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UNDERSTANDING IMPORTANCE OF ECOTONES IN PENNSYLVANIA'S WHITE-TAILED DEER POPULATION

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ABSTRACT

An organism's habitat plays a critical role in sustaining its success. In Pennsylvania – a state whose land area is 58% forested – White-tailed deer (*Odocoileus virginianus*) maintain a large, healthy population abundance. As such, many would believe that areas of forest thus account for successes of this species. However, White-tailed deer are habitat generalists surviving in various habitats. Namely, ecotones – transition areas between two different communities – are thought to be the most favored habitat among White-tails, as they provide the species ideal forms of food and cover. To understand this relationship between White-tails and their habitat, data was gathered via an annual report from the Pennsylvania Game Commission Bureau of Wildlife Management Research Division (Wallingford, 2000) regarding percent forest cover and estimated winter population densities of White-tailed deer for PA counties from the years 1995-2000. From this data, correlation and regression analyses were completed. Results of these analyses indicated that a statistically significant inverse relationship exists between percent forest cover and average estimated winter population densities of White-tailed deer in Pennsylvania. Thus, it could be determined that forests do not necessarily indicate the success of White-tail populations, offering credence to the idea purported by previous research that ecotones are among the most favorable habitats for White-tailed deer. Wildlife biologists could utilize these findings to better conserve and/or control White-tailed deer populations in other parts of the world where they are either limited or particularly abundant.

Keywords: correlation analysis, ecotone, percent forest cover, regression analysis, White-tailed deer (Odocoileus virginianus)

INTRODUCTION

An organism is closely connected to the habitat(s) it frequents. Arguably, the most critical factors which influence the success of an organism are the availability of food and the avoidance of predators or competitors. These factors ultimately influence habitat selection. Without being able to successfully control these two factors, organisms cannot live successfully in these areas. In Pennsylvania, White-tailed deer (*Odocoileus virginianus*) sometimes become a burden to humans with whom they co-exist, as they are abundant in most areas of the state. More specifically, it is generally believed that White-tailed deer exist and survive most successfully – and thus is most populous – in moderately forested areas that provide adequate resources to survive.

However, White-tailed deer are generalists who can survive in a many different habitats. In North America – and thus Pennsylvania – this species is most often linked with shrubland, woodland, and forest ecosystems. They may require forests and shrubland for cover; being close to these habitats is critical in determining their local population density (Innes, 2013). These transition areas between two different communities, known as ecotones, provide White-tails with various forms of food and cover and are thus essential to White-tail population density and stability

(Clark and Gilbert, 1982). And, since Pennsylvania's forest land area accounts for about 58 percent of the area of the state (Albright, 2017), data was analyzed (Wallingford, 2000) – percent forest cover and estimated average winter population density of White-tailed deer – to reach a consensus concerning the importance of ecotones.

Ultimately, I believed that this data would yield an inverse relationship, as a greater percentage of forest cover leaves less land area for these transition regions to support White-tailed deer populations, leading to decreased population density estimates. My null hypothesis (H_0) is that there will be no difference between White-tailed deer average population density estimates in relation to percent forest cover in Pennsylvania counties. On the contrary, my alternative hypothesis (H_A) is that there will be a difference in White-tailed deer average population density estimates in relation to percent forest cover in Pennsylvania counties. Regardless, these hypotheses are important in that it allows quantification of which type of habitat White-tailed deer most prefer – forests or ecotones. If it is found that the data does support an inversion relationship between % forest cover and estimated White-tailed deer population density estimates, other intrinsic (e.g. body size, tropic level, life history, behavior, etc.) and extrinsic (e.g. climatic or geographical barriers) factors may be evaluated in their role in the regulation of White-tail population densities.

METHODS AND MATERIALS

The cornerstone of this study was data gathered via an annual report from the Pennsylvania Game Commission Bureau of Wildlife Management Research Division (Wallingford, 2000). This data – percent forest cover and estimated winter population densities of White-tailed deer for PA counties from the years 1995-2000 – was utilized to construct a novel table that included 15 counties each with small, medium, and high percent forest cover. This did not include every county which made data was made available for, but still provided an adequate sample size concerning the variability of percent forest cover depending upon the county. In preparing my table of data for the estimated winter population densities of White-tailed deer by county, I compiled the average estimates for years 1995-2000 as given by the original data (Wallingford, 2000).

After the construction of this table, a correlation analysis was completed using Microsoft Excel. Subsequently, a sample correlation coefficient resulted ('r'), which offered information about the strength of the relationship between percent forest cover and the average estimated winter population densities. Once this was completed, it was necessary to perform a regression analysis via Microsoft Excel that provided a p-value with which to evaluate the significance of the relationship between the above variables. These analyses, ultimately, allowed me to discern the importance of White-tailed deer habitats in question.

RESULTS

As seen below, Table 1 includes the data used to perform both the correlation and regression analyses. As said, it includes 45 Pennsylvania counties for which % forest cover and White-tail average population density estimates were quantified, including 15 points from counties with low, medium, and high percent forest cover.

Table 1. Displaying percent forest cover and average White-tail population density estimates for winter 1995-96 through 1999-00 for 45 Pennsylvania Counties (data adapted from Wallingford 2000).

Pennsylvania County	% Forest Cover	White-tail Population Density Estimated Average for Winter 1995-96 through 1999-00
Lancaster	13	50.4
Montour	27	61.2
York	27	59
Adams	33	49.4
Lebanon	34	31
Northampton	34	47.4
Cumberland	35	35.8
Berks	35	55.4
Mercer	39	38.8

Lawrence	42	23.6
Franklin	44	37.4
Beaver	48	24.6
Crawford	48	36.8
Butler	50	44
Dauphin	50	24.6
Columbia	53	41.6
Armstrong	54	46.6
Greene	56	54.6
Bradford	59	36.6
Clarion	61	39.4
Fayette	61	29.2
Jefferson	61	38.2
Indiana	61	36
Wyoming	62	31.6
Blair	64	39.2
Cambria	64	32
Perry	64	36.2
Somerset	64	30
Susquehanna	65	37.6
Juniata	66	32.6
Mifflin	72	28.8
Bedford	72	31.2
Clearfield	74	36.8
Carbon	75	28.4
Huntingdon	75	58
Monroe	76	22.6
Lycoming	77	26.4
Warren	79	30.4
McKean	81	26.4
Pike	82	24
Potter	86	26.6
Sullivan	86	23.8
Clinton	87	18.4
Elk	91	24.6
Forest	93	35.2
Cameron	94	17

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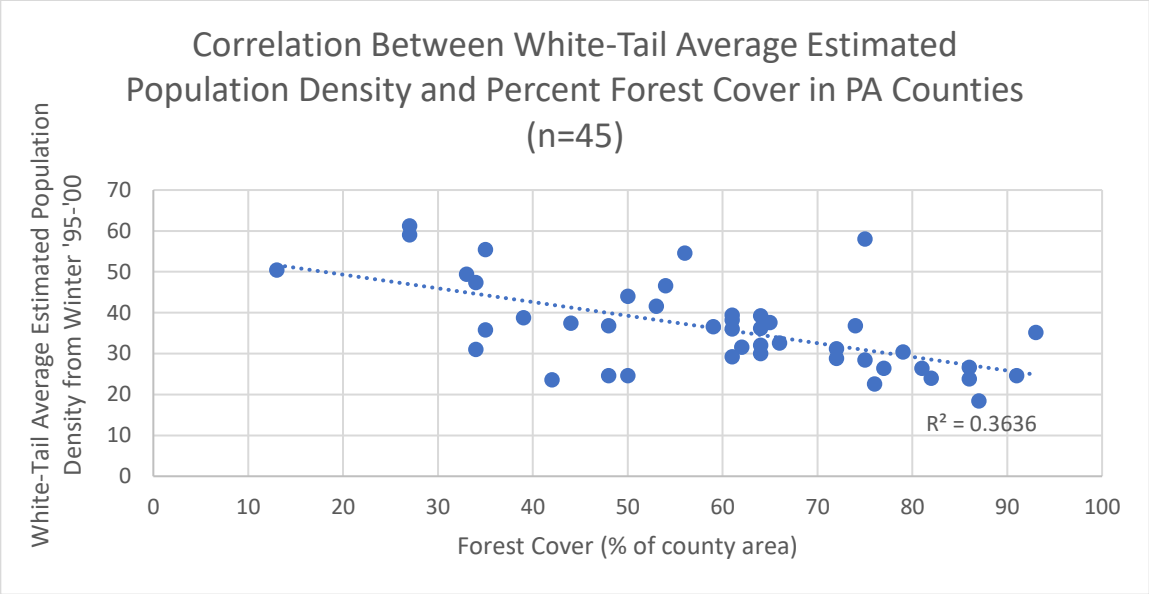

Figure 1. An XY-Scatter Plot showing the results of a correlation between White-tail average estimated population density and percent forest cover in 45 Pennsylvania counties.

Concerning Table 2, the result of this correlation analysis was made possible by data from Table 1. Figure 1 shows an XY-scatter plot associated with this correlation. Table 3 offers more information regarding the Pearson correlation coefficient, sample size, and p-value. The goal of this analysis was to establish and estimate the relationship between percent forest cover and White-tail population density average estimates. The resulting sample correlation coefficient, r = -0.603032, indicated an inverse relationship between the two variables. In terms of this study, it suggests that, as percent forest cover in a county increased, the estimated average population density estimate of White-tailed deer decreased. Although this does suggest an inverse relationship, the strength of the relationship is only slightly close to -1, which would represent the strongest possible inverse relationship between the two variables. However, this analysis only offers information on this relationship and does not confer its significance.

	% Forest
% Forest	1
White-Tail Population Density Estimated Average for Winter 1995-96 through '99-'00	-0.603032

Table 2. Results of correlation analysis done via Table 1 data comparing the strength of the relationship between % forest cover and White-tail population density estimated average by county. The resulting correlation coefficient indicated an inverse relationship between the two variables.

Table 3. Tabulating the Pearson correlation coefficient, r, sample size, N, and p-value which resulted from the correlation analysis.

Pearson Correlation Coefficient, r	-0.603032
Sample Size, N	45
P-Value	1.16E-05

To determine whether or not the relationship between the two variables was significant, a regression analysis was completed. The results of this analysis are as seen in Table 4. One such result was an Analysis of Variance (ANOVA), which offered a '*Significance F*' variable. This value is identical to the p-value, as it represents the probability of obtaining a more extreme test statistic by chance alone. And, if this p-value is less than the α value of 0.05 – and indeed it was, at $P<0.001$ – we can reject the null hypothesis, and instead conclude that a statistically significant relationship exists between White-tailed

deer average population density estimates and percent forest cover in Pennsylvania counties. It is similarly possible to arrive at this conclusion utilizing the test statistic found under the '*F*' column. If this test statistic, 24.57, is greater than the critical value, 74.78 – the intercept between 'Residual' and '*MS*' – H_0 may be rejected and the conclusion of a statistically significant relationship may be reached.

Table 4. Results of Analysis of Variance (ANOVA) given by the summary output of regression analysis. Column 'Significance F' represents the desired p-value. Concerning $\alpha = 0.05$*, this p-value deduces a significant negative relationship between the percentage of forest cover in PA counties and population density estimates of White-tailed deer by county.*

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1837.44731	1837.44731	24.5725603	1.1649E-05
Residual	43	3215.38469	74.7763882		
Total	44	5052.832			

DISCUSSION

The results of both the correlation and regression analyses provide two key pieces of information concerning my hypotheses. First, the correlation analysis offered conclusive evidence that a moderate negative (inverse) relationship exists between White-tailed deer average population density estimates and percent forest cover in Pennsylvania counties. This suggests that, as percent forest cover in a county increased, the estimated average population density estimate of White-tailed deer decreased. As for the regression analysis, in relation to $\alpha = 0.05$, $P<0.001$ allowed conclusive determination that a statistically significant relationship exists between White-tailed deer average population density estimates and percent forest cover in Pennsylvania counties. Both analyses are fundamental in offering a conclusion; since a statistically significant negative relationship exists between the two variables, it can safely be deduced that White-tailed deer do prefer ecotones between two different habitats. Thus, in these transitional areas, White-tail population densities will likely increase. It makes sense, as these zones provide the deer with various plant species that offer valuable forms of food and protection. Even more, this favorability aligns both with the results of this study as well as data from previous studies. The variability of species – and its importance in allowing White-tails ample resources – results in increased use of these zones in areas with high population densities of deer. And, even though these areas do not always contain a White-tail's favorite plant species, they are productive enough for purposes of foraging and protection. In this way, the zones reach a certain 'productivity' threshold in which the deer no longer have to stick to normal areas (e.g. shrubland, woodland, and forest ecosystems) but instead can broaden their distribution (Massé and Côté, 2009). White-tails, ultimately, are freely – and successfully – able to leave their forests, shrublands, and woodlands, and compete, reproduce, survive, and expand their local distributions, respectively.

In conducting this study, few minor setbacks occurred. First, little usable data existed on deer population densities in relation to other factors. In this situation, a study was found that compared the percent forest cover to deer population density estimates between 1995-2000 (Wallingford, 2000). While using estimates of this variable certainly was not ideal, averaging the 5 estimates and comparing it to percent forest cover in 45 Pennsylvania counties was sufficient. Reliable results were obtained, and so I am pleased with the study. However, if I could have found more concrete data on population densities of White-tailed deer by county, I likely could have attained stronger results in, for example, my correlation analysis – which offered only a moderately negative relationship between the variables. Another factor that was slightly hindering was the effect of COVID-19 in the United States. I was unable to carry out any type of field research on my own, however, I do not believe field research would even have been appropriate in this study. The data I desired likely is much too advanced and hard to collect for an undergraduate student like myself to obtain in just a few months.

As the data utilized was not exactly ideal – but still provided a reliable conclusion – I would be excited to see future studies concerning the importance of different ecosystems and habitats for White-tailed deer. Do they always favor ecotones, or, in other regions of the world in which they are found, do they prefer shrublands, woodlands, or forests? Perhaps performing studies of White-tailed deer in the different regions where they occur would provide a more clear answer to this question. Remember – my sample correlation coefficient was not a strict negative correlation between percent forest cover and the average estimated winter population densities of the deer. In performing such an all-encompassing study, wildlife biologists could use the findings to better conserve or control White-tailed deer populations in states where they are either limited or particularly abundant.

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