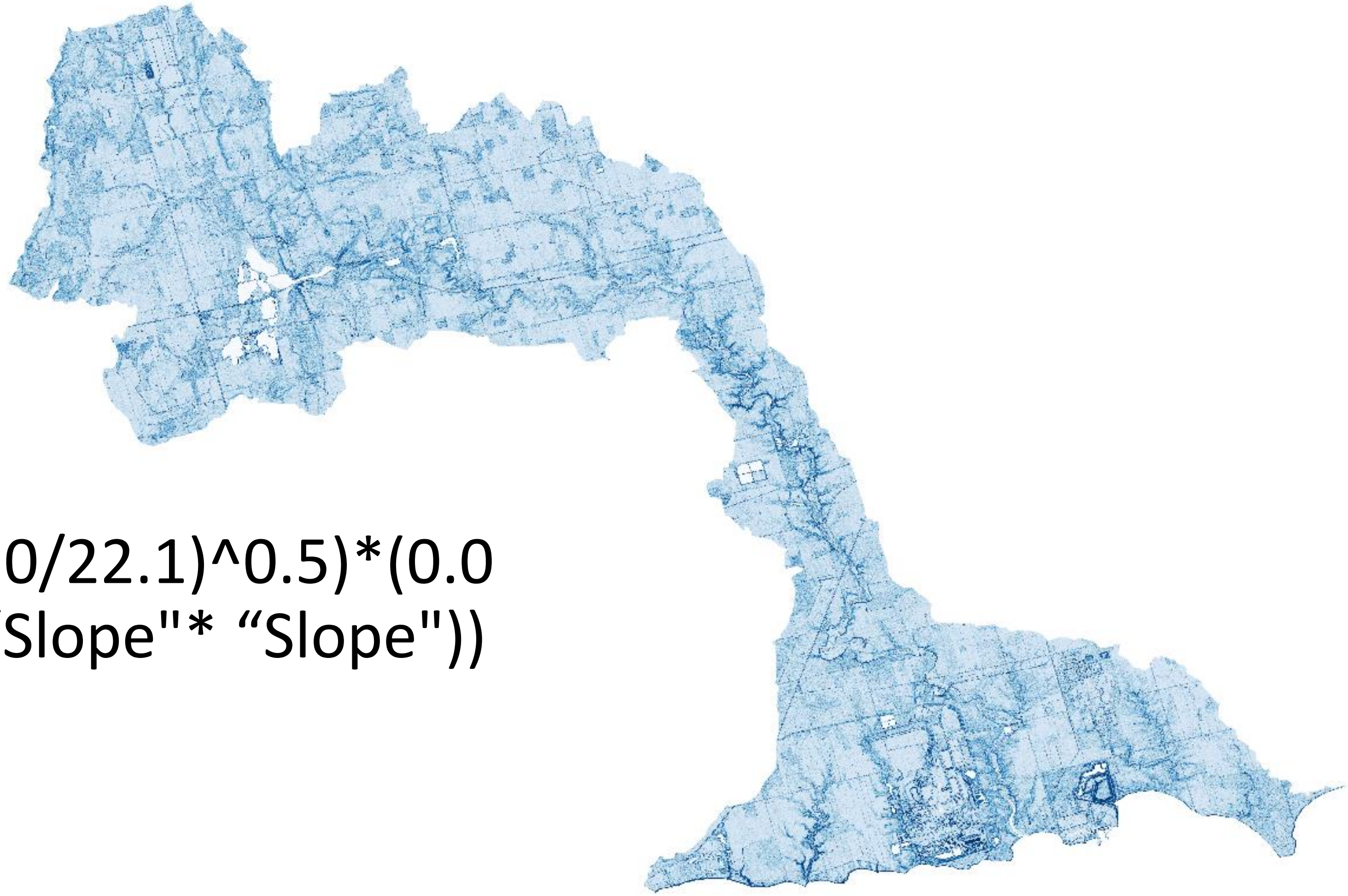
- *Modified RUSLE Analysis*
- *Potential for Sheet Erosion =* ***K*LS*R***
  - K = soil erodibility factor
  - LS = length of slope
  - R = terrain roughness factor
- Result is a watershed raster of values

# Soils

- *The original methodology was run on a single small watershed*
- *K factor was determined by soil sampling*
- *For this project, the 'kfactor1' field of the Ontario soils layer used*
- *Some data not updated since the 1950's*
- *Different values between townships/counties*
- *Settlement/Industrial areas had no value, had to be manually added*



# Length of Slope

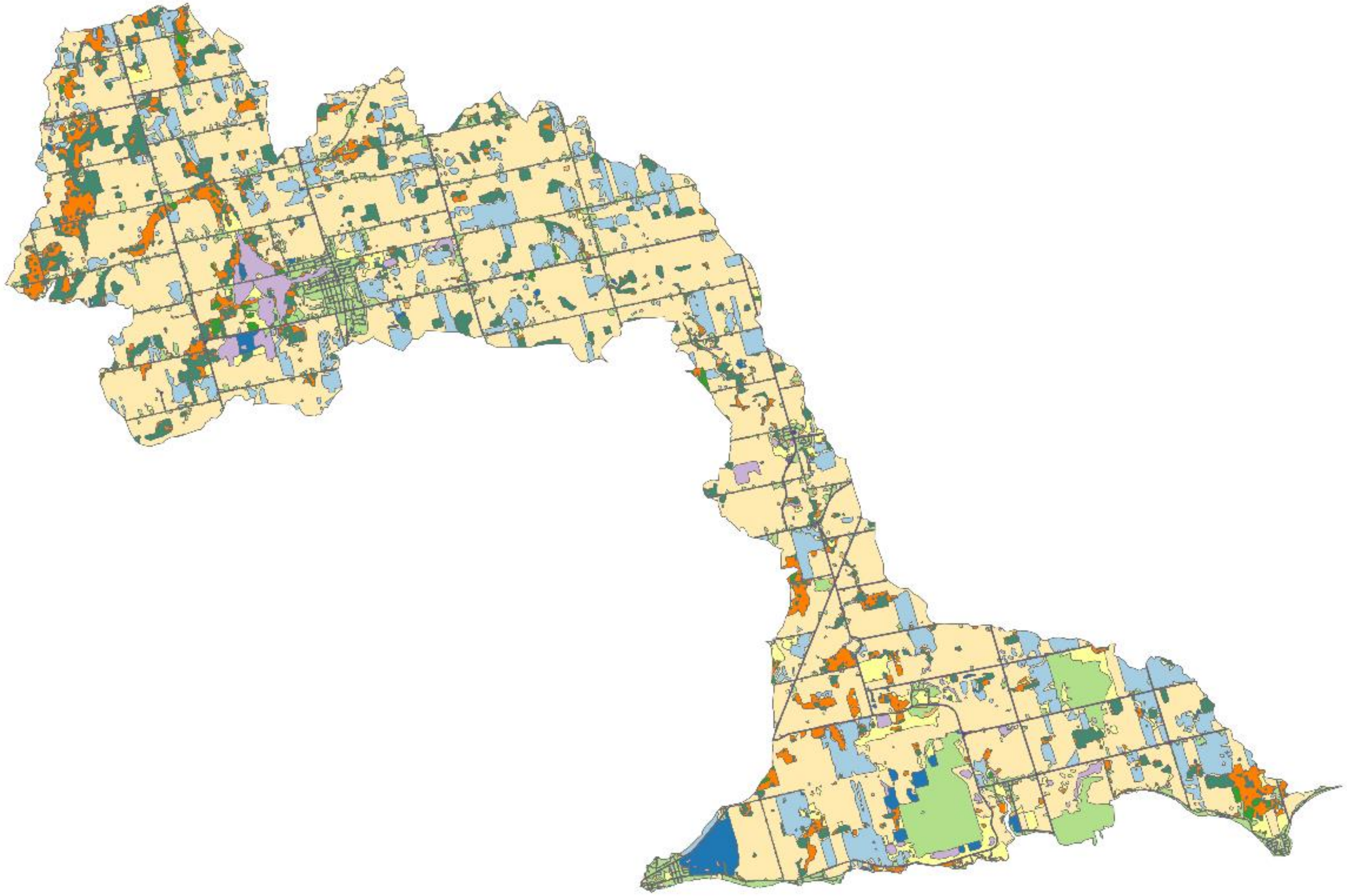


LS=((“FlowAccumumation"*30/22.1)^0.5)*(0.065+0.045*“Slope"+0.0065*(“Slope"* “Slope"))

# Roughness Factor

- *SOLRIS and LPRCA's Land Cover layer used*
- *Aligned values with those found in methodology:*

| R_Factor | Land use |
|---|---|
| 0.36 | Agricultural crops |
| 0.10 | Woodlands |
| 0.03 | Farmsteads |
| 0.042 | Rough lands (i.e., pastures, meadows, ditches, grassed waterways) |
| 0 | Water, roads |



# Potential for Gully Erosion

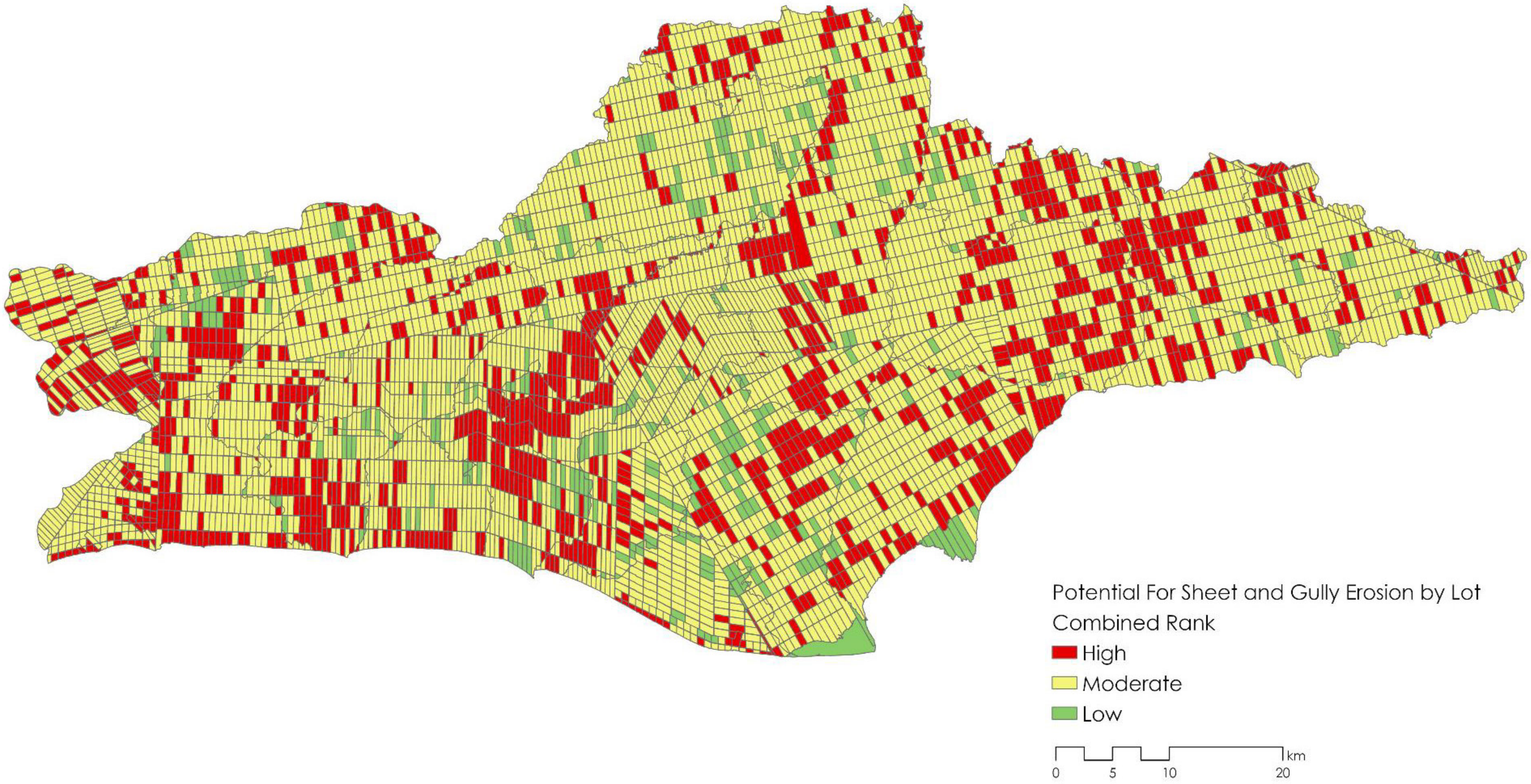
- ***PGE*= Ln(flow_accumulation_dem+0.001)*(slope_dem/100)+0.001)**
- Use the already created Flow Accumulation and % Slope rasters
- Result is a watershed raster of values

# Adding PSE/PGE Values to Agricultural Fields

- Methodology selected used zonal statistics to calculate mean value for each field
- As individual field data not available for project area, the provincial lot fabric used to create a screening layer
- Mean PSE/PGE value for each lot was calculated
- Ranked high/moderate/low risk based on standard deviation
- <-0.5 SD Low/-0.5 – 0.5 SD Moderate/>0.5 SD High
- PSE/PGE ranks than combined to create overall risk

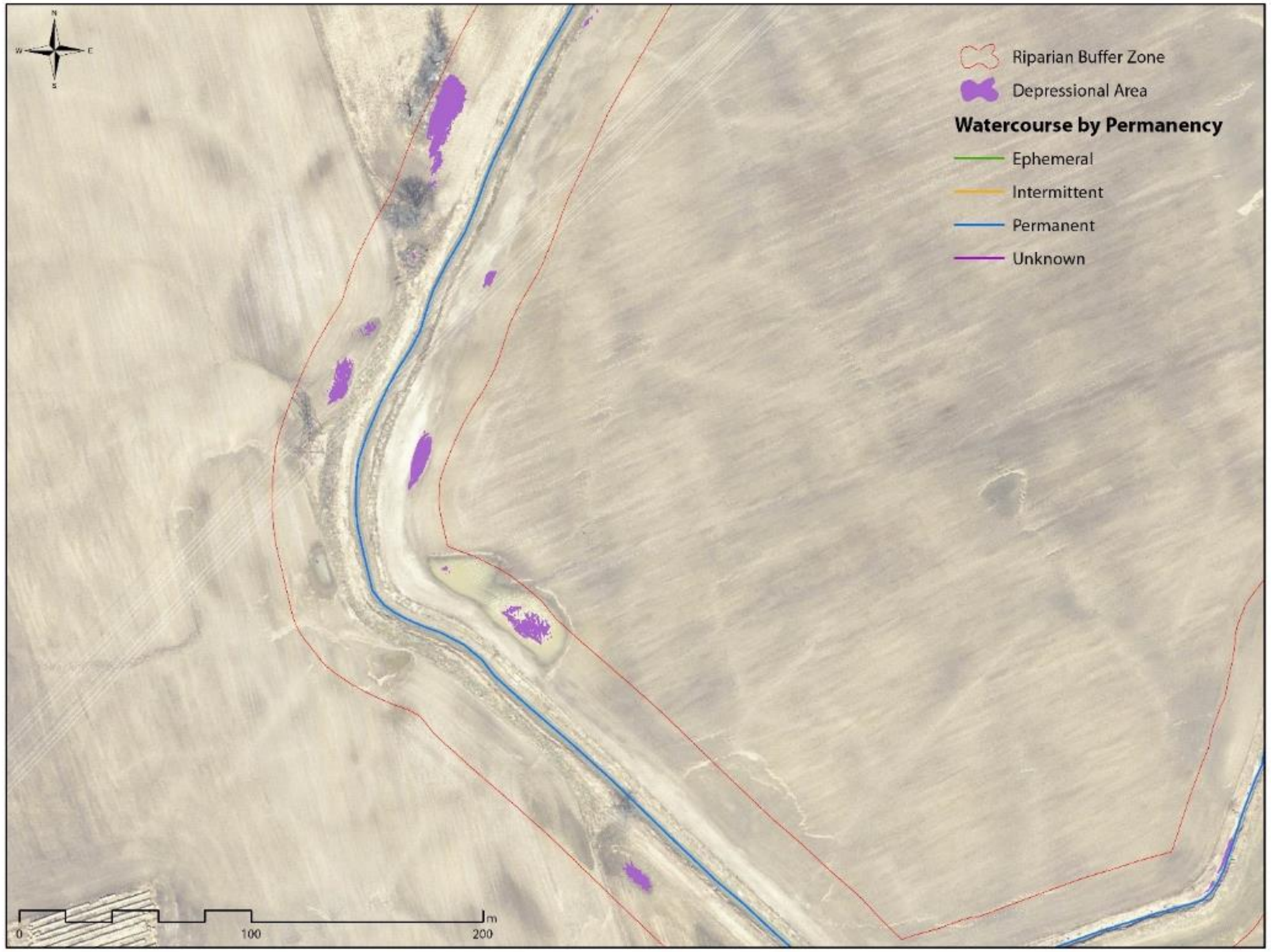
# Ranking Matrix

| | Potential for Sheet Erosion (PSE) (K*LS*R) | | |
|---|---|---|---|
| **Potential for Gully Erosion (Stream Power Index)** | Highest (3) (> 0.5 SD. above the mean) | Moderate (2) (0.5 SD. above to -0.5 SD below the mean) | Low/flat (1) Low ( < -0.5 SD below the mean) |
| Highest (3) (> 0.5 SD dev. above the mean) | High (6) Combined | High (5) Combined | Moderate (4) Combined |
| Moderate (2) (0.5 SD dev. above to -0.5 below the mean | High (5) Combined | Moderate (4) Combined | Moderate (3) Combined |
| Low (1) ( < -0.5 below the mean) | Moderate (4) Combined | Moderate (3) Combined | Low (2) Combined |

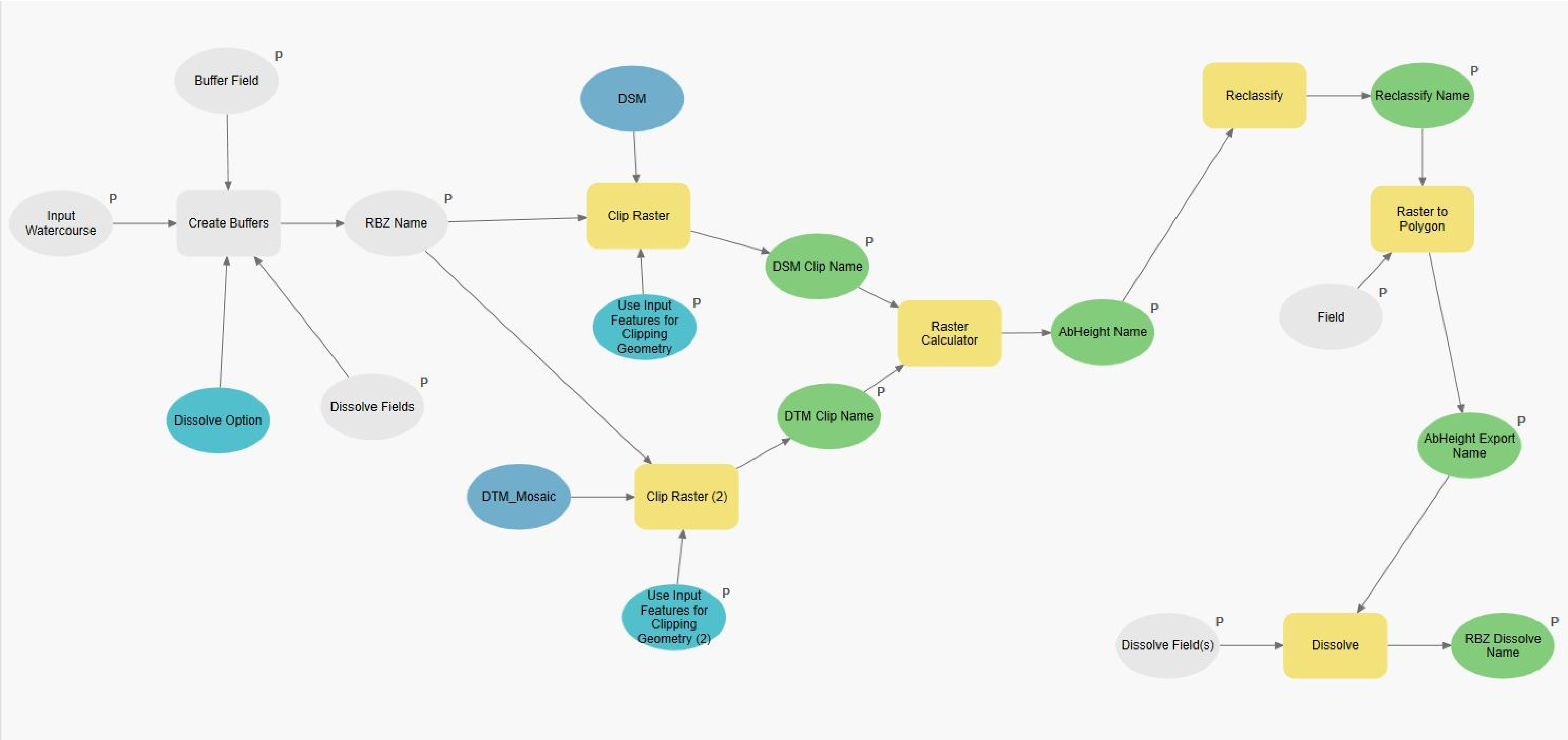

Potential For Sheet and Gully Erosion by Lot
Combined Rank
High
Moderate
Low
km
0
5
10
20

# RBZ Depressions

- Using hydrological tools, it is possible to located depressions in the landscape with the Lidar DTM
- Depressions adjacent to watercourses within an RBZ are prime locations for the construction of wetlands



# Automation of the Data Processing



# Web Application

- Allows those without specialized GIS software to view and query the data
- Test application was built to show how data can be used
- Application has filters which can be used to pinpoint areas of interest
- Can identify areas along permanent watercourses with no vegetation cover adjacent to agricultural fields
- Application can be viewed on mobile devices and incorporated into field collection initiatives

Toronto and Region Conservation Authority

www.trca.ca