Bee-yond the Roof: Assessing Plant Health and Invertebrate Biodiversity on a Restored Urban Green Roof

Sarah Persad, Arianna Jenkins, Willie Mouzon, Faheya Rahel, A'naija Riley, Alexa Rodriguez, Camila Rodriguez

Summer Research Symposium | August 2026

Introduction

The Center for Global Conservation (CGC) at the Bronx Zoo, founded in 2009, features a three-story green roof– a technology that has reduced the building's energy consumption by 48 percent. While green roofs are essential for reducing energy consumption, they also prevent rainwater runoff and can serve as habitats for local wildlife in urban habitats, including pollinators and other ground-dwelling invertebrates. After over five years without maintenance, the Green Roof at CGC has become a habitat for many species as it is being restored by Bronx Zoo Education, with the goal of using it as an outdoor, community-based learning space. This project will be part of their initiative by monitoring the early stages of success for the newly planted native plants and providing the first set of data on which plant species are doing well on the roof and the types of pollinators being attracted.

While pollinator abundance and diversity are crucial to green roof success by fueling plant reproduction, the biodiversity of other invertebrates is also important, as it indicates the green roof's success and its ability to serve as a viable habitat (Williams et al 2014). Plant species diversity and invertebrate species diversity are directly related: if one increases, so does the other (MacIvor and Ksiazek 2015). To maintain plant diversity, plant health must be maintained. Green roof communities may vary in diversity due to factors such as age, direct solar radiation, and the organic matter and moisture level of the soil (Coulibaly S. et al 2023). This project aims to examine the factors affecting plant health on an urban green roof and to compare the biodiversity of its managed and unmanaged halves. Through this, we can begin to incorporate newly observed factors into future green roof projects to facilitate habitat recovery in urban areas. The questions we aim to address are:: **1) How do factors such as weed presence, pollinator species, and plant health factors, such as coloration, predation, and texture, vary based on the overall health of native plant species on the green roof? 2) How does biodiversity of pollinators and ground-dwelling invertebrates on the managed area of the green roof compare to biodiversity of invertebrates on the unmanaged area of the green roof?**

Methods

Site

This study was conducted at the Bronx Zoo's Center for Global Conservation (CGC) in July and August 2026. In Spring 2026, the entire site was cleared of all existing vegetation, and 1,000 seedlings of 20 different native forb species were planted in June in the top third of the roof (~ 2,000 ft^2). The slope of the green roof remains unmanaged, leading to natural growth of plants without human intervention, most of which are unwanted and non-native species. Planted species were selected for their tolerance to green roof conditions and their likelihood of attracting pollinating insects and other invertebrates, and were planted in same-species clusters of around 8-9 seedlings per cluster. The native species in each plot were referred to as target species, and all plants other than the target species were considered weeds.

Image 1. A map of CGC and the location of the different sites.

Image 2. A photo of the mentees building pitfall trap covers.

Pitfall Traps

Non-lethal pitfall traps were used to passively capture and monitor ground-dwelling invertebrates on the green roof. To randomize trap locations and to compare the unmanaged and managed halves, a transect line was used to place traps at 5-meter intervals at the top of the green roof and at 10-meter intervals at the bottom. A total of eight traps were placed: four in the unmanaged area (U1-U4) and four in the managed area (M1-M4). Pitfalls were left overnight and checked about 24 hours later, with a completed total of 24 pitfall surveys. All captured invertebrates were released at the point of capture.

Point Count Surveys

Fixed-point-count surveys were used to record the presence and richness of pollinating insect species. Two observers stood at an assigned plot for ten minutes and recorded the taxonomic group and abundance of all observed invertebrates. Invertebrates were identified to an Order or, when possible, a Family level.

Plant Health Assessment

A total of three plant health assessments were conducted for each plot to evaluate the overall health of the plants at the top of the green roof. Plots (n = 120) were numbered and labeled with the corresponding plant species using flags. At each plot, the health of the target species was assessed by observing the plants' flowering status, leaf color, texture, and discoloration. Based on these factors, the overall health of the target species in the plot was assigned a rating from 1 to 5, with 1 being unhealthy and 5 being the healthiest.

Using the Lux Light Meter Pro app, members recorded the number of lux – a unit of measurement for the intensity of light on a surface received by the plant – by placing their devices directly above the plot in the general area of the target species' growth. A 1x1m quadrat was placed over the center point of the plot to estimate the percentages of weed coverage, bare ground, and target species coverage within it. To support green roof maintenance, any weeds found were removed immediately after completing each plot survey.

Soil Testing

Soil samples were collected from each of the three different sites on the green roof to which the pitfall traps were assigned: top, middle, and bottom (n = 12). At each site, composite sampling was used to combine fifteen soil samples. The soil from each of the three sites was then tested for pH using a LaMotte Garden Kit.

Abstract

This project investigated the biodiversity and plant growth on the green roof of the Center for Global Conservation (CGC) at the Bronx Zoo. The presence and species richness of ground-dwelling and pollinating invertebrates were compared between the unmanaged bottom and the managed top of the green roof. Exactly 1,000 seedlings from 20 different native pollinator species were planted across 2,000 square feet of the roof's managed site in June 2026. The growth and health of these plants were monitored for the subsequent six weeks. The managed area experienced a greater amount of pollinator activity due to the native flower species; pollinators were most likely attracted to the newly flowering plants. For example, *hymenoptera, diptera,* and *odonata* were more common pollinators found within the managed site. While the managed area contained a greater abundance of ground-dwelling invertebrates such as *hemiptera* (aphids and assassin bugs), *coleoptera* (beetles), *araneae* (spiders), and *isopoda* (roly-polies) with lesser species richness, the unmanaged area had a greater species richness and a lesser abundance. While these findings describe the rate of biodiversity and soil quality over a six week period throughout the summer, further initiative should be taken in the future in order to continue establishing a strong correlation between soil quality and plant growth, and the factors affecting the presence of flying and ground-dwelling invertebrates.

Figures

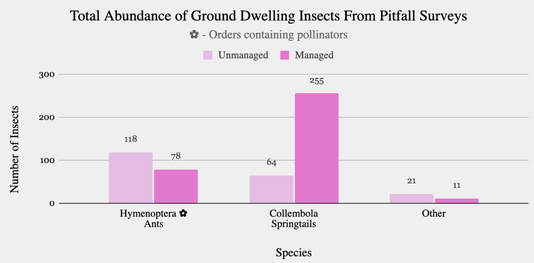

Figure 1. Shows the abundance of ground-dwelling invertebrates on the unmanaged and managed halves of the green roof. The other species were *hemiptera* (aphids and assassin bugs), *coleoptera* (beetles), *araneae* (spiders), and *isopoda* (roly-polies).

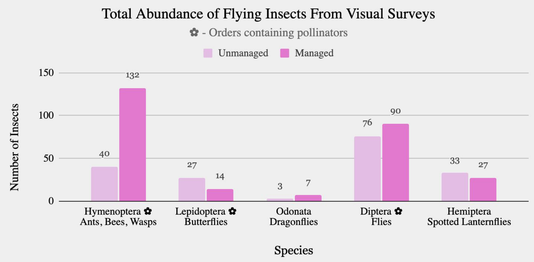

Figure 2. Shows the abundance of flying invertebrates on the unmanaged and managed halves of the green roof.

Site	Average Soil pH
Top	6.09
Middle	6.09
Bottom	6.59

Figure 3. Shows the average soil pH for three different sites on the green roof.

Image 3. A photo of a carpenter bee on Swamp Milkweed *(Asclepias incarnata)*

Image 4. A photo of Common Yarrow *(Achillea millefolium)*

Results

Plant Health Assessment

The plants on the green roof are relatively healthy, with most receiving scores between 4 and 5 on the plant health assessment. There are five plants so far that flowered during the study period: the Swamp Milkweed (*Asclepias incarnata),* Blue Vervain *(Verbena hastata),* Common Yarrow *(Achillea millefolium),* Blue Mistflower *(Conoclinium coelestinum),* and Orange Coneflower (*Rudbeckia fulgida).* A high number of pollinators visiting these species was recorded from the point count surveys and general observations. The least successful plants, which received scores of 1.5 to 2.5, are Smooth Blue Aster (*Symphyotrichum laeve)*, Little Bluestem (*Schizachyrium scoparium)*, Hairy Beardtongue (*Penstemon hirsutus)*, and Wild Bergamot (*Monarda fistulosa)*. These plants have shown little growth and have remained at about the same length since the start of the research project. Interestingly, *R. fulgida* and *S. scoparium* started off with scores of 1.5 and 2, and now both have scores of 5, receiving the most progress in overall success. At the start of the project, almost all of the plots had a weed coverage of over 50%, with most of those weeds overgrowing the target species. The most common weed found was Purple Amaranth *(Amaranthus blitum)*. With continuous weeding throughout the study period, many plots had weed coverage of about 10% by the end of the project, with some as low as 5% and others with no weeds at all. The top and middle areas have an average soil pH of 6.09, and the bottom has an average pH of 6.59; all of these values indicate healthy soil, as the ideal soil pH range for all plants is between 6.0 and 7.0.

Invertebrate Diversity

The unmanaged half of the green roof was shown to have a higher abundance of Hymenoptera (n=118) than the managed half, which had a higher abundance of Collembola (n=255) than the unmanaged half. Although the managed half had a greater total abundance of ground-dwelling invertebrates, the unmanaged half had a greater species diversity. A diverse number of pollinators were observed on the unmanaged (n_1) and managed (n_2) halves of the green roof: bees (n_1=13, n_2=44), wasps (n_1=18, n_2=44), flies (n_1=59, n_2=82), butterflies (n_1=20, n_2=8), and ants (n_1=114, n_2=75). House flies from the visual pollinator point count were excluded, since they are not known to be pollinators. The managed half of the green roof was shown to have a greater abundance of Hymenoptera, Diptera, and Odonata than the unmanaged half, which had a greater abundance of Lepidoptera and Hemiptera. There was a higher total abundance of pollinating flying invertebrates on the managed half than on the unmanaged half.

Discussion

Plant Health

Our hypothesis stated that the healthiest native plant species will have a high abundance of pollinator species, a moderate amount of weeds, and minor discoloration and signs of predation or dryness. Our data supported this hypothesis; plants with lower weed coverage and higher pollinator activity scored 4-5 on the plant health scale, whereas plants with higher weed coverage and lower pollinator activity scored 2-3. Those plants also showed minor discoloration and wilting. Managed plants on the green roof are relatively healthy, with most plants, especially flowering plants, scoring an average of 4-5 on the plant health scale. As the research progressed, various plants that were previously scoring extremely low increased to 4-5, with minor exceptions increasing to 3-4. Alongside this, weed coverage in plots has readily decreased with management. This supports the notion that continued maintenance of newly planted native species (including regular watering, mulch, and weed removal) is vital in the early stages of restoration. These results are specific to the unique structure of the CGC green roof (due to its sloped connection to the ground); other types of green roofs may show different results and different maintenance needs.

Flying Invertebrate Abundance/Biodiversity

Our second hypothesis stated that the unmanaged side of the green roof will have a higher biodiversity of pollinators and ground-dwelling invertebrates compared to the top of the green roof. Our data partially supported this hypothesis; the managed area of the green roof exhibited higher biodiversity and abundance of aerial invertebrates, though results differed slightly for ground-dwelling invertebrates. This is likely due to the abundance of flowering native plants in the managed area, as most flying invertebrates were pollinators feeding on plants such as Swamp Milkweed and Blue Vervain.

The managed green roof site has a higher abundance of ground-dwelling invertebrates but lower diversity than the unmanaged site. This is presumably because the plants at the managed site are catered to pollinators due to the native flowers planted, whereas the unmanaged has a high amount of non-native plant growth. Pollinators can easily travel between the managed and unmanaged sites of the green roof, whereas ground-dwellers have more limited mobility. The unmanaged area is also closer to the base of the roof and adjacent forested habitat, which may attract more ground-dwelling invertebrates to use it as a habitat. Originally, the unmanaged area was completely unmanaged, but at the very start of the project, it was mowed continuously to help prevent the spread of non-native plants to the managed half, which may also have affected the presence of invertebrates.

Soil Quality

Considering the sloped nature of the green roof, the findings suggest that critical soil nutrients may pool downward due to water flow from weather events such as storms, resulting in a higher soil pH towards the unmanaged site of the green roof, as there is no substantial accumulation of organic acids. Furthermore, the unmanaged site of the green roof had a higher pH than the middle and top due to its lack of management. Although the soil pH levels are ideal, they are not immune to factors that could increase acidity, such as mulch.

Image 5. All weeds and non-target plants were regularly removed from plots and disposed of.

Image 6. A picture of a monarch butterfly on a leaf. A future goal of this study is to create monarch stopover habitat. Photo Credit: Julie Larson Maher © WCS

Acknowledgements

We would like to thank Max Falkenberg, Noor Kazmi, and Brian Saville for overseeing this study, and to The Wildlife Conservation Society, and The Pinkerton Foundation for supporting this study. We would also like to thank the Xerces Society for the generous donation of the native plants to the green roof, and their support in creating a pollinator habitat.

References

Coulibaly, Sékou F.M. & Aubry, Christine & Provent, Fanny & Rousset-Rouvière, Sophie & Joimel, Sophie. (2023). The role of green roofs as urban habitats for biodiversity modulated by their design: A review. Environmental Research Letters. 18. 10.1088/1748-9326/acd801.

MacIvor, J Scott & Ksiazek-Mikenas, Kelly. (2015). Invertebrates on Green Roofs. 10.1007/978-3-319-14983-7_14.

Williams, Nicholas & Lundholm, Jeremy & MacIvor, J Scott. (2014). FORUM: Do green roofs help urban biodiversity conservation?. Journal of Applied Ecology. 51. 10.1111/1365-2664.12333.

iNaturalist. (2026). *Seek by iNaturalist* (Version 2.15) [Mobile app]. iNaturalist.

Polyanskaya, M. (2017). *Lux Light Meter Pro* [Mobile app]. Apple App Store.