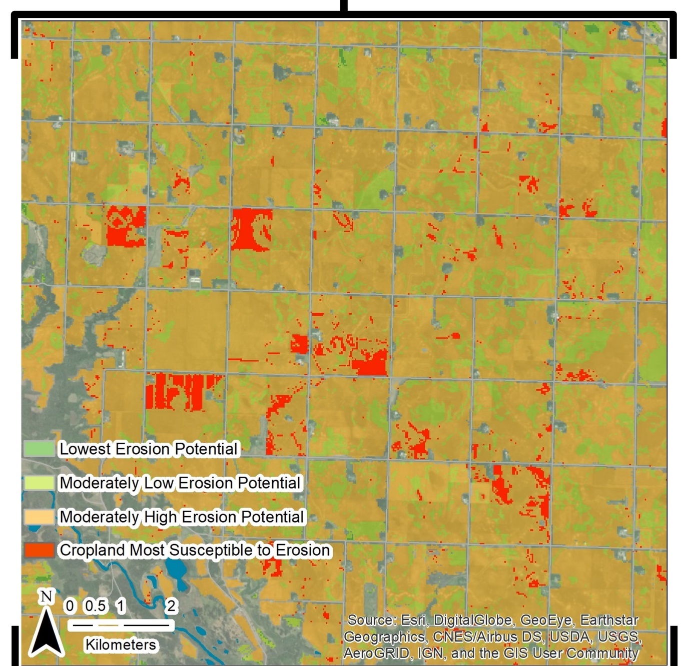
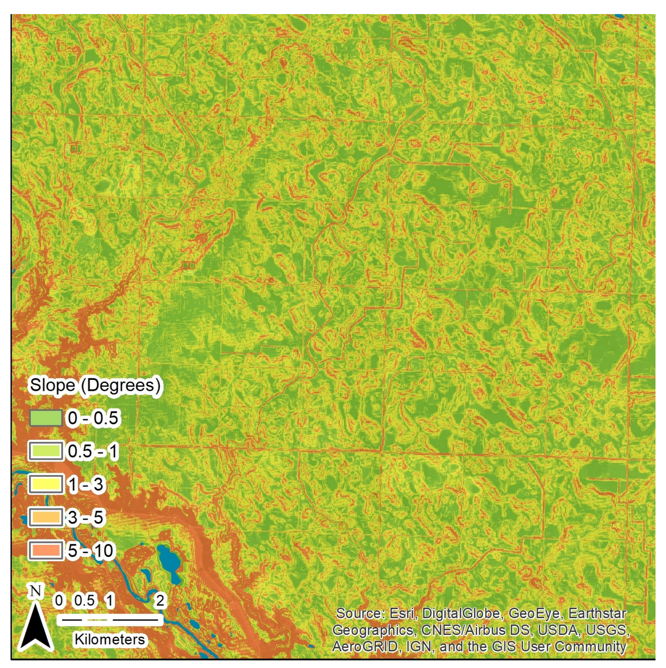
PREDICTING WINTER SOIL LOSS IN THE MINNESOTA RIVER VALLEY

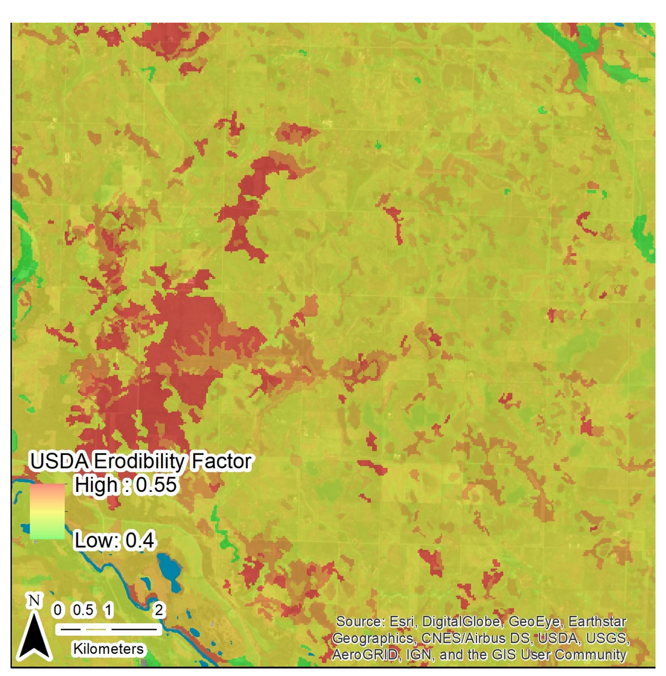
INTRODUCTION



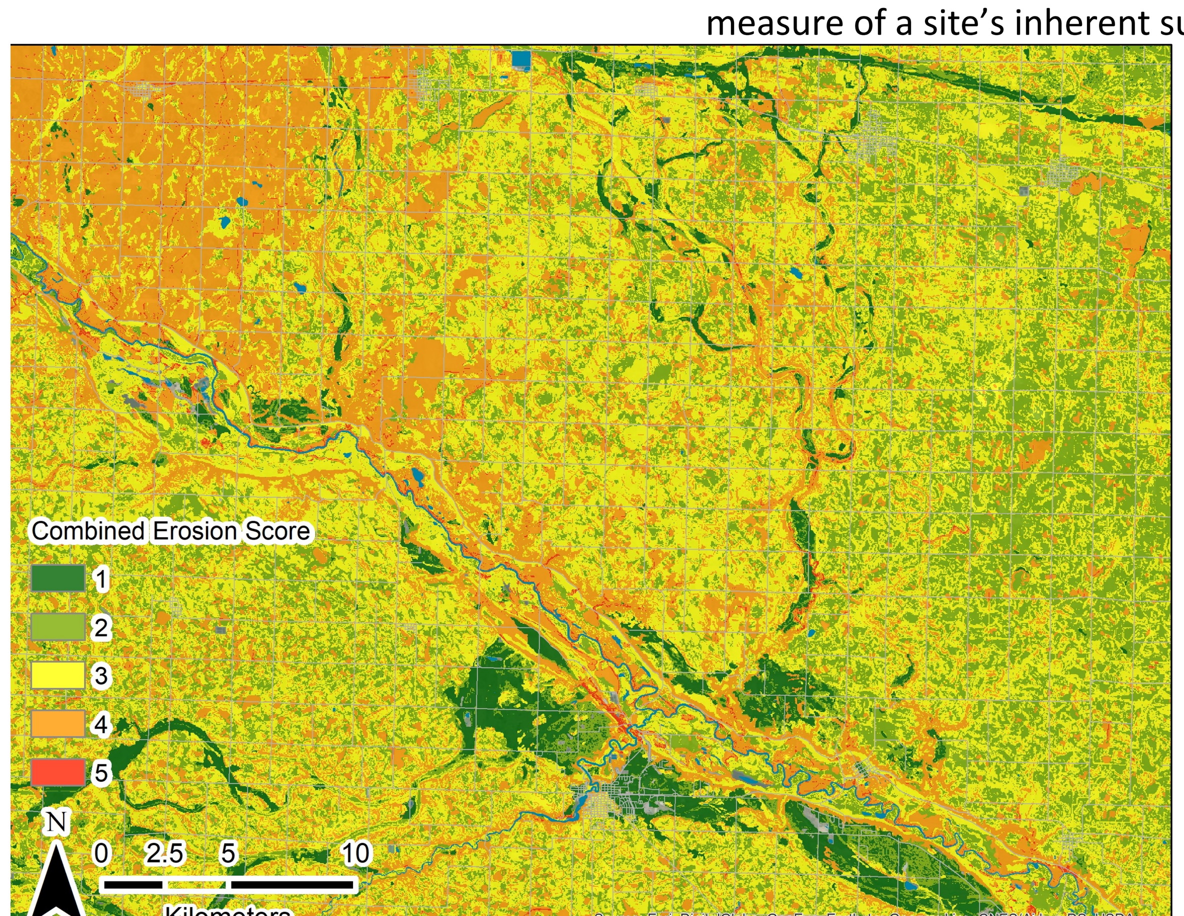
Soil loss from water erosion is a major problem on farmland, and can lead to a significant loss of soil organic matter. This significantly impacts crop yield by reducing the soil's potential to hold water and nutrients. Most of the soil erosion on fields in the Midwestern United States occurs during the period between harvest and establishment of the next year's crop in the spring. Growing a winter cover crop such as winter rye, oats, or clover can help stabilize the soil, bind up excess nutrients, and improve soil conditions for the following crop (Lazarus &Keller, 2018). The aim of this project is to identify areas within the Minnesota River Valley that might be particularly susceptible to winter soil loss and would most benefit from a cover crop. Given that growing a cover crop is an investment of capital and time for farmers, policy makers would be interested to know where wider adoption of cover cropping would have the greatest impact, as this information might help to determine apportioning of conservation program funding for farmers.

METHODS: PART I



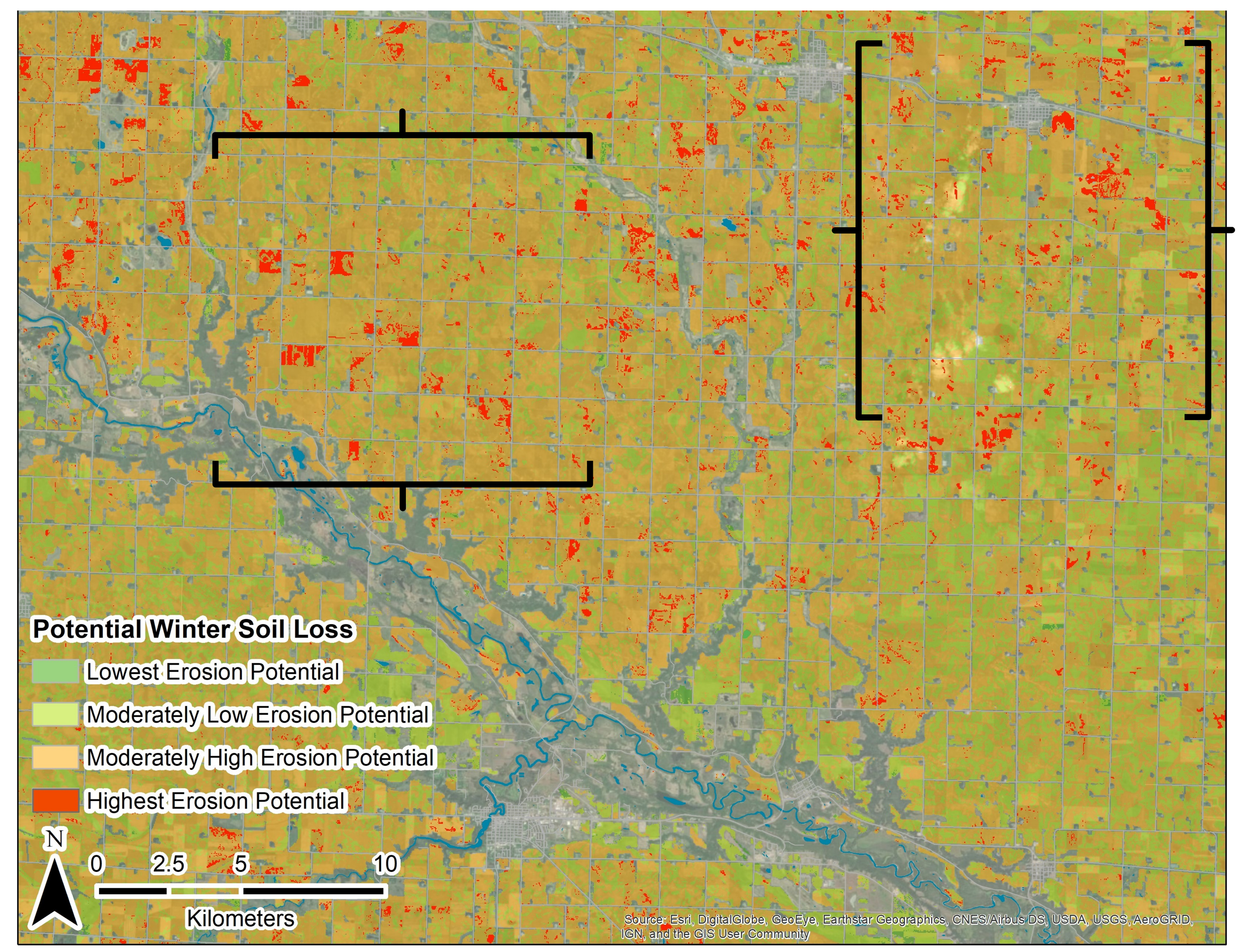


This model combines rasters for slope, k-factor, and crop data and reclasses them into a combined model that assesses areas that would be most vulnerable to winter soil loss. The first half of the model, which combines slope and k-factor data, here. Elevation raster from the National Elevation Dataset produced by the USGS were converted into slope rasters measured in degrees. The slope raster was then re-ranked by a 5 class scheme to reflect the range of slopes over the mapping area, where a 1 denotes the mildest slope and a 5 the steepest. Similarly, the K-factor data, which was originally obtained from the USDA Gridded Soil Survey Geographic Database was also reclassed into a 5 class scheme. The two rasters were combined and re-weighted to produce a new 5 class measure of a site's inherent susceptibility to erosion, pictured below. The area highlighted on this side of the map has several areas which are listed as being highly susceptible to erosion largely due to high scores on the site-inherent properties portion of the model.



CONCEPTUAL MODEL

This model analyzes winter soil erosion as a factor of slope, inherent physical erodibility, and cropping pattern and combines these factors to highlight areas which would most benefit from a winter cover crop. While the farmland of the Midwest is fairly flat, even small variations in slope within a field can impact the speed and direction of water within a field. Field boundaries often have steeper slopes than cultivated areas, and this can also impact erosion. This is particularly true in a river valley. Soil K-factor is a measure of susceptibility to sheet and rill erosion based on the physical composition of the soil. Soils with a low K-factor are high in clay and highly resistant to erosion, while soils high in silt tend to have higher K-values and are more susceptible. Finally,



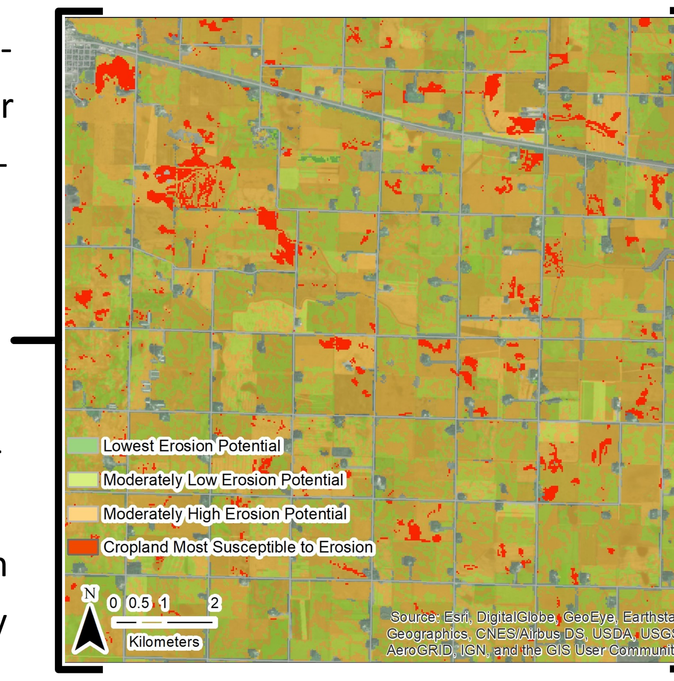
RESULTS

This analysis identified 10,238 hectares of cropland as being under the greatest threat from winter soil loss. Given that no area in the analysis was classed as a 5, this means that the areas most at threat from site-inherent properties and those most at threat from crop-management factors largely do not overlap—this suggests that farmers are already sensitive to the quality of their soil and avoid taxing rotation in vulnerable areas. Still, adding a winter cover crop could significantly reduce soil losses in these areas.

Erosion Potential	Hectares
Low	2,053
Moderately Low	210,423
Moderately High	389,638
Highest	10,328

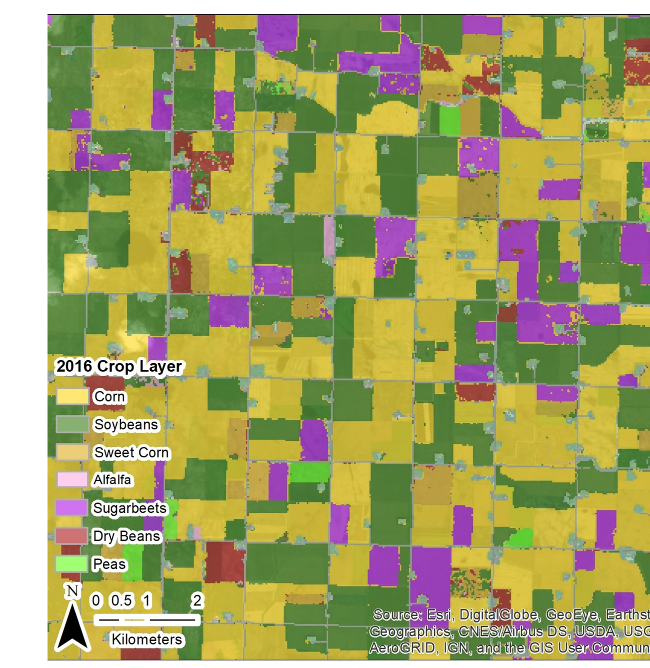
While this model incorporates many of the significant factors contributing to erosion, it has significant limitations. Among the most significant omission is tillage. While limited/ conservation tillage that preserves crop residue is widely practiced across the corn belt, it is far from universal. The classing scheme for crop residue relies on the assumption that tillage was limited and residue was preserved. This model also lacks the capacity to tell where cover crops are already in use, as CropScape records only the main crop of the summer.

Crop residue, the portion left behind in the field after harvest, can slow water running across a field, increase water infiltration, and prevent soil loss (Leys et al., 2016). Different crops leave varying levels of residue—small grains leave ample, fine residue that dramatically reduces erosion, while tuberous crops like sugar beets and potatoes leave little to no in-field reside. While other factors like winter precipitation and wind also strongly influence erosion, they vary over much wider scales than slope, soil type, and cropping pattern, and were thus excluded from the model as they would be fairly constant over the study area.

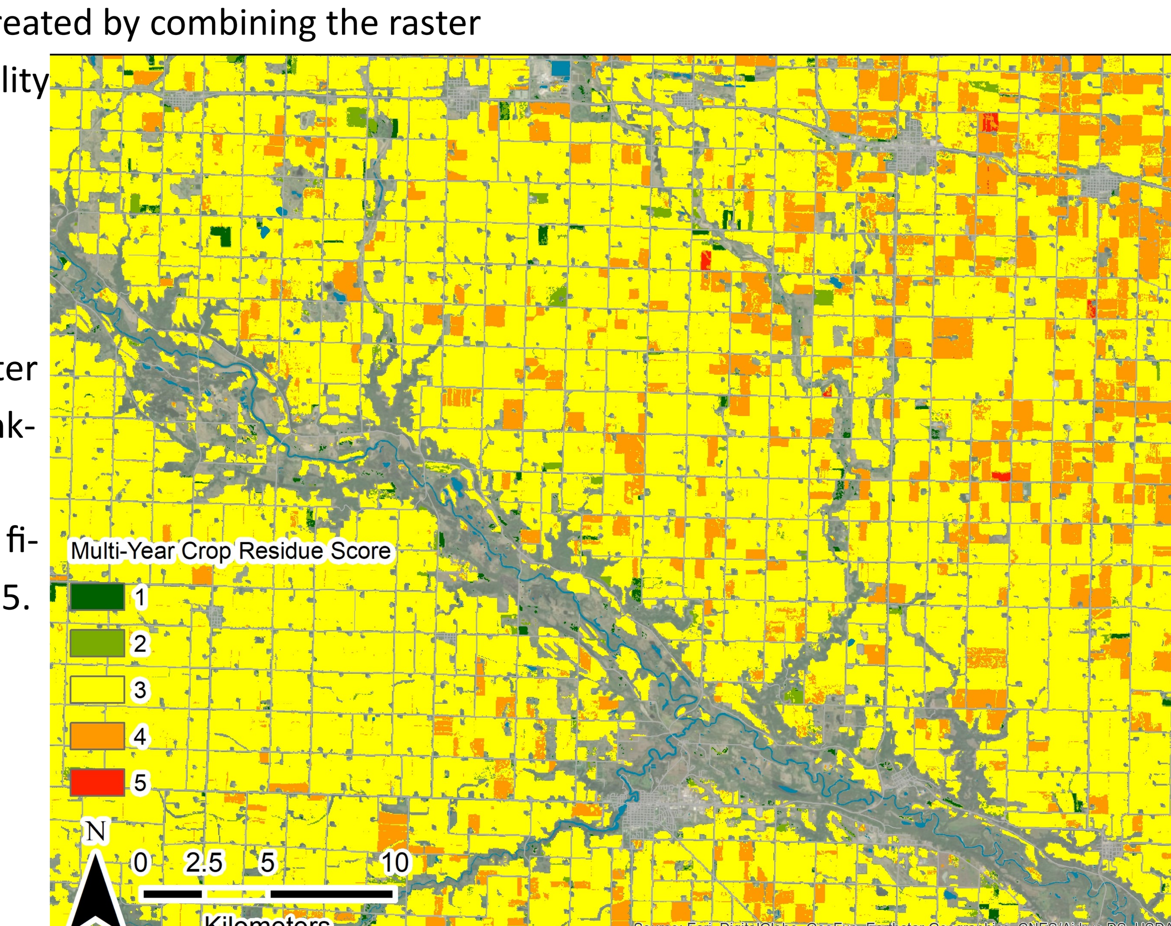


METHODS: PART II

Crop data was obtained from the USDA CropScape tool, which uses satellite imagery to gauge the type and extent of the main crop over the United States annually. Crop rotations around the Minnesota River are based in corn/ soy, but also often include sugar beets. As these rotations are multi-year, this model combines information from the 2014-2017 data layers to get a more accurate idea of land use. To better understand erosion potential, these crops were organized into 5 ranked classes by the amount of post-harvest residue they leave behind. Perennial forage crops, such as alfalfa and other hays were given a weight of 1, since they leave little soil uncovered over the winter. Crops that leave high residue, such as small grains, were ranked as a 2, while tuberous crops, some vegetables, and other low-no residue crops were ranked as a 5. Corn and soy, the two most common crops, were ranked as a 3 and 4, respectively. Each year was weighted equally and combined to create a single, 5-class raster that highlighted areas where cropland was primarily rotated between low-residue crops. The display here depicts a portion of the final map which has a high score mainly from its rotations. The 2016 and 2017 crop layers depicted here show that much of the highlighted area is under frequent sugar beet rotation with fewer small grains and other crops.



The combined map was created by combining the raster of site-inherent susceptibility and the crop score, which were equally weighted in the final analysis. While both inputs were 5-class rasters, the combined raster displays only a 4-class ranking of potential for winter erosion as no areas in the final map were ranked at a 5.



Sources:

Crop Rotation: USDA National Agricultural Statistics Service Cropland Data Layer. 2012-2017. Published 2017. Available at https://nassgeodata.gmu.edu/CropScape. Accessed 29 November 2018;USDA-NASS, Washington, DC

Soil K-factor: USA Soils Erodibility Factor, 2018. From Gridded Soil Survey Geographic (gSSURGO), USDA – NRCS. Published by ESRI, https://www.arcgis.com/home/item.html?id=ac1bc7c30bd4455e85f01fc51055e586 accessed November 29, 2018.

Slope/Elevation: National Elevation Data 1/3 arc-second DEM, 2018, US Geological Survey; published USGS, https://www.sciencebase.gov/catalog/item/4f70aa9fe4b058caae3f8de5, accessed December 5, 2018.

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Tufts University | GERALD J. AND DOROTHY R. Friedman School of Nutrition Science and Policy

Ryan Nebeker

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