Implications of rural, suburban, and urban milkweed waystation sites on monarch butterflies, Danaus plexippus

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Introduction

There are many modern environmental stressors that can contribute to the decline of the population of the monarch butterfly, *Danaus plexippus.* Among these stressors is ambient temperature, which is typically higher in urban areas due to a phenomenon known as the urban heat island effect. For example, high temperatures can cause a decrease in food source availability and lipid energy sources[1]. There are factors that can mitigate extreme temperatures, such as increased density of canopy cover[2]. Nighttime light pollution (NLP), often higher in urbanized areas, has also demonstrated negative ecological impacts[3] that could be detrimental to the success of the monarch butterfly. Different conservation efforts, such as the Monarch Waystation Registry program, aim to help protect the monarch butterfly through the development of milkweed plots that provide resources and breeding sites for the monarchs along their migration route[4].

Results

ANOVA Test

After extracting the raster values from QGIS for canopy cover, urban imperviousness, and nighttime light pollution (NLP), an ANOVA statistical analysis test was performed for each parameter. Urban imperviousness, canopy cover, and nighttime light pollution all had P-values of <0.0001, as shown in Table 1.

Tukey HSD Test

Along with an ANOVA test, a Tukey HSD test was performed for each parameter. For each variable, comparisons between urban waystation sites to suburban waystation sites, urban sites to rural sites, and suburban sites to rural sites all resulted in a P-value of <0.01, as shown in Table 2.

Data Averages

Average percentages were taken from each data set, as shown in Table 3. The average percentage of canopy cover was highest in rural waystation sites, and lowest in urban waystation sites. The average percentages of urban imperviousness and nighttime light pollution were highest in urban waystation sites, and lowest in rural waystation waystation sites.

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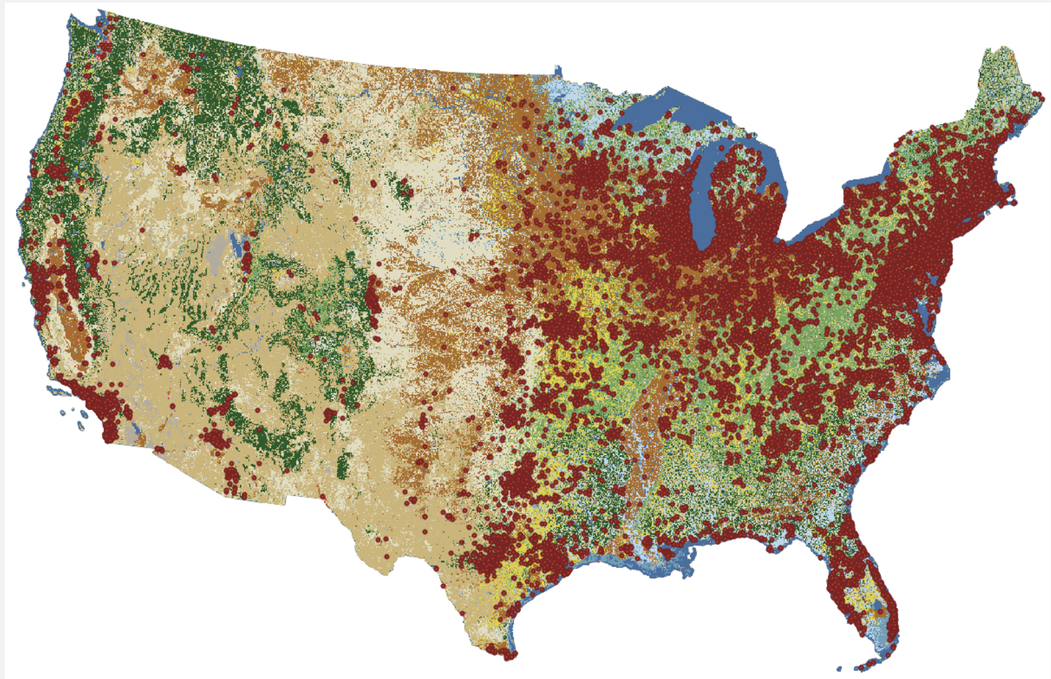

Figure 1. Locations of registered waystation plots in the United States, in 2019. Registered waystation plots are represented by the red points. Imaged made with QGIS, with land cover layer.

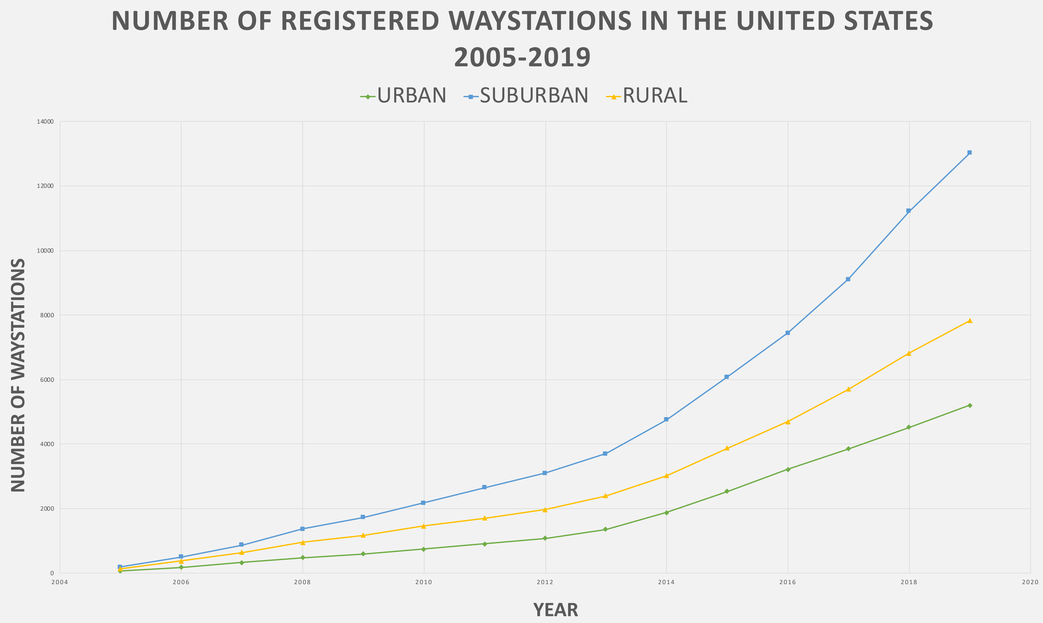

Figure 2. The total number of registered milkweed waystation sites in the United States by year, from 2005-2019. Locations of waystation sites are separated into urban, suburban and rural categories.

ANOVA Test Results	
Variable	**P-Value**
Urban Imperviousness	<0.0001
Canopy Cover	<0.0001
NLP	<0.0001

Table 1. ANOVA test results for urban imperviousness, canopy cover and nighttime light pollution variables. Three ANOVA tests were ran, comparing the variables between urban, suburban, and rural waystation sites.

Tukey HSD Test Results			
Variable	**Urban vs. Suburban**	**Urban vs. Rural**	**Suburban vs. Rural**
Urban Imperviousness	<0.01	<0.01	<0.01
Canopy Cover	<0.01	<0.01	<0.01
NLP	<0.01	<0.01	<0.01

Table 2. Tukey HSD test results for urban imperviousness, canopy cover, and nighttime light pollution variables. For each ANOVA test, there was an additional Tukey HSD test that compared the locations to each other.

Data Averages			
	Average % Canopy Cover	**Average % Urban Imperviousness**	**Average % NLP**
Urban	15.10 %	40.23 %	33.04 %
Suburban	18.95 %	31.76 %	18.77 %
Rural	26.35 %	17.12 %	6.93 %

Table 3. Averages of canopy cover, urban imperviousness, and nighttime light pollution percentages for the urban, suburban and rural waystation sites.

Methods

Using data obtained from the Monarch Waystation program registry, the latitude and longitude points of each monarch waystation were plotted on a US map using the QGIS program, as shown in Figure 1. Layers, obtained from the Multi-Resolution Land Characteristics Consortium (MRLC), for canopy cover, urban imperviousness, and nighttime light pollution (NLP) were then uploaded onto the QGIS map. These layers provided raster values for every waystation site, which were then extracted from QGIS into a numerical format. The numerical raster values provided the percentage of canopy cover, urban imperviousness, and NLP for each waystation site. The raster data were then separated based on location type (urban, suburban, and rural), and then ANOVA analysis and Tukey HSD tests were performed for each investigated environmental parameter.

Conclusion

We found that there is a significant difference in canopy cover, urban imperviousness, and nighttime light pollution between urban, suburban and rural waystation sites. Specifically, there were significant differences in canopy cover, urban imperviousness, and nighttime light pollution between urban and suburban sites, urban and rural sites, and suburban and rural sites. The averages of the raster data show that canopy cover levels are highest in rural locations, and lowest in urban locations. Urban imperviousness and nighttime light pollution levels, on the other hand, are lowest in rural locations, and highest in urban locations. Based on these results, it can be inferred that the location of monarch waystation sites can have a potential impact on the growth, developmental and migratory stages of the monarchs. Therefore, the placement of waystation sites in more urbanized areas poses potential harm to the monarchs, with rural areas being the most preferable sites for waystation site placement.

References:
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