DASYMETRIC MAPPING of NITROGEN and PHOSPHORUS LEVELS PRODUCED by CONFINED CATTLE OPERATIONS

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Geography 492/592 Dr. Geoffery Duh Winter 2017

INTRODUCTION

Nitrogen and Phosphorus are two elements essential for hearty and healthy plant growth, and are commonly ingredients in fertilizers. Should these elements be used in quantities that are too high for the plants to uptake, it is often eventually washed into water sources like streams. Excess nitrogen and phosphorus cause an enormous amount of plant growth, which in turn can reduce the amount of oxygen in the water through decomposition or excessive algae growth, block light from deep areas and cause large scale death of aquatic animal species.

Introduction of these elements into the environment do not always come in the form of synthetic or chemical fertilizers; animal by-products, particularly cattle manure, are sources as well. Confined Animal Feeding Operations (CAFOs) and dairy farms can contain thousands of animals in a contained area. The production of waste from these animals are collected and either spread as fertilizer on nearby crops, or get washed and absorbed into the land and eventually the watershed.

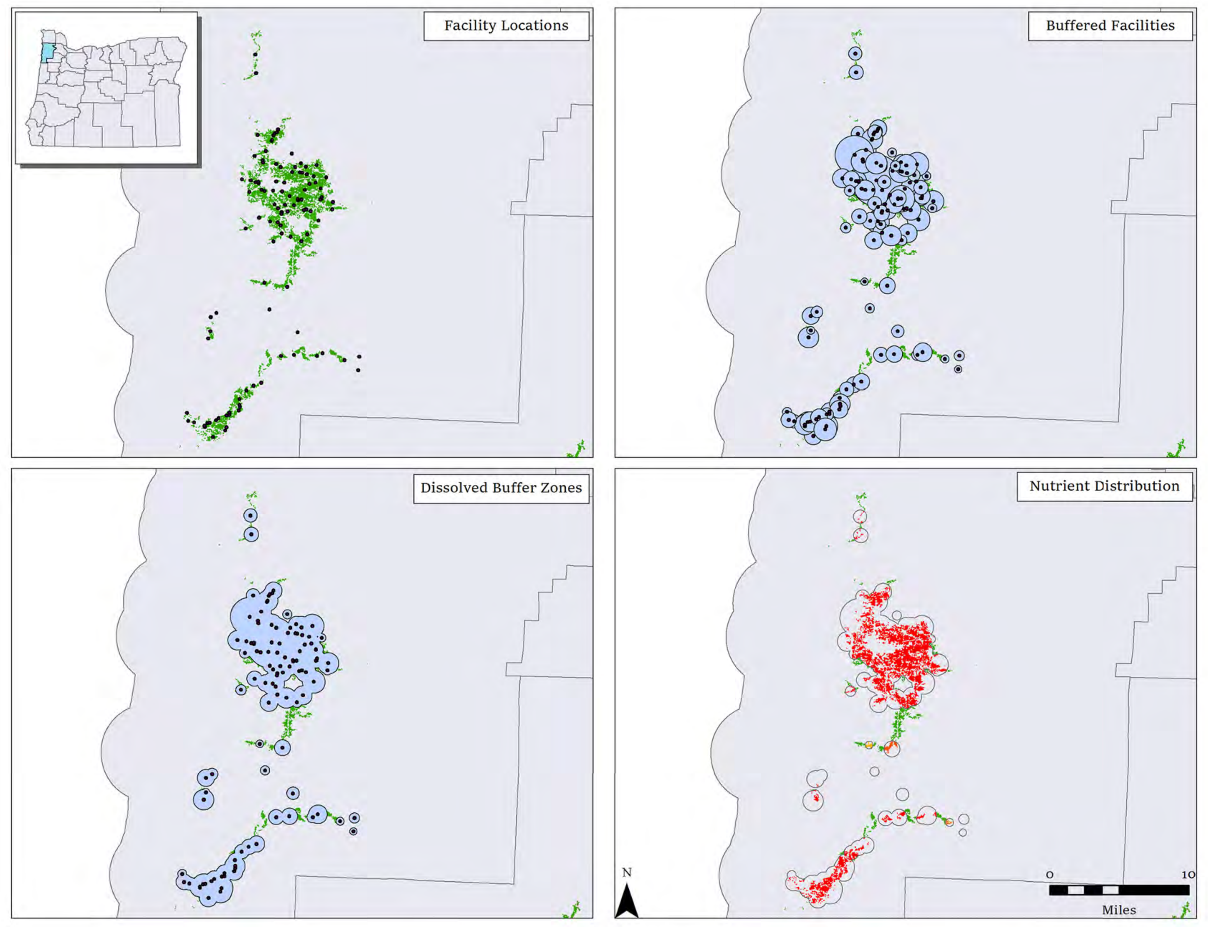
For this project, we set out to assist the USGS in providing a more refined understanding of the concentrations of nitrogen and phosphorus around CAFOs and dairies. In past projects, the USGS has distributed the N and P levels evenly acros the NLCD land classes 81 (pasture/hay) and 82 (cultivated crops). This project is meant to display the concentrations of nitrogen and phosphorus around CAFOs and dairies in Oregon.

METHODS and ANALYSIS

The data we received included a shapefile containing the locations of dairies and CAFOs in the state of Oregon, in addition to a spreadsheet containing estimated amounts of nitrogen and phosphorus produced by all cattle (confined and unconfined) throughout the entire state, as well as the total cattle population; both datasets were provided by Dan Wise of the USGS. The shapefile also contained the number of cattle on each farm, which we used to determine the number of confined cattle in the state, on a county-by-county basis, as well as the proportion of cattle that were confined (as opposed to unconfined). To calculate the kg of nitrogen and phosphorus produced by confined cattle per county, we multiplied the proportion of confined cattle, the total nitrogen/phosphorus production for the county and the average recoverability factors (which compensates for the volatilization of N and P into the air). These values were then used to determine the amount of N and P produced by each farm, based on the number of cattle at each location. Additionally, a 30m NLCD 2011 raster was clipped to the study area, resampled to 100m and reclassified to designate land classes 81 and 82 (pasture/hay and cultivated crops, respectively) with a value of 1 and all other land classes with a value of 0. The 81 and 82 land classes were designated with equal weight, as there was no literature to provide us with any reasoning to weight them differently, and according to Mr. Wise, past projects had likewise given them the same weighting.

Points designated the locations of the farms, so to apply the amount of nitrogen and phosphorus to an area of the land, we used the buffer analysis tool. Based on information from the Natural Resources Conservation Service from the USDA, a recommended area for a single cow is 1.8 acres. Using this information, we were able to produce a different buffer size for each facility based on its total number of cattle, using the equation $r = \sqrt{(A/\pi)}$, which was written into a script with the buffer analysis tool; to produce the correct units, the conversion factor 7284.34 sq m = 1.8 acres was used. Several areas of the state exhibited tight clustering of facilities, and in these areas many facility buffers overlapped. The Dissolve tool was used to avoid depicting multiple applications of manure at points of overlap.

Once the polygons were dissolved, we utilized Tabulate Area to find the total area of the designated land classes within each buffer zone. In order to ensure the total N and P values were evenly distributed throughout each respective buffer zone, the number of cells per buffer were calculated by dividing the total area of land class 1 in each buffer by the area of a raster cell (100x100 m, or 10,000 sq m).



Using the raster calculator we distributed the nitrogen and phosphorus from the farms within each polygon to the land class below. With the water gauge data provided to us from the USGS we adjusted the symbolization to display them with graduated symbols based on the mg of nitrogen and phosphorus measured in the flow levels We visually assessed if there were clustering of high levels around farms and found that the gauges with high nitrogen levels did not coincide with the areas of high density nitrogen from livestock.

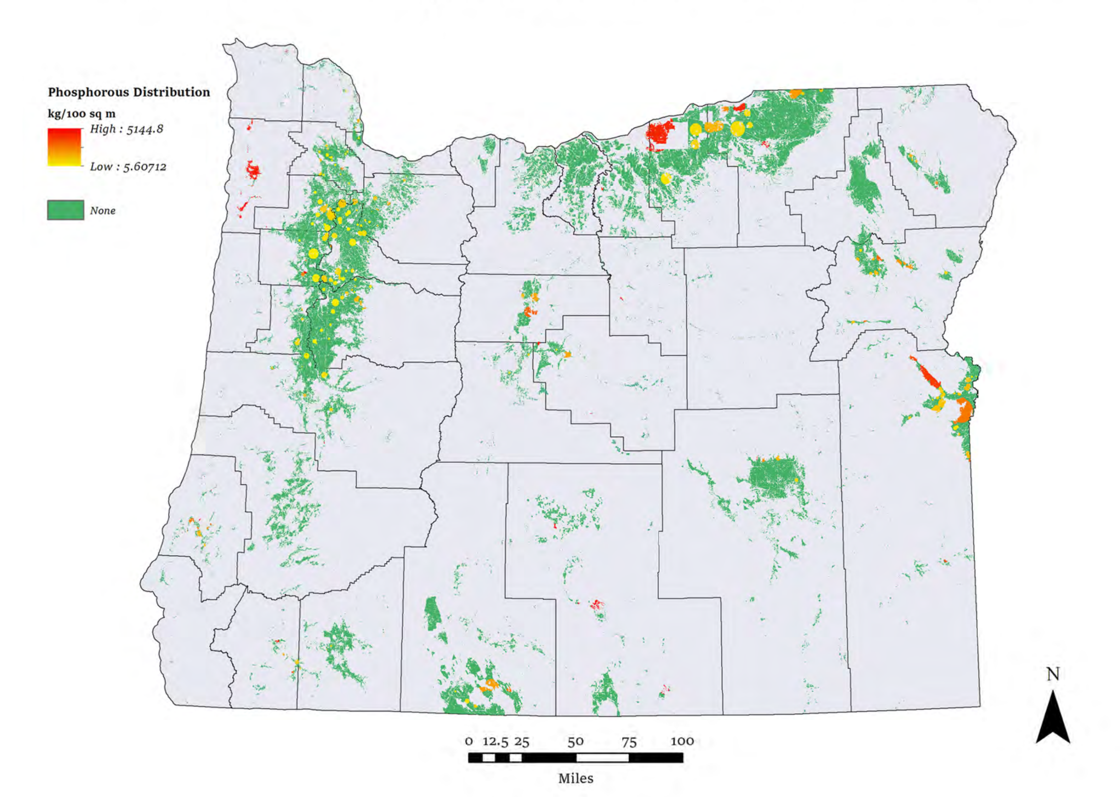
DATA/SOURCES

- Shapefile of CAFO and Dairy Farm locations, with cattle population for each farm
- USGS data on confined cattle nitrogen and phosphorus production totals per county
-USGS data on total cattle population per county
- USGS gauge location and measures data
- NLCD land cover raster dataset

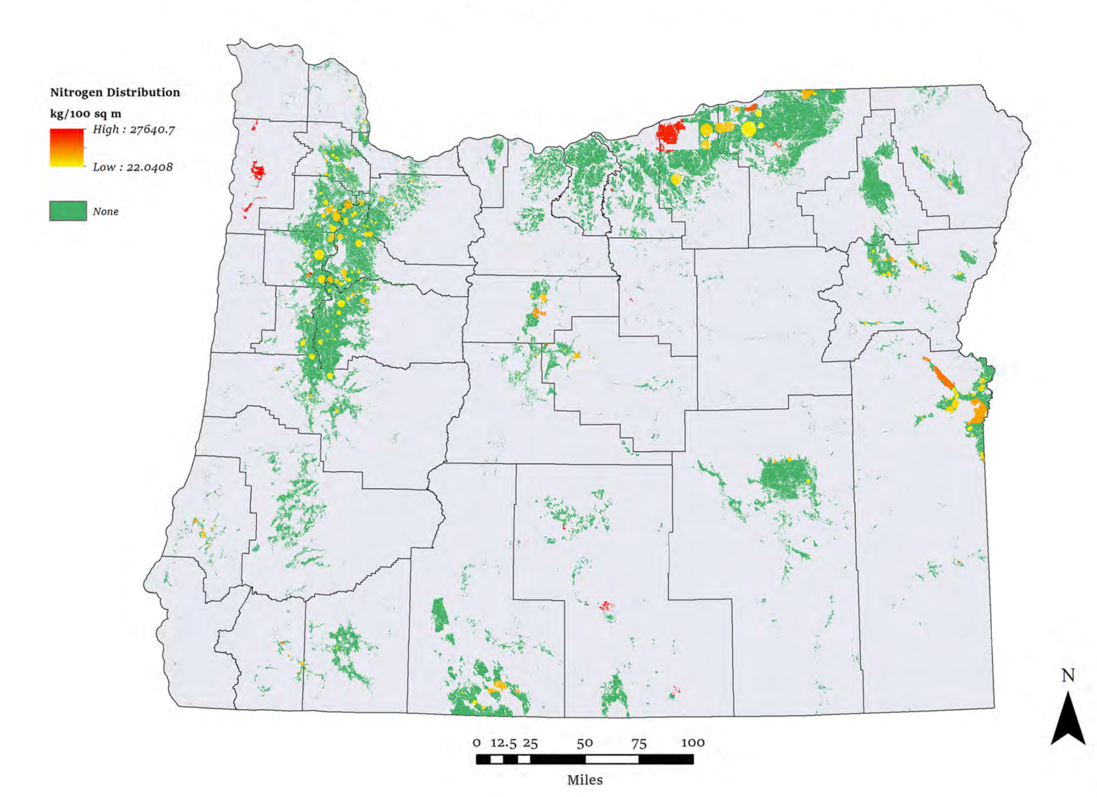
https://water.usgs.gov/edu/nitrogen.html
https://www.mrlc.gov/nlcd2011.php
https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1097070.pdf
http://opensourceecology.org/wiki/File:Cow.jpg

RESULTS

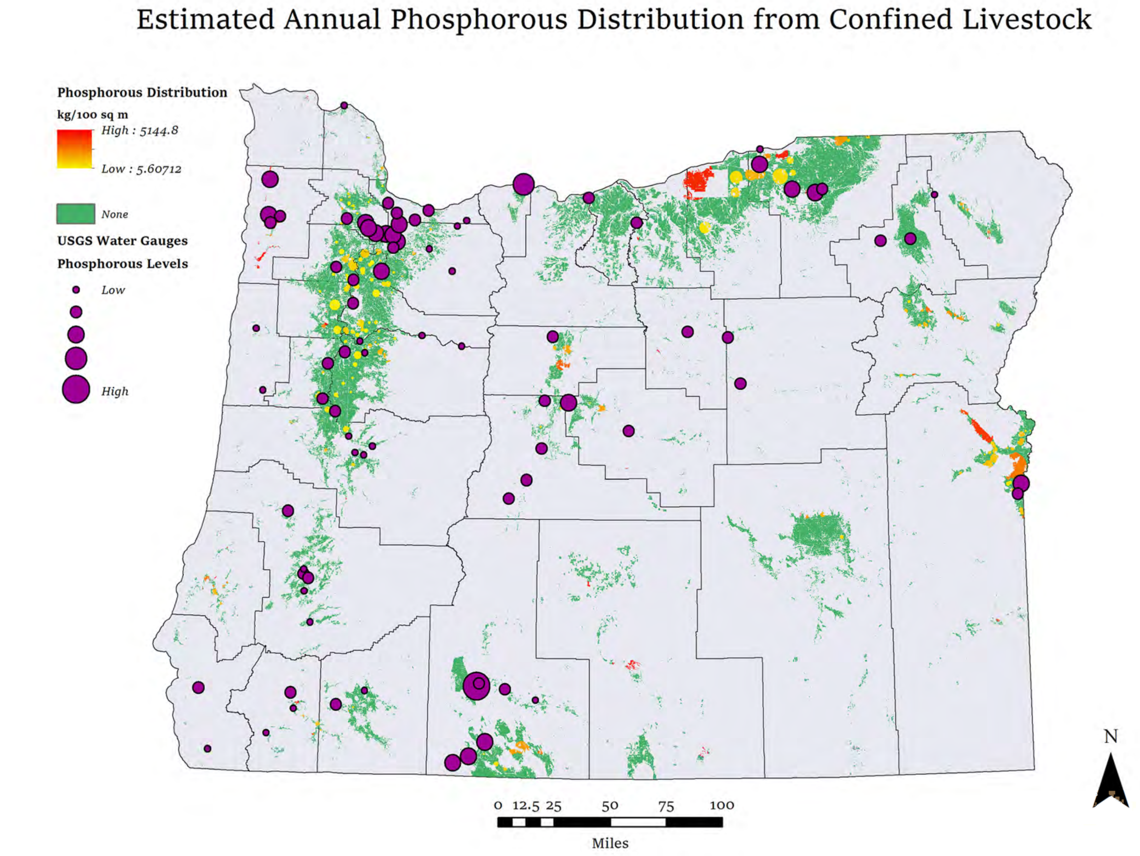
Estimated Annual Phosphorous Distribution from Confined Livestock



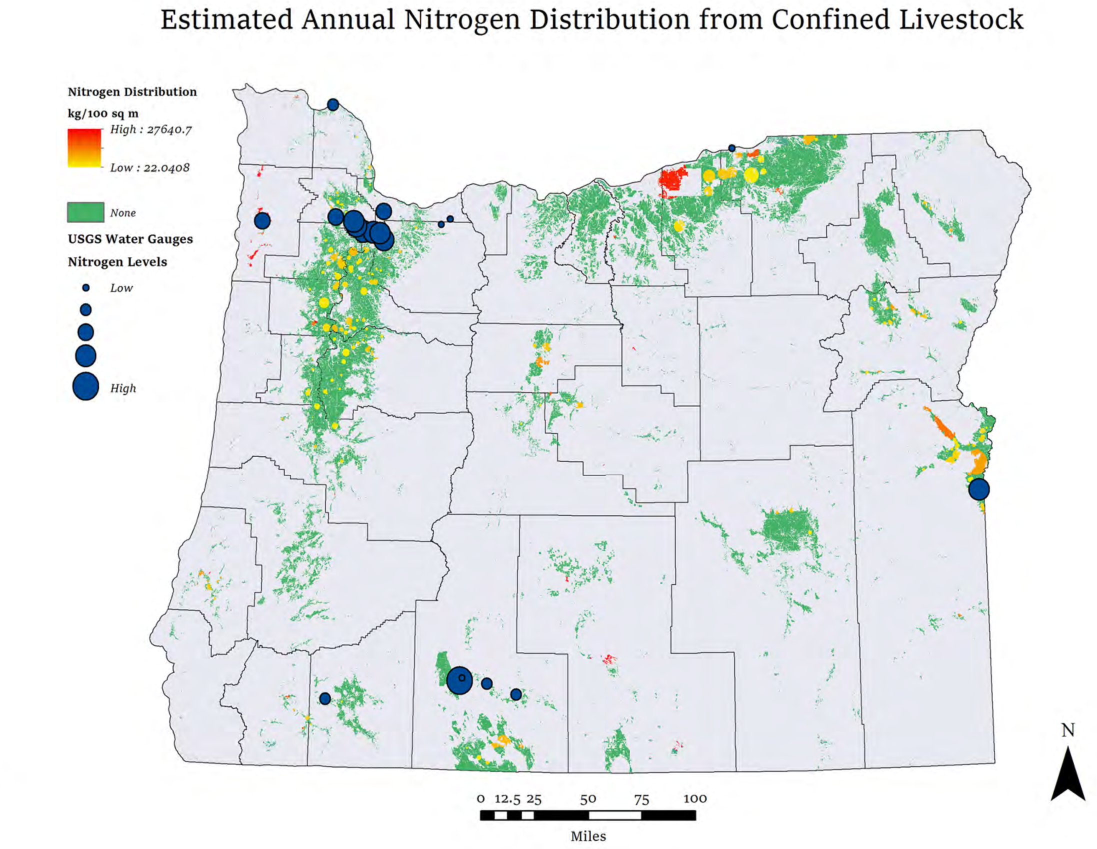
Estimated Annual Nitrogen Distribution from Confined Livestock



Estimated Annual Phosphorous Distribution from Confined Livestock



Estimated Annual Nitrogen Distribution from Confined Livestock



The results produced depict areas of pasture/hay and cultivated crops with different concentrations of nitrogen and phosphorus based on dairies and CAFOs in the area. After analyzing the locations of the gauges, we found that there was little to no correlation in the location of cattle-produced nitrogen levels and the levels measured at the gauges. There does seem to be a little more correlation between the amount of phosphorus measured and the amount produced by the farms, particularly in the Middle Snake, Umatilla and Tillamook areas. One gauge that was not near any cattle facilities measured a significantly higher level of phosphorus and nitrogen, however we do not have an explanation for that occurrence.

DISCUSSION

There were several difficulties with this project. In the initial iteration, we were going to perform this analysis on several states, however due to the lack of data retrieval and time constraints, we designated the analysis to just one state. We were tasked with performing a dasymetric mapping, however this technique is not possible with point data, so the next difficulty was finding an appropriate manner to turn the point data of nitrogen and phosphorus measurements into areas. Next, the Tabulate Area tool does not work if there are overlapping polygons. So while we were able to create appropriate buffer distances around each farm, the Tabulate Area dropped many overlapping areas. ESRI produced a new tool, the Tabulate Area 2 tool, which claimed to overcome these errors, however we found it to perform even worse than the original tool. This led us to the decision to dissolve the buffers.

While we wanted to analyze the gauges in a more appropriate manner than simple visual analysis of graduated symbols, there were time and skill constraints in performing a more complex validation. Truly, we should have performed the point distance tool on the gauges, measuring their distance to the farms, and calculated the mean of a select number (the top three shortest distances, perhaps) of those values to determine an appropriate buffer distance for each gauge. We would be able to use proximity to infer the influence of the farms on the gauge measurements. The point distance tool produces over 7000 records, and without automation, it is too time intensive to work through by hand to extract these values.

The visual analysis seems sufficient enough to say if there are any visual coincidences, but because it is merely an estimation, there could undoubtedly be inaccuracies present. Any validation from here is purely speculative and further research and analysis must be performed in order to provide a justifiable conclusion.