Ecological limitations to plant and pollinator restoration on a capped landfill in the New Jersey Meadowlands

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SUMMARY

Large landfills in the New Jersey Meadowlands provide human-derived environmental conditions that are quite different from the surrounding marsh ecosystems. How does human intervention through restoration impact the succession of these communities? Plant restoration efforts may facilitate the restoration of other organisms, such as pollinators, and thereby increase the ecological function of the landscape. We tested the potential for restoration of the plant communities on capped landfills by conducting a seed and soil addition experiment on Erie Landfill within the New Jersey Meadowlands. We found that plant community composition varies depending on the restoration technique used. Environmental factors, soil moisture in particular, were found to interact with seed addition treatments to determine plant community composition. Restoration practices impacting the plant community have cascading effects on pollinator communities where abundance and species richness of bees is related to plant community composition. In order to support diverse bee communities, and increase the pollination services they support, land managers of capped landfills will want to focus on overcoming these ecological limitations for pollinator friendly plants.

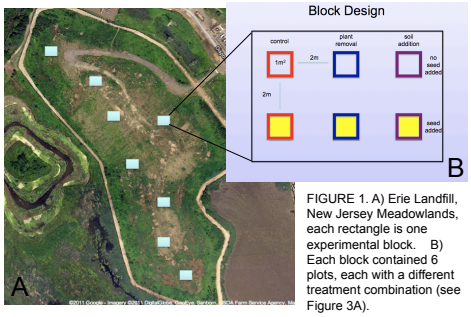


FIGURE 1. A) Erie Landfill, New Jersey Meadowlands, each rectangle is one experimental block. B) Each block contained 6 plots, each with a different treatment combination (see Figure 3A).

INTRODUCTION

Many ecologists have found that plant communities are formed through a hierarchy of processes or filters, beginning with dispersal and environmental factors such as soil suitability, then followed by competition and interaction with other trophic groups, including pollinators. In the case of capped landfills, these filters are largely human-derived, creating novel ecosystems. The New Jersey Meadowlands are host to a number of capped landfills providing upland environments within a landscape matrix dominated by wetlands. These landfills are isolated from other natural (not human-made) upland communities, reducing the potential for dispersal of native plants. As a result they are dominated by non-native species. The management of these landfills impacts their ability to provide different ecological services. Human intervention in the form of restoration may alter plant community development by overcoming the existing ecological filters. We sought to test the efficacy of standard restoration techniques as a means to overcome ecological limitations and influence plant community composition. Plant restoration efforts may facilitate the restoration of other organisms, such as pollinators, and thereby increase the ecological function of the landscape.

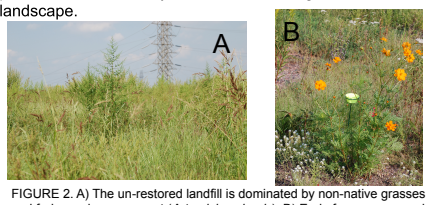


FIGURE 2. A) The un-restored landfill is dominated by non-native grasses and forbs such as mugwort (*Artemisia vulgaris*). B) End of season example of a seed addition + soil addition plot. The yellow bowl in the center of the plot is a trap that samples for bees.

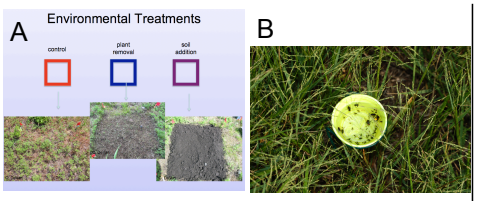


FIGURE 3. A) Three environmental treatments were used within each block to test for environmental filters of soil quality. Using a block design, each environmental treatment was combined with a seed addition treatment, which tested for dispersal filters (see Figure 1B). B) A yellow pan trap used to catch bees.

EXPERIMENTAL APPROACH

We tested the potential for speeding up ecological processes within plant communities on capped landfills by conducting a seed and soil addition experiment with a fully factorial design on Erie Landfill within the New Jersey Meadowlands. Our experiment was performed on an un-restored capped landfill where the extant community had developed "spontaneously." Using a block design, we created 8 blocks each with one replicate treatment combination (Figure 1). Three plant restoration treatments based on existing post-landfill capping practices were tested: 1) removing existing plants and allowing "natural" colonization onto the bare ground, 2) removing existing plants and adding top soil but still allowing "natural" colonization", and 3) removing existing plants and adding top soil as well as seeding. Controls were plots of un-manipulated existing vegetation. The seed mix added was comprised of hardy, native, early successional species that are commonly used by land managers after a landfill has been capped. Soil moisture was used as an indication of soil quality. Bees were sampled within each plot to determine how plant community composition impacts other trophic groups.

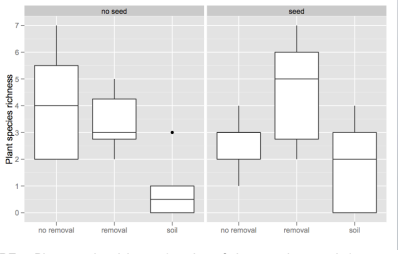


FIGURE 4. Plant species richness (number of plant species per plot) averaged across each treatment. There is a statistically significant interaction between environmental and seed addition treatments on plant species richness.

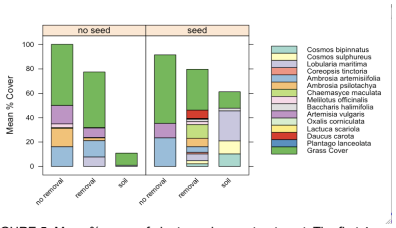


FIGURE 5. Mean % cover of plant species per treatment. The first 4 species listed were seed additions, the rest were extant species. Grass cover includes all grass species combined. Community composition varies greatly between treatment. Existing vegetation may act as a biotic filter preventing new individuals from establishing.

FIGURE 6. *Helianthus annuus* (common sunflower) with two bee visitors. Sunflowers are found at the base of the landfill. Bees are dependent on flowers for food and in exchange provide pollination services. Therefore plant community composition can have important impacts on bee communities.

RESULTS & CONCLUSIONS

- We found a statistically significant interaction between seed and environmental treatments, suggesting that urban plant communities are impacted by:
  – Dispersal limitations (Figure 4)
  – Environmental conditions (Figure 4) such as soil moisture (Figure 7)
  – Competition from existing species (Figure 5)
- Soil moisture is highly correlated with plant species richness (Figure 8)
- There is a trend for bee abundance and bee richness to be related to plant species richness.
- Environmental conditions significantly impacted bee species richness but not total bee abundance.
- More research is needed to determine the mechanisms between plant restoration techniques and bee community diversity indices.

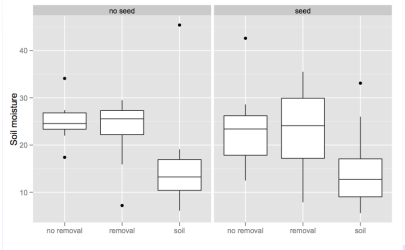
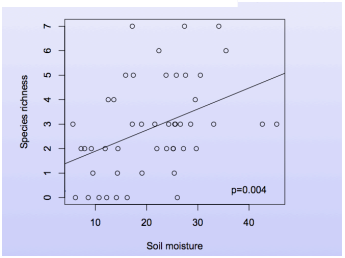


FIGURE 7. Mean soil moisture (% volumetric water content) per treatment. Soil moisture is generally lower for the soil addition treatment.

FIGURE 8. Correlation between plant species richness and soil moisture. Correlation is statistically significant indicating that soil moisture may act as an environmental filter for plant communities.



INNOVATION & RELEVANCE

By using various restoration techniques as an experimental approach to test for ecological filters, we are able to provide a mechanistic understanding of plant community development in urban areas. Our study shows that plant communities vary depending on restoration technique used and provide indications of which treatments are likely to be most valuable for pollinator restoration. These results are being shared with land managers at the Meadowlands Environmental Research Institute in order to support their efforts to restore ecological function to degraded urban areas.

ACKNOWLEDGMENTS

This material is based in large part upon work supported by the Meadowlands Environmental Research Institute. We thank Dominic Evangelista and Timothy Blockus for field assistance and Michael Newhouse for help coordinating site access and generally facilitating research efforts. Thanks also to Dr. Claus Holzapfel for plant identification and Sarah Kornbluth for bee identification help.