BUZZ CITY
Bee-builder's Toolkit

by

Ryan Sisourath
Bachelor of Architectural Science, Ryerson University, 2011

A thesis

presented to Ryerson University

in partial fulfilment of the

requirements for the degree of

Master of Architecture

in the Program of

Architecture

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ABSTRACT

Bee populations are directly linked to the sustainability of our environment, as healthy bees are required for viable food production. Habitat loss and fragmentation from rapid urban development are some of the major factors that have led to an alarming decline in recent bee populations. Without bee pollination, our global food supply would diminish immensely leading to shortages and crises that threaten our food security.

This thesis will explore architectural strategies to create dedicated bee habitats within the urban realm. The designs will encompass the crafting of a bee builder's toolkit, which consist of bee-friendly components that can be adapted to various urban site conditions. It will look at opportunities for integrating bee-friendly habitats within the public sphere. These will create networks of pollination corridors that connect existing fragmented urban green spaces.

This strategy aims to strengthen pollination and pollinator health while stimulating public engagement and awareness of the environment.

Ryan Sisourath

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Thesis Supervisor: Dr. June Komisar

Second Reader: Scott Sørli

Program Representative: Vera Straka

Program Director: Dr. John Cirka

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Dr. June Komisar

Associate Professor, Department of Architectural Science, Ryerson University

Scott Sørli

Contract Lecturer, Department of Architectural Science, Ryerson University

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DEDICATION

I dedicate this to my loving and understanding family (Siel, Nee, Priscilla and Bobby Sisourath) for supporting me every step of the way.

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INTRODUCTION

01

*“Hope is the only bee that
makes honey without flowers”*

- Robert Ingersoll

// figure 01.01 Bumblebee looking for pollen by Author

01.0 INTRODUCTION

The main focus of this thesis is to recognize the contribution bees provide from pollination and the impact that they have on our environment. Through design, this thesis maintains, bee habitats can be fostered in the urban core, enabling bees to serve as an essential part of many natural ecosystems. Their unique role in flower pollination is vital to the development of certain plants, fruits and vegetables. Unfortunately, the importance of bees is still vastly misunderstood. The critical position this thesis takes is that the bee population is directly linked with our own survival, as healthy bees are required for food production and are linked to other aspects of a healthy ecosystem. Habitat loss, habitat fragmentation, industrialized farming practices, pesticide and herbicide use, climate change and parasitic infestations have led to a recent crisis within pollinator health. The result is an accelerated decline in bee populations.

Negative connotations which have labelled bees as pests have allowed the current global crisis to become overlooked. For that reason, it is necessary to address this lack of awareness and the potential serious repercussions that will result from the current rapid bee population declination.

This thesis will analyze the importance of the bee population and their role as pollinators and utilize architecture as a vehicle to help to reverse the ongoing rapid decline of the bee population. The design interventions will encourage consistent, healthy and sustainable bee population growth within the City of Toronto.

THE PROBLEMS

HABITAT LOSS

Exploitation of the urban environment for development has created a *concrete jungle* which attributes to habitat loss and fragmentation. Habitat fragmentation has created isolated pollination pockets which are separated from other green spaces by the surrounding hardscape environment.¹ These pollination pockets, not made with the bee in mind, are a futile attempt by the developer at creating limited public spaces within the heavily built urban milieu. Although these pockets are the pollinators' last place of refuge, these isolated sites cause pollinators to expeditiously saturate the remaining available resources. The extensive depletion of resources produces a potential in the shortage of adequate nourishment for pollinators within the urban realm. The nearest alternative pollination pocket, as a result, is beyond the native pollinators maximum travelling distance; therefore, they are forced to abandon their current home and seek a new nesting location.

// figure 01.02 In search for pollen by Author

FARMING PRACTICES

What was once a safe haven for pollinators – the farm – has now transformed into a field of harmful chemicals. The demand for agriculture has been increasing with human population growth causing the global demand to exceed the readily available food supply. This trend has resulted in industrialized farming practices such as monoculture, excessive use of fertilizers, insecticides, and other pesticides and herbicides. Monoculture is an agricultural process of growing a single species of crop for an entire season. This practice largely contributes to bee population decline as hectares of land are cleared to plant a single species of crop (agricultural food desert) resulting in a lack of biodiversity which is crucial to bee health and sustainability. The increased use of pesticides and herbicides to prevent pest infestation has both directly and indirectly affected the bees. If the treatments do not harm the bees externally, it will damage and weaken them from the inside from chemical consumption by severely affecting their immune system.

CLIMATE CHANGE

The drastic changes in today's current climate also attributes to the bee population decline as the harsh winters become unbearable for the bees to withstand. The length of the winter season has fluctuated over the decades causing some winters to last longer or commence earlier than anticipated. This simple inconsistency immensely disrupts the bees' pollination

schedule which subsequently affects the time in which bees begin to pollinate.

DISEASE AND INFESTATION

Several diseases and infestations have contributed to bee decline. One infestation is the Varroa Destructor mite, a major parasitic infestation that the bees have to face. These mites attack honey bees in particular by attaching onto the bee and sucking its blood causing it to weaken and eventually decay. The American Foulbrood (AFB) is a very serious and deadly disease that quickly spreads within the hive and can wipe out entire colonies. This pathogen is highly contagious and difficult to eradicate, often times resulting in a burning of the hive if not treated fast enough.² All the beekeepers equipment must be thoroughly sterilized as the disease can cause a relapse in a new hive if not properly and completely cleaned.³ These contributing factors will be discussed in greater detail within their respective chapters later on in the thesis.

THE CITY OF TORONTO

The thesis will investigate the City of Toronto as a case study for the components of the bee builder's toolkit. Toronto has been undergoing an intense wave of urban development with predictions that the city will run out of vacant land between the years 2031 to 2041.⁴ Subsequently Toronto's lands will be fixed by this time with limited available lands to rectify the existing fragmented habitats that bees require to

// figure 01.03 Harvesting pollen by Author

sustain healthy populations. In response to this, the design community must establish building practices that do not create a negative impact on the current bee population decline, but rather facilitate in their future health and growth. This can be achieved through a *kit of parts* where the components are not site specific and can be deployed and adapted to a variety of site conditions.

The work of this thesis engages with the discipline of architecture by crafting a new approach to architecture and urban design through a bee builder's toolkit. The concept is to use the components within the *toolkit* to produce bee-friendly habitats that would establish a pollination corridor connecting the fragmented pollination pockets within the city. This strategy will create an evolutionary network of connected public spaces which ensures continued healthy and sustainable growth of bee populations within the City of Toronto. As a result, these networked pathways become a place of refuge for the bees to safely inhabit as they travel through the corridor. Introducing refuge paths will help to reduce further stress upon the already sensitive population. The intention to protect and enhance bee populations in Toronto has already been mandated; as of April 1st, 2016, it was announced that Toronto became Canada's very first Bee City.⁵ The *bee builder's toolkit* would be the perfect addition to showcase bee-friendly components and habitats within a designated bee city. This also creates an opportunity for Toronto and its citizens to lead by example by reinforcing the importance of bees and their pollination on a micro and macro scale.

// figure 01.04 Honeybee in flight for nectar by Author

IN THE BEGINNING

02

02.0 IN THE BEGINNING

The earliest record of the existence of bees was approximately 100-million years ago, discovered by a team of researchers at Cornell University.⁶ It is speculated that the species originated within Africa, in the Northern hemisphere of the world, and not the Southern hemisphere as originally suggested by other researchers.⁷ This discovery coincides with the timeline in which the oldest flowering plants were known to be in existence.⁸ This relationship is the critical clue in explaining how the flowering plant evolved and diversified over centuries⁹ and reinforces the symbiotic relationship that flowering plants and bees have had beginning 100-million years ago.

Scientists later deciphered from rock paintings that over 17,000 years ago people called “honey hunters” raided feral beehives strictly for their honey.¹⁰ These “honey hunters” did not care for the beehive or the bees; they were opportunistic hunters and saw the value that honey had to offer them. This early practice established the importance of honey to man as a commodity. Early civilizations began domesticating and cultivating bees in a highly primitive method that eventually evolved into modern day beekeeping. Recent exploration on Stone Age pottery uncovered that beekeeping began around 9000 years ago, 4000 years earlier than previously believed.¹¹ Eventually,

*“To hunt successfully, you must know your
ground, your pack and your quarry”*

- K.J. Parker

// figure 02.01 Modern day honey hunter in Nepal

honey and beeswax were highly sought after resources that they became a form of currency or trade amongst the Egyptians and Romans.¹²

Records from the early 1600's indicated that European colonist began shipping honeybees to parts of North America.¹³ This began the globalization of commercial beekeeping for honey production and trades. As beekeeping grew and began spreading around the world, the man-made beehive had undergone various metamorphoses by different beekeepers. The main issue that beekeepers faced was that every time they extracted honey, it would involve destroying the entire hive or killing the colony.¹⁴ Many iterations surfaced but all seemed to have similar problems with honey extraction. It was not until 1851, where L.L. Langstroth, an American beekeeper, revolutionized the beekeeping industry with his development of the movable beehive frame.¹⁵ Langstroth developed a beehive that opened at the top and utilized the "bee space" more efficiently with removable honey comb frames.¹⁶ This design allowed beekeepers to open the beehive without disturbing the bees and allowed individual frames to be removed at any time for harvesting or inspection. Langstroth's honey bee frames are still widely used amongst beekeepers today and have become a standard in the beekeeping industry. His publication in 1853, Langstroth's "Hive and the Honey-Bee: The Beekeeper's Manual" paved the way for many upcoming beekeepers. The manual goes beyond the

// figure 02.02 L. L. Langstroth revolutionary removable beehive frame

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Movable Comb Hive, with glass on all sides.

*"The father of
beekeeping"*

// figure 02.03 Lorenzo Lorraine Langstroth

basic description of traditional beekeeping. Instead, he addresses every aspect involved in beekeeping from bee physiology to what to feed the bees to his innovations in beekeeping.¹⁷ Langstroth was considered by many to be the "father of modern day beekeeping" due to his contribution to the industry and practice.¹⁸ Following Langstroth's design, other iterations began to rapidly surface, eventually leading to the development of large-scale beehives that made commercial beekeeping achievable.¹⁹ Around the same time, Italy began exporting queen bees to the rest of the world which made it easier for beekeepers to increase their commercial beehive count.²⁰ Ordering queen bees allowed commercial beekeepers to split existing honeybee hives into several new hives thus increasing their honey production and hive count.

During World War II, honey became the main substitute when sugar rations were put in place for the war efforts.²¹ The demand for honey surged immensely and reinforces the importance that honey became as a resource during that time. Honey was not only used for consumption but was also used medicinally to treat wounds and became a key ingredient for the medical industry as it was believed to have fast healing properties.²²

13

// figure 02.04 Honeybee foraging for nectar by Author

In the late twentieth century beekeepers began to notice a change to their beehives. Their colonies were dying at an alarming rate but the source of the cause was unidentified. It was later discovered that a parasitic mite called the Varroa Destructor was responsible for the deaths.

In 1995 it was reported that Pennsylvania lost more than half of its entire bee colony in a year without a clear understanding of the cause.²³ Entire honey bee colonies would disappear without a reason, but it was not until 2006 that the United States experienced its first rapid decline in its honeybee population.²⁴ Beekeepers could not understand why entire bee colonies would decide to randomly disappear from the hive. This strange bee phenomenon led to the coined term of Colony Collapse Disorder (CCD).²⁵ This decline was not an isolated case to the domestic honeybee; native wild bee populations also suffered with rapid population loss.²⁶ Studies reveal that in the last 100 years, more than 50% of our Midwestern native bee species have disappeared from their habitats.²⁷ A report by the Xerces Society, a non-profit environmental organization who specializes in the conservation of invertebrates, lists all of the native bee species that are in decline within the United States. With more than 50 species at risk on the chart, it is suggested that 9 species are believed to be extinct as the sighting of those species have ceased to exist.²⁸

// figure 02.05 Varroa mite attached onto honeybee

It is clear that bees have been facing a decline in their population as society develops; however as of late, that decline has been rapidly accelerated due to the many factors outlined within the thesis. It is essential to understand what the source of the decline is and what architectural strategies can be implemented in counteracting the problem.

// figure 02.06 Varroa destructor mite [left]

// figure 02.07 Colony Collapse Disorder beehive [above]

POLLINATION 03

*“Where wise actions
are the fruit of life,
wise discourse is
the pollination”*

- Bryant McGill

// figure 03.01 Bloomed sunflower by Author

03.0 POLLINATION

The pollination world consists of more than just bees including; hummingbirds, butterflies, flower beetles and even certain types of bats, however, bees are the most effective and efficient pollinators. It has been proven that bee pollination is the quintessential component of food production as it accounts for 80% of the overall global flower pollination.²⁹ If bees become nonexistent under today's continuing trends, we would lose one third of our global food supply causing instability and a potential crisis to our global food security.³⁰ Maurice Maeterlinck has been noted for stating “that if bees were to go extinct, mankind would fall in 4 years after their extinction”, within his published book, “The Life of the Bee”.³¹ He adds: “no more bees, no more pollination, no more plants, no more animals, no more man”.³² At the time this book was initially published, it was plausible that the extinction of bees would cause a major collapse to mankind. Though there has been no proof to substantiate Maurice's claims, it is likely that their extinction will initiate a food crisis which would create a domino effect as time progresses. Just one example, coffee crops, can provide an idea of what could occur. Coffee bushes do not required bee pollination as they self-pollinate through the wind³³ however; bee pollination increases the yield of coffee beans by an enormous rate. Without bees; therefore, the prices of coffee beans and coffee

itself would inflate because the global demand would exceed the readily available supply we have come accustom to. For more essential crops, this may result in famine. This is just one of many issues that would occur if bees were to become extinct which demonstrates the importance bees possess. If the health and population of the bee is not preserved the outlook into the future would present itself as a bleak, grave and smelly (for non-pollinating flowers often give off a rotting meat odor).³⁴

Plants require pollination in order to flower and bloom, this process takes place though the transfer of pollen from the male part (the stamen) to the female part (the stigma) of the same plant.³⁵ In the case of transferring pollen from the stamen to another plant's stigma is called cross-pollination and that produces much stronger plants.³⁶ It should be noted that cross-pollination works only on the same species of plants, rose pollen cannot be used to pollinate an apple tree flower.³⁷ Pollinators, especially bees are the main enablers of this action, nicknaming them the “messenger of love” for plants. As articulated by Pieter Basedow, the Chief Apiarist at the University of Toronto BEES:

“pollen can be transported in many different methods depending on the type of pollinator. For instance, it can be transferred from the feather of a hummingbird, the hair of a fly, the tongue of a bat, aerial currents by the wind; however, the majority of the pollen is transported on the hairs of a bee. Bee pollination can directly or indirectly affect the organisms of the planet, although there is currently not enough understanding as to the scale of proportions these effects can cause, present documentation indicates that whatever the outcome may be will cause negative effects onto the environment.”³⁸

// figure 03.02 Cross-pollination, Illustration [above]

Artificial pollination is something that is practiced within China as that is the only way they can get pollination as bees cannot live in that environment. Artificial pollination is just not possible here in Toronto, the amount of labour required cannot justify the profits and as Basedow states: “to meddle with nature, to me is very dangerous.”³⁹ Artificial pollination however is not uncommon in some parts of the world as it is practiced to increase annual yield rates or it is their only source to grow certain crops.⁴⁰ Honeybees are limited to the types of plants they can pollinate as they cannot create a strong enough vibration to loosen the pollen.⁴¹ This makes bumblebees and other large solitary bees vital to the environment, because without their aid in pollination, we would need to rely solely on artificial pollination to grow certain crops.⁴² Green City Growers in Boston hand pollinate their squash plants, however there is a 3-day window for that pollination to occur otherwise the plants will not flower.⁴³ This ties back to Pieter Basedow’s concern of meddling with nature. If we start to really tamper with the nature of things, it could cause some serious negative side effects onto the natural environment.

// figure 03.03 Hand pollination

// figure 03.04 A beekeeper tends to a beehive

03.1 BEE ECONOMICS

Bee diversity is very important for crop growth as it leads to fuller, rounder healthier produce.⁴⁴ In order to maintain this kind of diversity, more wildflowers need to be introduced within the hardscaped city. Solitary bees unlike their respective relatives the honeybees are not easily manageable. Bee hotels and plots of natural undisturbed land will help increase their population which will help intensify pollination. This subchapter on the bee economics however is more tailored towards the honeybee as the discussion is about instrumentation and how it can be used to advance the practice of beekeeping. Solitary bees are not managed and therefore do not require the same type of instrumentation but they could benefit from some of the same techniques that would be applied towards the honeybee.

THE HIVE

During the winter months, beekeepers either insulate their hives with dark corrugated sheets (much more cost effective) or they use a product called the “*Bee Cozy*”⁴⁵ which is a sleeve that wraps itself around the brood chambers of the beehive. Inside of the sleeve is R-12 insulation and the system is topped off with Styrofoam insulation which is then sealed off with a lid.⁴⁶ Even this method however is unpredictable as there is no way of knowing how cold the temperature

// figure 03.05 “Beecozy” winter hive wraps

can become and the insulation can only perform for what it is rated for so often times it can become somewhat of a gamble for the beekeeper as they can apply the “*Bee Cozy*” and just hope for the best. Assuming there are no extreme cold warnings, the “*Bee Cozy*” maintains an average temperature of 20 degrees Celsius within the hive.⁴⁷

Pieter Basedow gives two examples of specially designed beehives that are successful in maintaining temperature control but are not scalable to commercial levels making them non economical. The first one is in Greece where the manufacture a hive out of plastic with insulation inside, therefore eliminating the need of wrapping the hive during the winter season, however the price is astronomical and at \$600 a hive it is not something the commercial beekeeper would consider purchasing.⁴⁸ The other hive is the *Flow Hive*,⁴⁹ it is a successful beehive because of its sleek design however the temperature needs to be above 25 degrees Celsius in order for the honey to flow out of the hive and the hand crank to get the honey to come out is not something natural to bees or beekeepers and during that process of turning the hand crank, bees are squished within the gears which can make the hive seem unethical and at \$900 a hive it is not economical for commercial beekeepers.⁵⁰

Finding the perfect material for beehives can be challenging especially when trying to balance out cost and material availability. Maintaining the hive at a consistent temperature while preventing humidity from creeping in is especially difficult in current climate conditions as one day it will be minus 15 degrees Celsius and the next day it can be 8 degrees Celsius which can be extremely detrimental to bees with such a sudden fluctuation in temperature. Pieter Basedow expresses that:

*“the warmer temperature would trick the bees into coming out of the hive, essentially causing them to break their cluster and when the temperature dips below freezing point within a few days, the bees will not have enough time to re-cluster themselves causing the entire hive to die off overnight.”*⁵¹

THE COLONY

Though it is possible to buy a new stock of bees every year (called a nucleus), commercial beekeepers breed their own queens and split the hives in order to be more commercially viable as it is critical in order to control the cost element. Bees get weaker after a hive split that could explain why the lifespan of the queen bee has decreased so dramatically. A queen bee was capable of being kept upwards to 5 years, however, it is now considered lucky if a beekeeper can keep them for 3 years.⁵² The average lifespan of a hive is about 2 years before having to re-queen the

colony.⁵³ This is becoming a big problem as hives are no longer staying alive that long anymore. Basedow claims: “*you have to be very scientific about keeping bees; you cannot just throw a hive into a backyard and hope for the best.*”⁵⁴ In order to maintain productivity there cannot be more than 40 hives per apiary, any more will cause an oversaturation in resources and they will not be able to produce an efficient amount of honey.⁵⁵ For example, a 100 acre land cannot be filled with 1000 hives; the next set of hives should be 10km away from the current area as bees can fly up to 5km when foraging for nectar.⁵⁶

INSTRUMENTATION

With the amount of new technology constantly being accessible to the public, it is time to take that available technology and turn it into instrumentation for the beehive. Proper instrumentation is critical to have in a beehive as it will give you the appropriate feedback as to what is currently happening inside of the hive in real-time. From discussions with beekeepers, it seems that thermal imagery, temperature control, live video feed and a scale are the main instruments that would greatly benefit beekeepers of the future. The idea of being able to check up on a beehive through the convenience of a cellphone is almost futuristic. This is not the case as saltwater reef keepers have had this kind of instrumentation available to them for quite some time now. Saltwater reef keeping is comparable to beekeeping as the parameters have to be almost

// figure 03.06 Beehive Instrumentation - Moisture Sensor [above]

immaculate. If the alkalinity is too low of the magnesium level drops below a certain level or the salinity is too high can all lead to *tank crashes* which can be similar to a hive collapse but everything within the tank will die. Reef keeping instrumentation allows the reef keeper to check on the parameters of the tank at any time form the cellphone, there are even capabilities of connecting to a live stream of the tank to see its current conditions. There are also auto-dosers that are programmed to dose certain trace elements into the tank when the levels are detected to be running low. Although the technology is made readily available there is still a large amount of *husbandry* involved as routine water changes are required to replenish elements and remove nitrates within the tank. This is very similar to beekeeping where the beekeeper must be vigilant and constantly checking on the hive, monitoring it for mites and diseases. Currently it is all a guessing game for beekeepers and that is not the proper way to continue in the practice as there can never be any reassurance. The winter time is the most crucial for this type of instrumentation as the beekeeper would prefer to monitor the status of their beehives in the comfort of their own home and not have to trek through 6-feet of snow and disturbing the beehive. Timing is key as bees can literally die overnight, much like a tank crash in a saltwater reef can kill everything within that tank in a matter of hours. Pieter Basedow says that the technology is available for the beehive but it is not viable for beekeepers, for instance a digital beehive scale can cost \$1000 per hive. Having the correct instrumentation allows the beekeeper to monitor and control the hive remotely and to follow up accordingly with the

appropriate action if necessary.⁵⁷

Currently, beekeepers are treating their hives with antibiotics on speculation and are doing it for precautions.⁵⁸ The antibiotic they are injecting is called Oxytetracycline, it is the only legal antibiotic in Ontario and it is not to be used during honey flow.⁵⁹ This current strategy helps keep everything in check, especially the *American Foulbrood* so it does not come out of the hive as it is extremely contagious.⁶⁰ The antibiotic does not get rid of the pathogen as it remains in the hive, as there is no cure for *AFB* but it prevents it from spreading as fast giving beekeepers enough time to destroy the hive.⁶¹ Beekeepers use it mainly in the winter time in hopes of keeping the colony healthy. The problem with pumping Oxytetracycline into the hive so aggressively is that it shows up in the wax and honey which eventually contaminates the ground water and raises a whole lot of other issues.⁶² Pieter Basedow is concerned that

*“this creates the same cycle that the meat and milk industry is currently facing, for instance, it is not natural for a cow to produce as much milk as she does now but this only happens because she is being treated constantly and artificially and that has its own negative side effects. It is becoming clear that these same side effects are beginning to surface in honey production. When honey is analyzed there are trace amounts of antibiotics found in it.”*⁶³

// figure 03.07 Beekeeper dosing bees with antibiotics

This is why instrumentation is very critical in future beekeeping practices. The all-in-one instrumentation would allow beekeepers to monitor the performance of the hive in a backyard versus rooftop. The data would allow beekeepers to determine where the most effective locations are to place beehives. They are currently being placed wherever there is left over space, usually out of sight away from the public and there is no documentation or proof that reveals that these current locations are significant, so it once again becomes a guessing game.

// figure 03.08 Dead-bees on a honey frame

03.2 COLONY COLLAPSE DISORDER

Colony Collapse Disorder (CCD) has been made to be a bit dramatized according to Pieter Basedow. It has been made to be a bit too simple in the sense that the negative agents for the bee population decline are mainly from: pesticides, insecticides and monoculturing, they are definitely a big problem but there are other factors that affect the bee population, as Pieter Basedow states: the biggest problem that beekeepers face currently is the Varroa Mite and there hasn't been enough research to discover a method to completely eradicate the parasite. High mite loads will cause a collapse; the hive will be empty with no dead bees in it.

It is possible to prevent a Varroa Mite infestation but even the most rigorous approach only accounts for a 95% eradication of the mites, meaning they cannot be completely rid of. The rigorous approach involves testing everything in the hive once a month, Basedow explains this is done by taking a sample of 100-200 and putting them into a shaker with alcohol or windshield washer fluid (more practical) shake the bees for a minute or two and the mites will fall off through a screen. The bees will die in this process but this sample allows the beekeeper to see mite load on a sample and assess the stages of infestation each hive is at currently. Basedow gives an example if 4 or

5 mites fall out of the sample of 200 bees that poses a problem for the beekeeper as a colony of 50,000 would have an infestation of over 1000 of the Varroa Mites and that means the hive needs to be treated immediately. People are profit driven and queens and bees are being imported from other provinces that are infected with the Varroa Mite which causes it to spread even more.

Biggest problem for urban beekeeping is the Varroa Mite contamination as bees meet at the same flower and the mite jumps from one bee to another bee,⁶⁴ therefore one beekeeper may be extremely rigorous in containing the Varroa Mite infestation while the other bee keeper may not be as vigilant. If both hives are within a 5-6km radius of each other, then both hives will be infected regardless of the stringent eradication and this creates a vicious circle. This can lead to an even worse disease called the *American Foulbrood* AFB, it is a pathogen that results in burning the entire hive and all the equipment used on the infected hive.⁶⁵

THE VARROA MITE

The Varroa Destructor originated in Asia and began invading parts of the world through contamination of not being vigilant with infected beehives and at that time there was not enough research in treating the hives that were infected with the mite.⁶⁶ This parasitic mite targeted honeybees in particular and was the culprit in causing collapsing beehives. It was first discovered in Florida where it began to spread through parts of the United States and eventually affecting all of North America.⁶⁷ Australia is the only known country that is currently mite free.⁶⁸ Being mite free, they have very strict rules when importing and exporting bees. Visiting beekeepers are not allowed to bring their own bee suits in fear of any diseases or parasites that might contaminate the facility. Recent reports; however, indicate that the Varroa mite may have finally arrived into honeybee colonies just outside of the Australian border.⁶⁹ The Varroa mite attaches itself onto the honeybee and begins to suck its blood. This weakens the bee and its immune system and the bee becomes lethargic and disoriented which eventually leads to death.⁷⁰ If the mites are left untreated, the entire colony will become infected leading to an inevitable collapse to the hive.⁷¹

Varroa mites do not affect solitary bees, they are only threatening in a managed environment and these parasites are brood driven so they are already on the brood when they break open from the comb.⁷² On feral beehives however, the bees are capable of dealing with minor Varroa Mite infestations because it is unmanaged and the lifespan of the bee is finite. Pieter Basedow noted that in contrast to managed colonies where everything is designed in maximizing honey production, the focus in nature is completely different, Basedow states: feral bees produce enough to feed

themselves and have enough storage for the winter time so they are keeping their numbers much lower than a managed hive. This is why the Varroa Mite is very threatening to managed hives and still a major problem today.

Understanding the life cycle of the Varroa mite

// figure 03.09 Varroa mite parasite in the beehive, Illustration [above]

NATURE’S CHILDREN

04

04.0 NATURE'S CHILDREN

Bees can be considered as the canaries in the coal mines, as they can signify vital information about the state of the natural world.⁷³ Areas that have undergone significant human activity are where the bees excel at indicating the current state of the environment.⁷⁴ Bee health can tell us a lot about the environmental health and even our own well-being.⁷⁵

Bees prefer semi-desert like conditions; it has been discovered that the bee diversity is considerably higher than any other type of habitat.⁷⁶ Bees do not like rainy or cloudy weather, if the location they live in is consistent with rain, they will often leave the current hive altogether and find a more suitable place with the appropriate parameters.⁷⁷ Ample amounts of wild flowers provide the essential resource that the bees need to live and thrive.⁷⁸

Ontario is home to 5 major categories of bee species: the *Apidae* (honey bees, bumble bees, carpenter bees and some solitary bees), the *Andrenidae* (solitary mining bees), the *Halictidae* (sweat bees), the *Megachilidae* (leafcutter and mason bees) and the *Colletidae* (plasterer bees).⁷⁹ Toronto is home to over 300 bee species making it a major city that has one of the most diverse pollinators in Canada.⁸⁰

// figure 04.01 The bee's natural habitat by Author

	live granitic	live aspen	solitary	social	ground nesting	tree/wood nesting	live nesting	sage	pasture
●	○	○	○	●	○	○	●	○
●	○	○	○	●	○	○	●	○
○	●	●	○	●	○	○	○	○
○	○	●	○	○	●	○	●	○
○	○	●	○	○	●	○	●	○
○	○	○	○	●	○	○	○	○
○	○	○	○	○	○	○	○	○
○	○	○	○	○	○	○	○	○
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// figure 04.02 Bee species per Canadian Ecozone by Author
source: <https://www1.toronto.ca/City%20of%20Toronto/City%20Planning/Environment/Files/pdf/B/Biodiversity%20-%20Bees%20of%20Toronto%20accessible%20final.pdf>

// figure 04.03 Bee species of Toronto by Author
source: http://www.davidsuzuki.org/issues/downloads/Pollinator_Guide_5pg.pdf.

04.1 THE HONEYBEE

The honeybee can be seen as the poster child of all pollinators, although not native to North America⁸¹, they are the most common species of bee known to society. Honeybees are the most hardworking pollinators as they literally work themselves to death, hence their 6-week life span. In the winter time, the queen gives birth to winter bees and they live for months because they don't need to fly and remain clustered within the hive for the entirety of the winter season.⁸² In order for this to be effective and for the winter bees to survive for such a long period of time, they need to have nutritious food available to them.

Honeybees whether feral or domestic live in colonies that range from 10,000 - 50,000 bees per hive, and they can fly up to a distance of 5km in search for nectar.⁸³ What is unique about the honeybee besides of their large colonies is that they communicate through a "*waggle dance*" that tell other bees where foraging areas can be found and what direction to fly in, the faster the waggle, the closer the location.⁸⁴ They also have a pheromone that is unique to each colony, therefore the bees know exactly which hive to return to at the end of the day.⁸⁵ Every bee in the colony has a specific role the moment they emerge from the brood cell.⁸⁶ The queen bee can lay up to 2000 eggs per day, any infertile eggs become drones and the fertile eggs

// figure 04.04 Honeybee searching for nectar by Author

// figure 04.05 Specific roles of the honeybee within the colony by Author
 source: <http://www.benefits-of-honey.com/roles-of-bees-in-a-hive.html>

lead to workers.⁸⁷ The worker bee is the heart of any hive as they are the ones who construct and maintain the hive, feed and care for the broods, scout new nesting locations, forage for nectar, filter toxins through their body and create storage for the gathered nectar and pollen.⁸⁸ The drones fly out in the afternoons and try to find a princess to mate with, otherwise they are usually exiled in the late fall/ early winter season by the worker bees because they bring no value to the hive and instead hinder the on the available supply and resources.⁸⁹

Unlike their larger counterparts, honeybees remain true to one type of flower or crop until they have finished pollinating every single floral within the vicinity before moving on to another species.⁹⁰ This makes them very effective and desirable for almond orchard pollination. 80% of almonds come from California and beehives from all over the Continental U.S.A are loaded onto a flat bed and trucked all the way across the states.⁹¹ Although almond pollination is good for bees, the scale is too massive and it creates a large strain onto the bees' health from moving the hives for such a long distance.⁹² Pieter Basedow supports that by stating:

*"bees do not like to be moved around, and that it already causes his hives major trauma just by moving it 10 feet from its original position because it forces all the bees to come out and perform a reorientation flight and they are already completely flustered, so imagine that on a massive scale in the middle of the night on a truck bed, unfortunately this is all a part of becoming an industrialization and a big business."*⁹³

Much like in the US with the almond trees, the honeybee is becoming a huge factor in blueberry farms in the eastern parts of Canada.⁹⁴ It is essentially becoming another major industry where the bees become the 'tool' or the 'object' and their overall health and well-being becomes disregarded.⁹⁵

// figure 04.06 California Almond Farm

BENEFICIAL OR OVERRATED?

Previous research has led to the question about the effectiveness of the honeybee pollination when compared to native bees. There have been studies done that illustrate that honeybees are interested in the nectar more than they are in pollen, thus making them not as effective at pollinating as other bee species.⁹⁶ Honeybees unintentionally pollinate flowers because of their pollination pockets which keep pollen relatively intact so when visit another flower for nectar, very little pollen drops out aside from the ones collected on their furry bodies.⁹⁷

This sparks the question of are honeybees beneficial or are they overrated? Often times when someone is asked to think of a bee, this first thing that comes to mind is the honeybee and when they are asked to draw it, without realizing, a bumblebee (native bee) is drawn instead. Despite this visual misconception, the honeybee is in the spotlight and they attract all the attention. As a result, native bees are neglected and unprotected. It is understandable why honeybees are glorified; they provide us with honey and beeswax, two important commodities.

// figure 04.07 Assortment of honey and beeswax products at a farmer's market [left]

// figure 04.08 Bumblebee foraging for pollen by Author

04.2 THE BUMBLEBEE

The bumblebee is the largest ground nesting bee species. The bumblebee is a very unique pollinator; it shares some characteristics with the honeybee. They both have colonies, however, bumblebee colonies range from 100-400 per hive depending on the species itself, they are also ground nesting and, although both species produce honey, bumblebees only produce enough honey for themselves to survive the season.⁹⁸ The lifespan of the bumblebee is quite fascinating as the entire nest naturally dies out by September.⁹⁹

Bumblebee queens hibernate in the winter by living underground and emerge around the months of February or March to begin a new colony.¹⁰⁰ Pussy willows are one of the few plants to flower at such an early time, making them the ideal resource for nectar (female tree) and pollen (male tree) for the queen.¹⁰¹ Pollen is a great source of protein and the queens ovaries have been shriveled up over the winter season, so by consuming the pollen, it expands the ovaries and helps develop the eggs.¹⁰² The queen will begin her search for a nest, because they are such poor diggers, she prefers to inhabit previously abandoned habitats from rats or birds as they also provide the necessary insulation required.¹⁰³ Once the queen has settled she will lay a set of eggs and care for them similar to a mother bird until they hatch. The

first generation of bees to emerge are all worker bees (females), they inherently become the ones who feed and care for all future generations of broods as well as the queen.¹⁰⁴

Unlike their cousin, the honeybee, bumblebees do not build an immaculate organized hive.¹⁰⁵ Instead, they build honey pots to store pollen and then build a wax dome over the nest for extra protection and insulation.¹⁰⁶ When July reaches, the nest should have grown to a colony of a few hundred bees. At that point, the worker bee production stops and the queen begins to lay both male and female eggs.¹⁰⁷ The female eggs she lays are not worker bees but future queen bees (princesses) and they grow up to be much larger than average.¹⁰⁸ Once the future queens become an adult, they leave the nest and mate immediately afterwards while storing the sperm in their body and then preparing for hibernation.¹⁰⁹ The reasoning for the early hibernation is to avoid parasitic infestations or potential predators.¹¹⁰ The current queen then becomes weak and frail and the again workers begin to slowly die off and the food supply eventually dries up and the entire nest dies by September.¹¹¹

Bumblebees are known to pollinate three times more apples per minute than honeybees making them productive pollinators.¹¹² Bumblebees are necessary for tomato production as their strong vibration frequencies are capable of loosening up the pollen

// figure 04.09 Bumblebee nest [above]

within the plant itself allowing for pollination to occur.¹¹³ Cultivating bumblebees for tomato farms is becoming an increasing trend now as it allows for efficient natural pollination.

Bumblebees cannot tolerate hot climates as they will overheat and die if their body temperature exceeds 44 degrees Celsius.¹¹⁷ In warmer regions, they have shorter fur and begin their foraging in the later afternoon to early evenings.¹¹⁸ Bumblebees have the ability to auto-regulate their body temperature to 35 degrees Celsius.¹¹⁹ This unique talent is achieved by their furry bodies and their wing flap. Their furry bodies provide ample insulation for them and they are capable of flapping their wings at a rate of 200 flaps per second which is equivalent to 12,000rpms. This alone generates ample heat for the bee itself and their fur allows them to retain that heat.¹²⁰ It is crucial that they keep their thorax warm as that is where the flight muscles are located and if it is not kept warm they will seize up and not be able to fly.¹²¹

EXTINCTION

The bumblebee is also on the decline, so far there have been reports of three types of species that have been known to have gone extinct globally and they are: the *Bombus rubriventris*, the *Bombus melanpoda* and the *Bombus franklini*.¹¹⁴ The Rusty Patched Bumble Bee (*Bombus affinis*) seems to be next on the list as it used to be a very common species that lived within the Eastern United States, but hasn't been seen since 2003.¹¹⁵ The species is now close to extinction as 95% of the population has been wiped out through urban development, habitat loss and contamination of pathogens and parasites from honeybees.¹¹⁶

// figure 04.10 Solitary bee gathering pollen and nectar by Author

04.3 THE SOLITARY BEE

The solitary bee is a non-social bee species, meaning it does not live in a colony.¹²² They tend to be small, dark and drab in colour which is why they often go unnoticed.¹²³ Each female solitary bee builds her own nest either in the ground, hollow flower stems or hollow wood chutes.¹²⁴ The mother lays her eggs in a mixture of pollen and nectar and then seals the opening of the nest and leaves letting the broods to hatch and fend for themselves.¹²⁵ This means that some solitary bee species can spend up to 11 months living in the nest before emerging.¹²⁶ Their behaviour and mentality is very different from that of the honeybee and bumblebee, they do not produce honey, have a queen, swarm and are completely docile.¹²⁷ They also do not produce wax, instead they use other materials to construct their nest and cells depending on the species.¹²⁸ The female can choose whether to lay a female or male egg, because males emerge quicker than females, they are laid at the forefront.¹²⁹ The eggs are laid much differently than in a beehive, each egg is laid with a mixture ball of nectar and pollen that acts as nourishment for the bee once it's hatched.¹³⁰ Each cell has a partition wall to create an individual space for each bee, once the tube is filled up, it is sealed and the mother will move on to another nest.¹³¹ Since the mother never sees her offspring grow, everything they need is provided to them from the beginning.¹³² The solitary bees drink nectar straight from the flower

and solely collect pollen that is later mixed with some nectar which becomes food for the young when hatched.¹³³ Solitary bees have been known to be far more effective pollinators than social bee species, depending on the species, one solitary bee can be equivalent to 120 honeybees in terms of pollination.¹³⁴ That is because they do not have pollination pockets, therefore any flower they visit, they lose a lot more pollen, which in turn makes them the overall better pollinator.¹³⁵

Solitary bees are a species in decline and this is mainly because of the encroachment by human on the solitary bees' natural habitat.¹³⁶ Neatness and uniformity of lawns and parks with no bare spots, non-flowering grass and pollen-less flowers all contribute to their habitat loss.¹³⁷ As all the media and attention has been directed towards the honeybee, perspective is being lost on the solitary bee. Field studies have been conducted and revealed that solitary bees are much more sensitive to seeds and fields that have been treated versus the honeybee.¹³⁸ The density in solitary bees was half compared to an untreated field and their nests were almost completely abandoned.¹³⁹ Certain solitary bees rely on specific wild flowers, if they cannot forage for that type, they will die.¹⁴⁰

Initiatives to build solitary bee hotels have been on the rise, however studies reveal that rooftop hotels result in a higher abandonment rate because the distance between their nest and foraging area is too great that they become exhausted and will search for a closer

home.¹⁴¹ Solitary bees tend to fly at a much smaller distance, averaging at approximately 1km, hence the term '*hotel*'.¹⁴² Providing rooftop meadows are crucially important as two-thirds to three-quarters of solitary bees nest in the ground, this means that the hotels only account for one-quarter of the species.¹⁴³

// figure 04.11 Solitary bee hotel

POLICY 05

// figure 05.01 Rooftop beehives in downtown Montreal

05.0 POLICY

There is no existing beekeeping typology that can house bees in a public setting with 100% safety. Bees are harmless and normally don't attack people, but there are the occasional bee sting which is why certain precautions are taken place. This is especially critical to people who are allergic to bee stings and require an epi-pen.

Beekeeping used to be a trade that was practiced by beekeepers in the farmlands where they had large plots of land to spare. As time progressed, that movement slowly crept into the city core. Urban beekeepers are becoming much more prominent and many people living in the city are starting to keep their own beehives. In Toronto, current citywide bylaw states that:

*"No person shall place hives or leave hives containing bees within 30 metres of a property line separating the land on which the hives are placed or left from land occupied as a dwelling or used for a community center, public park or other place of public assembly or recreation. 2002, c. 17, Sched. F, Table."*¹⁴⁴

This means that beehives are usually kept on the rooftop of tall buildings or in secret, similar to a "guerilla garden." The issue with both methods are

that they remove the beekeeping away from the public eye as the idea is to remain out of sight. Because of the reactions to this bylaw, educating the public about the importance of bees and their impact on the environment becomes difficult. It simultaneously contradicts the city's current title as a "Bee City". The awareness about the importance of bees or how beekeeping works will remain shrouded to the public if the practice is continuously secluded.

Subsequently, the Toronto bylaw on beekeeping needs to be addressed as the current 30 meter rule is not appropriate for urban beekeeping to successfully flourish. Pieter Basedow expresses his disbelief by stating: *"who has a property that big? Not even 10-million dollar homes in Rosedale have that kind of property."*¹⁴⁵ This means that unless there is a change in policy, all beehives presently within the City of Toronto are non-compliant. Universities however, can be exempt from the non-compliance by claiming that the beehives are for research purposes and are attached to faculty.¹⁴⁶ For example, the University of Toronto beehives are technically not compliant with the bylaw but because the beehives are associated with the Faculty of Forestry for research, they are excluded from the non-compliance.¹⁴⁷ At the present time, the property line bylaw is not strictly enforced by the city; it is however, based off of a complaint only basis which is then investigated by city inspectors.¹⁴⁸ Instead this bylaw would be much more apprehended if it was

// figure 05.02 Policy and standards

driven by actual need. In a case where a beekeeper has 3 beehives in their backyard and they have neighbouring residents whom some are highly allergic to bees (i.e. someone who carries an epi-pen on them at all times), then the bylaw would be enforced. The beekeeper therefore must comply with the property line rule and has to find someplace else to store their beehives.

POLICY CHANGES

Apart from changing the bylaw to be driven by an as needed basis, there are additional items that should be mandated which would further supplement the property line compliance. Hive registration is a critical aspect and beekeepers need to be compliant in terms of registering their hives with the ministry. Identifying hive locations is mandatory in case of a disease or parasite outbreak, all beekeepers within the proximity can be immediately notified via email or text message about the potential epidemic. This would allow beekeepers to take the appropriate preventative measures to mitigate any possible contamination ahead of time (i.e. injecting an antibiotic called oxytetracycline into the hives to prevent the American Foulbrood from infecting the colonies). Hive registration is currently not required; therefore any disease or outbreak spreads fairly quickly without any warning to neighbouring beekeepers. This has become a common problem within Toronto.¹⁴⁹ From a policy perspective, registration of the hives should be made mandatory by all beekeepers within the City of Toronto. One of the biggest benefits to hive registration is swarm control. Honeybees are known to swarm when finding a new nest or rescuing a queen bee and that can be a frightful sight to the public. How registration can help with swarm control is if for example a hive is registered to 510 Spadina Ave and all of a sudden there is a swarm of bees in a neighbour's backyard. They can call the City describing that there is a swarm of bees on their property. The City will then be able to look up the address and be able to identify all the beehives that are registered within that area. They can call the appropriate beekeeper explaining that their bees are swarming a neighbouring property and from there the beekeeper can work together with the City to figure out the cause of the swarm and plan on how to move the bees safely back to their hive. If unregistered hives are discovered, the corresponding beekeeper and related parties will be charged with a hefty fine as a consequence and it will be recorded under their record as an offence. If additional offences are issued to the same beekeeper, other ramifications such as license suspension could occur to illustrate the seriousness of registration.

On April 28, 2015, the City of Edmonton passed an amendment that permitted urban beekeeping as the recognition in the potential and benefits of keeping bees in the city increased.¹⁵⁰ The City of Edmonton has a beekeeping licensing program that would be a perfect example for the City of Toronto to adopt.¹⁵¹ The application process is broken up into

4 steps. Step 1, requires the potential beekeeper to read and understand the City's Urban Beekeeping Guidelines.¹⁵² They need to acknowledge the responsibilities and commitment needed on becoming a successful beekeeper. Step 2 is registering and identifying the hive location with Alberta's Premises Identification Program as a part of the Animal Health Act.¹⁵³ This system allows all the beehives within the city to be traced so in a case of a disease outbreak, the infected hive(s) can be immediately quarantined to prevent contamination amongst other hives and all nearby beekeepers can be warned instantly. Step 3 is an annual requirement for all beekeepers to register with the Provincial Apiculturist by June 30th as this is a part of the City of Edmonton's the Bee Act and Regulation.¹⁵⁴ Step 4 is to apply for a beekeeping license with the city through an online form provided by the city's website.¹⁵⁵ This part requires the beekeeper to provide information about the beekeeping site, the training completed, who your mentor is and if the person is a first time beekeeper. All this information is vital in determining whether or not the person is capable in becoming a safe and successful beekeeper. Unfortunately the City of Toronto does not have something in this manner; however, the whole point of the policy change is to address and incorporate policies from the more successful urban beekeeping cities. As a result this would encourage the number of certified beekeepers.

How Toronto can improve upon the City of Edmonton's licensing process is to include a successful completion of mandatory beekeeping courses as a part of the overall application. Before operating a beehive, the potential beekeeper should complete an introductory course in beekeeping to give them some background in the practice. Pieter Basedow advocates for this type of licensing process to take place in Toronto he states:

*"It is crucial for people to have rudimentary knowledge before going into beekeeping. They need to have some basic knowledge in applications of what works and what doesn't, how the bees function during different times of the seasons, how to discover early symptoms of potential outbreaks, the proper steps in treating bees for mites and other diseases, how to set up a routine maintenance schedule and precautions and general rule of thumbs. These should form the base line for all beekeepers in order for them to obtain their license."*¹⁵⁶

This fundamental knowledge will prevent issues of an introductory beekeeper owning 8 active beehives in a tiny backyard in a busy neighbourhood. Although bees do not normally sting, the fact of having a large number of them flying around could make people feel uncomfortable.

The mandatory courses on beekeeping should also be made available to the general public to increase awareness and knowledge of the bees. People who are interested in learning can do so by signing up through the City of

Toronto's beekeeping website. Having the general public learn about the basic knowledge of beekeeping is a great way to initiate local neighbourhood beekeeping initiatives. Generating interest among the public with neighbourhood managed colonies can provide the participating community with local organic honey.

The City of Toronto can look towards other jurisdictions on an international level where they have successful beekeeping as a template in creating proper policies and guidelines for urban beekeeping within the city. For instance, the City of London in the United Kingdom has exemplary jurisdictions as every borough within the city has its very own beekeeping association.¹⁵⁷ Each organization takes care of all the beekeeping requirements such as hive location and registration. Every borough knows where each and every single hive is located, therefore in case of an outbreak; all the beekeepers can treat the hives at exactly the same time. Any potential outbreak of disease is significantly reduced and as a result it creates a much more stable environment for the bees.¹⁵⁸ This is also a good strategy for marketing as many restaurants in London have their very own rooftop beehives where they collect and serve the honey within their own establishment. Toronto can relate to this by creating an organization for each ward within the city. That would create a better flow to registering and licensing beekeepers and beehives. Everything can be streamlined so that each ward will have access to the same information and process to maintain consistency and efficiency.

There has been extensive research conducted within London's medical field regarding the positive effects of local honey consumption collected within a few miles of where the residents live. Pieter Basedow noted these benefits, including a reduction in consumers' allergies, asthma, and even the severity of autism symptoms. This evidence provides an even greater incentive to increase urban beehives within the city. London has interactive digital maps that allow residents to locate nearby hives and their respective organizations. The residents can therefore contact the corresponding association for details in obtaining the localized honey. Basedow also states that all of the medical research information can be found on the same website as the beehive location map. There are medical and public testimonials by residents who have been treated with the honey which provides more authority to the advantages of honey. What was once used as a sweetener is now becoming a natural healing agent within the medical field, supported by research to suggest it has positive medicinal applications. This may soon become a regiment for people in their daily life where they routinely consume a spoonful of honey every day to maintain good health. A change in policy is required within Toronto to support their position as a "Bee City", encourage local neighbourhood beekeeping as well as to increase the benefits obtained through the cohabitation of bees. These policy changes are possible with successful city precedents aforementioned.

PROJECT: BUZZ CITY

06

*“If you build it,
he will come”*

- Field of Dreams

// figure 06.01 Toronto Botanical Gardens solitary bee habitat by Author

06.0 PROJECT: BUZZ CITY

Humans and bees once shared a symbiotic relationship similar to the bee and the flower. As society developed over time, that connection has eroded. Bees are now conceived as an economic asset without any regard to their natural health and well-being. People talk about genetically modified foods and the negative side-effects to it; however what they seem to forget to consider is that the cultivation and domestication of honeybees over the centuries has also caused genetically modifications to the bees themselves.¹⁵⁹ Feral and domestic honeybees are no longer the same type of species; they have been modified through cultivation.¹⁶⁰ As a result, their immune system is not as strong and they become weaker and more susceptible to diseases and parasites.¹⁶¹ As the global bee population declines, the awareness in developing bee-friendly guidelines does not seem to display the same type of concerns as other initiatives. As the development of the city continues, bee habitats are destroyed and green spaces are becoming increasing isolated and fragmented, deteriorating the natural pollination corridors for the bees.

Architecture has the ability to seriously affect change onto the world and society in a positive or negative manner. For instance, the overdevelopment of the downtown core combined with the lack of public

green spaces in Toronto is a perfect example of a change for the worse. Architects and developers are building for a rapidly increasing population; however, the most crucial item is often overlooked – *public space*. The area of the public space is usually designated with the available left over space, creating an underwhelming social space for the residents. This underwhelming space also affects all of the native pollinators in the surrounding vicinity, as that is their habitat and place of forage. Without it, they would have to scour the ends of the concrete jungle for nourishment causing more stress onto the species.

The project, Buzz City investigates how architectural strategies can be developed in creating bee habitats within the existing built environment. The bee habitats will be created by using a bee builder's toolkit, which contains bee-friendly components that can be adapted to various urban site conditions. As the components are applied to the various sites, they essentially form a pollination corridor that connects multiple pollination pockets. A pollination pocket is an existing green space or public space that becomes a node for both pollinators and the public. The pollination pocket is the stating node for the corridor. The corridor then creates a route to the next closest pollination pocket.

The architecture involved in crafting the bee builder's toolkit works on both the macro and micro scale. On a macro scale, it envisions a network of pollination pockets within the City of Toronto that could ultimately spread into other parts of the Greater Toronto Area. On the micro scale, the bee builder's toolkit enables the creation of additional bee habitats and turning unusable wasted spaces into pollinator-friendly habitats. The strategy attempts to create the possibility of innovatively cohabitating with bees, thus strengthening their overall health and population and providing stimulating and engaging public spaces within the urban realm. As the City of Toronto has been designated as Canada's first *Bee City*, the bee builder's toolkit will reinforce that title and become a catalyst for all other Canadian cities nationwide to take part in becoming a *Bee City* of their own.

After conducting initial primary research, the next step was to develop the appropriate direction for the design research to head in through the aid of a cloud diagram. The cloud diagram enables the researcher to map all the research that has been conducted so far in a graphical manner. This allows for the possibility of developing connections and relations between topics and information. At the core of the diagram is the fundamental topic or question.

STRUCTURE OF THE THESIS

Habits of urban bees are the subject of this analysis, from the communication and behaviour of the bee and the diversity of bee species to the roles they play in the ecosystem. This core topic was divided into four quadrants of questions and sub-topics: 1) Pollination, which looks at the importance of pollinators and why it is so important; 2) The Bee + Me, looks at topics pertaining on methods and strategies of cohabitating with bees and how they can be preserved; 3)Bee Architecture investigates current guidelines and bylaws for bees but also investigates what new protocols can be developed and integrated into future planning and design, creating a bee-friendly environment. 4) The Environment category analyzes environmental strategies on how Toronto became a *Bee City* and what can be taken and turned into a template for other cities to adapt. (figure 06.02)

// figure 06.03 Early bee pavilion/ installation concept by Author

06.1 CONCEPTS

The initial design concept began from reading reports and articles concerning the rapid decline of the bee population and the importance of bees in the ecosystem. The research pertained to why the bees were declining at such a rapid rate, the cause of the decline, and what efforts can be taken to preserve the current bee population. The first step was to understand what bees require to live and thrive. Bees need 3 essential things to survive, they are: flowers (preferably wild flowers), a safe place to create a nest and a pesticide free environment. Once these criteria were identified, the next step was to determine how design – from the landscape to architecture – can play a crucial role in both raising awareness and preserving the bee population. Further investigation revealed that bees living in the city are stronger than bees living in the suburbs. This is due to a variety of factors, including the warmer city environment with all the heat generated from electricity and greenhouse gases. In addition, for Toronto in particular, a ban on pesticides was beneficial and greater diversity of plant life within cities in general contributes to the strength of bees in cities over their suburban counterparts.

These factors suggest that a focus on the urban environment as a site and catalyst to produce safe bee habitats would be a perfect solution to reversing

the bee population problem. People however, have not yet learned to cohabitate with bees. Bees are treated as minor annoyances or insects to fear, due to the associated risk of getting stung. It is understandable that people who are allergic to bees have something to fear; however, there is common misconception about bees and that they are aggressive and sting everyone. Bees in general have no interest whatsoever in any food items or sweeteners that humans consume. The misunderstanding comes from the bee's relative, the aggressive wasp. Wasps are carnivorous and are always in the search for meat, which is why they are always hovering around popular picnic areas in search for human food.¹⁶² When they sting someone, they take a chunk out of their flesh and can sting repetitively without dying.¹⁶³ This bad impression wasps provide is what contributes towards society's negative notion of bees as a pest rather than a crucial actor in the ecosystem.

A honeybee will sting if someone if she is directly in front of the bee's hive as the bee will treat it as a threat or invasion so she will become protective of the hive.¹⁶⁴ Another scenario of when a honeybee could sting is when bee keepers are accessing the hive and unintentionally squish some bees in the process. When they are squished, the body releases a pheromone which agitates the surrounding bees and that causes them to become aggressive.¹⁶⁵ A honeybee will only sting when threatened as drone bees die not long after stinging the subject.¹⁶⁶ For this reason, urban roof top beehives – rather than ground level hives – are becoming more popular within the city; however, this segregated solution does not ultimately increase awareness or promote the importance of bees. With cohabitation as an existing concern, design investigations which are visible to the public but incorporate a buffer space between human and bee will be explored in order to create a sense and balance of comfort.

BEE CULTIVATION – EXPLICITLY SHOWN OR REMAIN HIDDEN?

There is an increased shift towards interactivity when creating a demonstration spaces with a growing interest of having visitor contribution to their environments.¹⁶⁷ Their popularity stems primarily from the meaningful experience obtained by visitors developed through the interactive components.¹⁶⁸ This creates a sense of fulfilment and the acquisition of new knowledge for the participant. The interactive installation goes beyond the static looking or listening¹⁶⁹ of the traditional “eyes-on” approach that society is currently used to; instead it creates a dialogue between the subject and the visitor by engaging in analytical thinking.¹⁷⁰ This generates interest and encourages the visitor to explore the exhibit further by being a part of it.

// figure 06.04 Bring back the bees

// figure 06.05 Kisses for bees [above]

Why should we cultivate bees in public? Bees have been primarily hidden from the general public due to the segregation of farming practices and Toronto by-laws which prohibit close proximities (2002, c. 17, Sched. F, Table).¹⁷¹ Although we may come in contact with bees within our daily lives, society is far removed from the practices of beekeeping. There is an increased awareness regarding the decline of the bee through recent campaigns led by large commercial companies such as; Honey Nut Cheerios (figure 06.04) or the recent Burt's Bees “Kisses for Bees” campaign installation at Nathan Philips square (figure 06.05); however, many are still unaware of the true threat their loss would create. Attached to the limited knowledge that individuals possess about bees is the ongoing stigma that bees are harmful or dangerous around people. Immersing both subject and observer within a safe, shared environment has the dual function of educating the observers and breaking down pre-conceived notions of danger or harm.

Traditional methods for individuals to increase their knowledge through observation were found typically constrained to museums, or exhibition centers. Visitors would enter the exhibit only to walk around and look at the items displayed, encased in glass boxes, known as the “eyes-on” approach.¹⁷² There was no interactivity and exhibitions became typically labelled as esoteric. The traditional eyes-on approach does not appeal to a broad range of audiences leaving

only those individuals who were interested in the specific theme or topic to gain any real appreciation, fulfilment or enjoyment from the exhibit. Bees are naturally “interactive” in that they are living creatures. Their nectar gathering process is fascinating to watch and easily attracts interest and curiosity. The Royal Ontario Museum (ROM) made use of the semi-interactive exhibit in the Biodiversity section of the museum which houses a beehive colony encased in glass. While the subject is living, the separation is still limited to the traditional museum display methodologies. The display is fitted with openings to the outdoors connected by a series of clear tubes sufficient for the bees to exit the building while allowing their busy work to be visible to onlookers. Though engaging and educational, its visibility is limited to those who decide to visit the museum and still separates human from bees and the environment.

The loss of bees is not only an environmental issue, it poses social, political, financial, policy and job security issues; therefore, any statement, solution or advocacy for the bee must not only reach a large body of individuals, it must also contribute to the restoration of the bee population and stimulate further interest for retroactive involvement by observers. The placement of an interactive component is vital to the success and influence it has on the observer. Studies have shown that traditional interior venues which house components or displays at the entrance of an exhibit

// figure 06.06 The ROM's Remarkable Bees [above]

attracts far more interest and engagement from visitors whereas components placed farther away from the entrance reduces the quality of visitor interaction.¹⁷³ In this same fashion, the location of a bee component is equally as important; one which will strengthen and produce pollination corridors to reconnect the fragmented remaining landscapes within the city, but is also located within existing highly populated areas to ensure visibility and foot traffic by pedestrians. The production of bee habitats within Toronto's public sphere will raise awareness and assist in the preservation of the bee population. The lacking public green space within the downtown core further escalates an already exacerbated issue. Sites which satisfied the following criteria were considered for design exploration as a result;

1. Located within the urban realm of Toronto's downtown core boundary
2. Central or public locations which already possessed large populations or heavy pedestrian foot traffic
3. Provide sufficient surface area to devote to plant life, bee components, designated space for hives and public space
4. Located between existing pollination pockets to establish pollination corridors within the city.

Recent proposals by the City of Toronto to convert the existing Rail Deck project revealed Toronto's last remaining prospect to produce large public urban green space within the core. It became evident that the proposal for bee habitats could serve a dual function; to serve bees while simultaneously providing more public green spaces within the city for people.

// figure 06.07 Early sketches of potential sites by Author [above]

Rail Deck - Bathurst & Blue Jays Way. → EAST WEST BORDERS.

// figure 06.08 Conceptual sketch of the Rail Deck Park by Author [above]

RAILDECK PARK

The first design investigation considered the use of the Rail Deck as a potential site for transformation into a bee sanctuary. Current plans for the Rail Deck Park are to split the site into two areas as it spans across Front Street past Spadina Avenue. One section, East of Spadina is planned to be approximately four acres utilizing the land to produce a biosphere reserve. A biosphere reserve would mean that everything within that space would be untouched by the public. It would create a safe haven for bees and other pollinators to live and forage in while living within the city. Reserving a section of the Rail Lands as untouched meant that the nature and ecosystem inside would be preserved. In my proposal, the remaining portion of the Rail Deck Park would be turned into a large public interpretive green space that demonstrated important bee related information to emphasize the awareness and significance of bees and pollination. Included within the initial design proposal was a bee research facility, beekeeping facility, bee related interventions and lots of vegetation to provide a lush and extravagant public space for people to visit, relax and learn within. There would be an abundance of flora for bees to forage within, creating a comfortable buffer space between human and the bee. Another similar approach was to turn the entire Rail Deck Park into a large biosphere reserve and allocating the perimeter space for the public realm. In this scheme a catwalk designed to span over the entire biosphere gives pedestrians an

aerial view of the green space maintaining the intimate connection between man and bee while preserving a natural habitat for bees. Locating the biosphere on top of an active rail deck, the site location doubles as an effective pollination distribution system. As the trains come into the city from the suburbs, they bring an abundance of pollen for the bees to harvest.

Further iterations included paved trails throughout the biosphere reserve similar to national parks. This would allow the public to immerse themselves within the biosphere rather than observing from a distance in the previous strategy. The trail would be an enclosed temperature-controlled environment comparable to a greenhouse allowing the resident bees to maintain their consistent pollination schedule. The enclosed biosphere would contain wildflowers that begin to flower at the same time every year allowing bees to begin their pollination regardless of a late spring or early winter. The challenge with this approach was that the bees became the client and the public was second tier within the design.

How would society react to a project specifically catered to bees, having no overt beneficial impact to the public realm? Society would benefit from bees and pollination in terms of food production and availability; however they would not benefit with a restricted green space, especially when public green space is already so scarce within the city's boundaries. Unlike suburban

detached homes which possess private back and front yard space, condo dwellers rely heavily on access to public green spaces provided by the city. A biosphere reserve at the Rail yards would not add to badly needed urban green space. An important question to keep in mind would be; would the benefits of the biosphere reserve outweigh the benefits of an active public green space or is there a way to benefit both parties equally?

// figure 06.09 Sketch of an environmentally controlled pavilion by Author [above]

// figure 06.10 Sketch apple orchard down a main street in Toronto by Author [above]

DUNDAS SQUARE

Dundas square became a natural site location for the investigation of the thesis as it satisfies all of the criteria presented previously. Its highly public and central location ensures the viability, longevity and impact of any design solutions proposed within the site. Dundas square has record numbers of approximately 137,700 individuals per day with 47million who pass through the Eaton Centre each year.¹⁷⁴ The location is also simultaneously controversial in that it is used both as a thorough-fair junction point between several surrounding business, public spaces and transit systems. The space itself also holds a number of public functions, events and concerts throughout the year. Claiming the highly used space for other purposes sends a clear message that the bees are important to Toronto as a leader and “Bee City”. The cities investment in their ongoing health and claiming back extensive hardscape within the city for bee population rehabilitation is controversial but necessary.

THE BEE BUILDER'S TOOLKIT – VERSION 1.0

The biosphere reserve design exploration eventually led to the concept of catering to two clients, in this case, the bee and the public. The challenge with this approach was to come up with a scheme that would balance both of the clientele's needs. The strategy of adaptable architecture began to arise and over the course of research led into the direction of crafting a toolkit of components that could adapt to various site

conditions. This concept informed the bee builder's toolkit. The bee builder's toolkit offers solutions to both sides of the clientele's needs. Each component within the toolkit is meant to be bee friendly and it is capable of adapting to diversified site surroundings. At the same time the components benefit the public by making a better space with ornate vegetation providing for a healthier environment. Some of the components have the ability of enhancing existing public space or can also create new public space depending on whether the site is capable of incorporating the components. This innovative toolkit can take place on all levels of the city from the pedestrian level to the roof tops of buildings, creating a natural buffer zone between the public and bees. The awareness and importance of bees will be much more evident as these interventions will be seen and potentially interacted with by the public on a daily basis.

PROCESS

INITIAL EXPLORATIONS

The initial sketches looked at components that would span far distances creating bridges or rivers of flora that flow into pollination pockets. The challenge with that was figuring out how to maintain the connectivity at all times and finding the appropriate space to do so. Land in Toronto is so expensive and scarce, open land may not be an economical solution for the placement of bee pollination pockets.¹⁷⁵ Another

// figure 06.11 Sketch of a Biosphere Reserve on the Spadina part of the Rail Deck Park in Toronto by Author [above]

// figure 06.12 Sketches of potential components by Author [above]

idea was looking at commonly wasted small residual spaces within the city as well as typical repetitive urban “street furniture” elements found throughout the city. Typical street furniture such as a newspaper dispenser is an example, as the top of the dispenser is either empty or accumulates trash. Instead it could be converted into a solitary bee habitat that still performs its utilitarian function: dispensing newspapers. The bottom panel would become a solitary bee habitat and the newspaper portion would remain the same. The top of the unit would be planted with native vegetation for the bees to forage in. Although primitive, it was a start to investigating potential components that would fit perfectly into the toolkit within an urban realm. The converted newspaper stand posed a challenge in creating buffer space barrier with the bees living in such close quarters to the newspapers. Would people be comfortable grabbing their paper from a dispenser with bees living below and foraging up top? An important aspect to maintain when crafting components for the bee builder’s toolkit is buffer space as is essential in order to create a comfortable space between the bee and human.

BEING PROVACTIVE

Design can be an effective and provocative tool, challenging the possibilities of space and its subject matter while simultaneously engaging the public. The overall vision is to transform concrete hardscaping into softscaped green spaces to intensify the greening of the public realm while creating a strategy for cohabitating with bees.

Rendering collages of the concept were produced to graphically illustrate what it could look like and what positive outcomes they may possess. The two test sites selected for this stage of the design research were Toronto’s Yonge-Dundas Square (located at the Southeast corner of Yonge Street and Dundas Street) and the intersection of Yonge and Gould streets. These areas were chosen because they are both very busy locations, ensuring adequate foot traffic and are mostly hardscaped spaces. The benefits of introducing greenery into these public points of interest include a change to the ambience and ecosystem of the environment as well as establishing the symbiotic connection between human and bee.

// figure 06.13 Sketch of hexagonal vineyard by Author [above]

// figure 06.14 Conceptual collage of Dundas Square with commercial billboards replaced by greenwalls by Author

The Yonge-Dundas Square collage (fig) transforms the extensive use of commercial billboards and hardscaping throughout the plaza. Sao Paulo has banned all outdoor advertisements from being displayed in an attempt to increase the overall quality of life and to enforce the Fight Against Pollution.¹⁷⁶ Sao Paulo achieved a grand accomplishment, meaning Toronto is more than capable in following in their footsteps. The intention here is to bring the space to life with pollinators by replacing the commercial billboards with green walls while providing foraging sites for bees. The notion is to create a sense of astonishment through provocation in illustrating the possible capabilities within the space. A public demonstration showcases the importance of bees while enforcing that combined initiatives must be taken to prevent further decline of the current bee population. Concepts can then be extracted and implemented from large scale installations into smaller real world situations.

The Yonge and Gould Street collage (fig) depicts a closure of one lane of roadway on each side of Yonge Street between Dundas and College streets for a total of two blocks. The lanes are replaced with orchards along the street and extend the west-facing green wall beyond the Yonge-Dundas Square site. This collage reinforces the notion of reconnecting the public realm with nature by planting all those trees and plants. Instead of demolishing and building new, the approach of working with what is existing is taken so the philosophy of building on top of is used. Both collages are intense, controversial and highly provocative but exemplify that this type of approach is possible and it is something that should be done immediately.

After the collages were complete, the concepts behind them were further studied to see what kinds of components would enable the realization of such ideas. This evolved into the Bee Builder's toolkit. Initial conceptual sketches were produced to illustrate each component and what its role would be within the urban realm. The components were not to be site specific, meaning that they would be applicable and adaptable to a variety of site conditions within the city.

// figure 06.15 Conceptual collage of Yonge and Gould integrated with apple orchard laneways by Author

// figure 06.16 Sketch of the billboard component by Author [above]

COMPONENTS

Initial components that were analyzed included the billboard structures as one of the key strategies seen in the initial collages. Yonge-Dundas Square alone is framed by three massive billboard structures and this strategy could be replicated throughout the city. Developing the structures that could be used shared its fair share of challenges. It was challenging due to the existing limited access, ie: no elevators or public access from connected buildings; a framework, which is not meant to allow visitors; the complicated structure and the exposure of the architecture to the elements. The advantage is that it is also a large surface area of unused space other than for commercial advertising purposes. The concept is being intentionally provocative and the advertising space provided is being used to present the concept of introducing bees to the urban core instead of commercial products. After a thorough investigation it was deemed that they would work best as elevated platforms for beehives. These structures are high enough creating a natural buffer space between humans and bees. This ensures that the bees that forage there would not intrude onto the public while remaining close enough that passers-by could experience the structures and engage with what is happening inside, thus reinforcing the importance of the bees.

Another component that was considered for the toolkit was the awning. Many buildings, especially those that face major streets, incorporate awning structures above their main entrances. Their almost ubiquitous existence within the urban environment, untapped surface area, and natural buffer off the ground plain made them suitable for developing into habitats for solitary bees.

Solitary bees, unlike honey bees, do not live in colonies and instead prefer crevices or openings in the soil or wooden blocks. The top of the awning design would incorporate a green roof attachment with a solitary bee habitat incorporated below. The green roof supplies the bees with a source of food and protection from the elements underneath when they seek refuge.

// figure 06.17 Sketch of the awning component by Author [right] Front Facade

Another major component was the bus shelter. Bus shelters are a typical piece of street furniture found throughout the city. The ability to fabricate these structures into a dual functioning unit would be highly beneficial. Within this concept, the top of the bus shelter is utilized as a green roof initiating the buffer space between people and bees. The bottom panels can be turned into solitary bee habitats consisting of wood blocks or bamboo shoots. The side advertisement panels which are hollow would become a transparent honey bee colony. Similar to the Yonge-Dundas Square billboard collage where the advertisements are replaced with green walls, the advertisement panel on the bus shelter would be transformed into a fully functioning beehive that beekeepers would tend to when appropriate. The bus panel is split into 3 equal sections with the entrance to the hive located on the exterior side of the bus shelter at the top of the panel. The transparent beehive entrance and green roof would be a perfect combination creating the buffer space between people and bees while initiating interactivity especially in existing nodes where there will be a large quantity of pedestrians waiting for public transit. This creates a perfect platform to educate the public in a space where an audience is already ensured.

// figure 06.18 Sketch of the bus shelter component by Author [above]

// figure 06.19 Map study of the bee flight radius by Author [left]

https://www.researchgate.net/publication/279887311_The_foraging_behaviour_of_honey_bees_Apis_mellifera_A_review

source: https://www.researchgate.net/publication/227994023_Foraging_ranges_of_solitary_bees

source: https://www.researchgate.net/publication/229858879_Foraging_habitats_and_foraging_distances_of_bumblebees_Bombus_spp_Hym_Apidae_in_an_agricultural_landscape

// figure 06.20 Map study of the pollination corridor and adaptable buildings by Author [right]

source: arcgis database, Ryerson University

// figure 06.21 Map study of points of interest by Author [bottom right]

source: arcgis database, Ryerson University

BEE FLIGHT RADIUS MAP

Legend:

Existing Pollination Pockets

Existing Green Spaces

Pollination Corridor

Existing Ravine

1 Average distance all bees 0.5km

2 Average distance solitary bees 1.0km

3 Average distance honey & bumble bee 3.0km

0 0.2 0.5 1.0 km

06.2 INITIAL DESIGN RESEARCH

This project proposes the development of bee-friendly elements that would be used to create pollination corridors to reconnect the existing fragmented pollination pockets throughout the city. The route the pollination corridor takes will decide which components from the toolkit are appropriate for each site. For example; where a corridor extends through an environment surrounded by vertical towers, components that utilize an elevated roof top plain will be deployed. In plan the result resembles a series of arteries reconnecting the existing green fragments into a continuous space. The pollination pockets act as nodes for the public and pollinators culminating at the future Rail Deck Park site within the Waterfront Neighbourhood. As noted earlier, the Rail Deck Park is a proposal from the City of Toronto to provide much needed public green space to offset the impact of the increasing populations from surrounding vertical neighbourhoods. Bee-friendly corridors which extend to the proposed park, utilize the park as a platform to enforce the “Bee City” title Toronto has recently obtained. It is also a great starting point as the Rail Deck area is intended to be a heavily pedestrian traffic area creating a natural path to the proposed component installations along the corridors.

// figure 06.22 The governing shapes to the creation of the toolkit components by Author

The foundation of the bee builder's toolkit was established from typical "user" dimensions. The way we live our lives within our environments such as; typical seating heights, table heights and comfortable viewing heights can all be quantified. . All dimensions and angles seen in the founding shapes chart were standards that were derived from the "Architectural Graphics Standards" which outline these typical dimensions. The governing shapes were then put through a series of exhaustive permutations by rotating, combining and subtracting the shapes. The intention was that these shapes would form a type of interactive play-scape when multiple components are combined. The play-scapes are designed to be temporary which require that the components are light and transportable when necessary without requiring the aid of construction workers or specialized tools. The result was a series of 13 shapes which were formed through the series of permutations which created a more refined kit of parts for the Bee Builder's Toolkit. Each component is given a name which is relevant to their function. Further evolutions to the shape highlight the potentials of these forms and the types of spaces they can create when connected. The components, when connected in a specific order form a hexagon on the outer edges making fabrication and transportation more efficient. Multiple combined hexagons can be stacked on top of each other for ease of shipment. This overall hexagonal shape embodies the efficiency that the honeybee uses

// figure 06.23 Series of permutations by Author [left]

when they are building the honeycombs within the nest. Each rotation of the component, when installed, creates a brand new form, making the possibilities seem endless. The ever-increasing number of forms has the ability to never replicate the same two play-scapes within the city. The external side houses an interchangeable panel that can be swapped with a vegetation or solitary beehive panel; therefore, no matter how each shape or set of shapes is rotated, bee friendly elements are incorporated. The reasoning for making these units geared towards solitary bees is that they are not as intrusive as honey bees and, as mentioned in the previous chapter, some solitary bees do not even look like bees. A space that will be used consistently by many people would cause stress for the honey bees and vice versa. The buffer space is still maintained with the center of the shape devoted for pedestrian use leaving the exterior dedicated for bees or vegetation only.

// figure 06.24 The first iteration of the bee builder's toolkit by Author

01 STAGE

The “STAGE” tool connects other components together creating a continuous walkway for pedestrians, it can also be placed together to create a presentation or performance space.

Variation studies show that the STAGE can be transformed into side walls for display boards, transparent bee habitats or vegetation panels.

- walkway
- display board
- transparent bee colony
- vegetation panel

// figure 06.25 The Stage component and study by Author

VARIATION STUDY

02 SEAT

The “SEAT” tool provides a seating component to the pedestrian.

Variation studies show that the SEAT can be transformed into digital or analog information units, a long bench or bridge with bee compartments incorporated within the exterior of the component.

// figure 06.26 The Seat component and study by Author

VARIATION STUDY

03 BAR

The “BAR” tool is a component that allows for pedestrians to gather and socialize while having an area to place food, drinks or belongings.

Variation studies show that the BAR can be transformed into an extended table, an illuminated seating component with digital or analog information panels or become large interactive display panels.

// figure 06.27 The Bar component and study by Author

VARIATION STUDY

04 COUNTER

The “COUNTER” tool serves as a component for pedestrians to place items on or to have discussions and personal presentations.

Variation studies show that the COUNTER can be transformed into an extended countertop, event lighting system or digital or analog information components bee compartments incorporated in the exterior.

// figure 06.28 The Counter component and study by Author

VARIATION STUDY

05 LOUNGE

The “LOUNGE” tool provides the pedestrian with a relaxed seating component allowing people to read, rest, sleep and reflect while creating a laid-back atmosphere.

Variation studies show that the LOUNGE can be transformed into illumination components and large interactive display panels with integrated bee-friendly habitats.

// figure 06.29 The Lounge component and study by Author

VARIATION STUDY

06 BED

The “BED” tool provides a relaxing component for the pedestrian. It adds to the relaxed and laid back atmosphere. The pedestrian can take a quick nap or soak up some sun.

Variation studies show that the BED can be transformed into light fixtures, information kiosks or reclined floor seating.

// figure 06.30 The Bed component and study by Author

VARIATION STUDY

07 AUDITORIUM

The “AUDITORIUM” tool creates an academic setting where pedestrians can watch presentations/ lectures/ workshops take place while learning in an interactive environment.

Variation studies show that the AUDITORIUM can be transformed into a projector stand for presentations, or illumination and event lighting components.

// figure 06.31 The Auditorium component and study by Author

VARIATION STUDY

08 THEATRE

The “THEATRE” tool allows pedestrians to partake in a public event or showing where they can grab a seat take out some snacks and enjoy the show.

Variation studies show that the THEATRE can be transformed into information kiosks or an alternative reclined seating component.

// figure 06.32 The Theatre component and study by Author

VARIATION STUDY

09 SPA

The “SPA” tool provides a personalized seating component for the pedestrian with a canopy to provide shelter or lighting with an illumination panel.

Variation studies show that the SPA can be transformed into an interactive information unit, a canopy, light fixture or an alternative seating component.

// figure 06.33 The Spa component and study by Author

VARIATION STUDY

10 KIOSK

// figure 06.34 The Kiosk component and study by Author

VARIATION STUDY

12 PRESENTATION

The “PRESENTATION” tool provides a component that allows digital presentations and displays to be displayed onto a surface for large audience viewing.

Variation studies show that the PRESENTATION can be transformed into a canopy, an event light fixture or a seating component.

// figure 06.35 The Presentation component and study by Author

VARIATION STUDY

12 CANOPY

The “CANOPY” tool provides a shelter or collonade component for pedestrians while incorporating an interactive display panel and bee habitats.

Variation studies show that the CANOPY can be transformed into a light fixture, reclined lounge seating, an elevated bridge or an interactive tunnel.

- bee habitat
- vegetation panel

- bee habitat
- vegetation panel

- display panel
- reclined seating

- bee habitat
- vegetation panel

- bee habitat
- vegetation panel
- illumination panel
- canopy
- display panel
- transparent bee colony

- bee habitat
- illuminated panel

- walkway
- illuminated panel
- canopy
- transparent bee colony
- display panel

// figure 06.36 The Canopy component and study by Author

VARIATION STUDY

13 HYBRID

The “HYBRID” tool consists of a combination of several components from the toolkit. It provides a comfortable seating shelter component for pedestrians while simultaneously serving as a bee habitat.

Variation studies show that the HYBRID can be transformed into an interactive display tunnel, shelter, light fixture or seating component.

// figure 06.37 The Hybrid component and study by Author

VARIATION STUDY

// figure 06.38 Physical model of the components by Author

// figure 06.39 Combination chart of the components by Author

COMBINATION 1

// figure 06.40 Combination 1 and study by Author

VARIATION STUDY

COMBINATION 2

// figure 06.41 Combination 2 and study by Author

VARIATION STUDY

COMBINATION 3

// figure 06.42 Combination 3 and study by Author

VARIATION STUDY

COMBINATION 4

// figure 06.43 Combination 4 and study by Author

VARIATION STUDY

COMBINATION 5

// figure 06.44 Combination 5 and study by Author

VARIATION STUDY

// figure 06.45 Rendered components with finishes by Author 140

// figure 06.46 Exploded axo of the Canopy component by Author

// figure 06.47 Rendered view of the components in context, Trinity Bellwoods Park by Author

LESSONS LEARNED

The goal with this initial design was to create a meaningful experience and fulfilment through user interactivity. The environment chosen for the components was Trinity Bellwoods Park. The lessons learned from this exploration were that the initial intent, which was meant for the bees, began to get lost in translation. It became more predominate that this design was geared towards public use and less about the bees. Although bee habitats were placed on the exterior parts of each component, it didn't create a compelling enough story illustrating the connection between the components and the importance of bees. The issue was that the bee parts were now seen as an afterthought even though that was not the original intention.

06.3 FINAL PROTOTYPE

Toronto is a “concrete jungle” in the sense that green space is often sacrificed for condominiums or office towers. The little green space that exists in the city is very limited and usually manicured. The idea is to create a space that resembles the bee’s natural environment which is untended native plant life. The final test site re-introduced the previously explored Yonge-Dundas Square block. The buildings highlighted in light green indicate the project scope within the site (figure number here). Yonge-Dundas Square is the core within the scheme which will extend to the surrounding context. The dark green areas shown in the illustration are existing green spaces within the site.

In this design, Yonge-Dundas Square would be turned into a space dedicated to wildflowers and where bee towers will be placed. This project is proposing a radical takeover of hardscape to change its focus to bee habitats. Yonge-Dundas Square can provide this habitat and be seen as a venue that would be highly beneficial in showcasing bee habitats and the importance they bring. Although the radical takeover means the elimination of public events from the area, the bees are giving something back as they are excellent pollinators. Replacing the current stage where public events take place and providing bee

// figure 06.48 Massing of the master plan by Author [left]

CONCEPT DIAGRAM

// figure 06.49 Concept of the thesis, past, present and outcome of the "Green City" by Author [above]

// figure 06.50 Rendered view of the overall master plan by Author

YONGE AND DUNDAS SITE SECTION

Existing Building Interior

// figure 06.51 Site section study
by Author

— Controlled Bee Funnel Entrance

- Glass Enclosure

— Beehive

— Green Wall System

Reduced Road and Increased Sidewalk

This conceptual experiential section cut through between Yonge-Dundas Square and the AMC building is an idea generator: an investigation to understand what kind of atmosphere is generated when a green softscape is carpeted onto the concrete and metal-panel exterior walls that comprise the hardscape. The lanes of the road have been reduced down to one lane on each end and access is strictly for TTC streetcars or emergency vehicles. The strategy of expanding the public realm and closing the street for public transit make public transportation and bicycles more dominant in the urban core, something that the city has been incrementally implementing for a while now. The green wall system spans down the exterior structure and canopies onto the streetscape. The canopy portion is not completely covered; however, perforations allow light to penetrate the structure along with several extensive openings between the bays for public access across the road or onto the streetcars. Dundas Square has been changed to mimic a natural habitat to stimulate pollinator health and encourage pollination. The green wall system acts as a second skin which helps to cool the building internally while also allowing beehives to be housed within the structure. The green wall system includes beehive funnel panels that span into a glass enclosure that houses a typical beehive. The funnel acts as the control point to ensure the bees fly within their designated flight path separated from the public space. The ground conditions have been carefully considered with several challenges which are addressed later in the development of the project.

// figure 06.52 Revised Dundas Square with components from the toolkit by Author

habitats contributes to the health and growth of bees in the city. In return, the bees would pollinate more and people can start to plant their own personal gardens in the urban core and watch them blossom with the fruits and vegetables that only bees can provide through pollination.

DUNDAS SQUARE – RE-VISITED

As mentioned before, this is a hyper commercialized space with heavy pedestrian traffic, making it ideal to implement bee-friendly strategies here as it is under consistent exposure (figure 06.52). Dundas square is an event space for the city, and a large part of it has been dedicated to bee-friendly components. Although we are taking away the event space, we are giving the bees back their natural habitat which in turn provides us with pollination for food and flowers, honey, beeswax and a thriving natural lush environment. We are encouraging the growth of the declining bee population by introducing more of their natural habitat within the city core.

// figure 06.53 Key plan of Dundas Square by Author

EATONS CENTER PARKING LOT

Through the site plan, it is clear to see that it implements similarities as the Dundas Square site plan. Again the idea here is being able to replicate the concept throughout the city. It looks at harmonizing the symbiotic relationship that bee and human once had. It is understandable that by introducing more bees into the city can pose an increased risk to those that have allergies towards bees. It is important to note that bee safety measures have been taken by the designs. Buffer space and natural barriers have been created to mitigate any aggression, although bees are pretty docile to begin with. The idea is to transform an under used space and adapt components from the toolkit to it. The upper level of the parking lot (figure 06.55) has been turned into an elevated sky park that integrates and harmonizes both public space and bee-friendly habitats with the necessary supporting components.

// figure 06.54 Key plan of Dundas Square by Author

// figure 06.55 Eatons Centre Parking lot with toolkit components adapted to it by Author

CURRENT BEE HABITATS

The current bee habitats stand at opposite ends of the spectrum spanning from feral beehives that are found in the wild which are raw and organically shaped to the standard row upon row of man-made organized stacked rectangular boxes of bee colonies kept by beekeepers. It is important to understand that both are not viable or suitable types to encourage in public spaces. In addition, domesticated beehives need to be kept at a distance from people. Feral beehives can be found in the forest of tree trunks or branches or even mountainsides. They can also host crevices, small openings or unused areas of a house or building. When that happens, an exterminator is called to eradicate the beehive for obvious reasons. The challenge is to create places where such bees are welcome. It is also important to note that the concentration of bees should be more spread out and not too clustered together. By providing them with elevated foraging locations creates an elevated buffer zone which in turn would help reduce the amount of bees flying within the public realm.

// figure 06.56 Typical bee habitats by Author

// figure 06.57 The bee tower sketch model study by Author

// figure 06.58 Render of the bee towers in context; Dundas Square by Author

BEE TOWER DIAGRAM

// figure 06.59 Concept diagram of the bee tower by Author [above]

THE BEE TOWER

The bee tower concept was inspired by the feral beehive, extracted from the shape of the feral honeycomb plate, in order to reflect the bees' natural habitat. The honeycomb plate is not a smooth, leveled surface; it is usually imperfect, wavy or curvy in form. The imperfect feral hive form was simplified into the angled protruding surfaces on the exterior of the bee tower. The bee tower comes in three varied heights, it is meant to replicate the various heights of the honeycomb plates within the feral beehive while adding visual interest. These towers are then clustered together to symbolize the layers that are contained in a feral hive (figure 06.59). The clustering of the hives also embodies natural bee behaviours. Both feral and domesticated bees form into a *bee ball* and use their body heat to keep themselves warm during the winter. These clusters deter wind and snow while creating a warmer core within colder climates.

The bee tower houses a fully operable beehive inside (figure number), accessible through a set of doors located on the back of the tower. Access for bees is controlled into the tower at the top front panel, through a thin opening just large enough for a bee to fit, preventing access from large rodents or pests. This creates a buffer space designed to direct the bees to fly well above humans to get in and out of the hive. The beehive sits one-foot off the ground and the bottom panel has an opening to allow fresh cool air to enter

BEE TOWER SECTION

// figure 06.60 Section of the bee tower by Author

BEE TOWER PLANTER SECTION

// figure 06.61 Detail of the integrated planter component by Author

from the bottom and be exhausted through the wide opening at the top. This acts as a passive ventilation system for the bees, keeping them cool during the summer months. The top can be covered with a plate to keep them warm in the winter season. All the openings are covered with a very fine mesh to prevent the bees, small insects or animals from entering and thus forces the bees to use the entrance designated. There is a light located inside the tower to provide the beekeeper with light as well as illuminate itself through the opening at the top during the night. The light is set on a timer providing more control for the user allowing the elements to double as light spectacles during the evening. At the top of the tower is a solar panel that is used to generate power to run the light. The solar panel and battery located inside of the tower are sized appropriately to ensure there are no discrepancies especially during days of consistent overcast. The triangulated panels are extruded at different heights to replicate the uneven surface of a honeycomb plate, and the front panel is extruded even further out to allow vegetation to be planted. The idea is to develop a simple system that is not difficult to maintain.

The front panel (figure 06.61) consists of a built in felt lined planter system that uses a very thick felt wick to absorb water as the plant requires through an acrylic water container. The container is meant to recycle rain water through a PVC pipe to be stored for use. If consistent rainfall for collection is not achieved, the beekeeper can replenish the storage

// figure 06.62 Bee tower heights by Author

container manually when required. Water overflow is prevented due to the built-in overflow system which takes all excess water out and expels it through the bottom of the planter. These towers are meant to be placed on top of fields of vegetation; therefore, the overflow will also help water the surrounding plant life. The front panel of the planter is removable allowing for quick and easy access for maintenance. The planter is designed to grow vines such as the Virginia Creeper which does not demand a lot of maintenance and becomes dormant in the winter, meaning it will still be visible and will not completely die off like perennials. The vines slowly shroud the bee tower as it grows; however, the idea is that it is never fully consumed by plant life. Parts of the tower will be left exposed to celebrate the bee tower's form and uniqueness and to initiate interactivity within the public realm.

Another possibility with the bee tower is the concept of *allotment beehives* which is taken from the idea of the allotment gardens. This is especially useful for people who do not meet the requirements of owning a beehive through the new citywide bylaw policies or do not have the capacity or time. They can apply for an allotment beehive through the City and once approved, they will be assigned to the closest bee association within their area. Once a location has been chosen, a third party professional beekeeping company will be designated in being responsible for the allotment beehives similar to the group currently doing it now in Montreal. For a

fee, the group will establish proper beehives for their clients and also teach them about the fundamentals of beekeeping. They perform routine inspections on the beehives and vigorously check for any parasites or diseases. This is a great alternative for people with limited or restricted property or circumstances but still want to be involved with creating a healthier pollinator-friendly environment.

// figure 06.63 Sketch model study of the sturcture of the bee tower by Author [above]

// figure 06.64 Rendered view from Yonge and Dundas Square by the stage by Author

THE BILLBOARD TOWER

The next phase to the project scope was to look at the massive billboard structures that surround the site. Currently there are three, a large one above the Atrium building along Yonge Street, the Olympic Spirit on top of the OMNI building and a smaller sized one on top of the Eaton Center entrance at the corner of Yonge and Dundas. Although all the billboards are different in size, structure and form, the intent is the same and can be applied to each billboard structure throughout the city. The inspiration of the billboard structure was derived from a standard domestic beehive. In a generic beehive, the hive would consist of a floor plate, the hive entrance, brood chambers, queen filtering screen, super frames which come in variable depths (shallow, medium and deep), a top cover and then a lid. However, the only places where things happen are the hive entrance, brood chambers and the super frames. The idea was to extract those components from the beehive and program them into the billboard structure. This makes the billboard structure function

// figure 06.65 Key plan of Dundas Square by Author

in a similar fashion. The billboard structure chosen to test this concept is located on top of the Atrium building, at the Northwest corner of Yonge Street and Dundas Street. The top section of the structure would house multi-level stacked beehives. The floors below would be dedicated to honey and beeswax extraction and preparation for distribution to the public. The remaining floors would be dedicated strictly for public access in order to maintain and control public engagement with a highly active bee facility. Below the public level that is storage for the beekeeper's equipment and honey.

The idea of designing the elevated tower and incorporating public engagement brought with it some challenges. After further investigation and site visits, an alleyway near the tower which is used as a garbage area between two commercial buildings (currently “Forever 21” and an office building called “The Atrium”) was reprogrammed to augment the billboard structure above. Since it is an under-utilised space the approach was to reprogram the

// figure 06.66 Concept diagram of the billboard structure by Author [above]

// figure 06.67 Section of the billboard structure by Author

BILLBOARD TOWER SECTION

// figure 06.68 Ground condition of the billboard structure by Yonge and Dundas by Author

area into a public space. This became the entrance and the connecting point between the public ground plain and the designated public space within the elevated structure. This allowed the perfect platform to create something that would catch the eye of the public and create intrigue surrounding the programs within the tower. The public level is separated from the active beehive levels allowing pedestrians to travel to the structure with a buffer between the two parties. Pedestrians may initially venture up the structure to view the city from the glass balconies that protrude from the side of the structure overlooking Dundas square; however, the public level also overlooks the production levels. This gives spectators a firsthand look at the process of honey extraction and preparation and increases exposure and awareness to the public. The public elevator connecting the spaces is enclosed with a bright red shaft to force the attention of the public at the ground level through design. A bright yellow set of stairs simultaneously wraps its way around the red elevator shaft and the Forever 21 building further engaging the public as they pass. Both the stair and elevator, while utilitarian in function, also mimic bee behaviour characteristics through design. The red elevator shaft represents the efficient flight after a bee has flown around the same circuit; where it eventually plans the most efficient flight path. The wrapping yellow stair symbolizes the flight path of a new bee when introduced into a new environment; it is usually inconsistent and erratic in its path. It also nods

to the bees' waggle dance, used to communicate to other bees about new foraging locations or scouting locations for a new place to build a hive.

The billboard structure is a unique construction where every other floor is inaccessible as a result of the existing structure which protrudes into the space, which would make the beekeeper have to "limbo" their way around the floor. (figure 06.69) This meant that those floors would be dedicated to vegetation only, and, since the intent was to recreate a natural bee habitat, they would not require the regular tending that a manicured garden would. The service elevator in the core of the structure would be used for bee related work with the exterior service elevator used as a backup or for access to the vegetation floors. The vegetation floors are designed to have various planters' widths that would grow wildflowers and full green walls that would grow vines. Once again the goal is to maintain a buffer space between people and bees and also provide ample foraging locations at that altitude.

// figure 06.69 Non-accessible floors of the billboard structure by Author [left]

A pop out structure (The Cell) gives the billboard structure additional depth and also symbolizes the beehive where not every single cell is occupied with honey or brood, so the tower has some openings which allow for cross ventilation and natural daylight penetration. The top floors house active beehives they are placed within yellow glass enclosures that have a staggered spaced wooden façade that allows the public to see the beehives. The staggered spaced wood façade symbolizes the series of different height beehives inside of each the pop outs. It is also a façade where messages can be displayed – similar to commercial billboard signage. For instance, the message “SAVE THE BEES” (seen in fig) has been written on the façade in the rendering to reinforce the importance of bees and to be provocative at the same time. The enclosure is to provide the bees with warmth during the winter months and there is a narrow opening at the top similar to the bee tower to control their entrances and exits. At the very top of the structure, a set of solar panels helps generate power to run the lights on each of the floor s and to power some of the tools necessary to extract honey on the lower levels. The honey and beeswax extraction levels are glass panel pop outs to allow the public to see exactly what is going on at those floors as they would be the most interesting. They will have the opportunity to see how honey and beeswax is extracted and prepared. If they want a closer look, they can take a trip up the elevator or stairs up to the dedicated public level. The service elevators are forbidden from public use, as they have their own dedicated methods of travel.

THE CELL

The next tool in the kit is the cell. The cell has no fixed dimensions as the concept is that it is adaptable to existing conditions as seen in the billboard structure. Each cell has its own set of function and responsibilities. Much like a beehive, many cells are required to create an efficient beehive and each cell has its own purpose for example brood cells and honey storage cells.

THE CELL (KIT OF PARTS)

SUPPORTING COMPONENTS

The bee tower and billboard structure are the two main bee components within the toolkit, however there needs to be a set of supporting elements in order to help the bees thrive. If the bee population surpasses the available resources, that can cause competition and saturation in the limited foraging areas. Therefore a set of supporting components have been developed to help nourish the increase in bees. This also leads to creating components that also tend to the beekeeper as they will have a much larger facility scattered throughout the city, therefore they will require certain equipment and tools to be within close proximity. All the shapes and forms of the toolkit components are an extension of nature.

MOBILE PLANTER (KIT OF PARTS)

THE PLANTER

The planter, which was inspired from the River of Flowers project by Kathryn Lwin is essentially a hexagonal planter designed to be purchasable from any home and garden retail store. This is very different from the River of Flowers project, where their planters are made based off of commission. The planter for the toolkit is something that anybody can purchase and put together. Their small size makes them mobile with a dolly once put together and the hexagonal shape makes it easy to place them together creating a corridor. The planters can be stacked with the heat treated plywood walls with either one, two or three rows depending on the type of plant being planted. Most of the plants will be native wild flowers which do not require much depth, allowing for smaller and shallower planters. Small native bushes can be planted on the triple stacked planters. The reason for the hexagonal shape is not solely for marketing purposes but the fact that the hexagon is an efficient shape when butted up with one another it created no wasted space. This mimics the honeybee's beehive as they use the hexagon shape when creating their honey and brood cells. When the planter is stored, it can be laid flat and packed, similar to prepackaged lumber. Assembly is very simple as the pieces are already attached onto piano hinges, the user just needs unfold the pieces and then line up the remaining piano hinge holes with the pre-drilled pilot holes in the last piece of wood and screw it together with the provided screws.

// figure 06.71 Mobile Planter diagram by Author

SUB COMPONENTS

Typical Construction

TYPICAL COMBINATIONS

Once that is complete, the plywood walls have grooves underneath which acts similar to Lego blocks and enables the walls to be securely stackable. The grooves provide vertical stability, while the piano hinges provide the planter with horizontal support.

The planter has several adaptable components within itself, for instance, there is only one type of base, which is a standard steel base, however there are four different types of base plates that can be added to create something different. There is a stand base plate for the option of creating a vertical solitary bee hotel. There is a flat solitary bee base plate that creates a habitat for ground nesting pollinators. If the area has contaminated soil, there is a plastic base plate that can be attached to create a barrier to prevent any cross-contamination. The final base plate allows the user to create a reservoir system within the planter. The reservoir system comes with an additional plastic plate that is meant to be added after the first set of plywood walls.

These planters are meant to be placed on hardscaped surfaces; they are elevated above the ground a bit for mobility and to create passive ventilation from underneath. The planters are not just a city initiative as these planters will be

readily available to the public and home and garden stores. The fixed sizes, shapes, stack-ability and adaptability allow the user to quickly and simply interchange between components or replace parts with ease, making it extremely user-friendly. This not only increases the floral count within the city, it gets communities engaged with bee awareness activities and why providing certain types of forage is better for them. These planters are also ideal for being used on existing rooftops applications that are not designed to have an active green roof system. Current rooftop beehives can have meadows which are provided by the planters. These meadows will increase foraging locations for the bees meaning they do not have to fly as far for nectar and pollen. Rooftop solitary bee hotels will also flourish as they will have local meadows provided to them, decreasing their flight path dramatically and creating an overall healthier environment for them.

// figure 06.72 Rendered view of the Mobile Planter component by Author

// figure 06.73 Physical model study of the Mobile Planter component by Author

THE TOOLSHED

THE TOOLSHED

The toolshed is a simple supporting component that is an extension of the planter concept. The challenge with the toolshed was to create something unique that upon first glance, it is not read as a typical shed. Often times, the shed is placed in the distance away from human sight; however, that is not the case with the toolkit. Everything in the toolkit is met to be seen and touched. The idea was to keep the toolshed in close quarters with the planters as they will go hand in hand; however, figuring out a way to mesh them together became interesting. The idea came by taking a planter and stretching it up to about seven feet tall. It became a narrow closet with a set of doors. The space inside was just enough for storing a dolly, large and small gardening tools. Since the base of the shed remained the same size, it meant that it could be integrated with the planters. Nothing could be placed on the outer three edges as it would block the doors from opening. Being able to have the toolshed blend together so nicely with the planters was a huge success. With its small footprint, it meant that it was just as portable as the planters making this rooftop applicable as well.

Attached at the roof of the shed is an integrated planter which acts an eco-diverse green roof. This is a green roof that is designed to grow into a natural meadow. How this works is that the meadow green roof consists of only soil. The seeds are brought in by the wind and whatever species of plant that thrives in that kind of

condition will flourish significantly. This planter does not need to be tended and it is meant to grow naturally and this becomes a perfect pollinator garden for the bees.

// figure 06.74 Toolshed component by Author

// figure 06.75 Toolshed component diagram by Author

THE EXTRACTION STATION

THE EXTRACTION STATIONS

As mentioned previously, the beekeepers will need supporting components themselves for the increase in beehives within the city. In order to provide for beekeepers extraction stations have been designed for placement near hives. They allow beekeepers to extract and store honey and beeswax and transport these products to local farmers markets or retail stores. These stations are prefabricated, meaning they can be taken down and moved to a different location as required. They come in two sizes; a nine feet long and six feet wide rectangle and six feet square, both are the same height of 10 feet at the highest point. The reason for creating the smaller station was to accommodate space constraints. Certain locations or rooftops may not offer the space necessary to house the regular sized station; therefore, an alternative was created. The smaller station houses the exact same equipment, it just has a smaller footprint. Solar panels are incorporated on the rooftops to generate electricity for some of the beekeeper's equipment. These stations can be placed at strategic locations making them very efficient in honey and wax production.

// figure 06.76 Extraction Station elevations by Author

// figure 06.77 Extraction Station diagram by Author

THE BEE BUILDER’S TOOLKIT

THE BEE TOWER

THE CELL

THE MOBILE PLANTER

THE TOOL SHED

THE EXTRACTION STATION

LEGEND:

THE MATRIX

The bee builder's toolkit matrix illustrates the variations that each component is capable of becoming. Each component has a status chart which indicates what categories each one contains, the level of difficulty in constructability, so the planters are easy constructability because that component is geared more towards the public in creating engagement and interaction. The more difficult ones are meant for professionals to construct, but that doesn't mean that it is denied to public access, as they have the ability to purchase the tools and place them in the city. For instance, a tenant living in a condo that wants to own a beehive can go to the city and apply for an allotment bee tower. They will be directed to their closest bee association which will help them set up everything that is required.

The idea of the crafted components is to encourage and increase the amount of bees within the city. As discovered from previous research that bees do much better in the city than they would in the suburbs, primarily because of banned use of pesticides and insecticides.¹⁷⁷ Bee diversity is also higher in the urban core as people are more sensitive to bees by planting meadows of wildflowers for them.¹⁷⁸ This can only be achieved with the aid of the supporting components, such as the mobile planter. AS the bee population increases, the amount of floral and resources will be required to sustain the increased demand from the bees.

// figure 06.78 The Bee builder's toolkit matrix by Author

// figure 06.79 Physical model of the site plan study by Author

CONCLUSION 07

// figure 07.01 Apple orchard by Author

07.0 CONCLUSION

Introducing more beehives within the city will increase the city's overall bee density; however there must be enough food and resources for them to thrive. As a general rule of thumb, one acre of blossoming trees, shrubs, native and non-native flowers are required to properly sustain one bee colony.¹⁷⁹ This means that for every bee colony being introduced, an acre of forage and resources is required for proper nourishment. This limit to the bee population in urban spaces, therefore, is dependent on the amount of floral landscaping available.

A study done by the University of Guelph revealed that Toronto requires 4855.5 hectares worth of land to grow 30% of its crops.¹⁸⁰ That means that it needs this many hectares which form their calculations it would require 7427 managed beehives within the city to pollinate the required 30% of crops.¹⁸¹ The study revealed that there are only 180 registered beehives which account for only 2.4% illustrating that more registered and managed beehives are necessary to reach that 30% goal of local food production.¹⁸² This also indicates that the flora within the city must also increase as the increase of bees would require additional resources to keep the bees nourished and thriving.

This means that as a Bee City, a lot of work is still required for pollinators to fully flourish in our built environment. As the shift towards becoming more sustainable continues, more and more buildings are beginning to install green roofs; this is an additional asset to the bees as their resources will be increased. This thesis project illustrates how the concept of a Bee Builder's Toolkit is possible, especially in a diverse city like Toronto. There are an abundance of different flower species, pesticides are banned within the city and there are a lot more local initiatives towards pollinator preservation. The toolkit can be adapted to any setting within the city, by doing so; it begins to create pollination corridors as it expands connecting existing fragmented green spaces. Working with the existing urban fabric becomes advantageous as there are fewer disturbances towards the environment as current hardscape conditions are being transformed into pollinator-friendly green spaces. With the development of the toolkit, we are giving back the bees a part of their natural habitat that was taken away from them because of our own development.

The current corridors in the city are vehicular priority and are filled with dense concrete structures that consume most of the street. The pollination corridors look to eliminate that feeling by turning it into a naturalized bee habitat creating a vibrant atmosphere. By establishing beehives in the city, more bees are brought into the city, making bees a part of the whole

urban environment. Bees are vital to society as they account for 1/3 of our global food consumption. These pollination corridors transform dull public spaces or political spaces into something lively and thriving. We must remember that design is altering our relationship with nature and the way we create our urban environment, if it isn't sustainable for bees, it isn't for us either.

// figure 07.02 River of Flowers [left]

// figure 07.03 Honeybee with full pollination pockets by Author

07.1 MOVING FORWARD

Some bee advocates strongly believe that in order to allow the bees to grow and prosper they should be left alone and people shouldn't develop initiatives or movements for them – these advocates believe that letting nature take its course is the best method for the bees. Another voice in this debate, Pieter Basedow states:

“leaving it up to nature where the strong ones will survive and the weak ones die is a very dangerous approach.”¹⁸³

Mother Nature is highly unpredictable and the development of mankind has caused negative side effects onto nature itself (i.e. climate change). Therefore, by leaving things up to nature, there is no guarantee that the bees will survive and if no further self-initiated actions are taken then the development of the human species will surely wipe out entire populations of not just pollinators but even animals. The Yellow-Face bee is the first bee species to be put onto the U.S. Fish and Wildlife endangered species list.¹⁸⁴ The Rusty patched Bumblebee has become a ghost in the shell as it is no longer existent in parts of the world where they used to thrive.¹⁸⁵ There have been attempts for it to be placed onto the endangered species list but it was always delayed.¹⁸⁶ As of February 10, 2017,

the U.S. Fish and Wildlife Services finalized the Rusty Patched Bumble Bee onto the endangered species list, making it the very first endangered bee species within the Continental U.S.A.¹⁸⁷ This list of species will only continue to grow negatively of something is not done immediately.

Architects and Biologists can work together in figuring out a way to create a hive that really services in any kind of climate condition, especially over the winter months as Pieter Basedow sated before, warm climate cities do not face the same type of problem colder city climates do with beekeeping.¹⁸⁸ Wood is a great natural material to use for beehives as it breathes and according to the bee population, that is their natural habitat. Bees are often seen creating nests inside of old tree trunks, openings along the tree or along tree branches. Reiterating what Basedow said:

“it’s not the cold but the moisture buildup in hives that kills bees, if there is over a certain level of moisture, the bees cannot cope with it and die, this is among the beekeepers worst fear is how to keep the moisture out and keep it under control?”¹⁸⁹

Wood shavings and mulch are good methods in moisture absorption and passive ventilation with screen tops and bottoms will allow airflow ton constantly circulate through the hive. Unless it is an extreme cold condition, bees can often handle temperatures of up

to minus thirty degrees Celsius; after all, there are wild bees that live in Siberia.¹⁹⁰

With the intention of creating a more conducive multifunctional environment, there needs to be an established baseline through instrumentation over a period of time. Basedow gives the example of:

“establishing a baseline through all the seasons in order to come up with a plan to outfit all the hives in a commercially viable manner to increase the lifespan of the bees and the instrumentation is the main part in creating the guideline in coming up with something that works even better. For instance, if a hive’s moisture level becomes too high how can the humidity be taken out? We can remove humidity immediately in our own architecture but how do we build that into the architecture of a fully functional beehive?”¹⁹¹

// figure 07.04 Organic Traditional Beekeeping in Siberia

Whether you like it or not, insects are always going to be all around us and bees are also a part of that category. The intention of the Bee Builder's Toolkit is to create an interest of bees within communities. It is also an opportunity in creating connections to nature that have been lost through urban development. This will cause people to take notice of them more which will lead to a better understanding of bees. The more people learn and know, the more awareness will increase about the importance of bees and the fear of being stung should decrease. Bees require three essential things to thrive: flowers, a safe place to build their nest and a pesticide free environment.¹⁹² We are more than capable of achieving this type of living environment. We should be working with technology to supplement nature, however the question is, what is taking so long?

// figure 07.05 No signs of life

// figure 07.06 Honeybee collecting nectar by Author

APPENDICES

The appendices that follow after this are:

Appendix A, which is a list of bee and beekeeping terminology to help the reader understand certain words better.

Appendix B lists the research questions and research methods which was what the whole thesis began with. It shows the thought process involved in performing design research and how the methods evolved from the questions.

Appendix C contains projects that try to introduce bees by increasing the awareness and importance of pollinators. These precedents are what influenced this thesis to become what it is today.

APPENDIX A – GLOASSARY

Anther

Part of the plant that develops and contains pollen

Apiculture

The Science and art of studying and using honey bees for man’s benefit.

Bee Dance

Anthropomorphic term for one of several physical maneuvers conducted within a bee colony; it has very inaccurate correlations relative to a forager’s flight experience in the field (distance and direction of the site visited), but odor on the dancer’s pollen source.

Beehive

Dwelling prepared for a colony of bees

Beeswax

Wax secreted from glands on the underside of the bee abdomen; molded by bees to form honeycomb

Cell

The six-sided compartment of a honeycomb, used to raise brood or to store honey and pollen. Worker cells approximate five to the linear inch, drone cells are larger averaging about four to the linear inch.

Colony

Social community of several thousand worker bees, usually containing one queen, with or without drones.

Comb

(See honeycomb)

Commercial Beekeeper

One who derives an income from apicultural endeavors

Cross Pollination

Transfer of pollen from an anther of one plant to the stigma of a different plant of the same species.

Drone

Male bee

Hive

Man-constructed home for bees

Honey

Sweet, viscous fluid elaborated by bees from nectar obtained from plant nectarines, chiefly floral.

Honey bee

A social honey producing bee of the class Insecta, order Hymenoptera, super-family Apoidea and family Apidae.

Honeycomb

Comb built by honey bees with hexagonal back-to-back cells on median midrib.

Larva

Stage in life of bee between egg and pupa; ‘grub’ stage. Second stage of bee metamorphosis.

Migratory Beekeeping

Movement of apiaries from one area to another to take advantage of honey flows from different crops.

Nectar

A sweet liquid secretion from the nectarines chiefly in flowers and on leaves of plants.

Pollen

Dust-like grains formed in the anthers of flowering plants within which are produced the male elements or sperm. It is the protein food essential to bees for the raising of brood.

Pollination

The transfer of pollen from the anthers of a flower to the stigma of that or another flower.

Pollination Corridor

Safe refuge for pollinators as they travel between pollination pockets. Connective arteries or network between two points.

Pollination Pocket

A collection ``pocket`` of native flowers that attract and support pollinating instects. Natural oasis for pollinators.

Pupa

Third stage of the developing bee, during which it is inactive and sealed in its cell.

Queen

Sexually developed female bee. The mother of all bees in a colony.

Stamens

The pollen producing organs of the flower.

Stigma

The part of the pistil of a flower which receives the pollen for the fecundation of the ovules; the end of the pistil.

Swarm

The aggregate of worker bees, drones and queen that leave the parent colony establish a new colony. Natural division of a colony of bees; usually in spring.

Worker bee

Sexually undeveloped female bee

APPENDIX B – RESEARCH QUESTIONS

1. Why has the bee – human symbiotic relationship changed in recent history?
2. How can architecture become an apparatus to preserve and support the bee populations?
3. How can bee pollination corridors also contribute to increasing public space within Toronto's downtown core?

APPENDIX B – METHODS

The design research that will be used to advance this thesis will include a 3D experiential model of the mapping strategy used to identify the pollination pockets and corridors within the Toronto core. The mapping strategy will incorporate an overlay of existing green zones, native plant species, vacant land maps and existing street networks. This will help identify the pollination pockets and allow the strategic mapping of the pollination corridor network.

A second piece of the design research will involve bee habitat test models. The idea behind the models is to investigate how bee habitats can be incorporated into the public urban environments where they will not be perceived as pests. The guides and steps that will be taken include but not limited to:

1. Mapping analysis, this helps determine locations of the pollination pockets and to strategically plan the network of pollination corridors. This will be preceded in both 3D and digital mapping strategies to outline the extent and scale of the overall thesis intervention.
2. Umwelt of the bee (the bee environment) will investigate the bee species and how they perceive the world around them through research and analysis. The research will examine what the native flora requirements are for sustaining healthy growth of a bee population.
3. The case study approach will introduce local and global projects which address bee habitat and population growth. All the information gathered will be used to supplement Toronto's Bee City title.
4. The design intervention aim is to produce and use a toolkit of bee-friendly components that will create connective networks that can increase the much needed public space within the city of Toronto while simultaneously strengthening the bee population through creating linked habitats.

POLLINATOR PATHWAY

By Sarah Bergmann

The Pollinator Pathway is a design project initiative created by, Sarah Bergmann. The initial concept of the project took place in Seattle and was to create a mile long corridor that connected the Seattle's University's campus to a small forest called Nora's Woods. This then becomes a pollination corridor where are the vegetation within that corridor are native to the pollinators. This eventually came to the expansion of a pollination corridor network where the corridors connect fragmented green spaces within the urban city eventually creating one large network that connects at the global scale. Other cities have places called "pollinator pockets" which are habitats offered to pollinating insects that are not interconnected.

The pollinator pathway is to create that connection between two pollinator pockets, thus forming a network between them that will eventually connect to other pollinator pockets. There are application forms that businesses, institutions, cities and agencies can fill out to see if they qualify to become a part of the network along the pollinator pathway and what they can do to become one.¹⁹³

The idea of this project is relevant to my thesis work as it looks at the larger question of deigning a

different future where we are not always concerned about saving a particular species but where essential species are not in danger. The thesis will look at creating supporting networks for native pollinators using the Earth's ecosystem as a whole. This pathway encourages the government to participate and allows the awareness to spread much faster. The pollinator pathway looks at creating a network of native self-sup-
porting ecosystems.

//figure AC.01 Pollinator Pathways [above]

FARMM'S B-SHACK

By McGill School of Architecture

Farmm's B-Shack is a student led design and construction project to develop a parametric urban beehive. The pavilion is sited to be on McGill's MacDonald campus. Understanding the importance of honey bees and pollination, the B-Shack is a beehive observation and educational center, where it will serve as a teaching and gathering space.

The space provides enough seating for a group of 12 with a small stage that will be used for demonstrations, presentations, lectures and workshops. The structure will house 3 small observation hives. The observation hives allow the public to view the inner workings of the beehive and to create a better connection between bee and human. The hexagonal façade allows for multiple uses as some hexagons will house solar panels, flowers to feed the honey bees and some will be left open to create a permeable space.

This is an interesting project as this is a scaled down approach compared to the sizable Honey Bee + Pollinator Research Center discussed earlier. Although the main purpose is to help foster Montreal's honey bee population, the discoveries made will be applied to honey bees around the world.

The students involved in this project really understand the critical role honey bees play in our food supply. They believe that there is an important connection between the health of food crops and the health of the bee colonies. With the pavilion they are trying to spread the awareness of recent honey beehive deterioration. It seems that many honey beehives are diminishing at an alarming rate and there hasn't been a solid link to why this is occurring.

//figure AC.02 B-SHACK [above]

ELEVATOR-B

By University of Buffalo School of Architecture

Elevator-B was part of a worldwide design/build competition ranging from residential to cultural to landscape. They placed first place and were selected to build their installation in the city of Buffalo. The hexagonal silo was designed with a goal of being able to relocate an entire honey bee colony that was currently occupying an existing building in the “silo city” of Buffalo. The tower stands at a height of about 22 feet with a triangulated facade that is supposed to resemble that of a working beehive. The inside of the beehive contains a wooden cab that acts as an elevator that allows beekeepers to raise and lower the beehive. The bottom of the cab has a laminated panel that allows people to go inside the hive and observe the bees at work. When it comes to time of collecting the honey or inspecting the bee colony, the beekeeper can lower it for easy access.

Although this is a small scale project, it contains a wealth of potential. What began as a design for a competition now stands a permanent installation that has generated numerous amounts of local pedestrian traffic and tourists on an annual basis. People that go in to observe the bees at work will have a much better appreciation towards the hard work that honey bee provide to us on a daily basis. This also establishes

a foundation in raising the awareness of the recent crisis of the pollination decline. It is interactive with the public allowing them to get up close to the beehive but still be safe from any potential harm.

//figure AC.03 Elevator Bee [above]

RIVER OF FLOWERS

By Kathryn Lwin

The River of Flowers is a pollination corridor initiative created by Kathryn Lwin. The challenge is trying to preserve wildflowers within the dense city environment; as the city develops, native green spaces get smaller and eventually disappear. The River of Flowers tries to create a river of floral forage and trees that flow through the built environment. These rivers provide a safe corridor for pollinators to live amongst. There are key guidelines that must be followed in order to qualify to become a River of Flower city. The main guideline is that there must be a minimum of three urban spaces (communities) where there are already wildflowers and trees growing or places that being planned to be planted with native vegetation. Wildflowers and trees will be planted within the path that connects to each space to create a flowing river of native vegetation.

The River of Flowers is a scaled down version of the Pollinator Pathway; however, it is just as powerful being a community led program which creates a great deal of community involvement. Communities produce partnerships to establish the link of the river between them through the infill of native plants. Awareness of the importance of pollinators will spread rapidly as the rivers extend into new communities. The involvement will also generate a much better understanding

amongst the public of the importance of creating these floral rivers and protecting our pollinators. This is a perfect way to create a relationship between people, plants and pollinators.

//figure AC.04 River of Flowers[above]

ENDNOTES

1. Bergmann, Sarah. "Reorganizing Human Landscapes." Pollinator Pathway. Accessed July 16, 2017. <http://www.pollinatorpathway.com/why/#connectivity>.

2. Snyder, Rob. "American Foulbrood (AFB)." Bee Informed Partnership. October 21, 2013. Accessed July 17, 2017. <https://beeinformed.org/2013/10/21/american-foulbrood-afb/>.

3. "American Foulbrood - Prevention and Management." Ontario Ministry of Agriculture, Food and Rural Affairs. Accessed July 17, 2017. <http://www.omafra.gov.on.ca/english/food/inspection/bees/afb-mgmt.htm>.

4. Malone Given Parsons Ltd., Cushman & Wakefield Real Estate Search Corporation The Centre for Spatial Economics, *Sustainable Competitive Advantage and Prosperity - Planning for Employment Uses in the City of Toronto* (Markham, Ontario: Malone Given Parsons Ltd.,[2012]),p. xiii

5. "Current Bee Cities." Bee City Canada. Accessed November 27, 2016. <http://www.beecitycanada.org/become-a-bee-city/current-bee-cities/>.

6. Cornell University. "Two Studies On Bee Evolution Reveal Surprises." ScienceDaily. www.sciencedaily.com/releases/2006/12/061209083342.htm (accessed November 27, 2016).

7. Ibid.

8. Ibid.

9. Ibid.

10. Ellis, Jamie, Dr. "The History of Beekeeping." Lecture. March 7, 2014. Accessed November 27, 2016. <http://leon.ifas.ufl.edu/agr/files/2014/04/History-of-Beekeeping.pdf>.

11. Graber, Cynthia. "Stone Age Pottery Reveals Signs of Beekeeping." Scientific American. November 12, 2015. Accessed November 27, 2016. <https://www.scientificamerican.com/podcast/episode/stone-age-pottery-reveals-signs-of-beekeeping/>.

12. Kevan, Peter G. "Beekeeping." The Canadian Encyclopedia. March 04, 2015. Accessed November 28, 2016. <http://www.thecanadianencyclopedia.ca/en/article/beekeeping/>.

13. Texas A&M University - Agricultural Communications. "Research Upsetting Some Notions About Honey Bees." ScienceDaily. www.sciencedaily.com/releases/2006/12/061211220927.htm (accessed November 28, 2016).

14. Ellis, Jamie, Dr. "The History of Beekeeping." Lecture. March 7, 2014. Accessed November 27, 2016. <http://leon.ifas.ufl.edu/agr/files/2014/04/History-of-Beekeeping.pdf>.

15. Oertel, Everett. "HISTORY OF BEEKEEPING IN THE UNITED STATES." *Farmers Weekly* 5 (1980): 2-9. doi:10.2307/2423024.

16. Ellis, Jamie, Dr. "The History of Beekeeping." Lecture. March 7, 2014. Accessed November 27, 2016. <http://leon.ifas.ufl.edu/agr/files/2014/04/History-of-Beekeeping.pdf>.

17. Langstroth, L. L. *Langstroth's Hive and the Honey-Bee: The Classic Beekeeper's Manual*. 4th ed. Dover Publications, 2004.

18. Oertel, Everett. "HISTORY OF BEEKEEPING IN THE UNITED STATES." *Farmers Weekly* 5 (1980): 2-9. doi:10.2307/2423024.

19. Ibid.

20. Ibid.

21. Simpson, Joy. "BBC - Wiltshire - Beekeeping in Swindon during WWII." BBC News. August 05, 2009. Accessed November 28, 2016. http://news.bbc.co.uk/local/wiltshire/hi/people_and_places/history/newsid_8184000/8184997.stm.

22. Ibid.

23. Holland, Jennifer S. "The Plight of the Honeybee." National Geographic. May 10, 2013. Accessed November 28, 2016. <http://news.nationalgeographic.com/news/2013/13/130510-honeybee-bee-science-europe-an-union-pesticides-colony-collapse-epa-science/>.

24. Ibid.

25. "Bee Colony Collapse Disorder." Bee Colony Collapse Disorder. Accessed November 28, 2016. <http://npic.orst.edu/envir/ccd.html>.

26. "Native Bee Conservancy." Native Bee Conservancy. Accessed November 28, 2016. <http://www.nativebeeconservancy.org/>.

27. Burkle, Laura A, John C Marlin, and Tiffany M Knight. "Plant-Pollinator Interactions over 120 Years: Loss of Species, Co-Occurrence, and Function." JOUR. *Science* 339, no. 6127 (March 28, 2013): 1611 LP-1615. <http://science.sciencemag.org/content/339/6127/1611.abstract>.

28. "The Xerces Society » Red List of Bees: Native Bees in Decline." The Xerces Society » Red List of Bees: Native Bees in Decline. Accessed November 28, 2016. <http://www.xerces.org/pollinator-redlist/>.

29. "Save the Bees." Greenpeace USA. Accessed November 27, 2016. <http://www.greenpeace.org/usa/sustainable-agriculture/save-the-bees/>.

30. Pollinator Partnership. "Selecting Plants for Pollinators." *North*, 2011.

31. Maeterlinck, Maurice. *The Life of the Bee*. Dover Publications, 2006.

32. Ibid.

33. Packer, Lawrence. *Keeping the Bees: Why All Bees Are at Risk and What We Can Do to Save Them*. First. Toronto: HarperCollins Publishers Ltd, 2011.

34. Ibid.

35. USDA. "What is Pollination?" United States Department of Agriculture. Accessed July 23, 2017. https://www.fs.fed.us/wildflowers/pollinators/What_is_Pollination/.

36. Krause, Jennifer. "Pollination." Biology of Plants. Accessed July 23, 2017. <http://www.mbgnet.net/bioplants/pollination.html>.

37. Ibid.

38. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

39. Ibid.

40. Spivak, Marla. "Why Bees are Disappearing." Lecture, March 23, 2016. June 2013. Accessed September 09, 2017. https://www.ted.com/talks/marla_spivak_why_bees_are_disappearing.

41. "Vibrators help flowers release their load as effectively as bees." GMA News Online. May 5, 2015. Accessed September 10, 2017. <http://www.gmanetwork.com/news/scitech/science/481866/vibrators-help-flowers-release-their-load-as-effectively-as-bees/story/>.

42. Spivak, Marla. "Why Bees are Disappearing." Lecture, March 23, 2016. June 2013. Accessed September 09, 2017. https://www.ted.com/talks/marla_spivak_why_bees_are_disappearing.

43. Wilson-Rich, Noah. "Every City Needs Healthy Honey Bees." Lecture, TEDxBoston, Boston, March 15, 2016. June 2012. Accessed September 09, 2017. https://www.ted.com/talks/noah_wilson_rich_every_city_needs_healthy_honey_bees.

44. TVO - Documentary. Canada, 2017. April 29, 2017. Accessed July 23, 2017. <http://tvo.org/video/documentaries/striking-balance/ep-3-mont-saint-hilaire>.

45. "Looking for an overwintering solution for your bees?" NOD Apiary Products. Accessed August 04, 2017. <http://nodglobal.com/bee-cozy-winter-hive-wraps/>.

46. Ibid.

47. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

48. Ibid.

49. "Honey On Tap From Your Own Beehive - Flow Hive ." FLOW. Accessed August 04, 2017. <https://www.honeyflow.com/>.

50. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

51. Ibid.

52. Ibid.

53. Ibid.

54. Ibid.

55. Ibid.

56. Bush, Michael. "Beekeeping." Bush Farms. Accessed August 04, 2017. <http://www.bushfarms.com/beesfaq.htm>.

57. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

58. Ibid.

59. "American Foulbrood - Prevention and Management." Ontario Ministry of Agriculture, Food and Rural Affairs. Accessed July 17, 2017. <http://www.omafra.gov.on.ca/english/food/inspection/bees/afb-mgmt.htm>.

60. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

61. Ibid.

62. Ibid.

63. Ibid.

64. Ibid.

65. American Foulbrood - Prevention and Management." Ontario Ministry of Agriculture, Food and Rural Affairs. Accessed July 17, 2017.

66. "Varroa Mite - Biology and Diagnosis." Varroa Mite - Biology and Diagnosis. Accessed November 28, 2016. <http://www.omafra.gov.on.ca/english/food/inspection/bees/varroa-biology.htm>.

67. Bessin, Ric, and Extension Entomologist. "VARROA MITE INFESTING HONEY BEE COLONIES.pdf," 1991.

68. Mann, ALEX. "Can Australia's Bee Colonies Remain Free of the Varroa Mite?" ABC - Australian Broadcasting Corporation. December 13, 2013. Accessed November 28, 2016. <http://www.abc.net.au/7.30/content/2013/s3911559.htm>.

69. Watson, Matt. "Bee-killing Varroa Mites Found in Port of Townsville." ABC News. July 06, 2016. Accessed November 28, 2016. <http://www.abc.net.au/news/2016-07-06/varroa-mites-found-in-townsville/7572540>.

70. Bessin, Ric, and Extension Entomologist. "VARROA MITE INFESTING HONEY BEE COLONIES.pdf," 1991.

71. Ibid.

72. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

73. Packer, Lawrence. *Keeping the Bees: Why All Bees Are at Risk and What We Can Do to Save Them*. First. Toronto: HarperCollins Publishers Ltd, 2011.

74. Ibid.

75. Pearson, Gwen. "You're Worrying About the Wrong Bees." Wired. April 29, 2015. Accessed September 10, 2017. <https://www.wired.com/2015/04/youre-worrying-wrong-bees/>.

76. Packer, Lawrence. *Keeping the Bees: Why All Bees Are at Risk and What We Can Do to Save Them*. First. Toronto: HarperCollins Publishers Ltd, 2011.

77. Ibid.

78. "Everything you need to know about solitary bees." Grow Wild: Flowers to the People. Accessed September 10, 2017. <https://www.growwilduk.com/content/everything-you-need-know-about-solitary-bees>.

79. Foundation, David Suzuki. 1900. "A Guide to Toronto's Pollinators," 9. http://www.davidsuzuki.org/issues/downloads/Pollinator_Guide_5pg.pdf.

80. "Toronto is Canada's First Bee City!" Toronto Urban Growers. April 1, 2016. Accessed September 09, 2017. <http://torontourbangrowers.org/news/toronto-is-canada-first-bee-city>.

81. Texas A&M University - Agricultural Communications. "Research Upsetting Some Notions About Honey Bees." ScienceDaily. www.sciencedaily.com/releases/2006/12/061211220927.htm (accessed November 28, 2016).

82. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

83. Ibid.

84. Imhoof, Markus, and Claus-Peter Lieckfeld. 2015. *More Than Honey: The Survival of Bees and the Future of Our World*. Vancouver: Greystone Books Ltd.

85. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

86. Imhoof, Markus, and Claus-Peter Lieckfeld. 2015. *More Than Honey: The Survival of Bees and the Future of Our World*. Vancouver: Greystone Books Ltd.

87. Ibid.

88. Ibid.

89. Ibid.

90. Ibid.

91. Ibid.

92. Spivak, Maria. "Why Bees are Disappearing." Lecture, March 23, 2016. June 2013. Accessed September 09, 2017. https://www.ted.com/talks/maria_spivak_why_bees_are_disappearing.

93. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

94. Ibid.

95. Imhoof, Markus, and Claus-Peter Lieckfeld. 2015. *More Than Honey: The Survival of Bees and the Future of Our World*. Vancouver: Greystone Books Ltd.

96. Pearson, Gwen. "You're Worrying About the Wrong Bees." Wired. April 29, 2015. Accessed September 10, 2017. <https://www.wired.com/2015/04/youre-worrying-wrong-bees/>.

97. "Everything you need to know about solitary bees." Grow Wild: Flowers to the People. Accessed September 10, 2017. <https://www.growwilduk.com/content/everything-you-need-know-about-solitary-bees>.

98. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

99. Goulson, Dave. 2016. *A Sting in the Tale: (the Birds and the Bees)*. Random House UK.

100. Ibid.

101. Ibid.

102. Ibid.

103. Ibid.

104. Ibid.

105. Ibid.

106. Ibid.

107. Ibid.

108. Ibid.

109. Ibid.

110. Ibid.

111. Ibid.

112. TVO - Documentary. Canada, 2017. April 29, 2017. Accessed July 23, 2017. <http://tvo.org/video/documentaries/striking-balance/ep-3-mont-saint-hilaire>.

113. Spivak, Marla. "Why Bees are Disappearing." Lecture, March 23, 2016. June 2013. Accessed September 09, 2017. https://www.ted.com/talks/marla_spivak_why_bees_are_disappearing.

114. Goulson, Dave. 2016. *A Sting in the Tale: (the Birds and the Bees)*. Random House UK.

115. A Ghost in the Making: Rusty-patched Bumble Bee. 2015. Accessed September 09, 2017. <http://www.rustypatched.com/>.

116. Ibid.

117. Goulson, Dave. 2016. *A Sting in the Tale: (the Birds and the Bees)*. Random House UK.

118. Ibid.

119. Ibid.

120. Ibid.

121. Ibid.

122. "Everything you need to know about solitary bees." Grow Wild: Flowers to the People. Accessed September 10, 2017. <https://www.growwilduk.com/content/everything-you-need-know-about-solitary-bees>.

123. Goulson, Dave. 2016. *A Sting in the Tale: (the Birds and the Bees)*. Random House UK.

124. Ibid.

125. Ibid.

126. Ibid.

127. "Everything you need to know about solitary bees." Grow Wild: Flowers to the People. Accessed September 10, 2017. <https://www.growwilduk.com/content/everything-you-need-know-about-solitary-bees>.

128. Ibid.

129. Ibid.

130. Ibid.

131. Ibid.

132. Ibid.

133. Ibid.

134. Ibid.

135. Ibid.

136. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

137. Pearson, Gwen. "You're Worrying About the Wrong Bees." Wired. April 29, 2015. Accessed September 10, 2017. <https://www.wired.com/2015/04/youre-worrying-wrong-bees/>.

138. Ibid.

139. Ibid.

140. "Everything you need to know about solitary bees." Grow Wild: Flowers to the People. Accessed September 10, 2017. <https://www.growwilduk.com/content/everything-you-need-know-about-solitary-bees>.

141. Hutchins, Aaron. "Are bee hotels the answer to saving a species?" Macleans. May 25, 2015. Accessed September 10, 2017. <http://www.macleans.ca/society/science/are-bee-hotels-the-answer-in-saving-a-species/>.

142. Gathmann, Achim, and Teja Tscharntke. "Foraging Ranges of Solitary Bees," no. Westrich 1996 (2002): 757–64.

143. Hutchins, Aaron. "Are bee hotels the answer to saving a species?" Macleans. May 25, 2015. Accessed September 10, 2017. <http://www.macleans.ca/society/science/are-bee-hotels-the-answer-in-saving-a-species/>.

144. Government of Ontario (2009, December 15). Bees Act, R.S.O. 1990, c. B.6. Retrieved April 30, 2017, from <https://www.ontario.ca/laws/statute/90b06#s19s1>

145. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

146. Ibid.

147. Ibid.

148. Ibid.

149. Ibid.

150. "Urban Beekeeping." City of Edmonton. Accessed July 20, 2017. https://www.edmonton.ca/city_government/initiatives_innovation/food_and_agriculture/beekeeping-pilot-project.aspx.

151. Ibid.

152. Ibid.

153. Ibid.

154. Ibid.

155. Ibid.

156. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

157. Ibid.

158. Ibid.

159. Varma, Anand . "The First 21 Days of a Bee's Life." Lecture, April 22, 2016. March 2015. Accessed September 08, 2017. https://www.ted.com/talks/anand_varma_a_thrilling_look_at_the_first_21_days_of_a_bee_s_life.

160. Ibid.

161. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

162. Ibid.

163. Ibid.

164. Ibid.

165. Ibid.

166. Ibid.

167. Patel, Menisha, Christian Heath, Paul Luff, Dirk vom Lehn, and Jason Cleverly. "Playing with Words: Creativity and Interaction in Museums and Galleries." *Museum Management and Curatorship* 7775, no. April (2015): 1–18. doi:10.1080/09647775.2015.1102641.

168. Adams, M, J Luke, and T Moussouri. "Interactivity: Moving beyond Terminology." *Curator: The Museum Journal* 47, no. 2 (2004): 155–70. doi:10.1111/j.2151-6952.2004.tb00115.x.

169. Ibid.

170. Ibid.

171. Government of Ontario (2009, December 15). Bees Act, R.S.O. 1990, c. B.6. Retrieved April 30, 2017, from <https://www.ontario.ca/laws/statute/90b06#s19s1>

172. Wang, Qi, and Yanhui Lei. "Minds on for the Wise: Rethinking the Contemporary Interactive Exhibition." *Museum Management and Curatorship* 7775, no. April (2016): 1–18. doi:10.1080/09647775.2016.1173575.

173. Adams, M, J Luke, and T Moussouri. "Interactivity: Moving beyond Terminology." *Curator: The Museum Journal* 47, no. 2 (2004): 155–70. doi:10.1111/j.2151-6952.2004.tb00115.x.

174. Powell, Chris. "Clear Channel revamps Dundas Square media tower." Marketing Magazine. July 22, 2015. Accessed August 04, 2017. <http://marketingmag.ca/media/clear-channel-revamps-undas-square-media-tower-152618/>.

175. Novakovic, Stefan. "Toronto's Housing Crisis: A Problem of Supply or Demand?" Urban Toronto. March 17, 2017. Accessed September 09, 2017. <http://urbantoronto.ca/news/2017/03/torontos-housing-crisis-problem-supply-or-demand>.

176. "São Paulo Bans Outdoor Ads in Fight Against Pollution." World Watch Institute. Accessed August 04, 2017. <http://www.worldwatch.org/node/5338>.

177. TVO - Documentary. Canada, 2017. April 29, 2017. Accessed July 23, 2017. <http://tvo.org/video/documentaries/striking-balance/ep-3-mont-saint-hilaire>.

178. Ibid.

179. Johnson, Dick. "Dick Johnson's Honeybee Corner." Catskill Mountain Beekeepers' Club. Accessed September 09, 2017. <http://www.catskillbees.org/honeybeecorner/>.

180. Bisailon, Rachelle, Kelsey Ducsharm, Luke Ecclestone, Kathleen Minkowski, Sandeep Sanghera, and Brooke Wallace. "Honey Bee Distribution and the Implications on Local Food Production in the City of Toronto," 2015.

181. Ibid.

182. Ibid.

183. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

184. Kennedy, Merrit. "Bees Added To U.S. Endangered Species List For 1st Time." NPR. October 03, 2016. Accessed September 09, 2017. <http://www.npr.org/sections/thetwo-way/2016/10/03/496402620/bee-species-added-to-u-s-endangered-species-list-for-1st-time>.

185. A Ghost in the Making: Rusty-patched Bumble Bee. 2015. Accessed September 09, 2017. <http://www.rustypatched.com/>.

186. Ibid.

187. U.S. Fish and Wildlife Services. "Questions and Answers Final Listing of Rusty Patched Bumble Bee as Endangered," 2017.

188. Basedow, Pieter. "Beekeeper Interview." Interview by author. December 22, 2016.

189. Ibid.

190. Ibid.

191. Ibid.

192. A Ghost in the Making: Rusty-patched Bumble Bee. 2015. Accessed September 09, 2017. <http://www.rustypatched.com/>.

193. Bergmann, Sarah. "Reorganizing Human Landscapes." Pollinator Pathway. Accessed July 16, 2017. <http://www.pollinatorpathway.com/why/#connectivity>.

BIBLIOGRAPHY

A Ghost in the Making: Rusty-patched Bumble Bee. 2015. Accessed September 09, 2017. <http://www.rustypatched.com/>.

Abou-Shaara, H.F. “The Foraging Behaviour of Honey Bees , Apis Mellifera : A Review” 2014, no. 1 (2014): 1–10.

“American Foulbrood - Prevention and Management.” Ontario Ministry of Agriculture, Food and Rural Affairs. Accessed July 17, 2017. <http://www.omafra.gov.on.ca/english/food/inspection/bees/afb-mgmt.htm>.

Basedow, Pieter. “Beekeeper Interview.” Interview by author. December 22, 2016.

Batra, Swt. 1995. “Bees and Pollination in Our Changing Environment.” Apidologie 26: 361–70. doi:10.1051/apido:19950501.

Benbow, Steve. 2012. The Urban Beekeeper: A Year of Bees in the City. Random House UK.

Bergmann, Sarah. “Reorganizing Human Landscapes.” Pollinator Pathway. Accessed July 16, 2017. <http://www.pollinatorpathway.com/why/#connectivity>.

Bisaillon, Rachelle, Kelsey Ducsharm, Luke Ecclestone, Kathleen Minkowski, Sandeep Sanghera, and Brooke Wallace. “Honey Bee Distribution and the Implications on Local Food Production in the City of Toronto,” 2015.

Bush, Michael. “Beekeeping.” Bush Farms. Accessed August 04, 2017. <http://www.bushfarms.com/beesfaqs.htm>.

Candace, S. 2008. Bees: Nature’s Little Wonders. Vancouver, Toronto, Berkeley: Douglas & McIntyre Publishing Group.

Dk, Emma. 2016. The Bee Book. DK.

Droege, Sam, and Laurence Packer. 2015. Bees: An Up-Close Look At Pollinators Around the World. Minneapolis: Voyageur Press.

“Everything you need to know about solitary bees.” Grow Wild: Flowers to the People. Accessed September 10, 2017. <https://www.growwilduk.com/content/everything-you-need-know-about-solitary-bees>.

Foundation, David Suzuki. 1900. “A Guide to Toronto’s Pollinators,” 9. http://www.davidsuzuki.org/issues/downloads/Pollinator_Guide_5pg.pdf.

Gathmann, Achim, and Teja Tscharntke. “Foraging Ranges of Solitary Bees,” no. Westrich 1996 (2002): 757–64.

Goulson, Dave. 2016. A Sting in the Tale: (the Birds and the Bees). Random House UK.

Greer, Lane. 1999. “Alternative Pollinators : Native Bees.” Specialist, 1–14. doi:<http://www.jswcd.org/Files/ATTRa%20native%20pollinators.pdf>.

Grissell, Eric. 2010. Bees, Wasps, and Ants: The Indispensable Role of Hymenoptera in Gardens. Portland: Timber Press.

Halter, Reese. 2011. The Incomparable Honeybee & the Economics of Pollination: Revised & Updated. Victoria, Vancouver, Calgary: Rocky Mountain Books.

Herbert, Mace. 2013. A Book About the Bee. Hard Press.

“Honey On Tap From Your Own Beehive - Flow Hive .” FLOW. Accessed August 04, 2017. <https://www.honeyflow.com/>.

Hubbell, Sue. 1998. A Book of Bees: And How To Keep Them. Boston: Houghton Mifflin Harcourt.

Hutchins, Aaron. “Are bee hotels the answer to saving a species?” Macleans. May 25, 2015. Accessed September 10, 2017. <http://www.macleans.ca/society/science/are-bee-hotels-the-answer-in-saving-a-species/>.

Imhoof, Markus, and Claus-Peter Lieckfeld. 2015. More Than Honey: The Survival of Bees and the Future of Our World. Vancouver: Greystone Books Ltd.

Johnson, Dick. "Dick Johnson's Honeybee Corner." Catskill Mountain Beekeepers' Club. Accessed September 09, 2017. <http://www.catskillbees.org/honeybeecorner/>.

Jordan, Crispin Y, and Lawrence D Harder. 2006. "Manipulation of Bee Behavior by Inflorescence Architecture and Its Consequences for Plant Mating." *The American Naturalist* 167 (4): 496–509. doi:10.1086/501142.

Keller, Laurent. 2003. "Behavioral Plasticity: Levels of Sociality in Bees." *Current Biology*. doi:10.1016/S0960-9822(03)00571-2.

Kennedy, Merrit. "Bees Added To U.S. Endangered Species List For 1st Time." NPR. October 03, 2016. Accessed September 09, 2017. <http://www.npr.org/sections/thetwo-way/2016/10/03/496402620/bee-species-added-to-u-s-endangered-species-list-for-1st-time>.

Krause, Jennifer. "Pollination." *Biology of Plants*. Accessed July 23, 2017. <http://www.mbgnet.net/bioplants/pollination.html>.

Langstroth, Lorenzo. 2014. *The Hive and the Honey-Bee*. Garland: Peacock Press.

Levy, Sharon. 2011. "What's Best for Bees." *Nature* 479: 164–65. doi:10.1038/479164a.

"Looking for an overwintering solution for your bees?" NOD Apiary Products. Accessed August 04, 2017. <http://nodglobal.com/bee-cozy-winter-hive-wraps/>.

Menezes, Cristiano, Ayrton Vollet-Neto, Felipe Andrés Felipe León Contrera, Giorgio Cristino Venturieri, and Vera Lucia Imperatriz-Fonseca. 2013. "The Role of Useful Microorganisms to Stingless Bees and Stingless Beekeeping." In *Pot-Honey: A Legacy of Stingless Bees*, 9781461449607:153–71. doi:10.1007/978-1-4614-4960-7_10.

Michener, Charles D. 1974. *The Social Behavior of the Bees*. Second. Cambridge: The Belknap Press of Harvard University Press. Biophy Library, Wits.

Moisset, By Beatriz, and Stephen Buchmann. 2011. "Bee Basics: An Introduction to Our Native Bees." *Bee Basics: An Introduction to Our Native Bees*, 40. http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5306468.pdf.

Novakovic, Stefan. "Toronto's Housing Crisis: A Problem of Supply or Demand?" Urban Toronto. March 17, 2017. Accessed September 09, 2017. <http://urbantoronto.ca/news/2017/03/torontos-housing-crisis-problem-supply-or-demand>.

O'toole, Christopher. 2013. *Bees: A Natural History*. Richmond Hill: Firefly Books.

Packer, Lawrence. 2011. *Keeping the Bees: Why All Bees Are at Risk and What We Can Do to Save Them*. First. Toronto: HarperCollins Publishers Ltd.

Pearson, Gwen. "You're Worrying About the Wrong Bees." *Wired*. April 29, 2015. Accessed September 10, 2017. <https://www.wired.com/2015/04/youre-worrying-wrong-bees/>.

Petrie, Iain. 2011. "Bee or Not to Bee?" *New Scientist*. doi:10.1016/S0262-4079(11)62286-0.

Pollinator Partnership. 2011. "Selecting Plants for Pollinators." North.

Powell, Chris. "Clear Channel revamps Dundas Square media tower." *Marketing Magazine*. July 22, 2015. Accessed August 04, 2017. <http://marketingmag.ca/media/clear-channel-revamps-dundas-square-media-tower-152618/>.

"São Paulo Bans Outdoor Ads in Fight Against Pollution." World Watch Institute. Accessed August 04, 2017. <http://www.worldwatch.org/node/5338>.

Snyder, Rob. "American Foulbrood (AFB)." Bee Informed Partnership. October 21, 2013. Accessed July 17, 2017. <https://beeinformed.org/2013/10/21/american-foulbrood-afb/>.

Spivak, Marla. "Why Bees are Disappearing." Lecture, March 23, 2016. June 2013. Accessed September 09, 2017. https://www.ted.com/talks/marla_spivak_why_bees_are_disappearing.

Thorp, R. W. 2000. "The Collection of Pollen by Bees." *Plant Systematics and Evolution* 222 (1-4): 211–23. doi:10.1007/BF00984103.

"Toronto is Canada's First Bee City!" Toronto Urban Growers. April 1, 2016. Accessed September 09, 2017. <http://torontourbangrowers.org/news/toronto-is-canada-first-bee-city>.

TVO - Documentary. Canada, 2017. April 29, 2017. Accessed July 23, 2017. <http://tvo.org/video/documentaries/striking-balance/ep-3-mont-saint-hilaire>.

"Urban Beekeeping." City of Edmonton. Accessed July 20, 2017. https://www.edmonton.ca/city_government/initiatives_innovation/food_and_agriculture/beekeeping-pilot-project.aspx.

U.S. Fish and Wildlife Services. "Questions and Answers Final Listing of Rusty Patched Bumble Bee as Endangered," 2017.

USDA. "What is Pollination?" United States Department of Agriculture. Accessed July 23, 2017. https://www.fs.fed.us/wildflowers/pollinators/What_is_Pollination/.

Varma, Anand . "The First 21 Days of a Bee's Life." Lecture, April 22, 2016. March 2015. Accessed September 08, 2017. https://www.ted.com/talks/anand_varma_a_thrilling_look_at_the_first_21_days_of_a_bee_s_life.

"Vibrators help flowers release their load as effectively as bees." GMA News Online. May 5, 2015. Accessed September 10, 2017. <http://www.gmanetwork.com/news/scitech/science/481866/vibrators-help-flowers-release-their-load-as-effectively-as-bees/story/>.

Walther-Hellwig, K, and R Frankl. "Foraging Habitats and Foraging Distances of Bumblebees , *Bombus* Spp . (Hym ., Apidae), in an Agricultural Landscape" 124 (2000).

Weidenhammer, Lori. 2016. Victory Gardens for Bees: A Diy Guide To Saving the Bees. Madeira Park: Douglas & McIntyre Ltd.

Williams, Neal M., Daniel Cariveau, Rachael Winfree, and Claire Kremen. 2011. "Bees in Disturbed Habitats Use, but Do Not Prefer, Alien Plants." *Basic and Applied Ecology* 12 (4): 332–41. doi:10.1016/j.baae.2010.11.008.

Wilson-Rich, Noah. "Every City Needs Healthy Honey Bees." Lecture, TEDxBoston, Boston, March 15, 2016. June 2012. Accessed September 09, 2017. https://www.ted.com/talks/noah_wilson_rich_every_city_needs_healthy_honey_bees.

Wilson-Rich, Noah. 2014. *The Bee: A Natural History*. Princeton University Press.

Winfree, Rachael. 2010. "The Conservation and Restoration of Wild Bees." *Annals of the New York Academy of Sciences*. doi:10.1111/j.1749-6632.2010.05449.x.

Winston, Mark L. 2014. *Bee Time: Lessons from the Hive*. First. Cambridge, London: Harvard University Press.