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Apr 25th, 9:00 AM - 11:00 AM

Analyzing landslide hotspots and susceptibility in East Tennessee transportation corridors

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Overview

Landslides in the Appalachian mountains are a large geohazard affecting the infrastructure causing thousands of dollars in damage on the roadway. Anderson and Morgan counties in East Tennessee have experienced approximately 93 landslides within the New River drainage system (Figure 1). These landslides are caused by various factors which will be analyzed in reference to the landslides (Garianao and Guzzetti 2016; Vianello et al 2022) (Figures 2A-2D).

- Goals: In this study, I plan to:
- (1) identify landslide hotspots
 - (2) evaluate geomorphic factors related to landslide activity

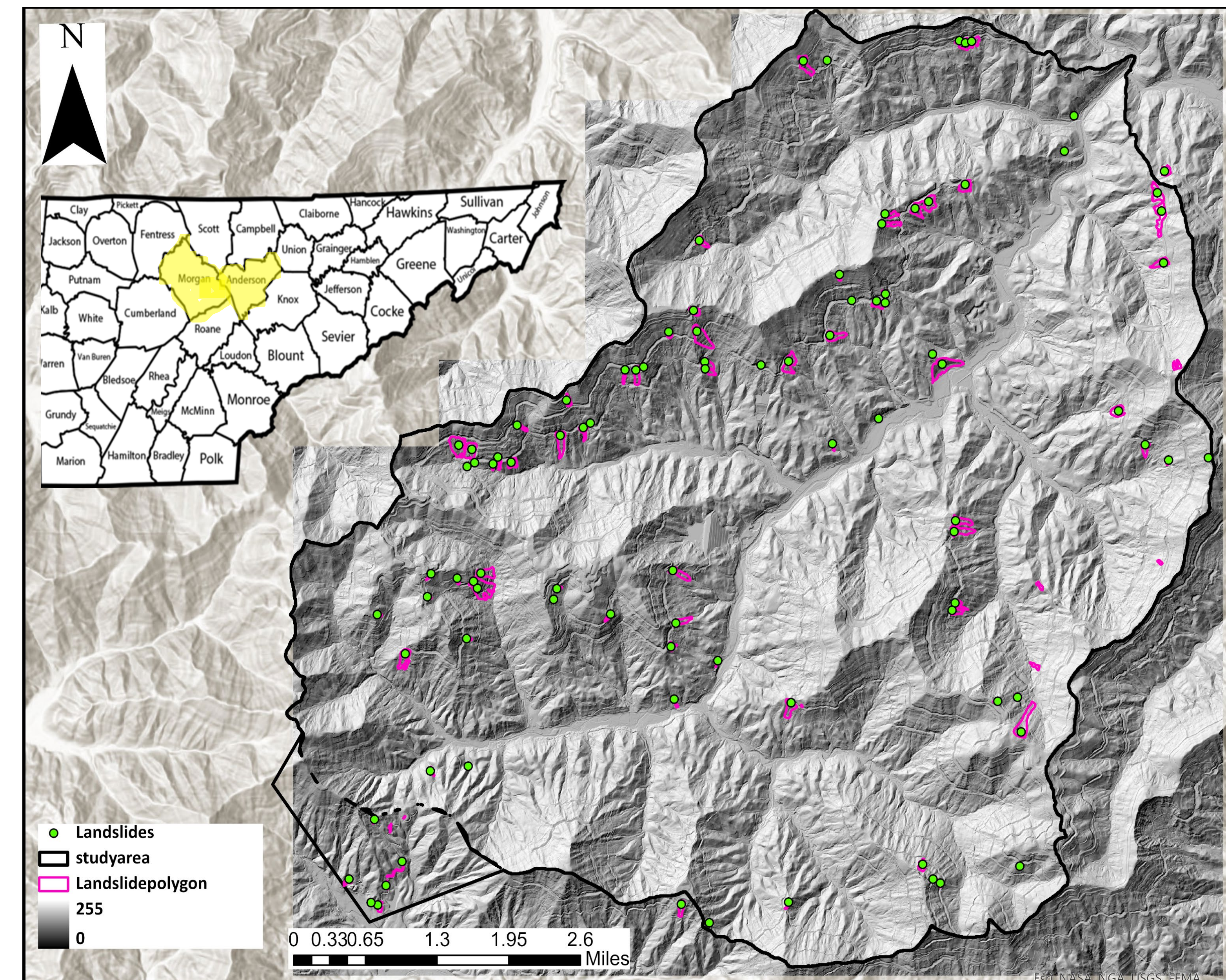
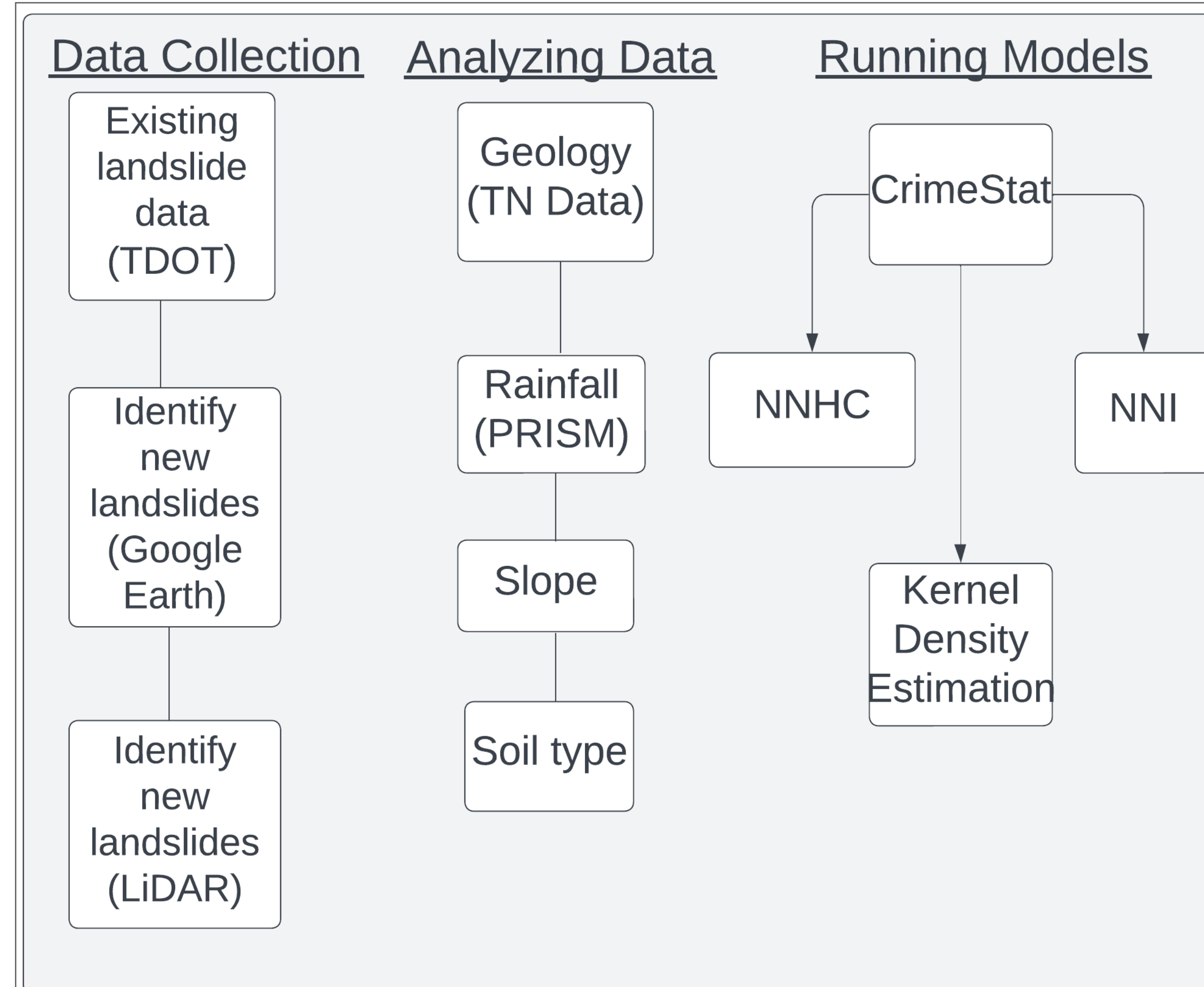


Figure 1. Study area highlighting Anderson and Morgan counties in the New River watershed in East Tennessee. Green points represent an approximate location where a landslide has been identified, and pink polygons represent the full extent of the path of the landslide.

Abstract

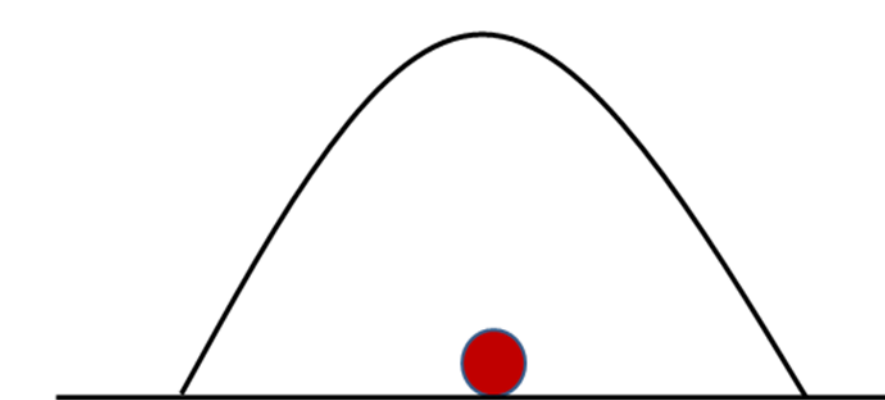
Landslides in the Southern Appalachian Mountains of East Tennessee often activate and reactivate. These landslides are often triggered by high-intensity or prolonged rainfall, which is landslides are responsible for infrastructure damage, closure of transportation routes, and even fatality. The study area is defined by the New River Watershed which has high elevation and steep slopes cutting through State Route 116 with previous landslide damage. Most drainage occurs from the New River, fed by runoff from slopes into roadways. This area experiences heavy rainfall with a yearly average of 70 inches. In response to previous landslides, the Tennessee Department of Transportation (TDOT) recently repaired six areas within the route intercepted by recent landslides. Aside from the landslides near TDOT's corridors, approximately 93 additional landslides have been found using Google Earth and LiDAR data. All landslide location data hotspots were identified were analyzed using kernel density estimation and the nearest neighbor index, and a landslide hotspot map was prepared. Results indicate that additional sites in Anderson and Morgan County should be studied further for potential landslide-related damage. The study will improve the proactive decisions of TDOT and justify timely monitoring, maintenance, and strategic protection of the route from slope hazards.

Methods



Quartic Equation

$$\hat{h}_o = 2.78\hat{\sigma}[n]^{-1/5}$$



Results: Nearest Neighbor Hierarchical Clustering

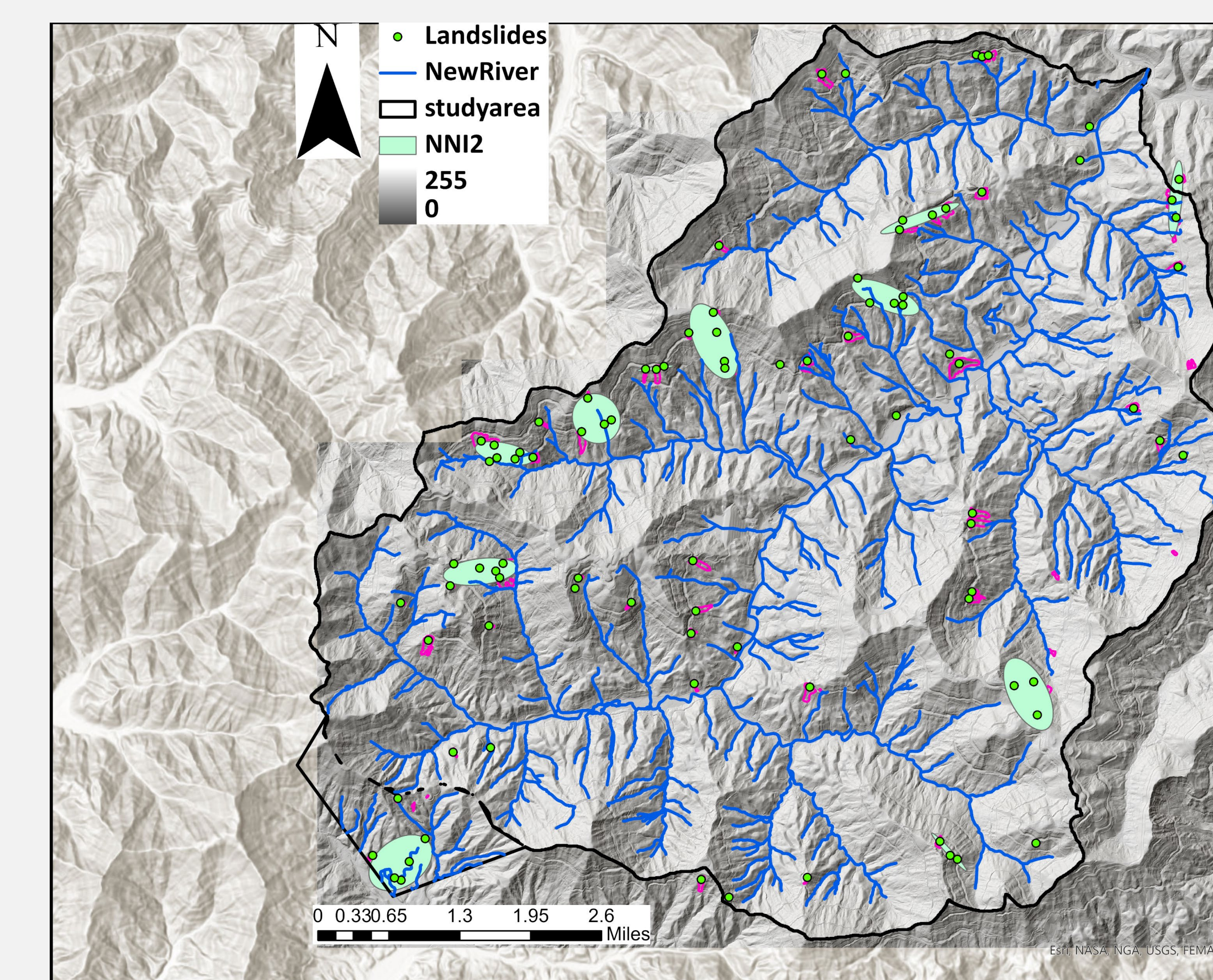


Figure 3. Nearest neighbor hierarchical clustering (NNHC) for the study area, clustering the landslides which occurred within a two-mile radius of each other. Clusters are identified in mint ovals.

Results: Kernel Density Estimation

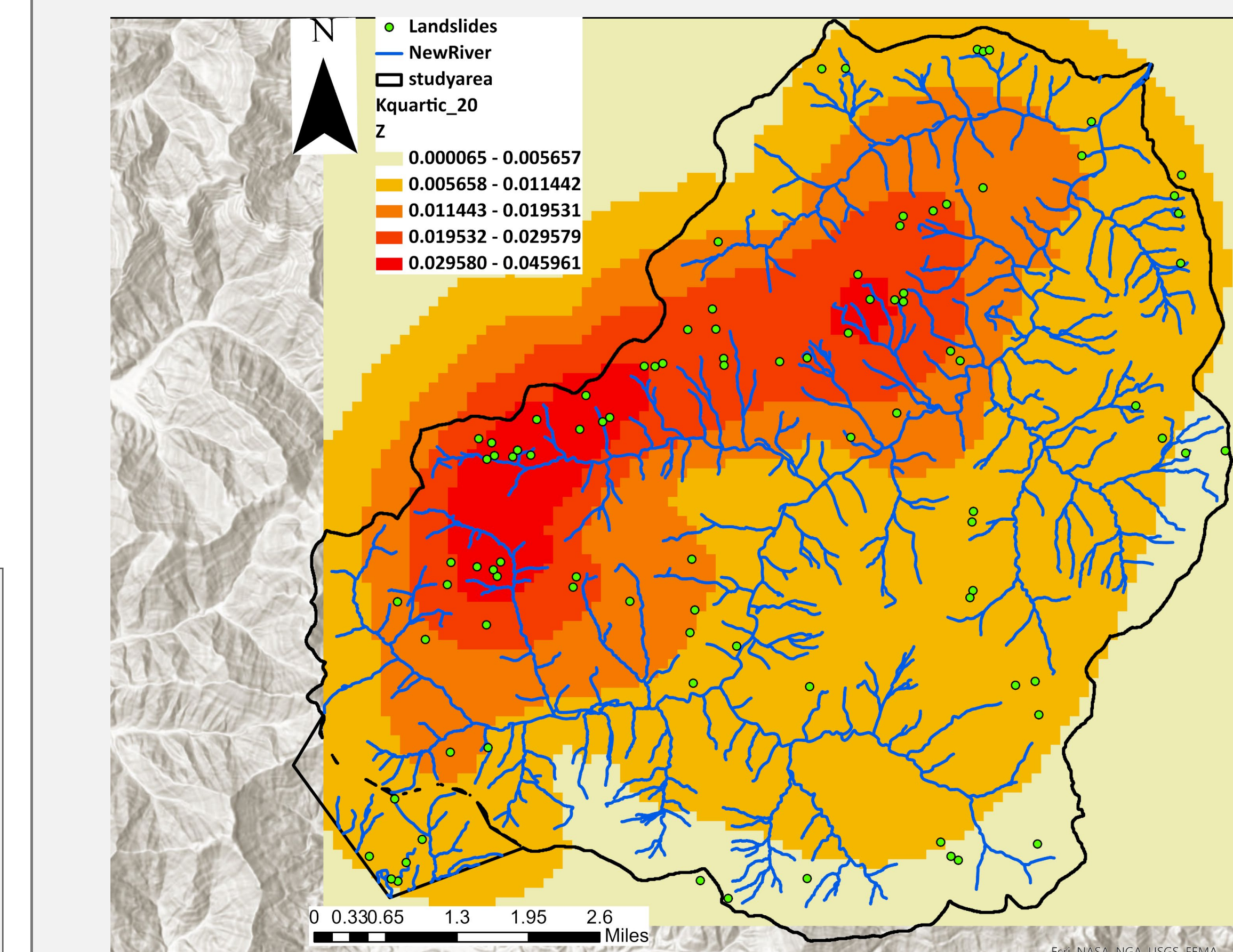


Figure 4. Kernel density estimation (KDE) using the quartic equation with a minimum sample size of 20 points. Red represents areas that are highly clustered and light yellow represents areas that are less clustered with landslides.

Results: Nearest Neighbor Index

Table 1. Nearest neighbor analysis of the study area and landslide point clusters.

Sample size	93
Mean nearest neighbor distance	1199.15 ft
Nearest neighbor index	0.64067
P-value	0.0001

Discussion

The nearest neighbor index reported 0.6406 giving the approximate clustering distance of the landslides. Since they are spatially clustered, the NNHC evaluated these clusters and reported seven clusters of landslides that occur in a two-mile radius (Figure 3). KDE reported a high cluster of landslides in the northwest region of the study area (Figure 4). When overlaying the landslide point clusters from Google Earth and LiDAR with the geology, rainfall, slope, and soil loss layers, each layer is assessed to determine which contributes to the landslide clusters in the KDE with the points. Rainfall totals surrounding the clusters ranged from about 82 inches to 70 inches, which were the highest peaks in the area. In the geologic unit prm, they had the highest number of landslides compared to any other unit. Soil loss surrounding these clusters was rated as a five, meaning the highest amount of soil loss was associated with the landslides.

Future Research

Future research will evaluate every individual landslide area in Anderson and Morgan counties, study these landslide factors in the field, and see how they're contributing to soil loss. Landslides will be rated using the Unstable Slope Monitoring Program (USMP) system to determine whether these slopes are poor, fair, or good.

Geology

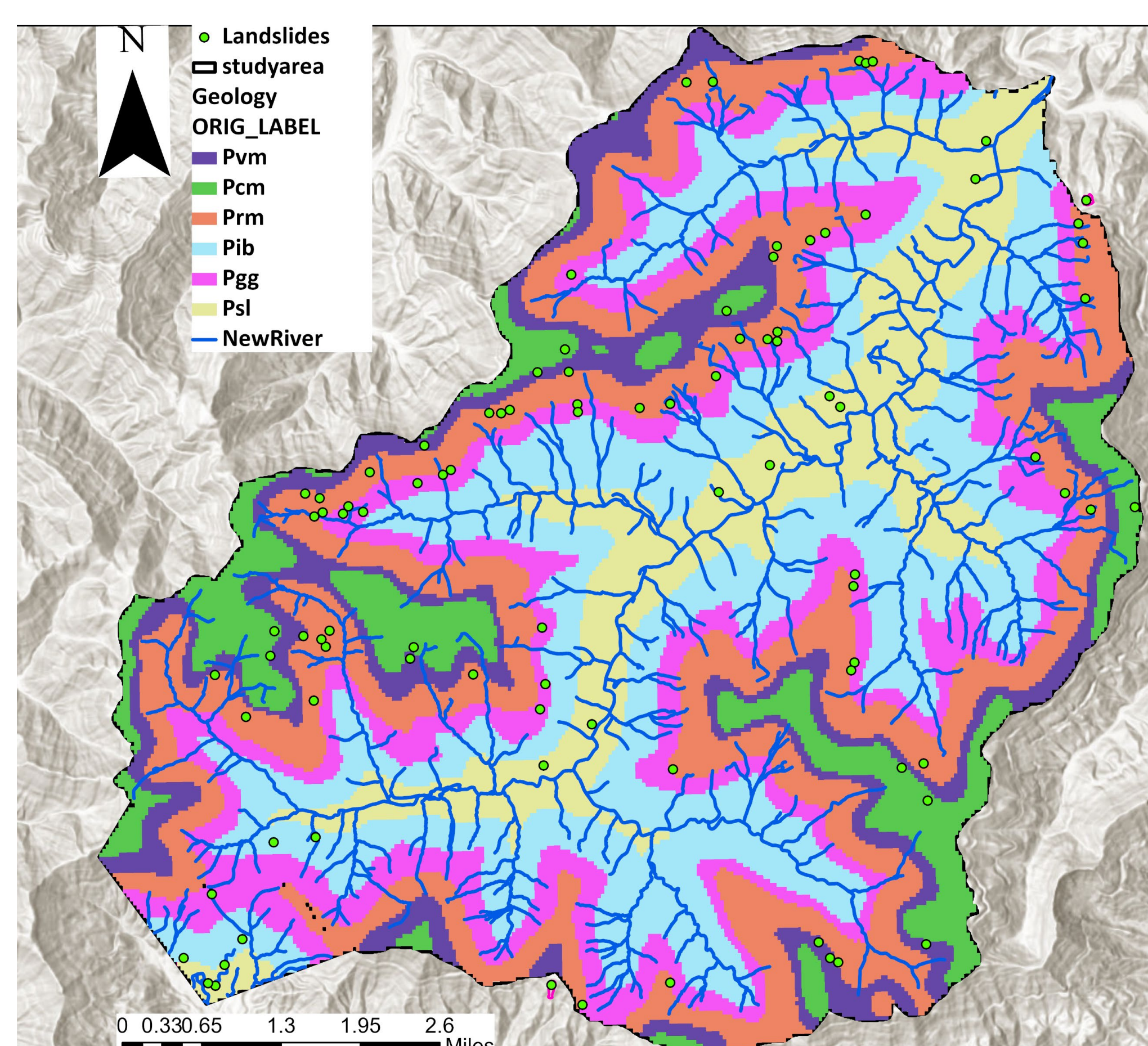


Figure 2A. Geologic units within the boundaries of the study area in reference to the landslide points

Rainfall

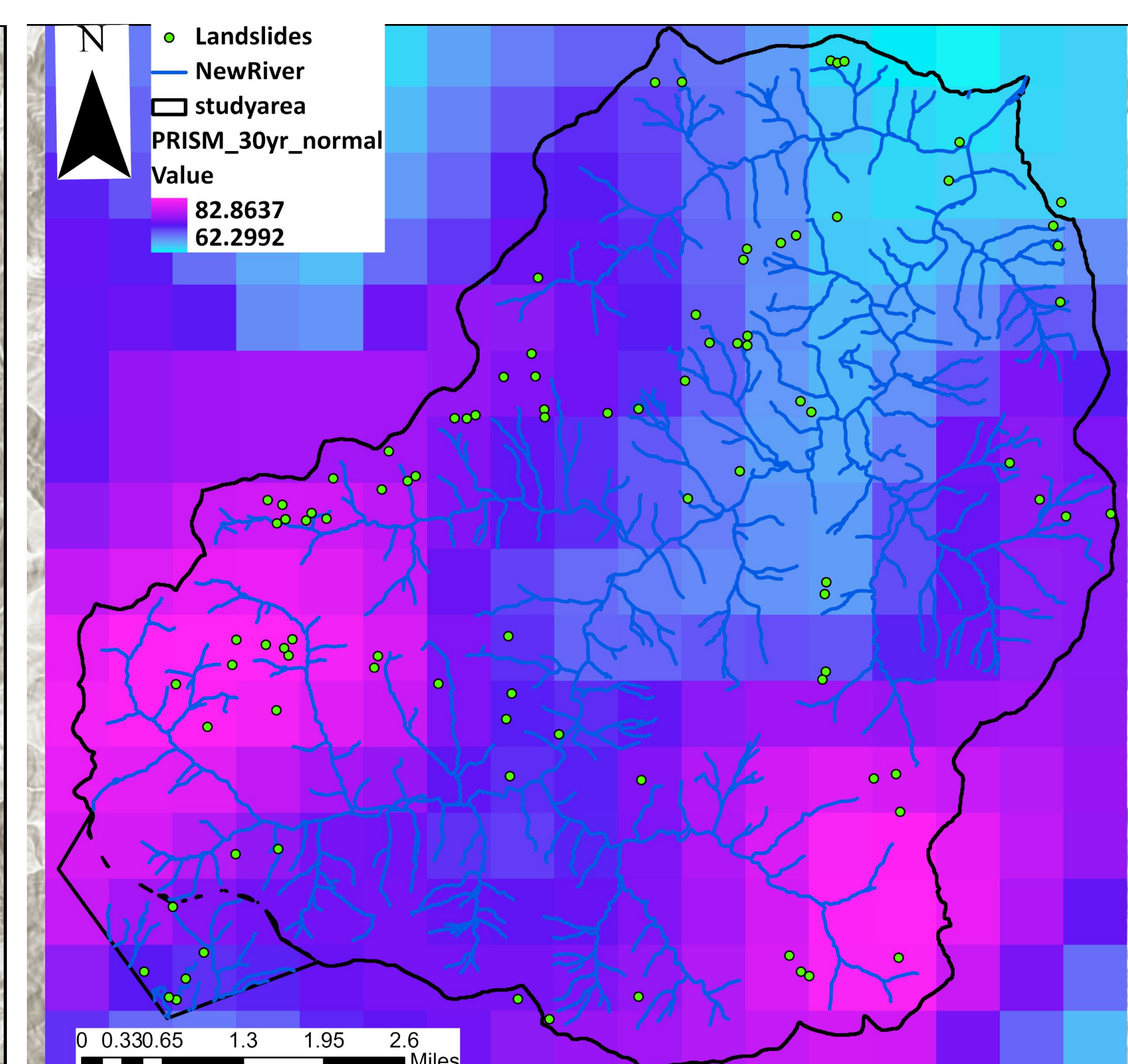


Figure 2B. PRISM rainfall data in inches representing a 30-year normal average in inches in the study area.

Slope

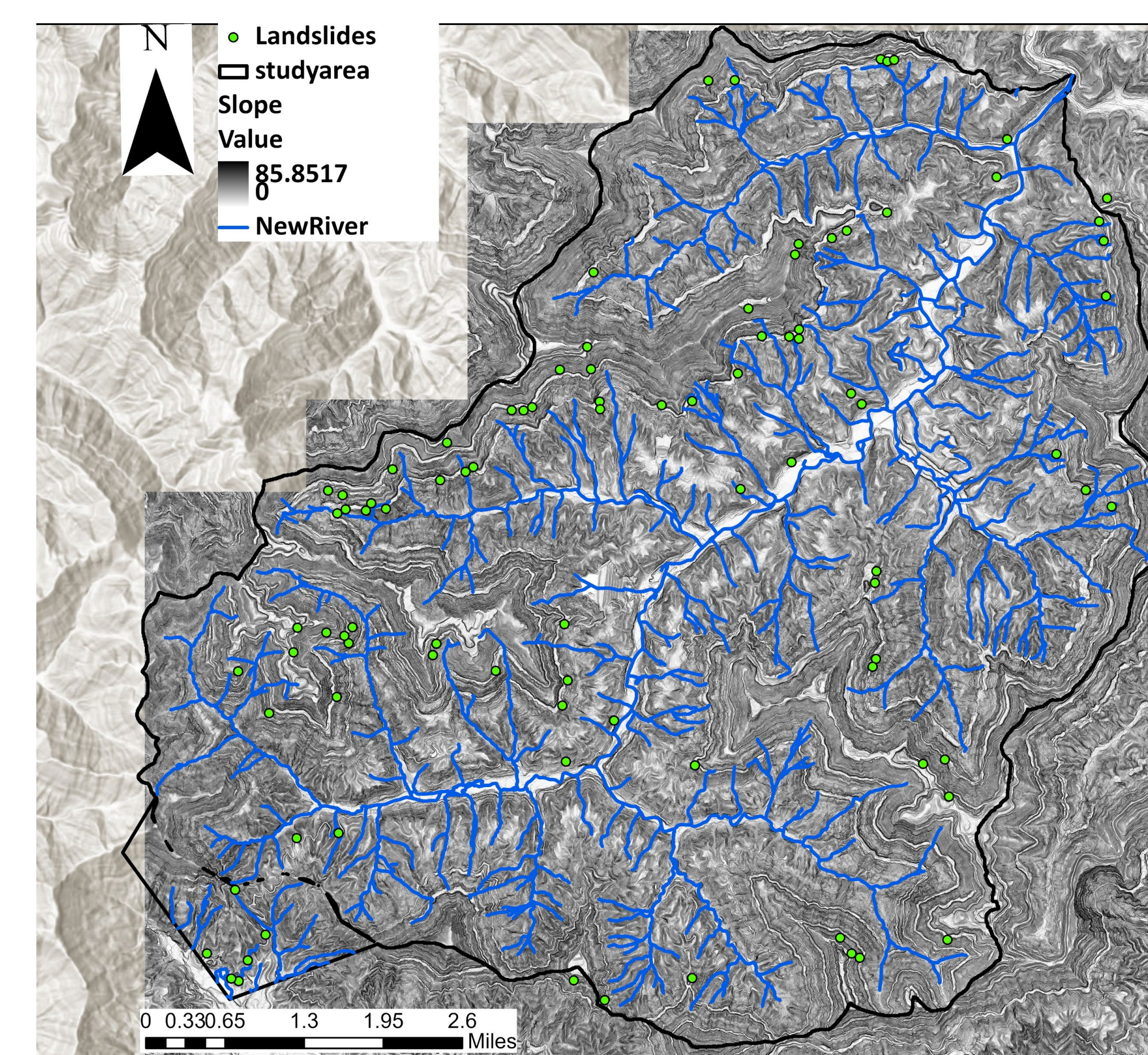


Figure 2C. Slope elevation in degrees in the New River Drainage system with landslide points overlain. The highest peaks are the darkest areas and the lowest points are the white areas.

Soil loss

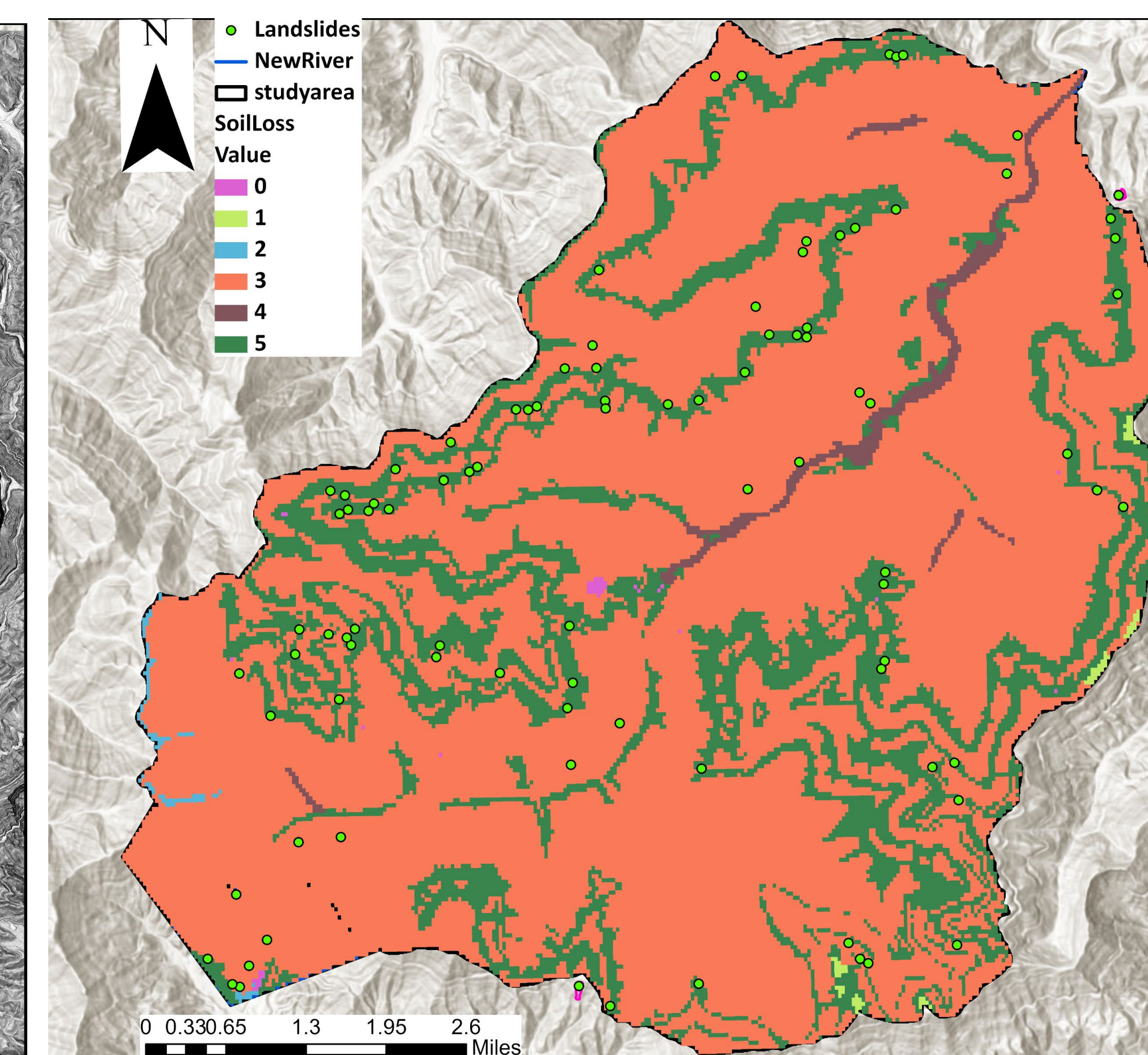


Figure 2D. Soil loss was rated between one and five for the study area compared to the landslides. One meaning there was less soil loss, five meaning there was a lot of soil loss.