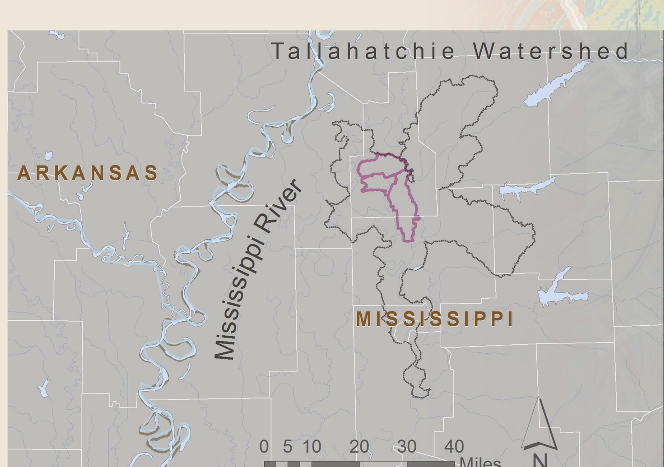
SWAMPED: Proposing wetland restoration corridors in Mississippi's Tallahatchie watershed

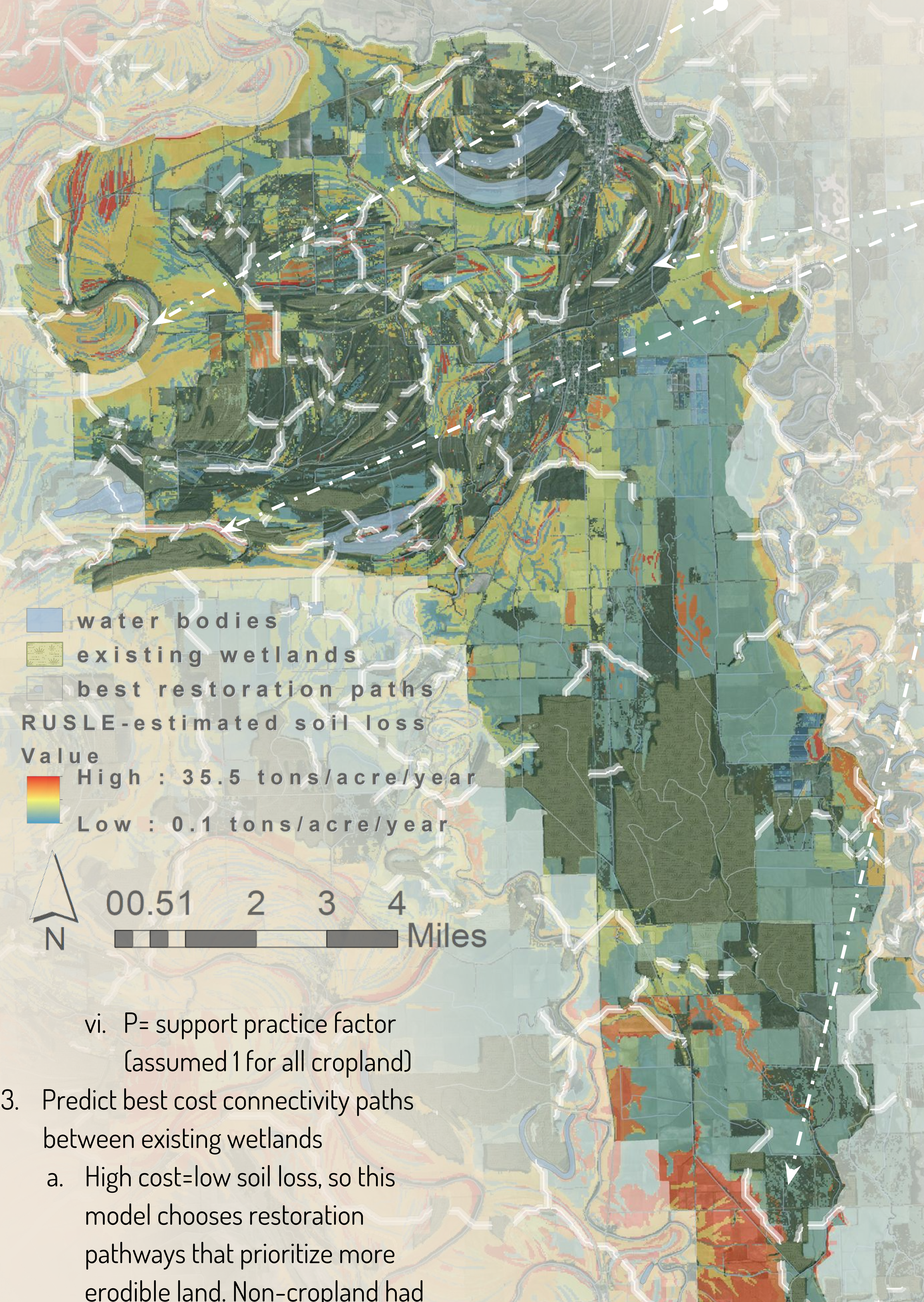
Introduction

Wetlands provide many functions including flood protection, nutrient and sediment pollution mitigation, carbon sequestration, and wildlife habitat. Prior to the Clean Water Act and during the era of "fencerow-to-fencerow" agricultural policy, however, draining wetlands for agriculture was relatively common in certain areas of the United States. Around 32% of America's cropland has been drained , and an even higher proportion was drained in the Mississippi Delta region.[1] More recently, though, conservation programs at the state and federal level can provide cost share payments to farmers who agree to restore wetlands on their properties, but funding in these programs is limited.

This project focuses on three subbasins of the Tallahatchie River watershed in Mississippi.



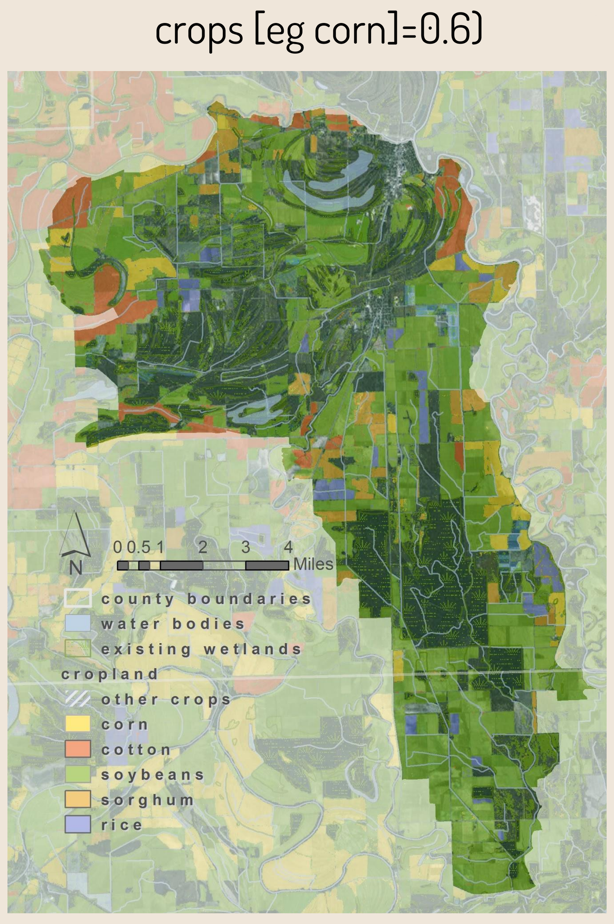
Highly segmented wetlands provide substantially fewer benefits than well-connected wetland systems.[1] Plus, agricultural areas which are losing tons of soil each year may be better off serving as agricultural pollutant remediation sites. In light of this, this project aims to predict areas where wetland remediation would be of most benefit, through restoring areas that were previously drained, prioritizing areas of high soil loss, and maintaining connectivity with existing wetlands.



Methods

1. Clip out areas that were cropped in 2015, have innately hydric soils, AND are not in the National Wetlands Inventory
2. Perform Revised Universal Soil Loss Equation (RUSLE) on these drained agricultural areas
   a. A= R*K*L*S*C*P
      i. A= average annual soil loss
      ii. R= rainfall-runoff erosivity factor (384 for entire area)[2]
      iii. K= soil erodibility factor (from SSURGO)
      iv. LS= slope length and steepness factor (length assumed 75 ft, then classified with conditionality matrix from USDA)[3]
      v. C= cover management factor (where higher residue/more soil-protective crops [eg small grains]=0.3 and less protective crops [eg corn]=0.6)
      vi. P= support practice factor (assumed 1 for all cropland)
3. Predict best cost connectivity paths between existing wetlands
   a. High cost=low soil loss, so this model chooses restoration pathways that prioritize more erodible land. Non-cropland had highest relative cost.
   b. Add a 100 meter buffer to these predicted paths to show possible wetland remediation areas.

2015 cropland

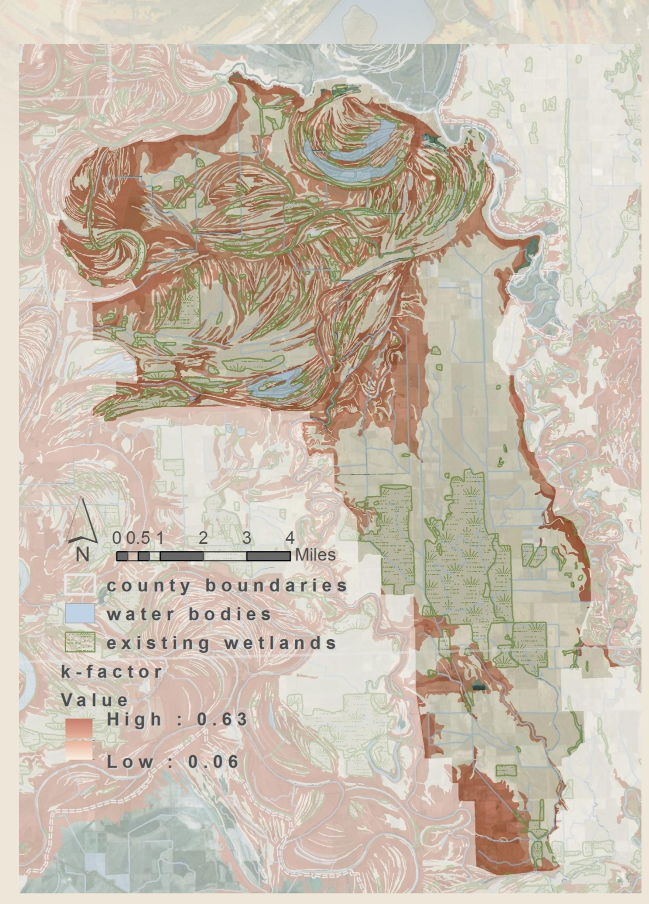


In 2015, these 3 subbasins were mostly cropped, and the area grew mostly soybeans (according to CDL). It should be noted that most crop farms would rotate crops, so these fields may have been mostly corn in another year. Rice production is also common in this area of Mississippi, and this rice cultivation is achieved with flooded fields for part of the growing season.

Drained wetlands

When using the methodology described above to determine areas that may have been drained for agriculture, it appears much of the region was indeed drained. About 85% of the farmed land in this region seems to have been hydrologically altered.

Soil K-factor



A soil's K-factor is a unitless number that describes the innate susceptibility of the soil type to erosion. This is important since conservation programs often use erosion as a criteria for retiring productive land. This factor is one of the most important drivers in the Universal Soil Loss Equation in my study area.

Results

This map shows all paths that were predicted via cost connectivity analysis, with a 100 meter buffer around each path to show regions where wetland restoration may be most beneficial, taking into account erosion rates and requiring paths to connect existing wetlands.

A few paths which show the capability of the model are displayed above. In many cases, paths snapped to narrow sections of high erosion as predicted by RUSLE, but in other cases, particularly when existing wetlands were near to each other, the model chose paths of relatively low erosion, owing to the lower cumulative cost distance.

These paths, coupled with aerial imagery of what is happening on the ground, show that areas of apparent intensive crop production and high erosion are often found around and between remaining natural wetlands, and that sometimes, the best path follows along the border of an existing wetland. Interestingly, some of the areas of high soil loss can be seen as areas of bare soil in aerial photos (see Path 1 above), even in cropped fields, giving credence to the spatial application of RUSLE used here.

Conclusions and Implications

Through working with these datasets, some problems were discovered. The SSURGO database shows noticeably different K-factor ranges for different counties, with no geographical feature to explain the discrepancy. The analysis shown covers two counties that had relatively similar ranges in K-factor but nonetheless these results may be skewed.

The Cropland Data Layer is known to have some measurement error, including isolated pixels of dubious crop determination within larger fields of likely accurate crop determination. For this work, these cells were left as-is because they were so few, but a better approach might be to clean this data source such that these isolated cells are converted to match the cells around them.

Many assumptions were made with the RUSLE calculation (e.g. assuming constant support practice factor), as this equation is designed more for field-level analyses. With more information about average management practices in the region as well as the length of crop fields, this calculation could be refined.

Finally, the "path" approach to wetland restoration has the function of connecting separate areas, but does not represent restoration benefits perfectly. Perhaps wetlands should not be restored in lines but rather in large blocks. Because of this, this analysis should be viewed as a starting point to develop more rigorous methods to produce variable-width wetland corridors, or include paths that simply expand existing wetlands.

The areas where paths were predicted are, of course, mostly privately owned, and perhaps more importantly, a source of income for landowners. This precludes the notion that a policymaker could simply reclaim these areas and restore them. However, with the incentives for conservation available now and in the future, policymakers could benefit from using a GIS method that informs prioritization and design of wetland restoration projects.

Data sources:
Cropland Data Layer. US Department of Agriculture. 2015.
National Wetland Inventory. US Fish and Wildlife Service.
HUC 12 Watershed Boundaries. US Geological Survey. 2016.
Web Soil Survey/SSURGO. US Department of Agriculture. 1982 (most recent).
Aerial imagery. ESRI World Imagery, DigitalGlobe, Geoeye, EarthStar Geographics CNESAirBus DS, USDA, USGS, AEX, GetMapping, Aerogrid, IGN, IGP, Swisstopo, and The GIS User Community
Hydrography: Rivers and streams. USGS. 2016.

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All maps use UTM Zone 15N projection

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1. Dahl, T.E., and Allord, G.J. USGS. (1997). "Technical Aspects of Wetlands History of Wetlands in the Conterminous United States." National Water Summary on Wetland Resources.
2. Cooper, K. (2011). Evaluation of the Relationship Between the RUSLE R-factor and Annual Precipitation.
3. USDA NRCS. Excel Spreadsheet. "LS Factor". http://www.iwr.msu.edu/rusle/lstable.htm.