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Term Project Summary: Hexapod Bee Forage Planter

Since 2012, beekeeping has been legal in New York City, with over 200 reported active hives.[13] However, urban bee populations have not proliferated in the way urban ecologists had hoped, and they question whether sustaining beehives will remain possible in urban settings. Some beekeepers hypothesize that New York City bees may be unhappy with their living conditions, hence why their numbers haven't flourished. The beekeepers believe that New York City does not have the necessary quantity and quality of plants to provide nutrition for urban bees. Anthony Planakis, a beekeeper with over 40 years of experience, says that a single beehive should have at least one acre of adequate foraging land, which is not currently available in New York City.[13] Green public space in New York City is always changing, with new construction and sprawls endlessly dominating the concrete landscape. When looking at a top view of New York's five boroughs, one definitely notices the amount of space that exists as unused tar covered rooftops rather than plant rich green spaces. Although it would be easy to implement, there is so little being done today to change the surface area of New York City to make it more environmentally friendly. What the city planners don't seem to realize is that more plants would not only benefit bee populations, but all the people living in the city as well.

A simple and efficient solution to New York City's lack of bee forage in urban environments is the Hexapod. The Hexapod is a modular planter that addresses this issue by making rooftop gardens easier to create and maintain for urban dwellers. In addition to directly targeting this issue, the Hexapod tackles other urban living issues, such as the heat island effect, water eutrophication, excessive carbon emissions, and the general poor health of city dwellers.

The Hexapod is a hexagonally shaped planter with slots and extrusions on each side, which makes it modular and easy to set up on any sized rooftop, in as small or large a configuration as desired. each planter is fourteen inches wide and eight inches tall, leaving plenty of room for multiple plants. The planter contains four main components: the plants and soil layer, a polyurethane water filter, the Hexapod planter, and a water retaining container with drainage pipes stacked underneath. The Hexapod and water retainer are both made of a thermoplastic called PETE (polyethylene terephthalate). PETE is widely used for a variety of products because it is strong, non-reactive, lightweight and long lasting.[17] Because of its qualities, PETE has become the most commonly used plastic for food containers and water bottles. While being a great consumer material, millions of PETE products are thrown away every year, ending up in landfills or the ocean, when they could be recycled.[17] The Hexapod manufacturing process includes collecting post consumer PETE products and shredding them down into plastic nurdles. These nurdles are then melted and rotationally moulded into

Hexapods. This process keeps plastic out of landfills and the ocean and reduces the need for more drilling of fossil fuels, which is damaging to the environment.[4] The use of post-consumer PETE drastically reduces the impact of the raw material and manufacturing stages of the Hexapod's Life Cycle Assessment (LCA).

While the user may choose whichever plants they want to grow, some plants have proven to act beneficially against pollution and heat loss in urban environments. Plants such as sedums are already being grown around the city because in addition to providing food for urban bees, they trap escaping heat and gases.[17] Other plants, such as Hyssops, Agujas, Agastaches, and Hydrangeas, also attract bees and are capable of thriving in an unnatural environment such as New York City.[11]

Hexapods need a consistent source of water and nitrogen compounds for nutrition. It so happens that nitrogen is already often present in city water supplies as a direct result of water runoff containing nitrate fertilizer and from the atmosphere, which carries nitrogen compounds from the burning of fossil fuels.[18] While nitrogen is a key element in the successful growth of plants, its presence in water systems creates a large threat for ecosystems: water eutrophication. Excess nitrogen allows plants like algae to bloom and suffocate water fauna, causing a major imbalance in ecosystems. The USGS states that over 5 milligrams of nitrogen in a water system can create algae blooms.[18] In 2015, the New York City Drinking Water Supply and Quality Report found up to 0.55 mg of nitrogen in the city's water, after only 291 samples.[19] To help solve this issue, Hexapods source their water from the city's many iconic water towers. The water towers store and pump the city's drinking water from via a pressure and pumping mechanism, which should be taken advantage of. The Hexapod allows the water to filter through a layer of plants and soil. This helps to absorb pollutants such as nitrogen to provide fertilizer for the Hexapod's plants without additional synthetic fertilizer. The water is then filtered through the polyurethane water filter and piped back into the city's water system through the Hexapod's drainage pipe holes. Hexapods also take advantage of rainwater falling on city rooftops, which helps to dissipate water during rains, and avoid flooding.

The United States EPA has documented a phenomenon known as the heat island effect,[3] which is when an urban area is significantly warmer than its surrounding areas due to higher levels of human activity. Large amounts of heat escape through rooftops due to poor insulation, while the black rooftops capture more heat.[3] Hexapods create a "living cover" that better insulate rooftops, and allow cities to cool down back to the regular temperature. In addition, the burning of fossil fuels for heating, cooling, and transportation has caused a large imbalance of the carbon cycle, as too much carbon is now produced to be reabsorbed by plants. The increase in biomass provided by Hexapods has the power of capturing and storing some CO_2, the molecule responsible for the warming of the earth's atmosphere. As a result, hexapods can help to dissipate the proliferation of carbon dioxide in cities and lower the amount of air pollution in urban areas, which will benefit not only bees, but people as well.

Lastly, Hexapods provide a monumental benefit to city populations, unrelated to bee populations. In addition to serving as a food sources for urban pollinators, Hexapods also provide a significant social and mental benefit to New York City dwellers.[11] A higher exposure to plants has proven to improve mental, cardiovascular, and respiratory health.[15] In New York City, people are trapped in canyons of buildings that block natural sunlight and fresh air. Taking care of Hexapods can motivate city dwellers to head to their rooftops, partake in regular physical activity, breathe more fresh air, get more sunlight, and socialize with neighbors.

Hexapods have the the potential to set an unprecedented example for the future of the "urban environment." These sustainably sourced and manufactured planters can be placed on any rooftop, anywhere in the city. They provide necessary nourishment to urban bees, that in return provide an essential ecosystem service: pollination. By sustaining bees, urban dwellers are intrinsically sustaining themselves, and thinking sustainably about the future of cities. As cities continue to expand outwards, people need to be expansive in their ability to work for the planet, rather than against it. Urban expansion will only continue to threaten the survival of wild bees, and Hexapods work with them in mind. Creating a better, healthier environment for bees to live in will create a bloom in city greenery growth. The biomass provided by Hexapods will make for busier, happier bees, a better regulated temperature, cleaner water, cleaner air, and an overall greener city.

Annotated Bibliography:

1. Can Green Roofs Provide Habitat for Urban Bees

This scientific journal explores the correlation between the growth of urbanization and the impact it has had on wildlife, and in particular: pollinators. Furthermore this journal explores the potential for green roofs in urban centers to be a strategy for improving the the population and lifestyles of urban bees.

Colla, Sheila R., Erin Willis, and Laurence Packer. "Can Green Roofs Provide Habitat for Urban Bees (Hymenoptera: Apidae)?" *Cities and the Environment CATE* 2.1 (2009): 1-12. *Digital Commons at Loyola Marymount University*. Web.

2. Integrating the Environment in Urban Planning and Management: Key Principles and Approaches for Cities in the 21st Century

This article from UNEP is a a full body analysis of the interactions of urban areas and the environment. This article explores the integration of urban planning with the environment and approaches to that goal. This source considers climate change, urban design, and even economic and political influences.

Dodman, David, Gordon McGranahan, and D. B. Dalal-Clayton. *Integrating the Environment in Urban Planning and Management: Key Principles and Approaches for Cities in the 21st Century*. N.p.: United Nations Environment Programme, 2013. Print.

3. Living Cover

This source is a great source of information on the green roofs that have already been established in the United States. This source includes materials and methods that have been used in theses urban gardens to maximize efficiency and harmony between plants and the buildings they reside on.

Fischetti, Mark. "Living Cover." *Scientific American* 298.5 (2008): 104-05. Web.

5. Product Design for the Environment: Concepts

This online source explores the potential for industrial product design to work for the environment. This website explores sustainable design and the life cycle of product design. This will be useful to merge the data of bee population loss and design that can aid that issue, without causing other sustainability issues.

Giudice, Fabio. "Product Design for the Environment: Concepts." *Product Design for the Environment: Concepts*. Department of Industrial and Mechanical Engineering, University of Catania, n.d. Web. 29 Sept. 2016. <http://www.productdesignenvironment.info/concepts1.htm>.

6. Green Roofs as Urban Ecosystems

This sources analyses urban rooftops as potential urban ecosystems. This article defines many terms regarding rooftops and their potential are viable ecosystems in cities.

Oberndorfer, Erica, Jeremy Lundholm, Brad Bass, Reid R. Coffman, Hitesh Doshi, Nigel Dunnett, Stuart Gaffin, Manfred Köhler, Karen K. Y. Liu, and Bradley Rowe. "Green Roofs as Urban Ecosystems: Ecological Structures, Functions, and Services." *BioScience* 57.10 (2007): 823. Web.

7. Structure in Nature Is a Strategy for Design

This book is an inspiration for industrial design because it illustrates many structures found in nature such as the honeycomb. Natural structures are often the way they are because the form is the most effective and best evolved in many cases. Structures in nature are a great source of help to designers for creating forms.

Pearce, Peter. *Structure in Nature Is a Strategy for Design*. Cambridge: MIT, 1978. Print.

8. Ready to Late Sedum Green Roofs and Walls

This sources is exclusively about the importance of sedums as plants for green roofs. In recent years, research on sedums has shown that they are beneficial plants to have on urban rooftops and are a good source of forage for bees.

"Ready to Lay Sedum Green Roofs and Walls." *Sedum Green Roof*. N.p., n.d. Web. 12 Nov. 2016. <http://www.sedumgreenroof.co.uk/benefits-of-green-roofs.php>.

9. Worker Bees on a Rooftop, Ignoring Urban Pleasures

This New York Times article explores the benefits of green roofs in New York City. This article gives a very novel point of view on New York City, the birds eye view. This article looks into the other benefits that green roof tops have on air and water filtration, in addition to aiding bee species.

Satow, Julie. "Worker Bees on a Rooftop, Ignoring Urban Pleasures." *The New York Times*. The New York Times, 06 Aug. 2013. Web. 19 Oct. 2016. <http://www.nytimes.com/2013/08/07/realestate/commercial/worker-bees-on-a-rooftop-ignoring-bryant-parks-pleasures.html>.

10. Impact of Different Green Roof Layering on Plant Water Status and Drought Survival

This is a scientific study that analysed the different types of green roof layerings and their ability to absorb water in the Mediterranean region. This source gives great insight into the design of soil, retention, and filtration layers for the optimal survival of the Salvia plants.

Savi, Tadeja, Sergio Andri, and Andrea Nardini. "Impact of Different Green Roof Layering on Plant Water Status and Drought Survival." *Ecological Engineering* 57 (2013): 188-96. Web.

11. Making a Bee-Friendly Garden

This source is a less data intensive source of how to create bee friendly gardens. This source is important in describing what kind of flora bees need to thrive and carry out important ecosystem services such as pollinating plants. This will be useful when planning out urban gardens to facilitate the lifestyle of urban bees.

Sydney Cameron, Terry Harrison, Michael McKelvey, and May Berenbaum "*Making a Bee-Friendly Garden.*" Making a Bee-Friendly Garden. Bee Spotter, University of Illinois, n.d. Web. 29 Sept. 2016. <https://beespotter.org/topics/beegarden/>.

12. Ecological Design and Planning

This book explores the possibilities of landscape ecological planning. Although this source is not exclusively about urban ecological development, it is enlightening about the general practice of ecological planning in landscape design.

Thompson, George F., and Frederick R. Steiner. *Ecological Design and Planning*. New York: John Wiley, 1997. Print.

13. Two Years After Legalized Beekeeping, City May Be Running Short on Forage

This WNYC podcast and article focuses on the rising numbers of beehives in urban areas, yet are still facing major issues. Beehive numbers have risen in urban areas, but there is a concern by city ecologists that there isn't enough forage to sustain them all.

"Two Years After Legalized Beekeeping, City May Be Running Short on Forage." *WNYC*. N.p., 25 June 2012. Web. 19 Oct. 2016. <http://www.wnyc.org/story/218358-urban-bees-may-be-running-out-foraging-ground/>.

14. The Nature of Urban Design: A New York Perspective on Resilience

This book is great resource because it focuses specifically on the ecological resilience of New York City. The premise of the book urge city dwellers to be in charge of the development of the cities they live in and create their communities. The author explores more social impacts of urban design and how urban ecology takes a role in those impacts.

Washburn, Alexandros. The Nature of Urban Design: A New York Perspective on Resilience. N.p.: Island, 2013. Print.

15. Natural Environments and Human Health

This article focuses on the health benefits that humans have from being exposed to the natural environment. This source is valuable because it evaluates numerous types of people in varying environments.

Wells, Nancy. "Natural Environments and Human Health." *How Natural and Built Environments Impact Human Health* (2014): n. pag. *Design & Environmental Analysis*. Cornell University, 2014. Web. <http://www.human.cornell.edu/outreach/upload/CHE_DEA_NaturalEnvironments.pdf>.

16. Stackable Urban Beehive Is Perfect for Beginner Beekeepers

This online source is a great source of design inspiration by showing beehive designs that have already been created for human environments. Precedent in design is a very useful tool to analyze what has already been done and how effective it was, which gives designers a point to build off of.

Zimmer, Lori. "Stackable Urban Beehive Is Perfect for Beginner Beekeepers." *Inhabitat Green Design Innovation Architecture Green Building*. Inhabitat, 30 Jan. 2013. Web. 19 Oct. 2016. <http://inhabitat.com/stackable-urban-beehive-is-perfect-for-beginner-beekeepers/>.

17. PET Basics

This website hosted by the PET Resin Association answers questions about PET, what it is, and why it is so popular today.

"FAQs - Frequently Asked Questions." *FAQs | PETRA: Information on the Use, Benefits & Safety of PET Plastic.* PET Resin Association, 2015. Web. Dec. 2016. <http://www.petresin.org/faq.asp>.

18. USGS FAQ Nitrates

This sources gives information about nitrogen compounds. It answer many vital questions about water eutrophication, how it's caused, how it can be harmful to humans, and what can be done to prevent excess nitrogen from entering water systems.

"Why Are High Nitrate or Nitrogen Concentrations in Water a Problem, and What Can Be Done to Maintain Safe Levels?" *Why Are High Nitrate or Nitrogen Concentrations in Water a Problem, and What Can Be Done to Maintain Safe Levels?* USGS, 16 Nov. 2016. Web. 11 Dec. 2016. <https://www2.usgs.gov/faq/node/2858>.

19. NYC Drinking Water Supply and Quality Report

This source is a PDF of the entire 2015 NYC Drinking Water Report, which gives data results on the amount of nitrates found in NYC water in 2015.

"NYC Drinking Water Supply and Quality Report." *Nyc.gov*. Bill De Blasio, Emily Lloyd, 2015. Web. <http://www.nyc.gov/html/dep/pdf/wsstate15.pdf>.

HEXAPOD

BEE FORAGE PLANTER

Hexapod is a modular planter that provides food for bees in urban settings. The planter is rotationally molded PETE plastic from recycled water bottles and has a hexagonal shape for easy arrangement on any sized rooftop.

FUNCTIONS OF HEXAPOD

BEE FORAGING

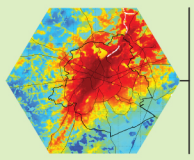
Urban bee populations have not been able to grow due to lack of plant food in cities. Adding Hexapods to rooftops will add to the available forage for urban bee populations to grow and thrive in cities.

HUMAN HEALTH

By going outside to tend to their hexapod gardens, urban dwellers will do more exercise, get more sunlight, and spend more time outdoors, which is beneficial to all aspects of human health.

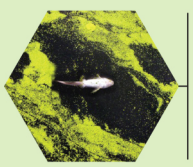
CARBON EMISSIONS

More hexapods means more plants in cities. Plants capture carbon dioxide that contributes to climate change. Making cities more green will help counteract climate change.



HEAT ISLAND EFFECT

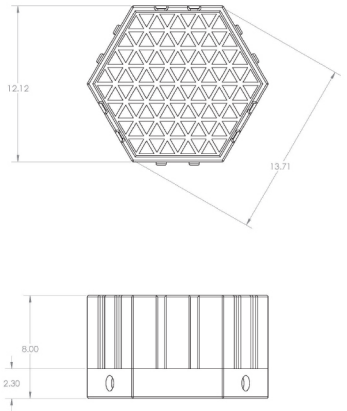
Hexapods and plants will help insulate rooftops and retain heat to make buildings more efficient and reduce the heat island effect in cities.

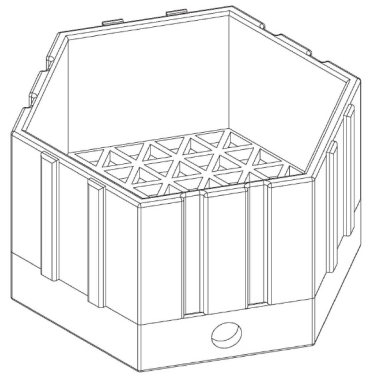


WATER EUTROPHICATION

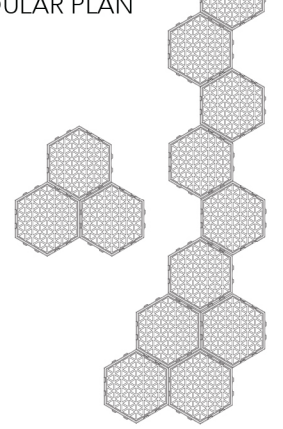
Hexapods allow water from water towers to filter through a plant, soil, and polyurethane layer which will fix nitrogen compounds that lead to water eutrophication. The plants will require less fertilizer and purify water in the process.

TECHNICAL DRAWING





MODULAR PLAN



THE PLANTS

These plants are able to survive and thrive in the un-natural environments of cities and attract bees and butterflies.

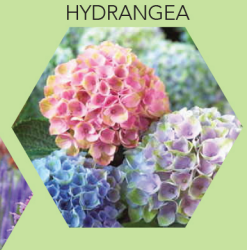
SEDUM

HYSSOP

AJUGA

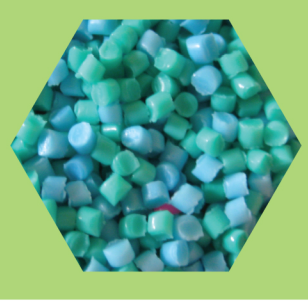
AGASTACHE

HYDRANGEA

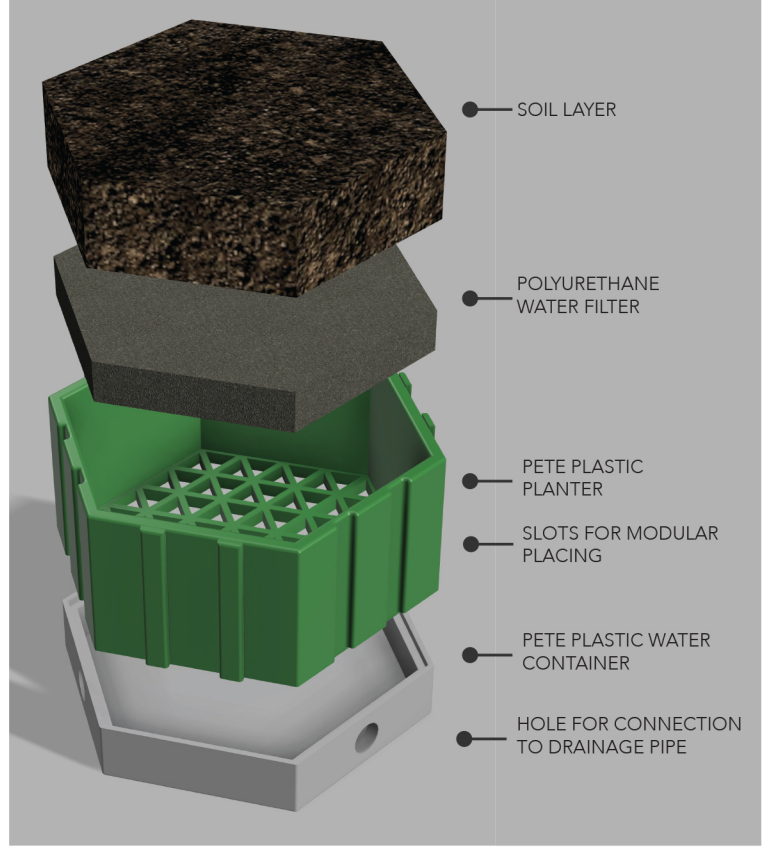


THE MATERIAL

Plastic water bottles are made of a lightweight thermoplastic called Polyethylene terephthalate. By collecting post consumer plastic water bottles and repurposing them to make Hexapods, the planters pose a much lower environmental impact in the raw material and manufacturing stage of the Life Cycle Assessment (LCA).



EXPLODED VIEW



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