

Nitrate Pollution in Kern County

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Abstract

Kern county, as a big agricultural area in the Central Valley, relies heavily on agriculture and the extraction of petroleum as their economic income. This project focuses on the agricultural aspect. Regions with large amounts of agricultural activity can be at risk of nitrate pollution from fertilizer run-off or infiltration, an issue which can be intensified by heavy storms such as those California has received in the last few months. We used GIS and Hec-GeoHSM tools to analyze the potential for nitrate pollution of the Kern river and other tributaries to Lake Evans and Lake Webb. Utilizing the digital elevation model data from United States Geological Survey (USGS), which is the most commonly used database in United States, we analyzed the watersheds and rivers in Kern County. In addition, agricultural land usage data available from the Kern county website was used to break down farms by specific crop.

Introduction

Kern County has large amounts of land dedicated to agriculture, and during heavy rain events surface runoff can carry nitrates from fertilizers and animal waste into rivers and canals, which lead to larger water bodies such as Lake Evans and Lake Webb. Once nitrates have reached these water bodies they can lead to eutrophication and environmental impacts. Health impacts also exist from high exposure to nitrates, including methemoglobinemia, or blue baby syndrome. Lake Webb is used for recreational purposes so pollutants or excessive eutrophication could be extremely damaging. In addition, Lake Evans is a manmade lake for recreational usage

such as sailing and fishing at the southwest of Bakersfield. Our project focused on spatially analyzing the risk of nitrate pollution from farms in the Kern County area based on shared catchment areas or subbasins.

Materials and Methods

We first chose to analyze the Kern River which is centered in Kern County and runs through Bakersfield. We focused our scope to the land surrounding this area, and then began to perform a hydrologic analysis of the region. Starting with DEM data from USGS, we then converted the DEM data from a geographic coordinate system, which is the default for USGS, to a projected coordinate system. There is a box to input the number of bands needed which is 1 for DEM data for holding elevation data and 3 for colorful image which holds red, green and blue data. Due to the data conversion, the DEM data can work well with HEC-GeoHMS procedures. Hec-GeoHMS tools were used following the process learned in class. The results of these processes are shown in Figure 1.

Step 1. Fill sinks: In order to prevent a cell cannot be assigned one any direction in a flow direction raster. After processing fill sinks, all cells were assigned to a flow direction instead of two-cells loop.

Step 2. Flow direction: The process assigned each DEM cell a flow toward another cell in the direction of highest descent by inputting fill data. Each possible direction was assigned to one of 8 different numbers.

Step 3. Flow accumulation: This process accumulated flow to each cells, and this is the process which took longest time in all processes. The time to finish this process depends on the resolution of DEM and the cover area of DEM data.

Step 4, Stream definition: This process used flow accumulation as its input and created a stream grid. The definition of this stream grid is dependant on the threshold values which are defined by users such as amount of cells and area of sources.

Step 5. Stream segmentation: The procedure gave identifications for creating stream segments.

Step 6. Drainage line processing: The procedure created a new feature which converted the result from stream segmentations into a drainage line feature class. Each line in the drainage line feature class is arranged to catch water from one or more catchments and shows the connection between each line.

Step 7. Catchment grid delineation: This procedure created a grid in which each cell carries a code indicating the catchment that the cell belongs to.

Step 8. Catchment polygon processing: Converted catchment grid into a polygon feature class.

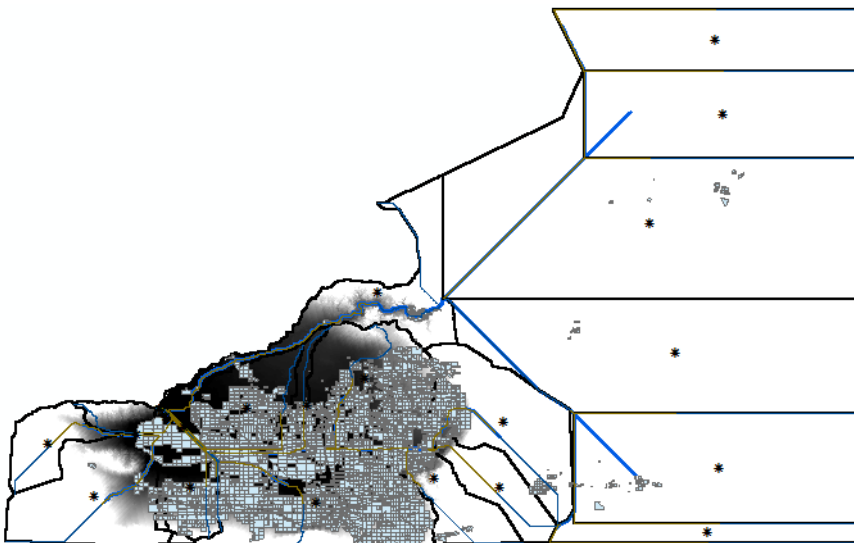


Figure 1: HEC-GeoHMS results and Farm data.

When we were trying to use HEC-GeoHMS tools box to analyze the river slopes, it showed that there was a spatial reference problem and therefore ArcMap could not finish the process. The reason why HEC-GeoHMS did not allow the DEM layer to be analyzed is that the default setting of the coordinate system from USGS was using geographic coordinate systems (GCSs). The DEM data with GCSs cannot work well with HEC-GeoHMS tools, therefore this data needed to be converted from GCSs to projected coordinate systems. Hence, the tool of Project Raster was used to convert the coordinate system for the DEM data.

Our goal was to estimate nitrate runoff risk, and we wanted to be more accurate than just counting the number of farms in each catchment. Therefore, research was done on the major crops in the region to determine their Nitrogen Application Rate. This value reflects the pounds of nitrogen applied per acre per year. While it would be impossible to estimate the amount of nitrate/nitrogen in the soil at any given time, this approach allowed us to analyze the relative risk between the various areas. The Nitrogen Application Rate of some crops such as potato and garlic was over 200, while other crops including alfalfa and grapes had a value below 50. Non-agricultural areas were discluded from our analysis, and very uncommon crops (less than 20 farms) were given a standard average value of 75 lb/acre to be conservative. It would have been unnecessarily time consuming to research application rates for crops which were only grown on 10 farms in this area for example, but we didn't want to eliminate them entirely. This data was accumulated onto an Excel sheet, where the names of the crops were carefully spelled to exactly match the names in the agriculture data shapefile before that sheet was added to our GIS project. Using the Join tool, we were able to join the agriculture shapefile and the newly added sheet so that the nitrogen application rate for every farm was present in the attribute table, based on the

specific crop. We then used Field Calculator to multiply the Nitrogen Application Rate by the farm area in acres to get the approximate total amount of nitrogen applied per year for each farm.

In order to make comparisons between the farms, the farm data had to be connected to the subbasin areas. To achieve this, we first used the Intersect tool. Intersecting the farm data and subbasin shapefiles resulted in a new shapefile which contained entries for every farm including which subbasin they were in (gridcode). Our next step was to use Summarize on the gridcode column to summarize by the Sum of farm risk. This resulted in a table which listed each subbasin that had farms within its boundaries and both the number of farms inside it and the total nitrogen applied. In order to add this data to the subbasin shapefile, we used Join to add the data based on the shared gridcode column. This allowed us to analyze our results, use symbology to portray them visually, and draw conclusions from them.

Result and Discussion

Our resulting data, displayed in Figure 2, shows that one catchment exhibited significantly higher risk than the others we analyzed. While this was expected because it contained the largest number of farms, it is still useful to see by what margin the risk is greater. Interestingly, the catchment with the second highest risk only had the third highest number of farms. This is due to the spatial variability of crop types and average farm sizes. Catchment areas on the outskirts of the analyzed area tended to have fewer farms and therefore a lower nitrate pollution risk.

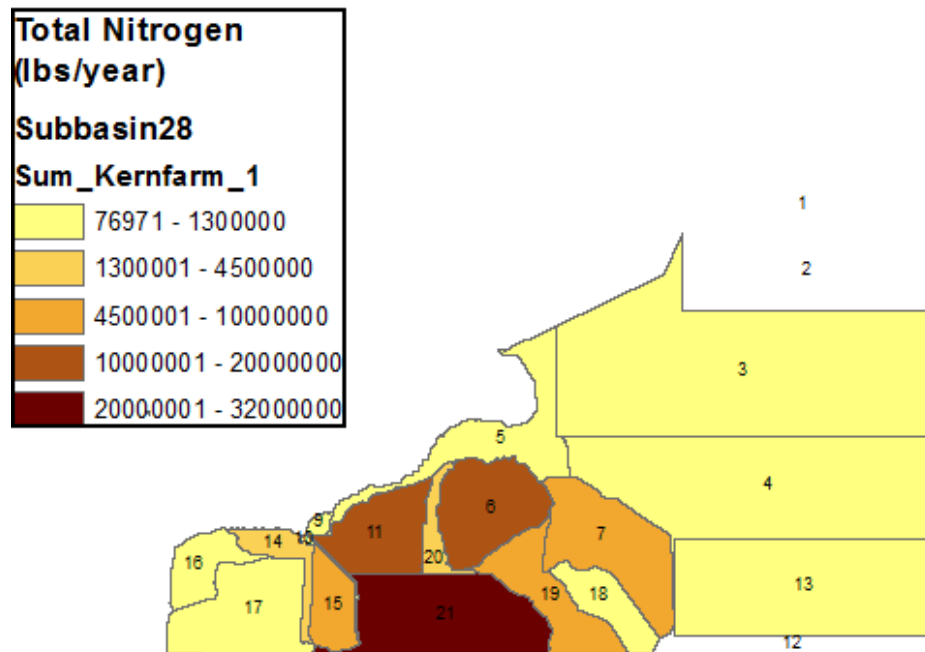


Figure 2: Total Nitrogen Risk per Subbasin

Conclusion

These results could be useful to aid in direction of regulations, remediation and other efforts to control the surface water pollution of nitrates. From a regulatory approach, restrictions could be made in the highest risk areas in order to reduce to possible concentration of Nitrates. Soil nitrate tests could be paid for in order to increase Nitrogen Use Efficiency (NUE) in the most at risk areas as well. Barriers or diversions could also be used if the problem was dire enough. Our data would allow for the more effective use of prevention/remediation funding, as opposed to applying them to the entire area. The general idea could also be expanded upon to encompass larger concerns and groundwater contamination as well.

References

Rosenstock, T.S., Liptzin, D., Six, J., and Tomich, T.P. (2013). "Nitrogen fertilizer use in California: Assessing the data, trends and a way forward." *California Agriculture*, 67(1): 68-79.