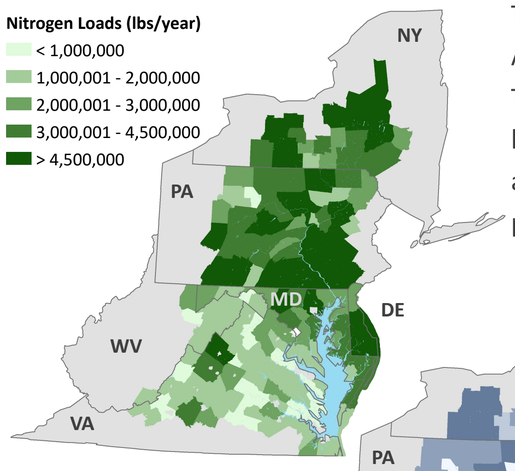
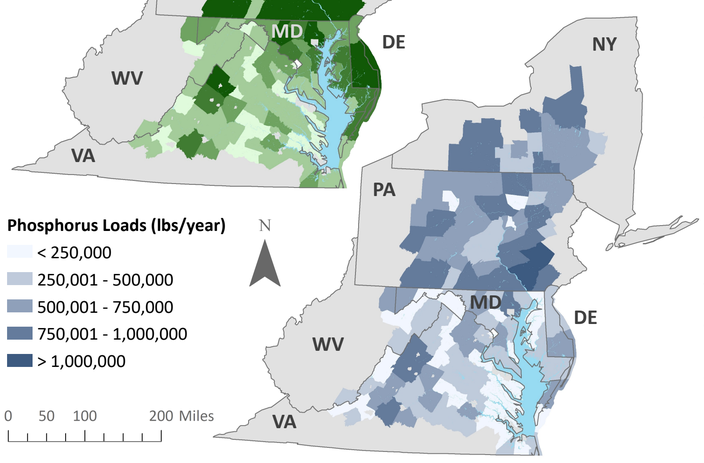
Mitigating Nutrient Pollution in the Chesapeake Bay

Agricultural determinants of nitrogen and phosphorus loadings

INTRODUCTION





The Chesapeake Bay Watershed is the largest estuary in North America, spanning over 64,000 square miles across six states. The watershed includes 150 major rivers and streams and is home to over 18 million people and 3,600 different plant and animal species. Since the 1930s, the Chesapeake Bay has experienced severe nutrient and sediment pollution stemming from agriculture, sewage treatment, and urban and suburban storm water runoff. Increasing nutrient pollution impairs waterways, threatening both marine life and environmental stability. Over 83,000 farms, accounting for $10 billion of agricultural production each year, can be found in the watershed. Accounting for 30% of the land in the watershed, agriculture is the greatest source of nonpoint source pollution in the Chesapeake Bay and is responsible for nitrogen (N), phosphorus (P), and sediment runoff. Producers can alleviate nutrient runoff from their operations by adhering to regulatory policies and implementing on-farm best management practices. This study seeks to identify the effect of specific producer characteristics on nutrient pollution mitigation.

METHODS

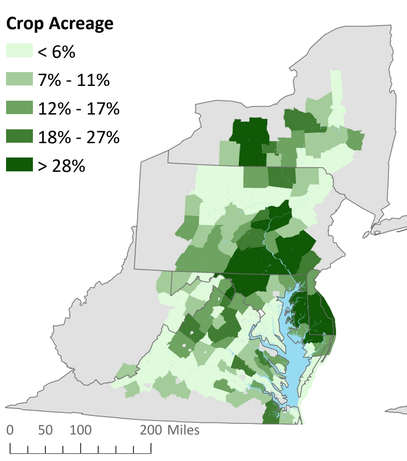
Table 1. PCA Variable Loadings and Emerging Producer Identities

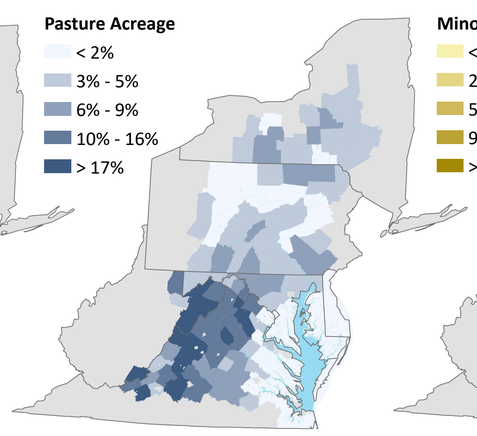
Farm Level Variables	Commodity Growers	Minority Growers	Young Hobby Farmers	Minority Ranchers
Vegetable acres / total county acres	0.32	0.15	-0.07	-0.23
Corn acres / total county acres	0.45	0.04	-0.03	-0.04
Soybean acres / total county acres	0.35	0.33	0.01	-0.18
Wheat acres / total county acres	0.35	0.30	0.00	-0.25
Pasture acres / total county acres	-0.10	-0.23	-0.35	0.26
Combined cattle and cow inventory	0.25	-0.34	-0.11	0.35
Market value sales per acre ($)	0.40	-0.08	-0.06	0.21
Producer Variables				
Average age of principal producer	-0.24	0.29	-0.50	-0.05
Minority producers / total producers	-0.05	0.46	0.14	0.50
White producers / total producers	0.06	-0.45	-0.20	-0.48
Principal producer is less than 35 years old	0.24	-0.32	0.31	0.22
Principal producer's primary occupation is farming	0.29	0.02	-0.30	0.29
Principal producer has 11+ years of experience	0.06	0.02	-0.61	0.08

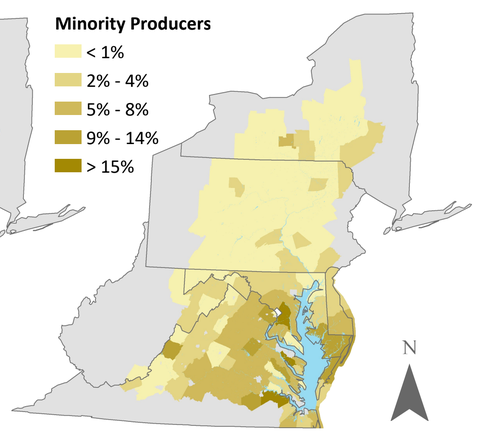
2017 county-level estimates of the nitrogen and phosphorus edge-of-stream loads were gathered from the Chesapeake Assessment Scenario Tool (CAST). The data was then matched with farm and producer information from the USDA Census of Agriculture. Principal Component Analysis (PCA) was used to generate meaningful producer components or identities from the large set of explanatory variables. Although PCA helps alleviate the issue of multicollinearity, precise interpretations become more difficult. Table 1 presents the PCA variable loading results; the top five contributors are highlighted for each of the emerging producer identities.

Commodity growers are high-value producers that predominantly specialize in cultivating commodity crops such as corn, soybeans, and wheat; they identify farming as their primary occupation. **Minority growers** are Asian, Black, and Hispanic producers that tend to be older and favor soybean and wheat cultivation. **Young hobby farmers** have limited experience, have yet to specialize their production, and are less likely to identify farming as their primary occupation. **Minority ranchers** are Asian, Black, and Hispanic producers that specialize in raising livestock on pasture and are more likely to recognize farming as their primary occupation. The maps below show the distribution of the most relevant variable loadings (total crop and pasture acreage as a percentage out of total county acreage; proportion of minority producers out of all county producers) for context.

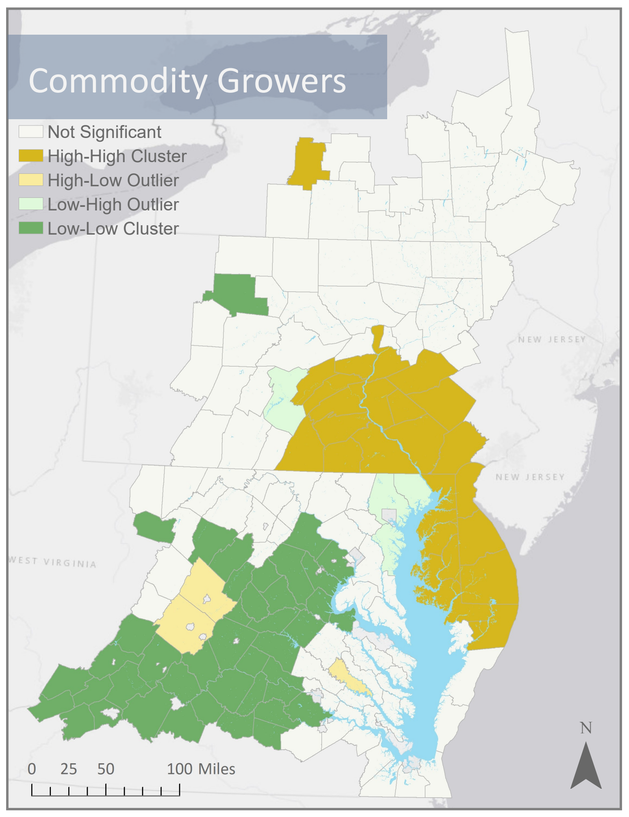
Next, the natural log of nitrogen and phosphorus loadings was regressed on the components constructed in the PCA to determine the relationship between farmer identities and nutrient pollution in the Chesapeake Bay. A multivariate OLS regression was run with an additional 50 mile spatial lag to account for the effect of nutrient loadings in neighboring counties. Regression results are presented in Table 2.

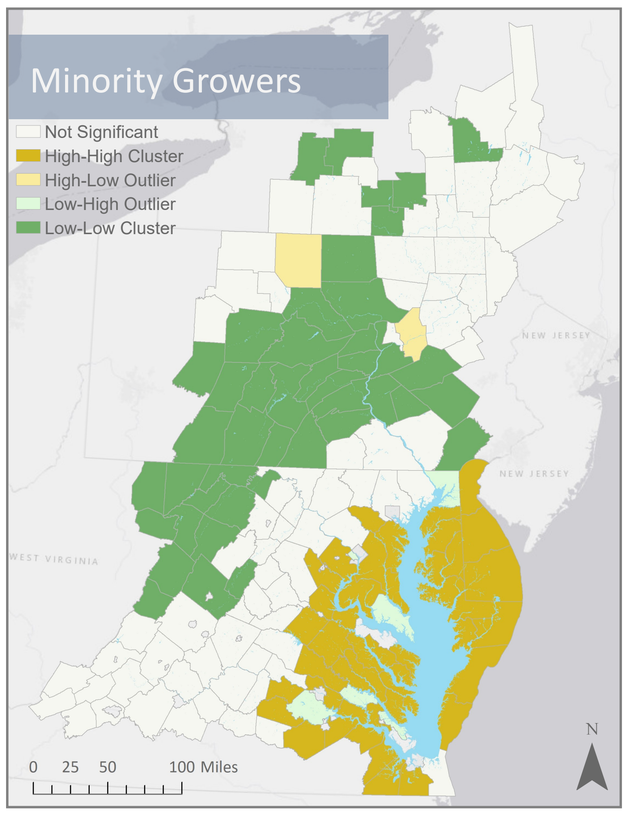


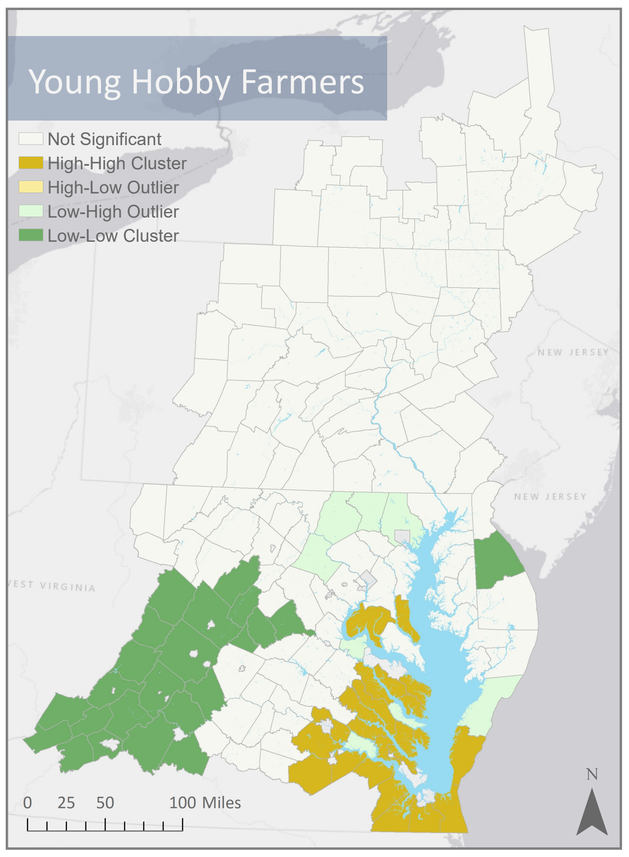


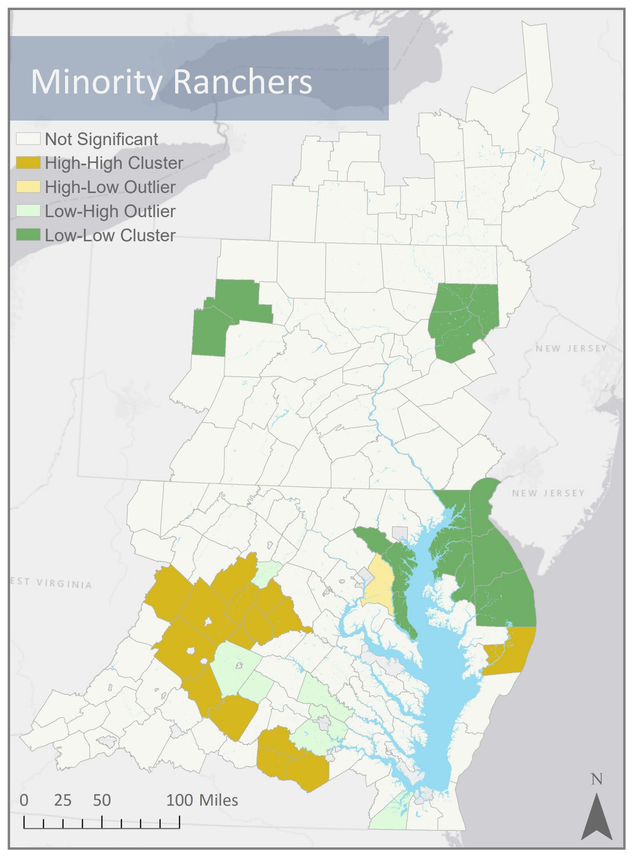


PRODUCER IDENTITY CLUSTERS









RESULTS

A closer look at the regression results shows that as anticipated, the spatial lag accounts for some of the effect, diminishing the overall trend. As previously mentioned, it is difficult to interpret the correlation coefficients across producer components. However, directionality and relative influence of the relationship can still be relevant.

The results suggest that commodity growers and minority ranchers are nutrient pollution contributors. Minority growers and young hobby farmers on the other hand appear to mitigate nutrient pollution. Although these results draw attention to specific nutrient pollution patterns across producer identities, it is important to consider that certain operations may inherently lend themselves to different levels of pollution. For example, commodity crops require high nutrient inputs therefore may be subsequently associated with increased nutrient runoff. This relationship alone does not account for the successful nutrient pollution mitigation efforts that may have already been implemented. Another limitation of this approach is that nutrient pollution is a complex issue as it is dependent on many variables that are beyond the agricultural sector.

Table 2. Regression Results

	ln(N)		ln(P)	
	OLS	Spatial Lag	OLS	Spatial Lag
Commodity Growers	0.23***	0.15***	0.11***	0.09***
	[0.05]	[0.02]	[0.02]	[0.02]
Minority Growers	-0.10***	-0.03	-0.16***	-0.09***
	[0.03]	[0.02]	[0.03]	[0.03]
Young Hobby Farmers	-0.12***	-0.10***	-0.14***	-0.09***
	[0.03]	[0.03]	[0.03]	[0.03]
Minority Ranchers	0.07*	0.12***	0.13***	0.14***
	[0.04]	[0.03]	[0.04]	[0.03]
R^2	0.46	0.63	0.39	0.51

Spatial lag model uses a 50 mile Euclidian radius as the spatial weight. Values in brackets are standard errors. Statistically significant at the 10% (*), 5% (**), and 1% (***) level.

This analysis draws attention to specific populations within the Chesapeake Bay who may benefit from targeted outreach both to alleviate excess nutrient pollution contributions and to build upon and support operations that are already mitigating nutrient pollution. Using the cluster maps above, state and federal-level officials can target specific counties.

Data: Chesapeake Assessment Scenario Tool (CAST); USDA Census of Agriculture
Sources: EPA, USGS, USDA NRCS

Tetyana Pecherska | UEP 294 Spatial Stats | May 2019
Created using ArcMap 10.6.1 | GeoDa
NAD 1983 UTM Zone 18N | Projection: Transverse Mercator

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