Architectura insectum sapien:
Crafting a framework to establish a new architecture that considers mutualistic relationships between humans and insects.

by

Courteney Gazdik

A thesis submitted in partial fulfillment
of the requirements of the degree of
Master of Architecture
in Lawrence Technological University
2022

Thesis Committee:

Scott Gerald Shall, Chair

Ralph Nelson

Sara Codarin

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0.0 ABSTRACT

In modern times, insects are viewed as pests. Due to this resistant relationship, we have established a built environment that pushes insects aside. This has helped to create a steady decline in the insect population, leading to resource shortages, changes in the environment, and the extinction of species.

This decline in insect population is frightful because insects make up ⅔ of all known species, and are vital to the health of humans and the planet. Architects are able to make a change because we are the designers of the built environment. By continuing to study insect and human architecture, we can then begin to design a new type of architecture that encourages positive interactions between humans and insects. Creating positive interactions between species will aid in creating a mutualistic relationship; this relationship will then help in the awareness and protection of all species, which will result in the improvement of the health of humans, insects, and the planet.

A framework will be established that creates mutually beneficial spaces that can be integrated to any preexisting structure.This redesign will then be evaluated by a classification system that will place the architecture on a spectrum from the original design to the most mutualistic design possible. This framework will ultimately improve our relationship with insects and provide us with a tool to measure our relationship,

which could lead to change. Although any city could have been selected for the comparative study, the first project will be located in Sacramento - a city with an ideal location to investigate this concern. It is an inland city with a growing population of humans; but also located in the state with the highest number of endangered insect species, while also providing the country with most of its fruits, vegetables, and nuts. The health of humans, insects and the planet will improve when an architectural framework is established that will create a mutualistic relationship between humans and insects.

PART ONE

1.0 INSECTS

1.1 HUMAN'S VIEW

Human's view of insects has changed overtime. At one point in history, humans described insects as being sacred and even implemented them into their art. One example being, the "dung beetles (scarabs) were sacred to the Ancient Egyptians. In the Medieval Era insects were often referred to symbolically, as markers of death and decay, or as examples of hard work and persistence."[2] Another example of this relationship was with the humans of the American Southwest. There were pottery items that were found with "a strikingly high proportion of insect subjects"[3]; most of them being caterpillars or grasshoppers.

But overtime, we grew away from insects, and the built environment began becoming a place based on a mostly antagonistic view of insects despite their vitality to our health and the planet. Humans began looking at them as pests, believing that insects' only purpose is to carry diseases, and started to design structures that kept these species out. There are several businesses whose sole purpose is to eliminate insects from inside or around buildings. As we began to educate ourselves about the roles that insects have in the world, humans have finally started to see the benefit of insects because "it has been realized that insects provide many useful ecosystem and cultural services"[2]. If we as architects continue to educate ourselves about these issues, we may be able to make a change.

1.2 VITALITY

Different insects have different roles in the ecosystem; a few of those roles include pollinators, soil fertility, clean up crew, biological control, seed dispersal and much more. Pollinators, including insects such as bees,wasps, flies, butterflies and moths, will move or carry pollen from the stamen, the male part of the flower, to the stigma, the female part. If this did not happen then humans would not have many things including, but not limited to, watermelon, chocolate, coffee, tea plants, and dairy products.

Another role is soil fertility; this would include insects such as beetles and termites. This role consists of fertilizing and transforming the soil by the insects moving through the soil, moving it and releasing proteins into it. This is important so that humans are able to grow crops and other plants.

As stated previously, flies are pollinators, but they are also known as nature's cleanup crew. “Blow flies, for example, lay their eggs in rotting carcasses. The maggots feed on the decomposing flesh, helping break the organic material into its components. Their digestive processes release the nutrients back into the soil.”[4]. There are a lot of roles that insects have in the ecosystem, and keeping the earth cleared of carcasses and feces is one of them.

Figure 1: A visual representation of the roles that insects have in the ecosystem. Not all insects/roles represented.

Insects also account for three-quarters of today’s global biodiversity. Not only are there a lot of different kinds of insects, they also have a large biomass. It is said that, “At any time, it is estimated that there are some 10 quintillion individual insects alive.”[5]. But, “A meta-analysis has found that land-dwelling insect populations are decreasing by about 0.92% per year, which amount to 50% fewer insects in 75 years”[8] Insects create biodiversity and are vital to the health of humans. They provide us with various types of food, fabrics, and a space not covered in feces. Because they are so important to our survival, we should be encouraged to create a closer relationship.

2.0 RELATIONSHIP

2.1 SYMBIOTIC

Symbiotic is a blanket term referring to a wide variety of relationships between different species. It can then be separated into three different categories along a spectrum. The first being parasitic, where one benefits usually off of the expense of the other, a common example of this being a flea and its host. Commensalistic is the next category which is described as, one benefiting while the other is unharmed. A common example of this being a shark and remora fish, where the remora fish lives off of the shark without hurting or helping it. And the last category is mutualism, where all partners benefit. A common example being a honey bee and a flower. The bee is helping the flower by moving the pollen, and the flower is giving the bee nectar. Mutualism is the end of the spectrum that is the focus of this study, a mutually beneficial relationship between humans and insects.

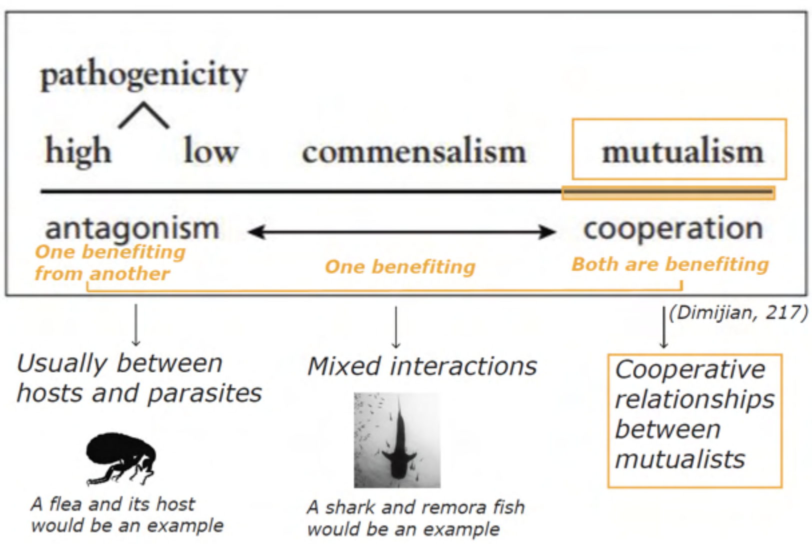


Figure 2: The spectrum of symbiotic relationships; ranging from parasitic to mutualistic relationships.

2.2 MUTUALISTIC

A mutualistic relationship can be split into two different categories: obligate, when the survival of one or both of the species depend on one another, and facultative, where both organisms benefit but are not dependent on the relationship to survive. Shelter, protection, nutrition and reproductive purposes are some reasons why two species might have this kind of relationship. It is common for one organism to be the only one to obtain nutrients, while the other species receives some type of service; but ultimately this type of symbiotic relationship will involve both species living and benefiting from each other.

This type of relationship is important because mutualism will cause species to benefit from each other in multiple ways. Not only will this mutualistic relationship benefit both species in its entirety, it could also start to change the ecological traits of the species that weren't always obtainable. "Mutualistic symbiosis can accelerate evolutionary innovation through the merger of once independent lineages, providing species with new ecological traits and allowing them to inhabit previously inaccessible ecological niches"[7]. This could be extremely beneficial currently since climate change is making it necessary for adaption to happen.

3.0 MUTUALISTIC ARCHITECTURE

3.1 DESIGNING AS INSECTS

A way to encourage this mutualistic relationship between humans and insects is to design the built environment to begin to pull these species together in a manner that will benefit both. As architects, we play a role in creating this relationship because we are the designers of the built environment; and that is directly related to habitat destruction, one of the major causes of inland insects seeing a decline in population numbers.. Architects and biologists have realized that there are many similarities between biological processes and design, and architects can learn a lot from insects.

Architects have already begun looking into insect architecture to learn new ways to design and construct, one well known example is learning about natural ventilation for high rise buildings from termite mounds. Eastgate Centre by Mick Pearce is a well known example. Learned from termite mounds on how to naturally ventilate high-rise buildings. Termites construct their mounds in a way that allows hot air to be pushed down to the bottom to be cooled before rising again due to heat. “This allows the heat difference to move air around and save energy.”[9]

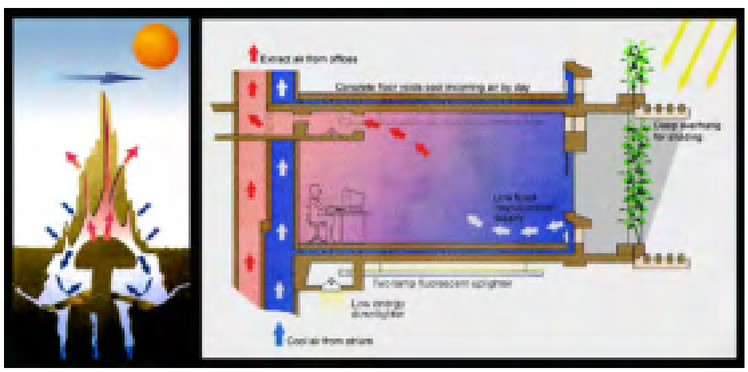


Figure 3: An image of the function of a termite mound, and how that function could be incorporated into human architecture.

Another common example is the use of the perfect honeycomb shape that is produced by bees in their hives. The honeycomb can be beneficial in multiple ways; take a look at Honeycomb Apartments by OFIS Architects as an example. Not only is the honeycomb aesthetically pleasing, this design offers sunlight to come into the space but still enough shading so that the space doesn’t feel too public. The honeycomb outdoor balconies are also designed for natural ventilation.

Figure 4: An image of the Honeycomb Apartment design, showing the use of sunlight techniques and natural ventilation achieved by the honeycomb shape.

As these projects begin to start incorporating what we can learn from insect architecture into human architecture, I want to push these ideas forward. Instead of designing for humans by taking ideas from insects, we should begin to use those design ideas in order to create a mutualistic relationship between humans and insects; a relationship where both species are benefiting, thriving, and living in harmony.

3.2 DESIGNING FOR INSECTS

Architects are learning from insects, but they are designing for them as well. Some have begun thinking about the health of insects like the Butterfly Effect by VenhoevenCS, and others to encourage movement to result in a healthier planet like the Vulkan Beehive from Snohetta. Other architects like The WEAK! have begun to learn from insects and nature and resemble forms created by insects in their projects The Bug Dome. And then other architects have thought about the interactions and thinking about how we are able to coexist with insects, like Joyce Hwang with, City Creatures or Hidden in Plain Sight.

As these projects are beginning to move in the right direction, there are some that have concerns. When considering the Vulkan Beehive, this project was to encourage the movement of bees into the area. This was the right approach, but the final product didn't seem to have much context to the larger problem, where are the bees? It seems like this structure was just placed on top of an existing building without much thought as to why bees were missing from the area, or considering the interaction between these bees and humans.

Figure 5: Vulkan Beehive designed by Snohetta pictured.

On the other hand, The Butterfly Effect, which is a project that is very new and still in the conceptual phase, is thinking about the movement of insects as well, but this seems to be a bit more successful. In this instance, the architects have learned that toxins from the cars on the highway are affecting the health of the insects flying over the road in order to get to the plants and forest on the other side. As a result, the architects were able to design a web that goes over the highway, protecting the insects from toxins, while also reducing the noise from the highway, and “nitrogen and particulates released by traffic would remain in the roadside woodland and act as a fertilizer for the soil.”[10] There is also talk about adding pv panels on top to then convert sunlight into energy. This project was more successful because the architects were able to recognize the problem, and design something that not only solved that problem, but has multiple benefits that originated from the design.

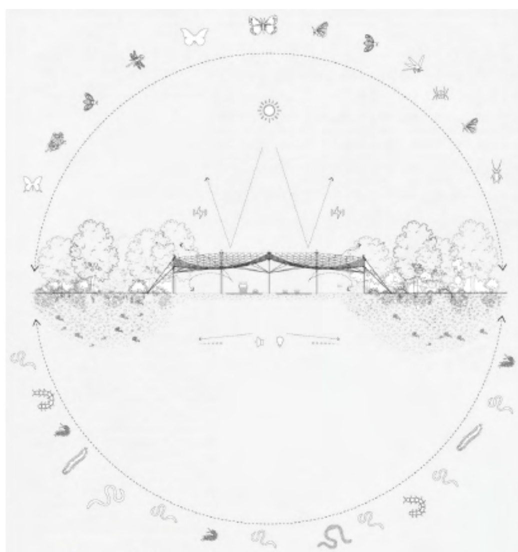


Figure 6: A graphic to show the impacts of the Butterfly Effect created by VenhoevenCS.

The Butterfly Effect was a great precedent to show how a design decision can begin to impact multiple species and ecosystems at once. In order to continue analyzing these precedents, I began to put them on a spectrum of least mutualistic to most mutualistic based on some initial observations. The precedents that found themselves at the latter end, such as the Butterfly Effect, found themselves considering more than one species when making design decisions.

PART TWO

4.0 MUTUALISTIC FRAMEWORK

4.1 A NEW TYPE OF ARCHITECTURE

As I continued to analyze different types of human and insect architecture, I found myself wanting to bring the two together; creating a new type of architecture. Instead of humans consciously pushing insects away and designing structures that have a lot of “unused” space, humans can begin to incorporate different materials, spaces, natural resources, and textures into or onto the facade of the building to allow for insects to reside in those places. This will be structured on a framework that could be incorporated into any existing building. With habitat destruction being one of the main reasons we are seeing this population decline, no more additional areas should be cleared or disturbed to incorporate this architecture.

As previously mentioned, this framework should be able to be incorporated into any preexisting structures anywhere, making location not a huge factor in the design. But in order to be able to establish and analyze the new framework, a site location has to be chosen. This will ensure that the framework is creating mutualistic relationships between humans and insects, and verify that this new type of architecture can stop this population decline.

4.2 LOCATION

The primary criteria for the initial location where this framework is being established, is it needs to be located in an inland city. This is where we are seeing a decrease in insect population while the aquatic insect population is actually increasing. I began with a broader scope, first determining which country would be best to establish this new architecture.

California is an ideal location in the United States to locate because it produces a great percentage of the nation's fruits, nuts, and vegetables, but it is the state with the highest number of endangered insect species, almost 30% more than Florida which is second. There are 94 endangered insect species in the United States, California is home to 57 of those species. California also "produces two-thirds of the nation's fruit and nuts and more than one-third of its vegetables"[12], meaning in order to keep those foods in abundance, insects need to be present.

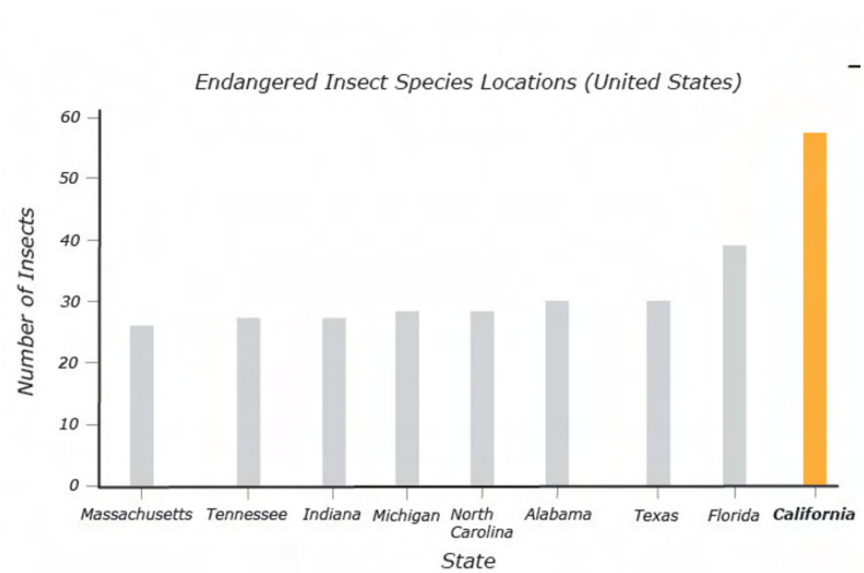


Figure 7: This figure shows the states with the highest number of endangered insect species.

Any inland city in California would have been appropriate to choose. To be considered an inland city, a city must be “generally less than 1,000 yards.”[13] Another aspect that would be beneficial in choosing a city is the history it has with research on insect population. Many places in California have been studied when it comes to insect population and species, but most of the articles and studies seem to focus on the San Francisco area as well as the Sierra Nevada area.

The site was chosen for a few reasons. Sacramento is the capital of California, and the capitol building which is located in the middle of downtown, sits on an axis stretching out to the river. The capitol building also sits on one of the largest areas of greenspace in the city, so locating nearby will give insects a better chance to populate throughout the city. Sacramento is an inland city in California, defined by the Sacramento River running along the perimeter. Because of this, the chosen site could not be within 1,000 yards of the river. There is a proposal submitted for this location; the Canopy by Hilton. It is supposed to be a 14 storey mixed-use building with ground floor restaurants and bars, with hotel rooms and apartments located above.

This site and program was also chosen because I was looking to establish an architecture where both species are considered at the same time and at the same value. Being able to adopt basic information such as connecting to the corner, number of hotel and apartment units, and program placement that was already figured out by the team who designed the Canopy, I am able to focus my time completely redesigning the

Canopy, keeping those assets, but complementing them with an equally powerful set of assets used to serve the insect population.

4.3 SACRAMENTO, CALIFORNIA

What is the architecture like in Sacramento? In studying the historic patterns of architecture in most American urban cores, including Sacramento, one notices a rather pronounced shift from insect-friendly to insect-agnostic to insect-antagonistic architecture. I looked at buildings overtime, analyzing them through the lens of an insect. Take a building such as the California Governor's Mansion designed by Nathaniel Goodell in 1877; there are a lot of large, shaded areas where insects could create their own architecture. There were even small crawl spaces covered by screens or weaving material that could also be a space for insects, where larger predators could not get in.

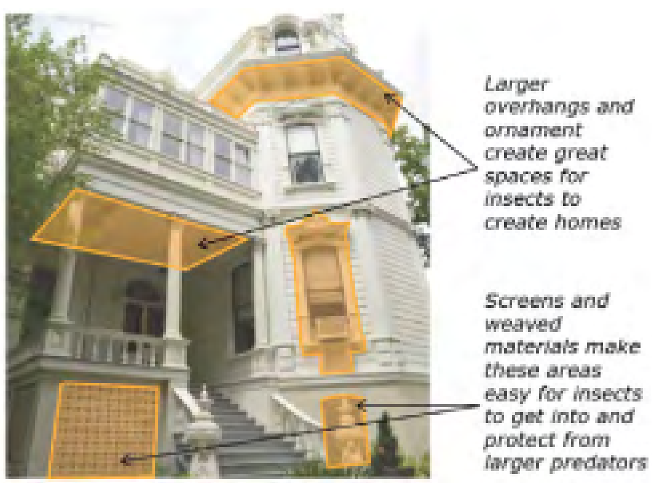


Figure 8: A photo of California Governor's Mansion designed by Nathaniel Goodell with spaces where insects could reside highlighted in orange.

As time went on and ornament and decoration were pushed aside for glass and straight, clean facades, insects seem to have less and less of a place to reside. Without large overhangs, or deep insetted windows, insects aren't able to find places on the facade to create their architecture. An example of this could be the Bank of the West Tower, designed by E.M. Kado Associates. This building is essentially all glass, with little to no window insets or overhangs. Most green spaces were eliminated from this site, besides very small, controlled ones that are located far from the building.

Figure 9: Bank of the West Tower designed by E.M. Kado Associates, this building shows less ornament and more glass facades that took over design.

How could we begin to rethink some of these current buildings? I began looking at precedents that were beginning to create ecosystems. How were some of these buildings successful or not successful in creating an ecosystem and bringing different species together? One that was interesting and something that could be rethought for the design of the Elks Tower, designed by Leonard J. Starks, is something similar that was incorporated in the Villa M. This project, designed by Triptyque Architecture, is focused on the health of humans and other species, letting nature create the facade. These little green spaces then create balconies for the apartment units. This type of design could easily be thought of to redesign the Elks Tower by adding these green balconies to the facade.

Figure 10: Elks Tower is pictured on the left and the Villa M pictured on the right.

4.4 CREATING AN ECOSYSTEM

In order to create this mutualistic relationship, a series of positive interactions need to happen between different species, creating an ecosystem. This ecosystem will consist of different squads. All of these squads play different roles in the ecosystem, and have different relations to each other and one another.

This project will be based upon indigenous pairings in the region for the study, and will include four squads. These squads are groupings of species' who have similar qualities and use spaces or other species in similar ways. The human squad will be based upon the program given by the hotel project, which will act as a comparative study. This squad will include the human residents of the apartment units, the human visitors of the hotel, and the human visitors of the retail spaces such as restaurant, bar, or cafe. The insect squad will be based upon the natural ecosystem of the region for the work. This squad will include a primary insect who is endangered in the area, and then secondary and tertiary species who aid in the survival of the others. The primary insect is the Valley Elderberry Longhorn beetle. This beetle has an already established obligate mutualistic relationship with the secondary species, the Blue Elderberry tree. Creating a space where the elderberry tree is able to thrive will directly cause the beetle to thrive. Correspondingly, the vegetative squad will include all vegetation on the site, the most important being the secondary species, but tertiary native species will be added to support the ecosystem, such as the Coast Live Oak and California Holly. And last the built squad will include any built environment on the site. This could be the physical footprint of the building, or any building material that is placed on the site that interacts with the other species or squads.

4.5 SITE

To let the ecosystem thrive, the ideal living conditions for each species needs to be considered. What is the ideal amount of sun, water, what type of soil, and how much space does it need to grow? Prioritizing this will cause the building footprint to be pushed back to the north side of the site where the least amount of sun is, and being fairly small and tall to provide as much of the grade level to the elderberry tree. In order to provide certain spaces to certain species, the green roof will be dedicated to the insect squad while the grade level and a plant nursery cafe separating the residential and hotel spaces will be areas of more potential interaction between the human and insect squads.

Also, other aspects that will be explored will be allowing for the building to be submerged below grade, this could create more space for the human and vegetation squads. Possibly allowing for parking or more retail space for the human squads, while allowing the walls to be living walls for the vegetation squad. Vertical gardens including tertiary and native plants will cover the facade while ornament and shade will create spaces for more species to reside.

Figure 11: Determining the location of the site. Downtown Sacramento sits on an axis running down to the river, creating this architecture overtime along the axis might begin to help this population decline.

5.0 COMPARISON ANALYSIS

5.1 ESTABLISHING CRITERIA

After doing much research and analysis, many aspects have been established. First, Creating a space where the elderberry tree is able to thrive will directly cause the beetle to thrive. This will include providing other species that help in its development and survival, enough space for it to grow, and as much sunlight as possible. This will cause the building footprint to react to sunlight, trying to orient the building in order for as much of the building's facade to receive direct sunlight as possible. The function lawn will house ponds to provide the vegetation and insect squads water in some of their more dominant spaces. Also adopting the program spaces from the Hilton; a strong street presence is a must for human needs, so providing much of the grade level to the humans with the restaurant, bar and cafe spaces will achieve this. Not all spaces will be appropriate for every squad; just as a restaurant or hotel room will be intended only for the human squads, the rooftop will be dedicated only to the vegetation and insect squads. Vertical gardens including tertiary and native plants will cover the facade while ornament and shade will create spaces for more species to reside. Texture will want to be added to a majority of the facade to allow for different squads to thrive.

5.2 COMPARISON MATRIX

How could all this information be put into a comparison matrix to establish a framework for a new type of architecture? First, breaking down the information into four categories of varying scales, Form, Greenspace, Material, and Aesthetics. Starting with laying out parameters of topics based on research, then looking at the current proposed design. Does the Hilton achieve these goals? If not, what could be added, subtracted, changed, to make the Hilton more mutualistic in that topic. Different mutualistic levels were created to see how the implications of these topics would change the overall design, starting with the mutualism level 1 being slightly more mutualistic than the original design; ranging to the mutualism level 4 which is much more mutualistic than both.

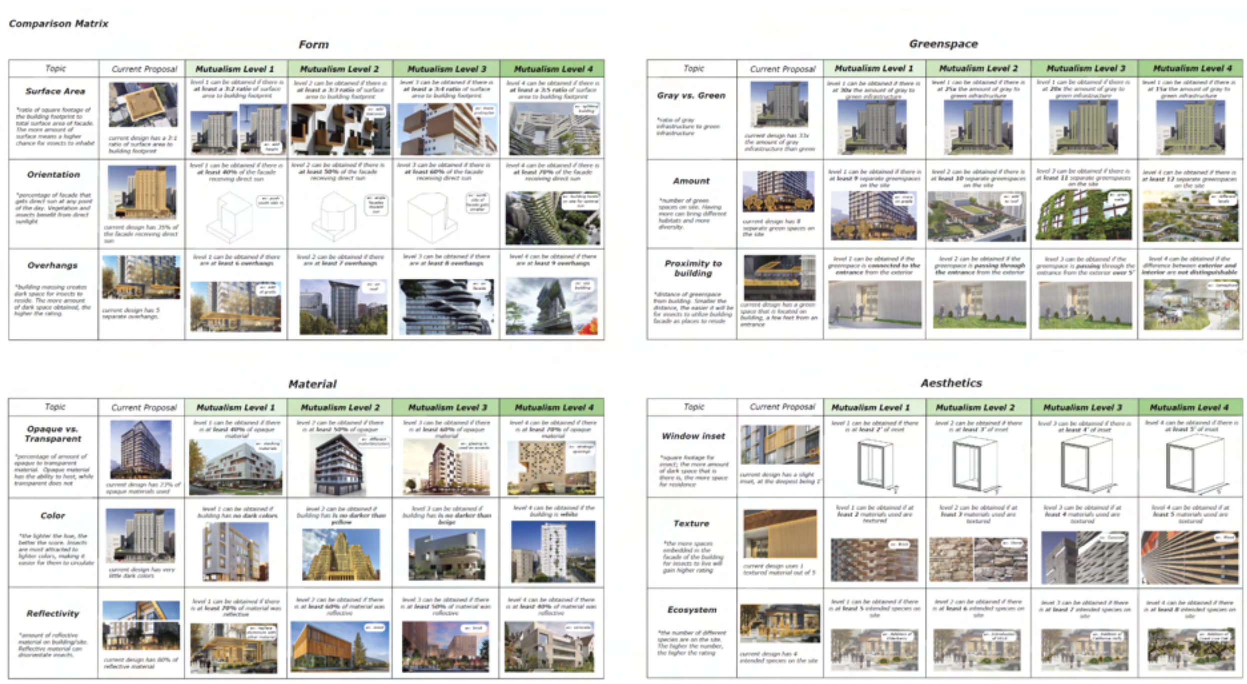


Figure 12: Comparison Matrix of all 12 topics.

Taking window inset for example; as previously discovered in other investigations, larger window insets allow for more places for insects to reside. If that window inset becomes larger, not only will it allow more room for more insects, but it will begin to allow room for other insects, plants and possibly humans, thus creating a more mutualistic relationship. This matrix is to show how it can become more mutualistic, but it does not mean that the mutualism level 4 is the most mutualistic that it can be.

PART THREE

6.0 DESIGN DEVELOPMENT

6.1 INCORPORATION OF COMPARISON MATRIX

Was there a hierarchy in any of these topics? Which topic determines where the design begins? There are topics about massing, such as the orientation of the building, how much surface area the facade has, and how large are the window insets. And then there are smaller detailing topics, such as the properties of certain materials, and the ecosystem that will begin to emerge when putting these species together.

By beginning to incorporate these 12 topics into the complete redesign of the Canopy, the comparison between mutualism levels became a thought. How are these different levels compared to one another? Is there a way to just add a few aspects in order to achieve a mutualistic building? Starting with the lowest mutualism level, mutualism level 1, where each topic is getting slightly altered. Then went straight to the mutualism level 4, where the design was being pushed even more to create a much more mutualistic relationship. Then finally, taking it full force and pushing each topic as far as it could go, ending with the Ultimate mutualistic design.

6.2 MUTUALISTIC DESIGN

Starting with the massing topics, first beginning to orientate the building. How could the orientation begin to change from the current design to become more mutualistic, and what does that look like? By thinking about sun studies performed earlier in the investigation, and the intent of having as much of the facade receive some sort of direct sunlight during the day, then manipulating the mass by taking away the “L” shape that was shading a good portion of the original building, also slanting walls towards the south to eliminate as much shading as possible, and having the building begin to be step back to obtain as much sunlight as possible.

As learned from previous precedents, such as the Butterfly Effect, we know that cars release toxins that kill insects and make it difficult for them to move from place to place. A large wall will act as a barrier between the site and the street, this will include the addition of tertiary vegetation species that will aid in removing these toxins which will create cleaner air for the other species on the site. This platform on grade level will be intended for the human squad, where the restaurants, bars, and cafe area will still be. While the large function lawn will sit on top of this platform, this space will be intended for all squads.

A ramp will lead species from grade level to the function lawn. This ramp will lead the squads to the function lawn and one of the most mutualistic spaces on the site. The ramp will ease the human squad into the space, beginning with simple teriterary species. The wall will use tertiary vegetation species in order to act as a filtration system for the toxins coming from the nearby street. This will allow for the secondary and primary species to safely be placed further along the ramp as the air begins to be clean again. The wall will act as a space for insects to reside, with divots and texture allowing the insects to make homes and create their own architecture.

Figure 13: Render of entry onto ramp from street, showing the ventilation wall.

As a user moves further up the ramp, more species will be added. The ramp will bring users to the function lawn, a major space for mutualism on the site. The function lawn will be intended for all species; this is an area where the insect and vegetation squads will thrive because there is great sunlight, a pond for water collection, and addition of more species in the ecosystem. This will be an area where the human squad is able to relax, read a book, talk amongst each other, or work from home. This gives a chance for all the squads to have interactions between one another.

Figure 14: Render of the function lawn, showing all species interacting.

The last space created for interactions between squads, are the plant nurseries located on every hotel and residential floor. The plant nursery will be an area where the human squad is able to view from the interior; as some users might not want direct contact with some of the other squads, this allows them to enjoy the space as well. But of course, this area will be open to the human squad to physically enjoy as well. This area is much like the function lawn, just at a smaller scale.

Figure 15: Render of plant nursery located on all floors.

7.0 CONCLUSION

Overall, this thesis is looking to use architecture to create mutualistic relationships between humans and insects in order to create a healthier planet for all. By creating spaces of interaction between humans and insects will start to build that relationship. Us, as humans and architects, should be more mindful when designing, who's space are we taking away to construct our new design? How are we giving back to those we are taking space from? And how are these design decisions going to affect our health, the health of other species, and the health of the planet.

Bibliography

6. Bailey, Regina. “Mutualism: Symbiotic Relationships.” ThoughtCo, Sep. 3, 2021, thoughtco.com/mutualism-symbiotic-relationships-4109634

4. Blaettler, Karen. “List of Tiny Insects.” Sciencing, November 18, 2019. https://sciencing.com/list-of-tiny-insects-12470401.html.

3. Capinera, J. L. “Insects in Art and Religion: The American Southwest.” American Entomologist 39, no. 4 (1993): 221–30. https://doi.org/10.1093/ae/39.4.221.

13. “Code Section.” Law section, 2016. https://leginfo.legislature.ca.gov/faces/codes_displaySection.xhtml?lawCode=PRC§ionNum=30103.

12. Cornelisse, Tara. “Tara Cornelisse: California Is Having an 'Insect Apocalypse.' the State Should Take It Seriously.” Tribune, San Diego Union-Tribune, 17 Dec. 2020, https://www.sandiegouniontribune.com/opinion/commentary/story/2020-12-16/california superior-court-insects-endangered-species.

2. Eggleton, Paul. “The State of the World's Insects.” Annual Review of Environment and Resources 45, no. 1 (2020): 61–82. https://doi.org/10.1146/annurev-environ-012420-050035.

10. Englefield, Jane. “The Butterfly Effect Creates a Bridge for Insects to Cross the Road.” Dezeen, July 20, 2021. https://www.dezeen.com/2021/07/08/the-butterfly-effect-sustainable-bridge-insects-cross-road/#:~:text=According%20to%20VenhoevenCS%2C%2085%20per,the%20road%20and%20pollinate%20plants.

8. Kimbrough, Liz. “Insects Decline on Land, Fare Better in Water, Study Finds.” Mongabay Environmental News, May 8, 2020. https://news.mongabay.com/2020/05/insects-decline-on-land-fare-better-in-water-study-fi nds/.

5. “Numbers of Insects (Species and Individuals).” Smithsonian Institution. Accessed January 30, 2022. https://www.si.edu/spotlight/buginfo/bugnos.

9. Rowe, Mark. “Architects Inspired by Engineers of Insect World.” The Independent. Independent Digital News and Media, March 14, 1999. https://www.independent.co.uk/news/architects-inspired-by-engineers-of-insect-world-1080524.html.

7. Sorensen, Megan E S, Chris D Lowe, Ewan J A Minter, A Jamie Wood, Duncan D Cameron, and Michael A Brockhurst. “Role of Exploitation in the Establishment of Mutualistic Microbial Symbioses.” OUP Academic. Oxford University Press, July 4, 2019. https://academic.oup.com/femsle/article/366/12/fnz148/5528313.

11. Win, Thin Lei. “Farming Insects May Solve One Problem but Create Others, Scientists Warn.” Reuters. Thomson Reuters, January 14, 2019. https://www.reuters.com/article/us-global-insects-food/farming-insects-may-solve-one-problem-but-create-others-scientists-warn-idUSKCN1P81VM.

Image Bibliography

Figure 2:

Dimijian, Gregory G. “Evolving Together: The Biology of Symbiosis, Part 1.” Baylor University Medical Center Proceedings, vol. 13, no. 3, 13 July 2000, pp. 217–226., doi:10.1080/08998280.2000.11927677.

Figure 3:

Pearce, Mick. Eastgate Building Harare, 2016. https://www.mickpearce.com/Eastgate.html.

Figure 4:

Gantar, Gal. “Honeycomb Apartments.” Honeycomb apartments, 2018. https://www.ofis.si/eng/projects/housing/honeycomb_apartments.html.

Figure 5:

“Vulkan Beehive” Snohetta

https://snohetta.com/project/186-vulkan-beehive

Figure 6:

Englefield, Jane. “The Butterfly Effect Creates a Bridge for Insects to Cross the Road.” Dezeen, July 20, 2021. https://www.dezeen.com/2021/07/08/the-butterfly-effect-sustainable-bridge-insects-cross-road/#:~:text=According%20to%20VenhoevenCS%2C%2085%20per,the%20road%20and%20pollinate%20plants.

Figure 8:

Whittle, Syd. “Governor's Mansion Historical Marker.” Historical Marker, January 3, 2020. https://www.hmdb.org/m.asp?m=13882.

Figure 9:

“Projects.” Rudolph and Sletten, 2022. https://www.rsconstruction.com/projects/tsakopoulos-investments-bank-of-the-west-tower/.

Figure 10:

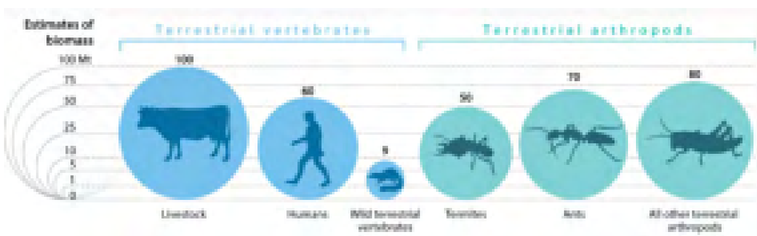
Moreira, Susanna. “Villa M / Triptyque Architecture.” ArchDaily, ArchDaily, 27 Aug. 2021, https://www.archdaily.com/967487/villa-m-triptyque-architecture?ad_source=search&ad_medium=projects_tab.

Appendix A: Literature Review

Eggleton, "The State of the World's Insects."

"However, in the past few decades, it has been realized that insects provide many useful ecosystem and cultural services: Many insects pollinate crops (47). These include bees, both social and solitary, moths and butterflies, wasps, and flies.

"The main threat to insects appears to be land use change, pesticides, and pollution, although climate change may become an increasing threat factor in time (62). The land use changes are multiple, but the most obvious are conversion of natural habitats to intensive agricultural (87, 88) and urban ones (89), the tendency for humans to tidy up seminatural and peri-urban ecosystems that they manage (90), overuse of pesticides (91), pollution (92), and global climate change (93). "



The reason for studying the state of insects is to better understand if there is a threat to insects in order to better understand if there needs to be a change in the way that humans live. This source will help me in doing that because it provides me with information regarding the interactions between humans and insects, that there is a decline in insect populations, and describes the main drivers of this decline is human disturbance. "The main threat to insects appears to be land use change, pesticides, and pollution, although climate change may become an increasing threat factor in time (62). The land use changes are multiple, but the most obvious are conversion of natural habitats to intensive agricultural (87, 88) and urban ones (89), the tendency for humans to tidy up seminatural and peri-urban ecosystems that they manage (90), overuse of pesticides (91), pollution (92), and global climate change (93)."[1]

Jackielsohn, "The Importance of Insects in Agricultural Ecosystem"

"Insects account for approximately 66% of all known species, constituting more than three-quarters of today's global biodiversity"

"Insects are the key components in diverse ecosystems as major role players in functioning of ecosystem processes [30]. Since insects are mostly perceived as pests or potential pests, this ecological importance of insects often goes unnoticed. The main

[1] Eggleton, Paul. "The State of the World's Insects." Annual Review of Environment and Resources, vol. 45, no. 1, 17 Oct. 2020, pp. 61–82., doi:10.1146/annurev-environ-012420-050035.

ecological functions of insects in ecosystems are ecosystem cycling, pollination, predation/parasitism, and decomposition"

"Insects are not pests in an ecological or evolutionary context [30]. Insects are vital for human survival, because crops cannot be produced without the ecosystem functions provided by insects."

Studying the importance of insects in order to find out how they contribute to the earth. In order to better understand if there would be a problem if we saw a decrease in the number of insects or biodiversity. This source will help me in doing that because it provides me with a lot of information on why insects are important to the earth and their role within the ecosystems. “Insects are the key components in diverse ecosystems as major role players in functioning of ecosystem processes [30]. Since insects are mostly perceived as pests or potential pests, this ecological importance of insects often goes unnoticed. The main ecological functions of insects in ecosystems are ecosystem cycling, pollination, predation/parasitism, and decomposition”[2]

Ireland & Garnier, “Architecture, Space and Information in Construction Built by Humans and Social Insects: A Conceptual Review”

"Some species of ants are known to clear debris and vegetation to form large trail networks the size of a football field, connecting their multiple nests to various resources [17–19]. Others have mastered the art of tunnelling to build underground networks of galleries connecting chambers housing their workforce, brood, food stockpiles and even subterranean fungus garden [20–25]. Many species of ants, termites, bees and wasps build structures by accumulating material (e.g. wax, saliva-imbibed soil or vegetable fibres) that will form walls, pillars, floors and ceilings"

"The emergent, adaptable and situated structures built by social insects offer intriguing insights in particular for architects to re-evaluate not only the sustainable aspects of the human-built environment but also to question the distinction between cognitive phases of human architecture (i.e. between design, construction and occupancy stages) and to think about these as continuous."

"Architects, on the other hand, who are becoming more aware of the parallels between biological processes and design, as well as the artefact-making capacities of animals, are turning more to biology to explore innovative methods of problem-solving and designing."

[2] Jankielsohn, Astrid. “The Importance of Insects in Agricultural Ecosystems.” Advances in Entomology, vol. 06, no. 02, Jan. 2018, pp. 62–73., doi:10.4236/ae.2018.62006.

Studying the similarities of human architecture and social insects’ structures in order to find out why architects could benefit from the way insects build in order to better understand a new form of architecture. This source will help in doing that because it begins to explore the construction of structures built by social insects, and looking at the difference between human and non-human constraints in regards to architecture. "Architects, on the other hand, who are becoming more aware of the parallels between biological processes and design, as well as the artefact-making capacities of animals, are turning more to biology to explore innovative methods of problem-solving and designing."

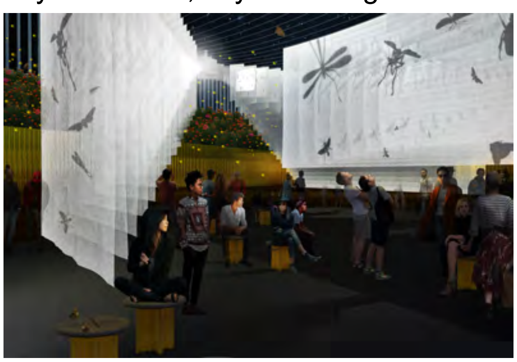
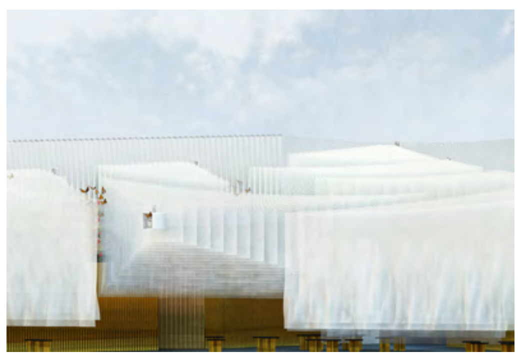
[3]Ireland, Tim, and Simon Garnier. “Architecture, Space and Information in Constructions Built by Humans and Social Insects: A Conceptual Review.” Philosophical Transactions of the Royal Society B: Biological Sciences, vol. 373, no. 1753, 2 July 2018, p. 20170244., doi:10.1098/rstb.2017.0244.

Appendix B: Precedent Review

Bug Dome, The WEAK!


I am studying the Bug Dome because I want to find out ways to learn from insects and nature to better understand how to create a mutualistic relationship between humans and insects. The WEAK! Architects came together to design a building that learns from nature and lets nature be the designer instead of the architect. The design was intended to be weak in order to let nature build upon it and make it strong. “What comes to architectural control, we must give up in order for the nature to step in and for the human nature as part of nature.”[1]

City Creatures, Joyce Hwang

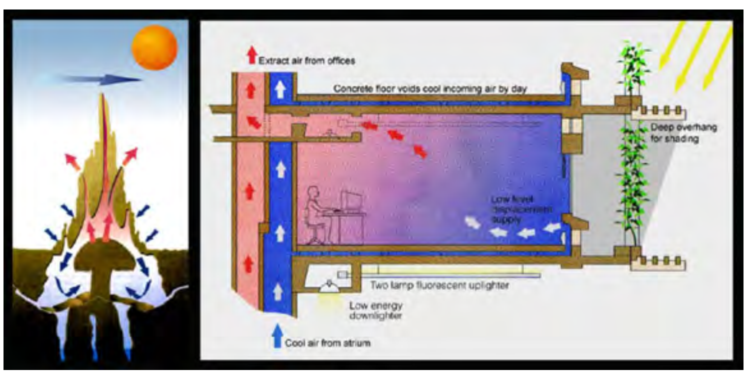
I am studying City Creatures because I want to find out ways that architects are already creating interactions between humans and insects to better understand how to create a mutualistic relationship with insects. Joyce Hwang’s project City Creatures began with the understanding that “city life” is always referenced about humans, but never about non-humans, which “insects and arthropods constitute over 80% of the world’s species population”[2]. Because we are interacting with these non-humans everyday without even knowing, Hwang chooses to propose a design that begins to illuminate these creatures.

[1] Cilento, Karen. “Bug Dome / the Weak!” ArchDaily, ArchDaily, 16 Jan. 2010, www.archdaily.com/46710/bug-dome-the-weak.
[2] Hwang, Joyce. “18. City Creatures.” Ants of the Prairie, www.antsoftheprairie.com/?page_id=2298.

Cricket Shelter, Terreform ONE

I am studying the Cricket Shelter because I want to find out ways to create a hybrid architectural typology to better understand how to create a mutualistic relationship with insects. “The UN has mandated that insect sourced protein will become a major component in solving global food distribution problems. This impacts people globally, since continuing to raise livestock is not possible at our current rate of consumption and resource extraction.”[3] Terreform ONE has recognized that it might be beneficial to design a single structure, that is self-sufficient, that acts as a shelter and an insect farm. This structure is a simple construction that can be placed virtually anywhere.

Eastgate Centre, Mick Pearce



I am studying the Eastgate Centre because I want to find out ways that architects are already learning from insects to better understand how I can use those skills and improve them to create a mutualistic relationship between insects and humans. Learned from termite mounds on how to naturally ventilate high-rise buildings. “Termites build their mounds to allow hot air to be pushed into channels and down to the basement where it is cooled before rising again as it gets hotter. This allows the heat difference to move air around and save energy.”[4]

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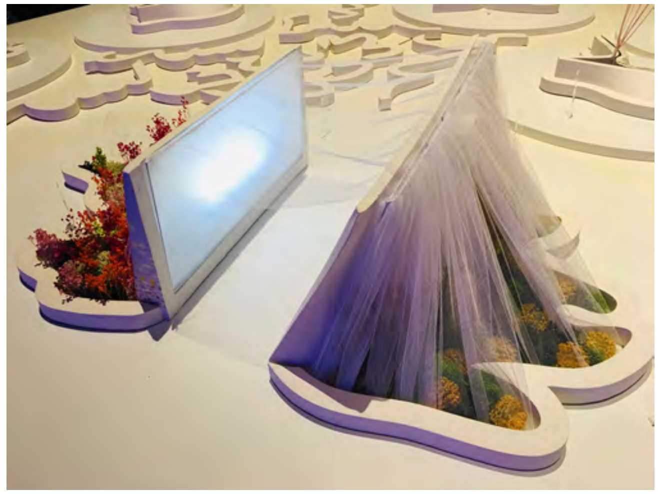
[3] “Cricket Shelter.” Terreform ONE, terreform.org/cricket-shelter.

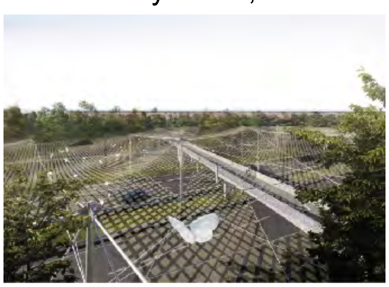
[4] Mark Rowe, “Architects Inspired by Engineers of Insect World,” The Independent (Independent Digital News and Media, March 14, 1999), https://www.independent.co.uk/news/architects-inspired-by-engineers-of-insect-world-1080524.html.

Hidden in Plain Sight, Joyce Hwang



I am studying Hidden in Plain Sight because I want to find out ways to amplify the presence of insects to better understand how to create a mutualistic relationship with insects. Joyce Hwang's project focuses on co-existing that happens everyday between humans and insects. "Hidden in Plain Sight deploys visual tactics to both enhance insect habitability, while also provoking human curiosity through new spatial and perceptual experiences. Stemming from the fascinating world of insect vision and perception, the project uses colors, patterns, and light toward both insect and human benefit."[5]

The Butterfly Effect, VenhoevenCS



I am studying The Butterfly Effect because I want to find out ways to encourage a healthier interaction between humans and insects to better understand how to create a mutualistic relationship with insects. VenhoevenCS has a conceptual design of a web that will be placed above a road in order to provide cleaner air space for the insects to cross and pollinate. This design could be easily replicated in other places as it is essentially just a series of honeycombs that could be fit to the width of the road, and then it is all tied back to surrounding trees. There is also talk of installing solar panels on the web to collect energy from the sun.[6]

[5] Hwang, Joyce. "19. Hidden in Plain Sight." Ants of the Prairie, www.antsoftheprairie.com/?page_id=2263.
[6] Englefield, Jane. "The Butterfly Effect Creates a Bridge for Insects to Cross the Road." Dezeen, 20 July 2021, www.dezeen.com/2021/07/08/the-butterfly-effect-sustainable-bridge-insects-cross-road/.

Vulkan Beehive, Snøhetta

I am studying the Vulkan Beehive because I want to find out ways to encourage the movement and residence of insects to better understand how to create a mutualistic relationship with insects. Snøhetta saw the great benefits of bees ,"Bees are among the world's most important food suppliers," said Snøhetta. "One third of the world's food production is depending on pollination, where bees play the largest role."[7] , and the firm decided to design structures that would encourage bees to live in them and pollinate the area around them. They collaborated with a local beekeeper which helped them with shapes and heights of openings which would help make sure bees felt comfortable but would also help with the beekeeping needs.

[7] "Vulkan Beehive." Snøhetta, snohetta.com/projects/186-vulkan-beehive.