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# Human Presence and its Impact on Hedera Helix and the Surrounding Ground Covering Plants of Willow Valley Nature Preserve

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**Abstract**

This study investigates the biodiversity of ground crawling plants in Willow Valley Nature Preserve in Mooresville, North Carolina, as well as the impact human presence has on plant growth. Data collection was conducted to determine the species richness (S), and species evenness (E), which was used to calculate the Shannon Diversity Index (H) between a site with human presence and a site without human presence. The data was collected utilizing the square plot survey method over the course of three weeks. This method allowed the recording of both plant growth, area of coverage, biodiversity, and how it changes over time. It was found that biodiversity measures were lower in the site with human presence, but that the growth of the species that covered the most area was higher in the human presence site. It was also noted that distinct species thrived in different zones. These observations led to various new investigations, not only do humans affect biodiversity, but non-native species are similarly devastating.

**Introduction**

Biodiversity is a necessity for all ecosystems. Biodiversity simultaneously provides food, shelter, and stability for plants, animals, and microorganisms. Ground crawling plants are particularly necessary for all life stated previously, but also to keep terrain stable and resistant to erosion. A variety of ground crawling plants is important to sustain the diets of various insects and the food chain that relies on them. Ground crawling plants also provide coverage for various animal dens. The growth and diversity of these plants are impacted by a variety of factors, types of soil, temperature, competing plants, human foot traffic, and more. Human foot traffic, however, can be heavily impactful. According to a study by Ellen MacDonald from the Department of Renewable Resources, summarized by Elizabeth Ng. (2013, July 2), plants may be disturbed not only on trails, but up to five feet away from them. This disturbance impacts growth and diversity, causing species of plants to grow in odd places.

Plants are reliable indicators of environmental change and health. With the color and brittleness of leaves, the drainage, density, and nutritional value is easily identifiable. Chemical spills of fertilizer or toxic chemicals are identifiable via surrounding ground crawling plant life sooner than in trees due to the shorter absorption and dispersal throughout the plant due to closer proximity of leaves to roots. If an algae bloom begins in a pond, surrounding flora may yield the cause upon observation.

Nature preserves, such as the Willow Valley Nature Preserve, are helpful to conserving wildlife. However, the rules for each nature preserve vary greatly. For example, at the Willow Valley Nature Preserve, the posted rules are no mowing, no cutting, and no vehicles. Unfortunately, with a road less than 30 feet from the preserve and a popular playground, park, and basketball court on the other side of that road, those rules do not discourage humans from walking on wildlife and littering. As stated by the Division of Fisheries and Wildlife. (2016, August 26), to protect a nature preserve, several guidelines should be followed: appropriate scientific/educational activities (if any), management guidelines with specific protection or conservation actions needed or to be taken by the managing agency, recommendations for special regulations pertaining to the particular site to be promulgated by the managing agency,

(if necessary) a detailed map of the area showing topography and boundaries, location of existing trails, and means/limitations on use of access. While on the Town of Mooresville (n.d.) website, no acknowledgement of the labeled nature preserve is found, only the park across the street is shown on the website. The intent of this study is to promote clearly defined and protected areas in communities like Mooresville, NC. To protect the environment, legislative measures must be taken to reduce negative human impact. Organizations such as the United States Fish and Wildlife service have a division specializing in the creation and promotion of said legislation to encourage life-long biodiversity and sustainability. It was hypothesized that areas with higher human activity may show lower rates of ground crawling plant growth, biodiversity, and that human presence may decrease the growth of *Hedera Helix*.

**Methods and Materials**

The Willow Valley Nature Preserve is the ideal location for this experiment due to its proximity to heavy human activity as well as heavy animal activity. All within half a mile, it is possible to find a popular playground accompanied by a basketball court, suburban houses, a cemetery, and on the other side of the street: a creek populated with Silver Perch, frog eggs, bird/squirrel nests, and a variety of plant growth. The first plant that catches the eye is *Hedera Helix,* it crawls, covering the ground and easily over overtakes various trees, shrubs, fences, etc. leading it to become the main variable considered when deciding the data collection method.

*Study Area and Sites*

1. Point Count Method, 5x5 Meters Visual Field in each area.

For the point collection method, a point was chosen in each section in the middle of a 5x5 meter area. From there each ground covering plant that was visible, and the amount of each plant was recorded.

Step 1: Mark observation point.

Step 2: Mark 5x5 meter area.

Step 3: Observe and record data with measuring tape, photos, and notes.

| Species | Human Presence Site | No Human Presence Site |
|---|---|---|
| *Hedera Helix* | 7 | 16 |
| *Kummerowla Striata* | 7 | 0 |
| *Taraxacum Officale* | 15 | 0 |
| *Trifolium Repens* | 72 | 11 |
| *Packera Anonyma* | 6 | 18 |
| *Alchemilla Arvensis* | 68 | 0 |
| *Sonchus Asper* | 2 | 0 |
| *Allium Vineale* | 29 | 17 |
| *Juncus Effusus* | 0 | 16 |
| *Dryopteris Erythrosora* | 0 | 3 |
| *Eleusine Indica* | 5 | 43 |
| *Glecoma Hederacea* | 3 | 24 |
| *Veronica Spicata* | 0 | 5 |
| *Rumex Obstusifolius* | 0 | 2 |

| | | |
|---|---|---|
| *Toxicodendron Radicans* | 1 | 2 |
| *Zorinia Diphylla* | 0 | 4 |
| *Conium Maculatum* | 0 | 1 |
| *Veronica Hederifolia* | 3 | 4 |

2. Square Plot Survey, 5x5 feet zone, one in each area.

To conduct the square plot survey method, a 5x5 foot area was marked out, one with human interference and the other without human interference. Each plant located was recorded along with the square inches of the zone that it covered.

Step 1: Mark 5x5 foot area

Step 2: Observe and record data with measuring tape, photos, and notes.

| Species | Human Presence Site | No Human Presence Site |
|---|---|---|
| *Hedera Helix* | 891 | 1140 |
| *Packera Anonyma* | 36 | 0 |
| *Veronica Spicata* | 0 | 20 |
| *Allium Vineale* | 16 | 24 |
| *Glecoma Hederacea* | 12 | 8 |
| *Trifolium Repens* | 14 | 6 |
| *Rumex Obstusifolius* | 0 | 187 |
| *Toxicodendron Radicans* | 2.5 | 8 |
| *Veronica Hederifolia* | 20 | 25 |
| *Conium Maculatum* | 0 | 4 |
| *Zorinia Diphylla* | 0 | 11 |
| *Juncus Effusus* | 0 | 44 |

*3.* Transect survey, 2 different 2 meter long transect lines, one in each zone.

The transect survey method was recorded by measuring out two different two meter long transect lines with one in the human interference zone and one in the non-human interference zone. Along each line the species of plant touching the line is recorded along with the amount that touches the line.

Step 1: Measure out two different meters transect line.

Step 2: Observe and record data with measuring tape, photos, and notes.

| Species | Human Presence Site | No Human Presence Site |
|---|---|---|
| *Hedera Helix* | 3 | 7 |
| *Taraxacum Officinale* | 1 | 0 |
| *Allium Vineale* | 4 | 3 |
| *Glecoma Hederacea* | 3 | 2 |

| | | |
|---|---|---|
| *Trifolium Repens* | 6 | 0 |
| *Rumex Obstusifolius* | 0 | 1 |
| *Toxicodendron Radicans* | 0 | 1 |

Consistency with the data collection is ensured with photos of where each measurement/observation point is taken. Each measurement and recording is double checked and each identification is double checked through sites such as GardendersWorld From the team at BBC Gardeners' World Magazine and the North Carolina Extension Gardener Plant Toolbox from NC STATE EXTENSION. Equipment taken out onto the field included a measuring tape, bamboo skewers (inserted no deeper than one inch to minimize disturbance to the root systems), and a Samsung Galaxy Z Flip3 5G version F711USQS6HXAF / F711UOYN6HXAF / F711USQS6HXAF to record data on.

***Chosen Method for Studying Biodiversity of Ground Covering Plants***

For further data collection, the square plot survey method is employed due to the detailed amount of data available to record in such a small area. This method conveyed how each plant occupied the space and by how much, displaying the difference in growth of each species. The square plot survey method allows not only the amount that the plant appears but also the density of each plant to be recorded in each zone. The area that Hedera Helix covers is necessary to keep track of due to its rapid growth and tendency to overtake other species of flora. While the point count method is ideal for tracking data like bird or other animal sightings. The transect survey method is also effective for measuring plant data, but not necessarily the data that was needed for tracking the growth of plants affected by human presence.

When recording data in the Willow Valley Nature Preserve, multiple rules are posted by the entrance to ensure the conservation of species in the area. The rules being, “No mowing, No cutting, No vehicles.” To collect data, the vehicle was parked away from the preserve. Care was taken to avoid stepping on any living flora and fauna or acting in a way that would disturb the ecosystem.

a)

b)

c)

Figure 1. a) An aerial view of the two sites. The blue square is the location of the human presence site, the orange square is the location of the no human presence site, b) an area with human presence, and c) a place without human presence. The yellow star in panel indicates the location of the Human Presence Site and the red star the location of the No Human Presence Site.

**Results**

The results of our data collection indicate that English Ivy grows quicker without human intervention, but that it thrives in both zones. Overall, greater plant growth is shown, and a larger variety of biodiversity is displayed in the No Human Presence Site (Table 1). The site with human presence exhibited has less space covered with flora, as well as different species of plants. Being proximal to the creek/marsh, the No Human presence site has greater biodiversity with its ability to sustain plants that require damp soil and high humidity. (Table 2).

**Table 1.** Species composition and area covered of flora for with human presence and without human presence in Willow Valley Nature Preserve, Mooresville, North Carolina.

| **Species** | **Human Presence Site** | **No Human Presence Site** |
|---|---|---|
| *Hedera Helix* | 894 | 1173 |
| *Packera Anonyma* | 35 | 0 |
| *Veronica Spicata* | 0 | 15 |
| *Allium Vineale* | 11 | 32 |
| *Glecoma Hederacea* | 14 | 37.5 |
| *Trifolium Repens* | 8 | 0 |
| *Rumex Obstusifolius* | 0 | 196 |
| *Toxicodendron Radicans* | 0 | 0 |
| *Veronica Hederifolia* | 25 | 48 |
| *Conium Maculatum* | 0 | 4.5 |
| *Zorinia Diphylla* | 18 | 24 |
| *Juncus Effusus* | 0 | 41 |
| *Digitaria Sanguinalis* | 0 | 66.5 |

**Table 2.** Biodiversity measures for sites with human presence and without human presence in Willow Valley Nature Preserve, Mooresville, North Carolina.

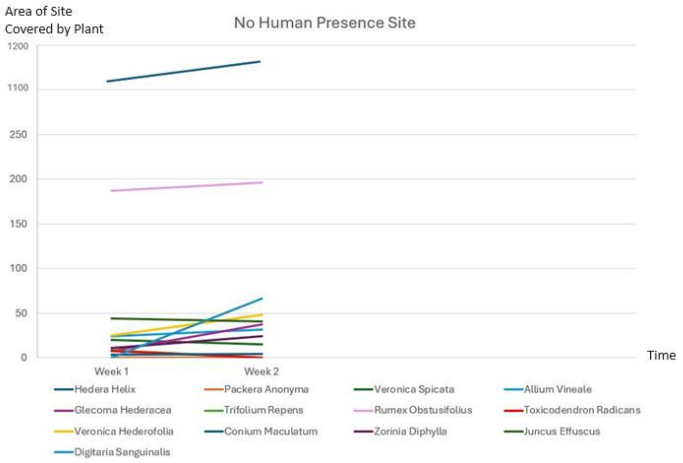
| **Biodiversity Measure** | **Human Presence Site** | **No Human Presence Site** |
|---|---|---|
| Total Area Covered by Individuals | 1005 | 1637.5 |
| Average Area Covered | 144 | 164 |
| Species evenness (E) | 0.274 | 0.479 |
| Species richness (S) | 7 | 10 |
| Shannon Diversity Index (H) | 0.532 | 1.1 |

**Data Measurement**

1. The total area covered by individuals is calculated by the area of each plant (Width X Length) added together.
2. The average area covered is the average of each individual's area compared to other species in the site.

3. (E) stands for species evenness, which is calculated by E= H / ln(k), k being the number of species. The number given from this equation will be between 0 and 1, the closer it is to one, the higher the diversity.
4. (S) is species richness. Species richness is the number of different species that appear in a designated area or ecosystem.
5. The Shannon Diversity Index (H) takes a variety of factors into account in its equation: $H = -\sum[(p_i)\times\ln(p_i)]$. The proportion of each species in the sample is indicated by $p_i$. Similar to species evenness, a 0 indicates little to no evenness. In the case of the Shannon Diversity Index, a 0 means that there is only one species.

a)

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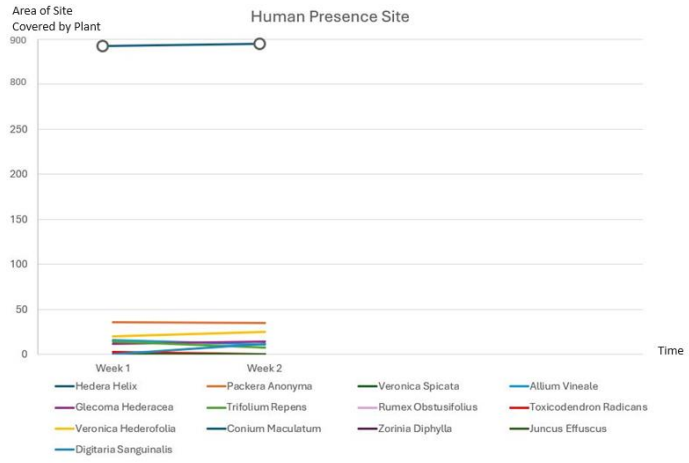
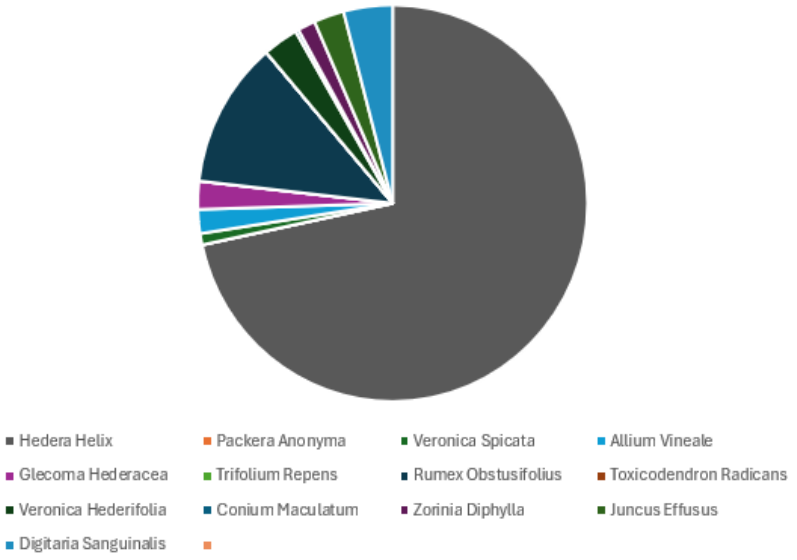



**Figure 1.** Species composition, area covered, and area growth at (a) the site without human presence and (b) the site with no human presence Willow Valley Nature Preserve, Mooresville, North Carolina.

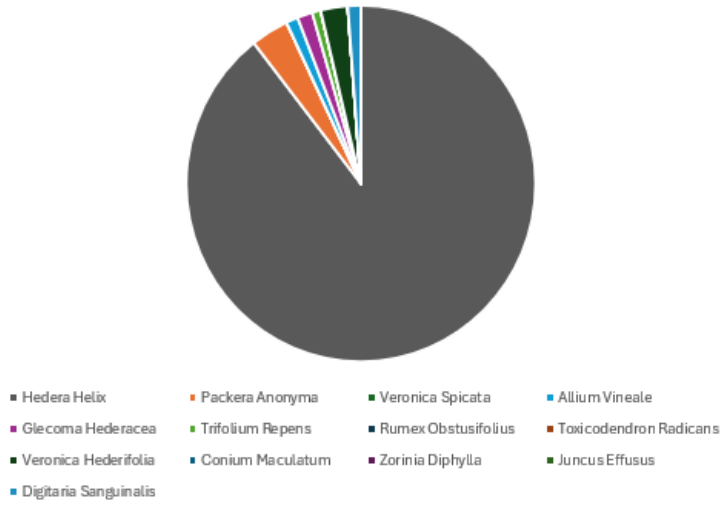
**a)**




No Human Presence

*Hedera Helix: 71.6%*
*Packera Anonyma: 0%*
*Veronica Spicata: 0.9%*
*Allium Vineale:2%*
*Glecoma Hederacera: 2.3%*
*Trifolium Repens: 0.0%*
*Rumex Obstusifolius: 12%*
*Toxicodendron Radicans: 0%*
*Conium Maculatum: 0.3%*
*Zorinia Diphylla: 1.5%*
*Juncus Effusus: 2.5%*
*Digitaria Sanguinalis: 4.1%*
*Veronica Hederifolia: 2.9%*

**b)**




Human Presence

*Hedera Helix: 89%*
*Packera Anonyma: 3.5%*
*Veronica Spicata: 0%*
*Allium Vineale: 1.1%*
*Glecoma Hederacera: 1.4%*
*Trifolium Repens: 0.8%*
*Rumex Obstusifolius: 0%*
*Toxicodendron Radicans: 0%*
*Conium Maculatum: 0%*
*Zorinia Diphylla: 1.8%*
*Juncus Effusus: 0%*
*Digitaria Sanguinalis: 0%*
*Veronica Hederifolia: 2.5%*

**Figure 2.** Species composition (a) the site without human presence and (b) the site with no human presence Willow Valley Nature Preserve, Mooresville, North Carolina.

*Ethical Considerations*

All data collection was observational so required no handling or animal use permits. Oaks Bottom Nature Preserve is open to the public 24/7 and requires no special permission to access the Study Area or Study Sites.

**Table 1.** Raw data collected for sites with human presence and without human presence in Willow Valley Nature Preserve, Mooresville, NC.

| **Species** | **Human Presence Site** | **No Human Presence Site** |
|---|---|---|
| *Hedera Helix* | 903 | 1215 |
| *Packera Anonyma* | 36 | 0 |
| *Veronica Spicata* | 0 | 18 |
| *Allium Vineale* | 13 | 38 |
| *Glecoma Hederacea* | 17 | 52.5 |
| *Trifolium Repens* | 4 | 0 |
| *Rumex Obstusifolius* | 0 | 189 |
| *Veronica Hederifolia* | 29 | 54 |
| *Conium Maculatum* | 0 | 5 |
| *Zorinia Diphylla* | 20 | 27 |
| *Juncus Effusus* | 0 | 38 |
| *Digitaria Sanguinalis* | 12.5 | 73 |

*Data Analysis*

The difference in the mean area of each ground crawling plant was investigated and analyzed. This was done by comparing the data collected from the Human Presence Site and the No Human presence site using t-tests. The data recorded was from the same 5x5 foot plots from the previous weeks at the Willow Valley Nature Preserve. The results from the statistical analysis were interpreted to determine whether the information recorded supported or negated the hypothesis. The significance level of $p<0.05$ was used to determine the statistical significance of any observed differences or relationships in **Table 1**.

**Figure 1.** Comparison of *Hedera Helix* growth with human presence (right, blue dot) and without human presence (left, orange dot). Measurements and data were recorded utilizing the square plot survey method in a 5x5 foot area in Willow Valley Nature Preserve, Mooresville, North Carolina.

Descriptive statistics are shown in Table 2 for all combined areas covered by ground crawling plants. The sample size is 12 for each group, the samples from each group are independent. The mean area covered (-1.05(22) = -21.93, p=0.3; Table 2) of the No Human Presence site demonstrated a greater range than that of the Human Presence site (-0.9969(22) = -23.1, p=0.92; Table 2). The t-value being ± 0.6858. Despite recording valuable data pertaining to the growth and biodiversity of flora and the effects human presence has on it, the p-value determines that this conclusion is not statistically significant.

**Table 2.** Summary statistics for the sites with human presence and without human presence in Willow Valley Nature Preserve, Mooresville, North Carolina.

| **Descriptive Statistic** | **Human Presence Site** | **No Human Presence Site** |
|---|---|---|
| Sample Size | 12 | 12 |
| Mean ± SD | 86.79 ± 257.29 | 142.45 ± 341.57 |
| Range | 899 | 1210 |
| Minimum | 4 | 5 |
| Maximum | 903 | 1215 |

**Table 3.** In-depth statistics for the sites with human presence and without human presence in Willow Valley Nature Preserve, Mooresville, North Carolina.

| **Description** | **Variable Name** | **Human Presence** | **No Human Presence** |
|---|---|---|---|
| Sample Size | N | 12 | 12 |
| Sample Mean (average) | $\overline{x}$ | 86.79166667 | 142.4583333 |
| Sample Variance | $s^2$ | 66202.88447 | 116670.9754 |
| Standard Deviation | S | 257.2992119 | 341.5713328 |
| Standard Error | SE | 74.27588464 | 98.60315046 |
| 95% Confidence Interval | CI | 145.5807339 | 193.2621749 |
| Lower Limit | LCL | -58.78906723 | -50.80384157 |
| Upper Limit | UCL | 232.3724006 | 335.7205082 |

**Discussion**

The results of our study revealed differences in ground crawling flora biodiversity when comparing sites with and without human presence at the Willow Valley Nature Preserve. The site without human presence demonstrated higher biodiversity with 10 unique species, while the site with human presence contained 7. When comparing all categories considered in the Shannon Diversity Index, including total numbers of individuals, average population size, species evenness, species richness, it is notable that each category in the non-human presence sit demonstrates greater evenness and biodiversity than that with human intervention.

Additionally, greater overall growth is visible in the site with no human presence; however, several species of plants are dying out from the change of seasons and rapid homogenization from *Hedera Helix*. Despite most likely being introduced at the human presence site, *Hedera Helix* thrives in the undisturbed location (similar to native plants) easily taking over native plants and maximizing its area covered. As non-native species naturalize, it is detrimental to biodiversity in the pre-existing ecosystem (Daru et al., 2021, December 6). For the 10,138 plant species that have naturalized outside of their native home ranges, 1,065 species have gone extinct. This equivales to what is estimated to be,"14,000 million years of evolutionary history." Continents with higher amounts of species extinction correlate with elevated levels of invasive species that threaten biodiversity. Even when extinction is not the inherent nor immediate outcome, in the study by Daru et al., it is shown that the decrease in biodiversity is predominantly caused by the introduction of non-native species.

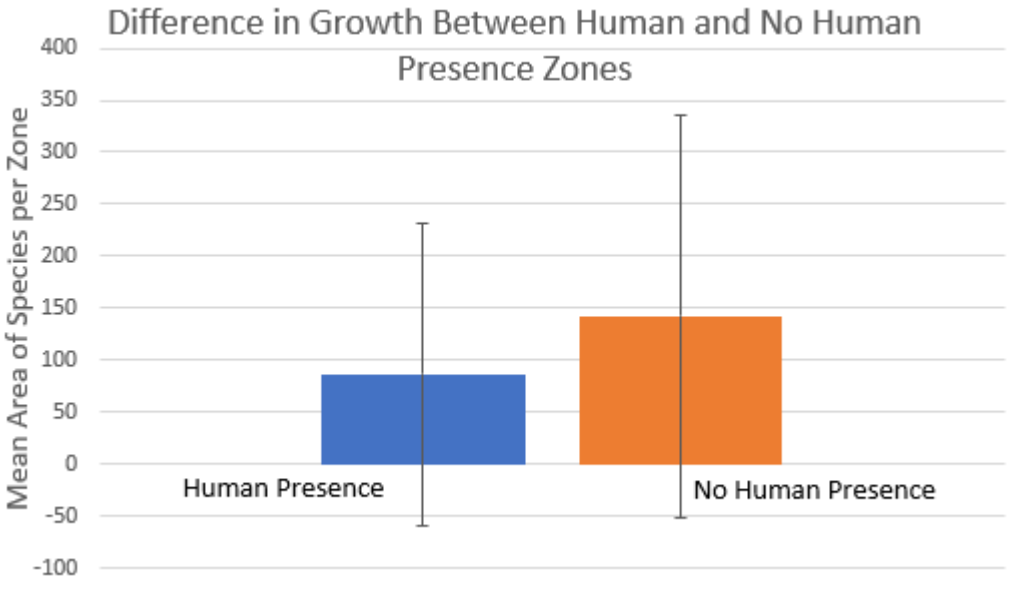



**Figure 2.** Comparison of mean area covered by plants in both the Human Presence site (Blue bar on the left) and No Human Presence zone (Red bar on the right). The black error bars indicate the confidence intervals.

Despite finding a difference in growth over several weeks, in **Figure 2** the results are shown to be not statistically significant. This is demonstrated by the overlap between the two error bars. Even though it is statistically inconclusive, this information may be utilized to determine what steps need to be taken and at what pace to protect native wildlife from non-native wildlife that has expanded its home range into various continents. Information has also been presented about the variety of plants that spread due to human presence, and which plants thrive with or without them.

In summary, from the research conducted and findings reported, the hypothesis that human presence significantly affects the growth of ground crawling plants must be rejected. If a more in-depth experiment is conducted over a longer period with a greater area covered, more conclusive results may be seen. Factors that may have influenced the results are lack of time to observe plant growth as well as the frequent, drastic, and often occurring weather changes of the area. The relativity to the creek may have also impacted the profile of species for the area. From what was gathered during this study, the growth of non-native plants versus that of native plants is a notable pattern that should be further investigated. However, the phenomenon of varied species of plants being observed near human presence versus no human presence was also observed by ALES researcher Ellen Macdonald from the Department of Renewable Resources (Ng, E. 2013, July 2). Macdonald found that many plants grow in unnatural areas around hiking trails which results in a decline of the species found in the area.

**Management Recommendations**

Based on our research, multiple guidelines are to be put in place to protect the biodiversity of the Willow Valley Nature Preserve, as well as surrounding areas:

1. Monitoring Invasive Species: With the rapid growth of *Hedera Helix* being recorded, it is heavily advised to continue monitoring and tracking the growth of English Ivy, as well as other non-native species to ensure that they do not continue to encroach upon native ground crawling plants, shrubbery, saplings, and trees.

2. Removal of Invasive Species: Removing species such as *Hedera Helix* is a necessity to protect the biodiversity of the Willow Valley Nature Preserve and surrounding areas. Without keeping non-native plants in check, there is a risk that native flora will decline, which impacts not only the surrounding plant life but also any other living creatures that utilize native plants for survival. An example of a vine with similar characteristics that has rapidly spread throughout the south over the past two centuries is Kudzu. Kudzu has proven to smother saplings and out-compete indigenous plants, harming the wildlife's nests, food, and access to other necessary resources (Blaustein, Richard J. 2001). Removal should not include the use of herbicides and only manual removal to protect native species. Volunteers/employees who remove the plants must be diligent and go through training to understand which plants are to be protected, which need to be removed, and how to identify them.

3. Modification of Rules Surrounding Human Intervention: Legislatively, it would be ideal to follow in the footsteps of South Carolina lawmakers and ban the sale non-native plants, as discussed in "*Clemson program to help homeowners swap Bradford pears for native trees ahead of ban" by Sarah Swetlik at the Greenville News.* It would be tactful to encourage the removal of non-native plants from landscaping with similar incentives as well. The incentive to remove the Bradford Pear tree is a free replacement tree on the property.

   However, specifically the Willow Valley Nature Preserve, updates to the rules to not only ban vehicles, but people as well from trespassing will prevent the disruption of native plants and the potential transport of invasive species into the area.

4. The Willow Valley Nature Preserve must get clearer definitions of what space it occupies to enforce rules effectively. Awareness needs to be spread, especially on official websites such as https://www.mooresvillenc.gov/government/departments/parks recreation/parks/willow valley park.php. Stricter monitoring and rules need to be enforced on littering and trespassing.

5. Native plants must have protected zones with consistent data collection and the removal of non-native species as well as pollution. During data collection, varieties of pollution and discarded items were found (See **Figure 3.**) Homeowners nearby should be aware of protected zones to avoid contributing to polluting the preserve or accidentally propagating non-native species in protected areas such as swamps and creeks. According to the Royal Horticultural Society (RHS), it is incredibly beneficial for pollinators and invertebrates to have access to native plants, flowers, and some spots of bare ground, which as demonstrated in **Table 1,** invasive ivies do not leave a lot of. Matthew Shepard (2020, April 20) elaborates on this point, citing a difference of often 20% or greater found during the research of the RHS.

**Figure 3.** An abandoned fire extinguisher (within the red circle) located in the human presence site in Willow Valley Nature Preserve, Mooresville, North Carolina.

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