Natural Reclaiming

Using a Natural Perspective to Address Important
Changes in our Waste Stream.

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A Special Thanks

To the **Professors** who have inspired me to think differently about the world and to challenge my conception of what is possible.

To my **Parents** who have always provided more than enough love and support.

To my **Friends** and the **Fencing Team** who truly made these past five years a memorable experience.

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Thesis Statement

The natural world is comprised of ecosystems that feed off one another and create sustainable closed loops. Our human ecosystem is different from those found in nature because often our human practices are inefficient and lead to waste. A series of explorations exploring human systems that are connected and disconnected from the natural environment has found that it is possible to use nature's ecosystems as precedents to improve and change our perspective on what waste is.

This research studies how natural ecosystems can change our perspective on organic waste and allow us to take steps towards a closed-loop ecosystem. In nature, organic matter is always reused in the continuous cycle of life and death. Our current organic waste stream however does not follow this pattern. Composting, which has been a widely known method of recycling for hundreds of years is hardly used. Instead, our organic waste joins all our other waste in landfills across the United States.

The reasons behind this disconnection with nature can be traced back to our complex society and environment. This thesis explores the different scales of urban environments present in our society and the waste resources they produce. In conjunction with these environments, it explores the different methods that are used to recycle organic waste in nature and the human systems that have been developed from them. With this knowledge, it provides insight into methods that can be used to create a closed-loop organic waste stream in small and medium-sized urban environments.

One important note is that these closed-loop systems are not economically sustainable without government incentives. Because of this fact, the thesis hopes to introduce a solution to gradually prepare these smaller and medium-sized environments to be included in the closed-loop organic waste stream.

Intention

This is my attempt to fill part of the gap that I found while studying the waste stream in Northern Michigan. There is a large opaque gap between the residents, designers, and companies involved in our waste stream. Residents often have little understanding of how their trash is handled and less incentive to care about it. Companies are driven by finances and have little incentive to promote public transparency.

I have intended to attempt to propose changes that will bridge these perspectives of the residents and companies. To passively allow residents to understand the waste stream and why their actions matter; and for companies to see the economic benefit of investing in these sustainable solutions.

Journey

During the year, this thesis changed direction. It was originally focused on greenhouses and their implementation into areas of need and buildings that are not being used.

The direction changed when I realized that the mechanism I was using to support these greenhouses had more potential than the greenhouses themselves.

This mechanism was a bio-digester that harvested the power of composting food to create energy, heat, and fertilizer. This direction led me to study bio-digesters further. I understood that their best application is in our waste stream.

I analyzed the different urban environments contributing to the waste stream and focused on two. These urban environments populate most of Northern Michigan.
My studies of the area have led me to propose changes to our infrastructure that will allow these urban environments to become part of a larger sustainable closed-loop waste ecosystem.

The Human and Natural Perspective.

Human Culture and Nature

Human Culture and Nature

Humans and Nature have existed together for thousands of years but our ecosystems are often at odds with each other. Our human activities lead to environmental destruction while nature finds a way to cope. Often times we view these coping mechanisms as environmental disasters. However, with a simple change in our human perspective, we can create resources from these disasters.

We'll use agriculture as an example. As crops are grown, farmers supplement their fields with fertilizer to ensure the plants have all the required nutrients to produce a bountiful harvest. Some of this fertilizer is washed away by rain or groundwater and enters our watershed. This fertilizer travels down the watershed until it is deposited in a large body of water. Once here, it fuels the growth of algae which multiplies until the fertilizer has been exhausted. While it is growing the algae is a source of oxygen and a haven for some aquatic life. However, once the fertilizer is gone the algae starves and dies off in large quantities. During this stage, the decomposing algae consume oxygen and starve local aquatic life in what is known as aquatic hypoxia.

A key concept in this process is that things eventually reach an equilibrium in nature, whether that be a good or a bad thing. The fertilizer that reaches large bodies of water is dealt with through an exponential and self-destructive process. However, there is a part of this process that I would like to isolate and look at. While the algae are growing, it is consuming fertilizer which is harmful to some aquatic environments. This consumption is not a bad thing and it can be replicated on a human scale.

We have algae farms that consume nutrients and produce biomass, which can be created into other products. Nature has already shown us that the fertilizer present in the water is conducive to growing algae. All that would be left is to intervene and create a system that leeches the fertilizer from rivers before it reaches large bodies of water. Essentially, instead of letting nature naturally bring things to equilibrium, we can replicate the natural path to equilibrium and prevent the harmful effects while retaining valuable resources.

This sort of thinking is meant to connect the two different ecosystems that are currently existing together but not working together. From a human perspective, we see fertilizer flowing down rivers as an agricultural loss because we cannot retrieve the fertilizer. We see the algae blooms in lakes as an environmental disaster because we cannot prevent it. However, when we combine these two circumstances and view the dissolved fertilizer as a resource and the algae as a potential product we begin to see a nature-like process forming where all the elements in a system balance each other.

Our human perspective is often a product of the complex and confusing human ecosystem where we discard products once they are no longer useful. There are many benefits we stand to gain from mixing our perspective with that of Nature's perspective. The natural perspective views all things like resources and strives to reach equilibrium. This is a reoccurring theme that can be seen throughout this thesis and is a core element behind my final proposal.

Greenhouse Systems

Greenhouse Typologies
Unique Strategies
Exploring the Natural Perspective
Bridging Fundamental Concepts

Greenhouse Typologies

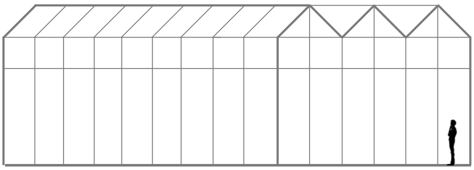


Figure 1.1

Greenhouses are a human invention that utilizes a natural perspective. Understanding the way plants respond to their natural environment is the first step towards finding the natural perspective of plants.

All plants grown in a greenhouse need sunlight. This light is an important part of photosynthesis. In addition to light, these plants need nutrients, water, and CO2. To create a building that grows plants efficiently, we need to place ourselves in in their perspective.

We have used this perspective to understand that plants have a preferred environment. This led to the creation of greenhouse: A human element that understands and works with the laws of nature.

These greenhouses have developed into three different types of categories: low technological, medium technological and high technological. These classes are divided based on the amount of technology and design that goes into each greenhouse.

High technological greenhouses are similar to Figure 1. These greenhouses feature large interior volumes that help maintain the interior climate.

These greenhouses are often at least 20 feet tall and can cover a large area. They feature the most automation, typically with automated windows and climate control. Some greenhouses feature fine screens in their windows to keep out any pests that might harm the produce.

Their construction is almost always modular. Because of the automation and size of the building it is cost effective to use modular sections.

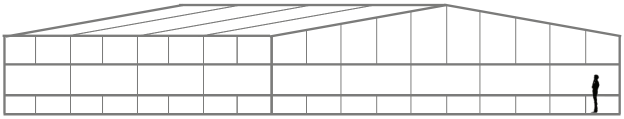


Figure 1.2

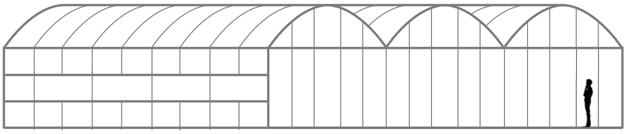


Figure 1.3

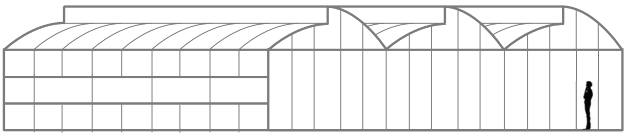


Figure 1.4

Medium technological greenhouses are slightly less advanced than the previous greenhouse. These greenhouses typically do not have automated climate control. They use passive strategies that utilize natural conditions to regulate the interior environment.

Figure 1.2 represents greenhouses found in Almeria, Spain. Due to high winds, these buildings have developed a shape that is wind resistant and much wider than other greenhouses.

The second building in Figure 1.3 represents a much more common typology. These buildings can be found around the world. Their shape collects rainwater and their operable sides allow for additional ventilation in the summer.

The third building in Figure 1.4 represents buildings that capitalize on a local wind condition. In some areas, wind patterns are seasonal and usually come from the same direction. These greenhouse developed fins that create a negative or a positive pressure that can be used to increase airflow in greenhouses in hot climates.

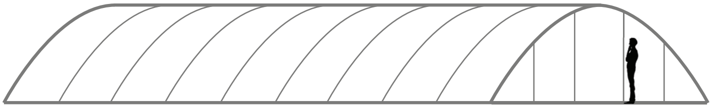


Figure 1.5

Last we have low technological greenhouses. These are the cheapest investment and usually feature poor ventilation. Their primary purpose is lengthening the growing season for crops. During the spring, it is common for frost to kill crops or stem their growth. These low-cost greenhouses provide a way to protect crops from the elements. Additionally, they are warmer and usually extend the growing season by a few weeks at least.

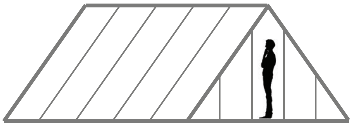


Figure 1.6

However, these greenhouses can be expensive if used on a large scale. It is uncommon for farmers to use these on open fields because they are typically not reusable and require intensive labor. (Figure 1.5)

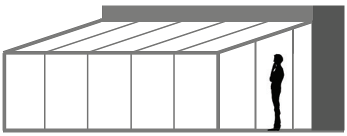


Figure 1.7

Smaller variations of these greenhouses in Figures 1.6, 1.7, 1.8 can be seen in neighborhoods and backyards. These are common ways for homeowners to get a head start on their gardens.

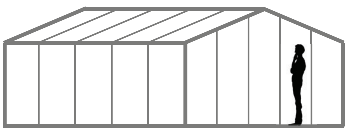


Figure 1.8

Because these greenhouses are often focused on collecting light and heat; their form is usually derived from this goal. Lean-to greenhouses like Figure 1.7 capture light from a specific direction. Other shapes like triangles or rectangles are used for aesthetics.

Unique Strategies

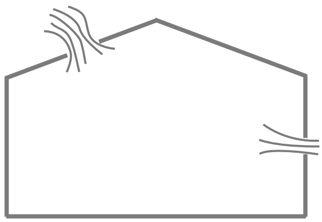


Figure 1.9

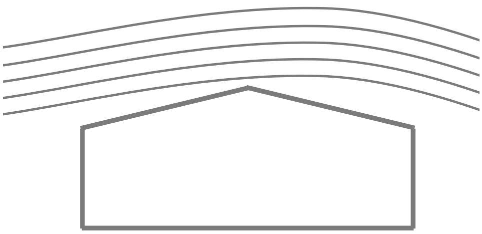


Figure 1.10

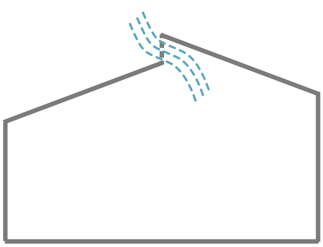


Figure 1.11

Low technological greenhouses are the cheapest kind of greenhouse and usually have one goal. Because of their low cost, they have adapted to serve many different purposes.

Figure 1.9 shows a greenhouse that attempts to increase airflow. Some greenhouses in Africa use this method to increase airflow to dry coffee beans.

Figure 1.10 shows a greenhouse that developed its shape to avoid high winds. This creates a calm interior environment to grow crops.

Figure 1.11 shows a greenhouse with a moisture-wicking vent. These strategies can be used in areas with high humidity to passively decrease humidity within the greenhouse.

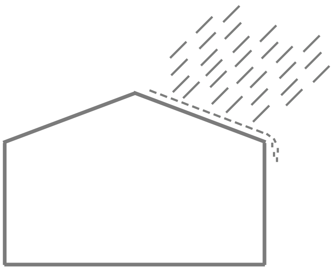


Figure 1.12

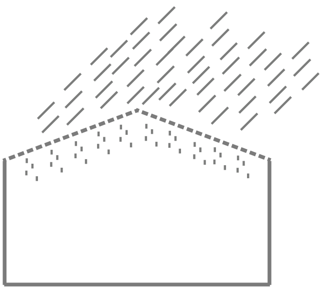


Figure 1.13

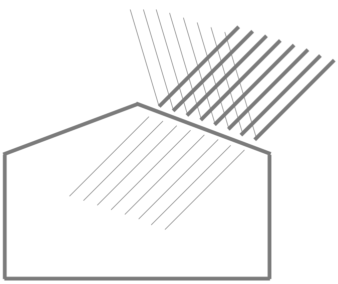


Figure 1.14

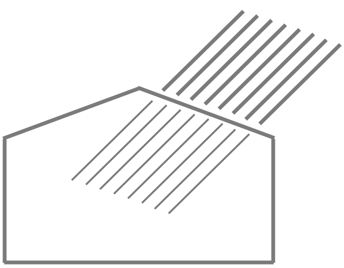


Figure 1.15

Figure 1.12 shows a common benefit of greenhouses: they shelter crops from the elements. Extreme weather events may damage the greenhouse but the crops within are usually safe from all other weather events.

Figure 1.13 shows a Net greenhouse that uses nets instead of a continuous plastic cover. This allows partial protection from the elements. Usually, these strategies help keep out bugs.

Figure 1.14 shows the use of a reflective coating to decrease solar heat gain. These strategies are often used in windows to help lower temperature gain.

Figure 1.15 shows the use of shades being used to reduce the overall sunlight entering the greenhouse. This strategy is a cheap alternative to altering the actual greenhouse. Strategies like this are used in areas where a few months might be too warm or bright for the crops.

Exploring the Natural Perspective

Figure 1.16

In retrospect of the creation of greenhouses, it is probably easier for us to see the natural perspective than it was for the creators. We can see the importance of light, we know plants need CO2 for food. We also understand that ventilation is a key factor, and the interior environment has an efficient range. These are all things we can see after the evolution of greenhouses.

However, if we were looking in the right places, we could have found this information in nature instead of through trial and error. Pants grow in different regions for specific reasons. This is an obvious observation partially because it is in hindsight. We have already learned this thing.

Figure 1.17

But it difficult to find inspiration in nature, partially because we don't know where to look. Nature's systems are complex and vast. Each system might inspire some human endeavor, but we don't know where in the human ecosystem to look.

This process is an iterative process to attempt to generate ideas and connections between the human and natural ecosystem. Pictured is the process that takes place in greenhouses substituted into various human environments.

In Figure 1.16 we can see the greenhouse as a tool for energy or as a source of pollution in Figure 1.17.

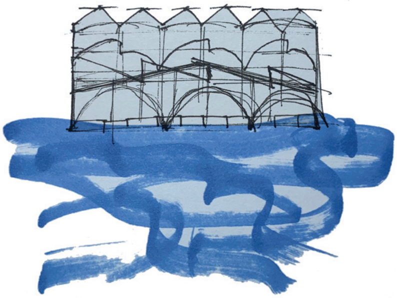
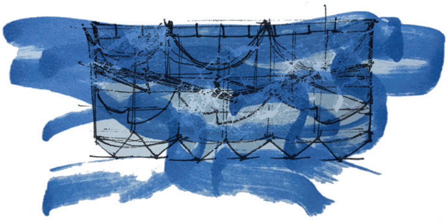


Figure 1.18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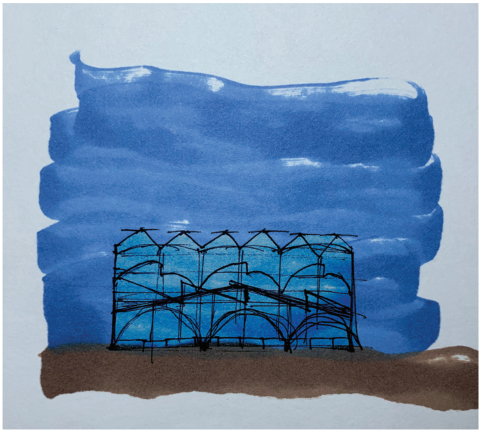


Figure 1.20


Figure 1.21


Figure 1.22

This iterative process was used to contemplate the different areas that a greenhouse could exist. By placing it in different environments we change our perspective of the greenhouse's different possibilities.

One important change was placing the greenhouse in the water. I had not realized I was constraining myself to land until I made these iterations.(Figures 1.18-1.20) This concept sparks very interesting ideas. Some companies use algae greenhouses to filter their by-products. This process is very similar to Algae blooms which occur in some lakes due to fertilizer runoff. [1]

The similarity between these processes begged the question: why couldn't these greenhouses exist in the water and harvest excess fertilizer?

The urban diagrams of the greenhouse within a city in Figure 1.22 were sparked by the book The Vertical Farm: Feeding the World in the 21st Century. This book focused on a greenhouse within a skyscraper. These types of buildings are what many people think the future will hold. Switching the perspective to an urban city of greenhouses in Figure 1.22 was interesting but did not generate any fruitful ideas.

Bridging Fundamental Concepts

Figure 1.23

Iterative drawings of the processes used within buildings sparked interest in what the function of the building was.

Advanced greenhouses control their food production through machines. The water and mineral content is monitored and regulated by those machines. Essentially the food is grown by a machine. (Figure 1.23)

The reciprocal of this was machines that are grown from food. Our human factories seem to operate in a similar way. The people working in a factory act as a sort of organism that produces parts or machines. (Figure 1.24)

Figure 1.24

This iterative process was simplified down to its most basic ideas. Plants being grown from dirt in Figure 1.25. Plants being grown from something inorganic, like a machine or conveyor belt in Figure 1.26, And inorganic items growing from the dirt in Figure 1.27.

These concepts proved interesting for contemplation, but they did lead me to a more real function. The growth of dirt from plants in Figure 1.28. This concept is not new, and I did know of it before this iterative exercise. But this connected the idea of composting, back to the greenhouse.

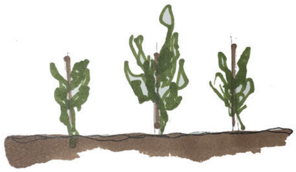


Figure 1.25

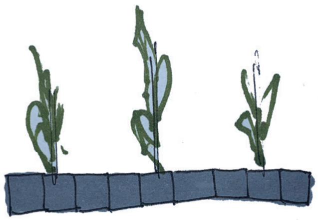


Figure 1.26


Figure 1.27

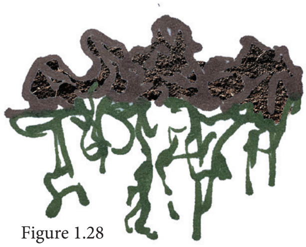


Figure 1.28

Nature as Precedent

Bridging the Natural Perspective
Conceptualizing Interactions
The Relationships of the Lived Building

Bridging the Natural Perspective

The typical greenhouse uses a single natural perspective. They look at plants and the environments they need and they create them using human devices. However, some greenhouses have been developed to use more than one natural perspective.

The greenhouse in Figure 2.1 has been designed to harness the heat that is produced through decomposing organic material. This strategy combines two different natural processes and attempts to have them work in unison.

This greenhouse was designed by the New Alchemy Institute in 1984 to explore possibilities of self-heating winter greenhouses. This was done in the pursuit of reintroducing local food production in areas with cold climates. [2]

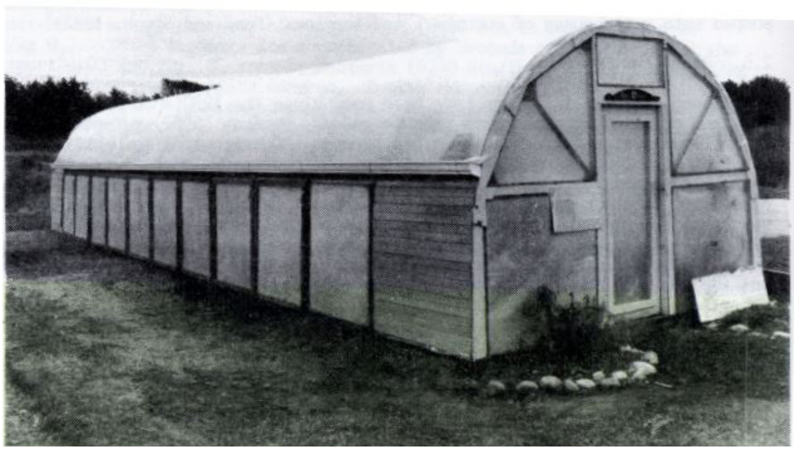


Figure 2.1

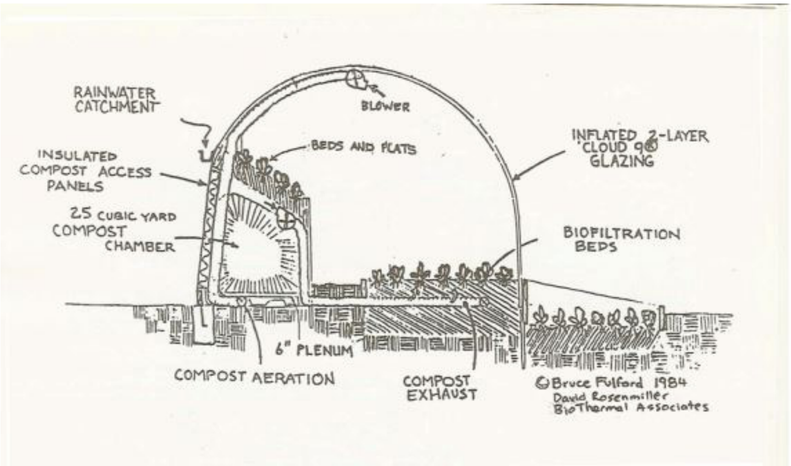


Figure 2.2

The greenhouse functioned as a typical greenhouse in the summer. During the other months, compost was added to the compost chambers to generate heat as shown in Figure 2.2. The compost radiated heat while generating CO2 and ammonia gas. These gases were funneled through a pipe into the soil. Here, the ammonia condensed and turned into a fertilizer for the plants. The rest of the ammonia was filtered out in the Biofiltration plant bed. The CO2 provided food for the other plants in the greenhouse.

This greenhouse was able to operate through the winter. Plant growth slowed due to the low light levels. The original experiment only ran for two years but the greenhouse is still being used to understand how these two natural systems work together.

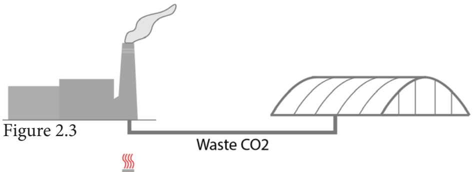


Figure 2.3

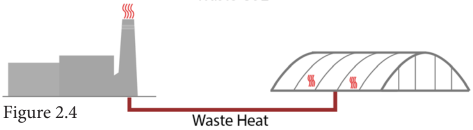


Figure 2.4

Figure 2.5

Figure 2.6

Figure 2.7

Figure 2.8

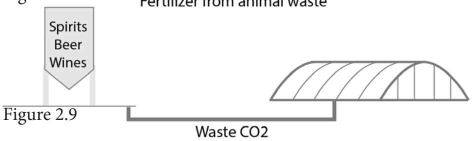


Figure 2.9

The New Alchemy's greenhouse isn't the only greenhouse that connects different technologies. Various other strategies have been tried to save heating costs or boost plant growth.

Heat saving strategies can be paired with almost any type of building that produces excess heat. These strategies can be seen in Figures 2.3[3], 2.4, and 2.6[4].

CO2 supplementation has been shown to improve growth in some plant types.[5] Some greenhouses harness alternative sources of CO2 to boost plant growth. Figures 2.3, 2.7, 2.9 show some sources of CO2.

Some methods have used other industries as a source of fertilizer for the plants within. Figures 2.5 and 2.8 show common sources of alternative fertilizers.

Aquaponic greenhouses are another type of greenhouse that pair two different natural systems together.[6] Figure 2.10 outlines how these two systems work together.

These greenhouses grow fish in large quantities. The feces from the fish are rich in nitrogen and can be used as a fertilizer. Leafy greens are grown in beds that extract nitrogen from the water while simultaneously cleaning the fish's environment. Figure 2.11 shows a dirty fish habitat while figure 2.12 shows an aquaponic habitat.

These greenhouses are the most efficient greenhouses that utilize multiple natural systems. This is because these systems are sometimes found together in nature. It could be argued that these aren't two separate systems. Instead, the greenhouse might be recreating the aquatic environment present in many ecosystems.

Figure 2.11

Figure 2.12

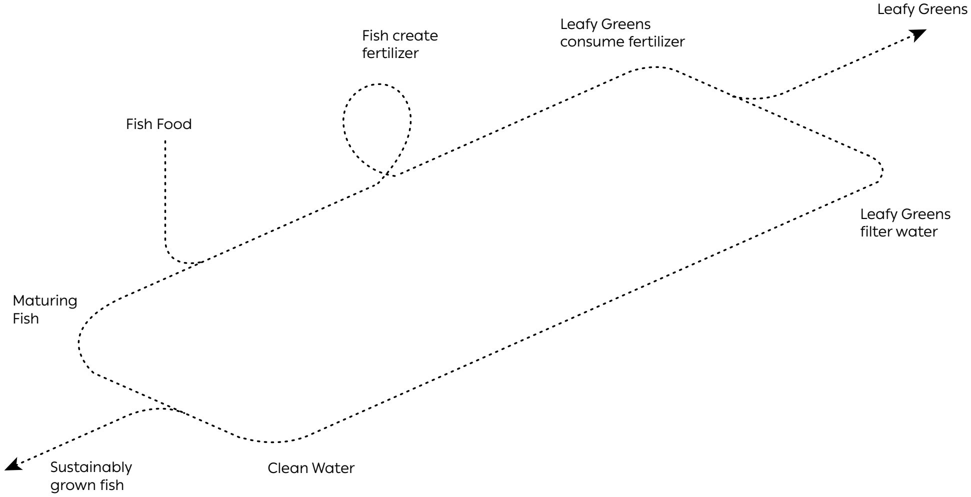

Leafy Greens
Fish create
fertilizer
Leafy Greens
consume fertilizer
Fish Food
Leafy Greens
filter water
Maturing
Fish
Sustainably
grown fish
Clean Water

Figure 2.10

The bio-digester is a machine that industrializes the process of composting. This process addresses each factor in the composting process. By paying attention to all the factors required for composting it can be incredibly efficient, and by addressing all the by-products it is sustainable.

In this system, organic waste is rapidly heated to the ideal temperature where it breaks down the fastest. It will stay at this temperature until it has been turned into compost. Then the heat increases temporarily to kill any dangerous bacteria in the compost.

Due to the variations in organic matter, these systems can be very expensive. Because of this they usually work best when working with large quantities of matter.

The diagram above in Figure 2.13 illustrates a bio-digester working in unison with an aquaponic system. This system was implemented by The Plant Chicago, an organization promoting closed-loop practices and the advancement of agriculture in cities.[7]

The Plant Chicago has a committed outreach program that researches and includes other agricultural products into their system. Because of this, they have developed a unique and complex bio-digester that helps heat their building and light their aquaponics operation.

While these systems can be expensive, some communities are investing in them. The Detroit Zoo invested in a bio-digester in 2016. Their new building digests 400 tons of animal manure and power's their animal health complex.[8] Additionally, instead of paying to haul that manure to the landfill, the zoo is left with valuable compost that can be sold or reused on the campus. The digester can be seen in Figure 2.14.

This $1.1 Million facility has saved the zoo an estimated $120,000 per year.[9] The sustainability of this project speaks for itself.

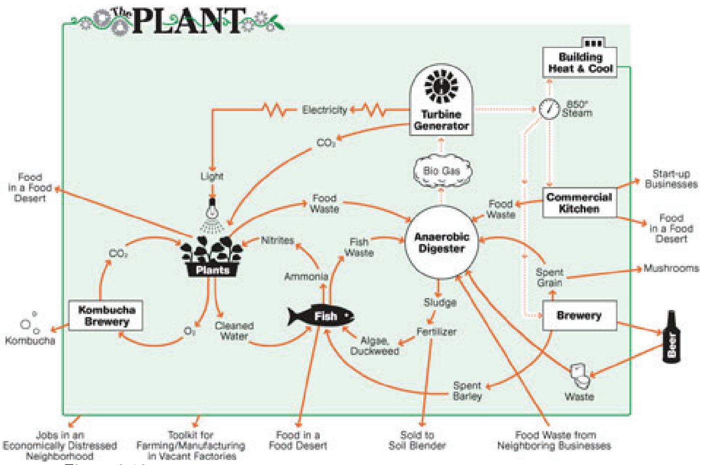


Figure 2.13

Figure 2.14

Conceptualizing Interactions

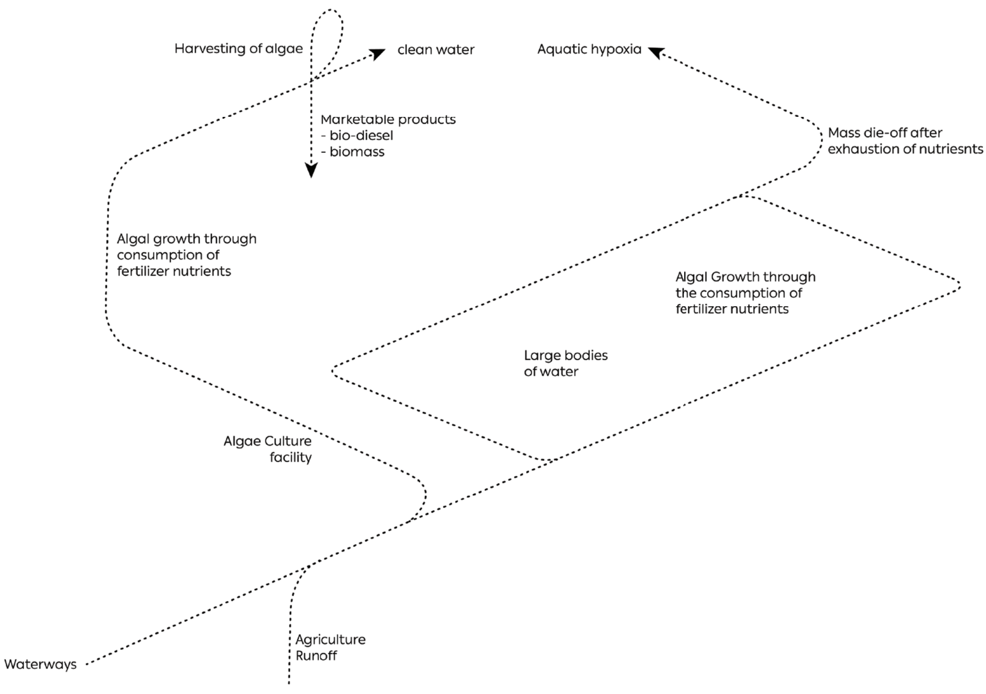


Figure 2.15

Much of our human ecosystem is still disconnected from nature. It is not uncommon to see imbalances in nature. However, these usually sort themselves out over time. The human ecosystem rarely mediates between itself and nature. This is because it is hard to spot imbalances until they create ecological disasters.

These diagrams look at areas that are currently causing ecological disasters and hypothesize solutions through finding similarities between the human and natural ecosystems.

Figure 2.15 shows the path that agricultural fertilizer takes once it enters the watershed. This diagram was modeled after Maumee that runs through Toledo, Ohio, and feeds into Lake Erie.

Left unchecked, the fertilizer stimulates the growth of algae in large quantities.[10] However, this growth is unsustainable. Once the algae runs out of fertilizer to consume it will die. The algae begins to decompose and in the process, it consumes all the oxygen in the water. This is known as aquatic hypoxia and it can destroy aquatic ecosystems.

This is interesting because with a change in circumstances this process would make a lot of money. Algaculture is the process of farming algae. Depending on the type of algae grown, it can be used for cosmetics, biodegradable products, or as fuel.

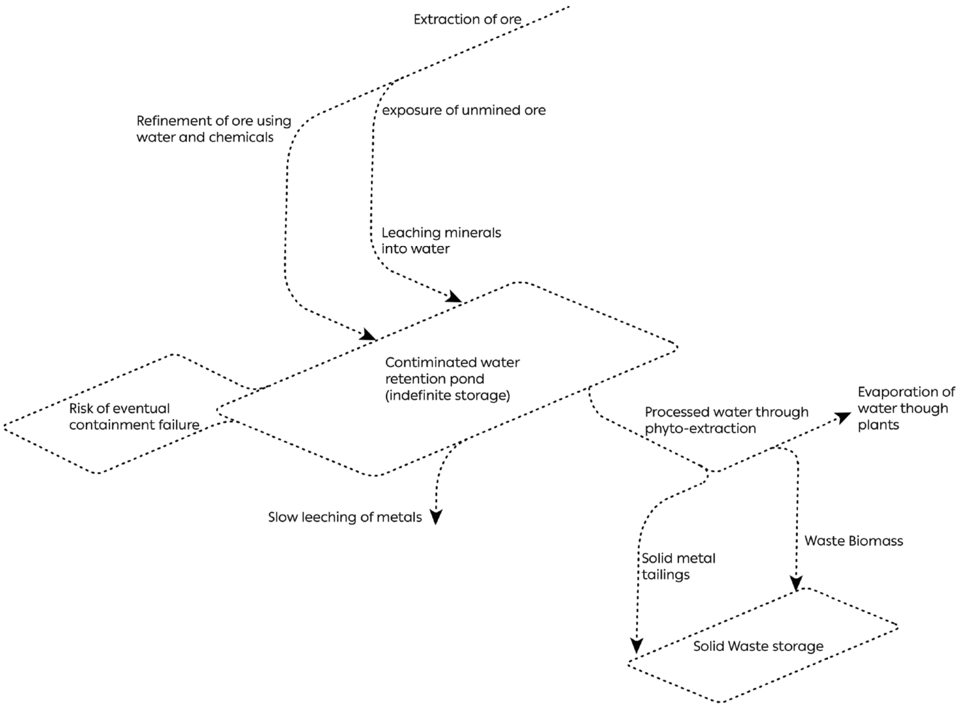
The main difference between these two processes is that one takes place in a greenhouse, and the other happens in a lake. By connecting these two we would create a conscious system that addresses the imbalances in the natural environment. This new system would take this wasted fertilizer and use it to create new products while simultaneously keeping it out of water.

Figure 2.16 analyzes the mining industry and attempts to connect a similar natural system.

The mining industry uses water to separate ore and to transport the resulting waste to a tailing pond. Once in the pond, the waste material is left to dry out. However, these ponds can be very large and often never dry out due to rainfall. As a result, these temporary ponds often become permanent structures. The largest risks these structures pose to the environment are the possibility of flooding. If a dam breaks, the liquid tailings can contaminate a large area and any nearby water supply.

The alternative to these tailing ponds is solid storage which is a much safer storage technique. However, this method requires that all the water be evaporated from the tailings mixture.

In nature, it is very common for plants to evaporate water during photosynthesis. Figure 2.16 explores the possibilities of the use of plants with a resistance to these metals being used to increase the evaporation rate in tailing ponds.



Extraction of ore
Refinement of ore using water and chemicals
exposure of unmined ore
Leaching minerals into water
Contiminated water retention pond (indefinite storage)
Risk of eventual containment failure
Processed water through phyto-extraction
Evaporation of water though plants
Slow leeching of metals
Waste Biomass
Solid metal tailings
Solid Waste storage

Figure 2.16

The Relationships of the Lived Building

This is an exploration into the idea of a lived building. I am exploring a few building types that may provide insight into my thesis; two of which are grocery stores and greenhouses. By writing this paper I hope to gain a new perspective of these buildings. However, I am not sure that it will result in any concrete conclusionary results.

I believe a living building has more human engagement than a 'non-living' building. First, this lived building is in use; humans are using the building. Through this use, I think there is an emotional connection to the building. This connection can form as an emotional connection through prolonged exposure to the building. It can also form through a more intimate connection of personalization and leaving one's mark on a building. This connection is typically found in the home. It is more intimate than other forms of human engagement because it leaves a personal touch on a building that is unique to that individual.

However, there must be additional forms of human engagement that make a lived building. For many travelers, a gas station is only a temporary stop on the road. Their interaction with the building is brief and many will never return. Locals might make a routine stop here a few times a month, but their interaction is also brief. These buildings are still lived buildings but in a different sense. Their lived-ness exists through the fleeting service they provide. Perhaps this is one of the most fragile senses of a lived building because of its unique relationship with the users.

As people pass through the gas station, they leave subtle marks of their passing. A receipt hanging from the pump, trash left in the trash cans, and a rare splash of gasoline on the concrete inform us of past users.

This brings me back to the reason I chose to analyze gas stations. Gas stations are usually dirty. This dirtiness manifests itself in multiple different ways and levels. One type of dirtiness is literal dirt and trash left behind by past users. This is what we usually perceive as dirtiness. But the other contributor to dirtiness is general wear and tear. Categorizing wear and tear as dirtiness is not correct. It should be categorized as general wear, but I believe that most people do not consciously see wear and tear. They just feel the cumulative effects of the chipped sidewalk, the worn-down handle, the permanently dirty floor and think to themselves: this place is dirty.

These two areas, dirtiness and wear, are two essential areas of the lived building. I believe all buildings from industrial to residential exhibit varying levels of these two areas. Partially because these are side effects of human occupation. When we look at a building we can almost immediately judge it based on its dirtiness and wear. This is judgment is based on is the level of care put into the building.

The gas station is a good example of this because it is very easy to see what zero care looks like. Without any upkeep, the building begins to look run down. Care is an essential aspect of the lived building. Without care the building cannot really be lived, it is almost dying. However, with too much care the building almost becomes inhuman. Imagine arriving at a gas station where everything was pristine. No visible marks from other people, everything presented just as it was meant to be. It seems almost utopian.

The gas station is a great example to analyze as a lived building. But I did not intend to explore the gas station in such depth. I'm going to transfer this analysis to the lived grocery store.
The lived grocery store is different than the gas station in a couple of ways. Typically, a grocery store is cleaner than a gas station. It also has a completely different set of customers and standards to live up to. Even though its circumstances are different, the grocery store still deals with the same concepts of dirtiness and care that a gas station has. Customers in the grocery store create similar dirtiness that they would in a gas station. Each customer wears down the tiles, bumps shopping carts, hits rub rails, and tracks in dirt. These actions all need to be countered through care for the store's environment. However, customers also take products. The lived grocery store keeps up with the demand of the customer. A store with partially empty shelves seems almost neglected.

I believe there are two sides to this argument and I am unsure which side is more correct. A truly lived grocery store is one where you can tell there have been hundreds of people there before you. The floor is slightly worn, the doors show wear, the parking lot may be old, and there may be wheel marks on the floor. But there are also signs that the building is cared for.

I should define these two areas better.

The first area is the sense that the grocery store is alive and cared for. Shelves are stocked, floors are swept, food areas are clean, registers are manned. But a brand new store has all these things. The new store lacks the eventual wear of the entryway floor, the scuff marks of customers, and the patterns created by the flow of traffic down the aisles. Maybe this second area is the mark of human occupation. The personal items of employees, the dirt, the wear from shoes, the fingerprints of customers. Now I think each of these areas are applied in moderation. Excessive wear becomes a sign of neglect just as meticulous upkeep of the store might remove all signs of occupation or lived-ness.

This seems to be the idea of the lived building. And I think this relationship could be applied to any type of building. The differences are in how much wear and care are building type requires. I would like to understand how the areas of human occupation and human care are balanced within the commercial greenhouse.

In the greenhouse, the balance between human occupation and care might look a little different. The sense that the building is alive is quite literal in the greenhouse. A lived greenhouse is full of plants growing, maturing, fruiting, and eventually being replaced. These plants clean the air, drop leaves on the floor, and moisturize the air. Their presence can be felt by the user. The human occupation is very similar to that of the grocery store. There are the personal items of employees and the wear of customers. Additionally, there is the wear of the plants. This could be dirt on the floor washed out from the planting pots. There is the sense that things have been moved around. Flowers reach maturity and are picked up by customers, new growth is moved into those vacant spots and in that process, the greenhouse becomes dirty. This is part of the lived greenhouse.

Another way to phrase this is to say a greenhouse is a place of creation, not finished products. Fallen Leaves, dirt, and bits of plants are all-natural side effects of the growing process. The existence of such things is natural. There is a standard of cleanliness for this area but it is a more loosely defined region, depending on the function of the greenhouse and individual rooms. A germination room might be messy because dirt is poured in pots, and plants are moved. This concept can be seen within the grocery store as well. A store is a place of safe, clean, and organized ingredients. The lived building reflects this by being organized, and clean. The food is packed in a way that tells the customer it is safe. And plants are displayed in a way that tells the customer they are alive. In both cases, the environment reflects the qualities exemplified by the produce.

A similar but very different building from the greenhouse is the botanical garden. The Biodome 2 was the closest thing to a botanical garden that I have ever visited. The purpose of a botanical garden and a greenhouse is are both to cultivate plants. However, the botanical garden is where we go to view cultivated plants. In the botanical garden plants are carefully arranged. Sometimes this is through artful displays, other times it could be to mimic the natural environment. In either case, these gardens usually have human paths that are separate from the plants. This is very different than a walk through nature because the path is usually a part of nature.

The indoor botanical garden typically displays plant species that are not native to the area. The building is recreating the natural biome of the plant. By adjusting the temperature and humidity and soil type, it can grow alien species of plants. However, one interesting thing to note is that these buildings do not recreate the nature used in those environments. I bring this up because this move to create a regular brick, tile, or paved path directly counters the attempt to create a natural environment. Not for the fact that brick isn't a part of the environment but because we have a relationship with the ground. We draw insight from our surroundings through all senses and it seems counter-intuitive to recreate natural pathways found in these environments.

Enclosed botanical gardens are public spaces and without human traffic, I am not sure they could be thought of as lived gardens. Yes, the plants are still alive and growing but their organization and existence were intended to be seen. Without a human, this building seems like a shell containing an alternate reality, a snippet of another world. This space would be alive, but I am not sure we would call it lived. I have been inside a glasshouse that contained no plants. Just glass and metal with plenty of tourists; the building felt oddly empty initially, but after a few minutes, I adjusted. However, it was impossible to ignore that the building was not built to a human scale; there was a missing element, and nothing had replaced it. Furniture did not occupy the place where plants once sat, it was just an open room. This empty space seemed to contain no character. The glass and steel structure that was once intended to accent the plants, sat naked. I think this was a lived building in the sense that each person who entered needed to reorient themselves by moving to areas like the corners which have a more human scale. The lived experience of this building is not manifested physically, but mentally on the occupants.

I have seen many similarities among the different buildings mentioned above. One very interesting concept has been that humans produce wear on their environment; and within the lived buildings, this wear is countered by care. This careful balance is at play within all buildings. It brings an interesting question when considering a vacant building that no longer has human occupants. Is there a different kind of care that can be applied to create something new or to attract new human traffic? I think every built intervention or renovation is attempting this in some form.

Another area that I believe will be useful for my thesis is the idea that all humans wear on buildings. The type of human wear speaks about the function of the building. It informs new users of circulation and programs. I believe this concept poses some of the most interesting insights for a built intervention.

Our Waste Ecosystem

Our Waste Ecosystem
Urban Environments

Our Waste Ecosystem

This chapter takes a look at the human waste ecosystem. Here we understand where organic waste winds up once it leaves our roadside bins.

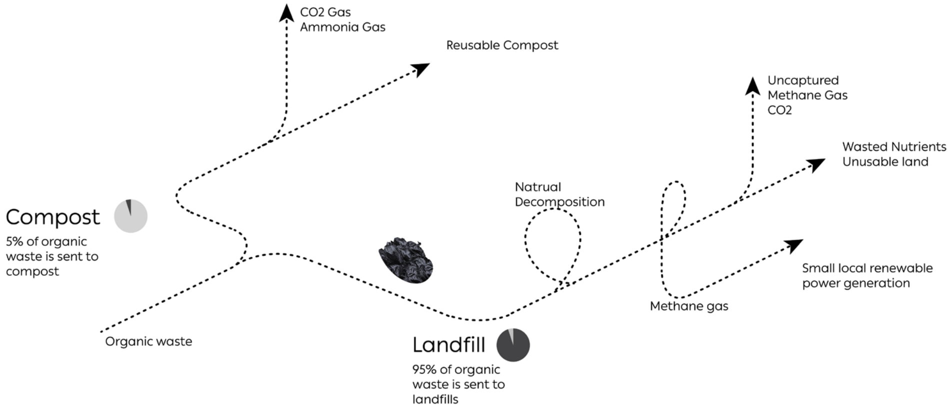


Figure 3.1

For much of the United States, organic waste only has two possible paths it may take. It can be condemned to a landfill or it can be turned into compost as shown in Figure 3.1.

When organic waste is sent to a landfill it is packed into the landfill and buried with dirt. Here it decomposes through anaerobic processes and generates methane and CO2 gas.[11] In large landfills, this gas is captured through a series of pipes and burned for energy. This is done because methane gas is a powerful greenhouse gas. It can be up to 86 times more harmful than CO2 in the first twenty years it is in the atmosphere. By burning methane gas, we convert it into CO2 which still has a lasting impact but it is not as harmful.

In smaller landfills, this gas is usually released into the atmosphere because these green strategies can be expensive.

Composting uses an aerobic process instead of the anaerobic one used in a landfill. This process produces CO2 instead of methane, making it a much more environmentally friendly process. However, it does require maintenance to 'turn over' the compost pile to continue the aerobic decomposition.

One of the most beneficial aspects of composting is that the resulting biomass can be used as a rich fertilizer instead of being condemned to a landfill.

There are other paths organic waste may take but they are either not environmentally friendly, or they are closely related to composting.

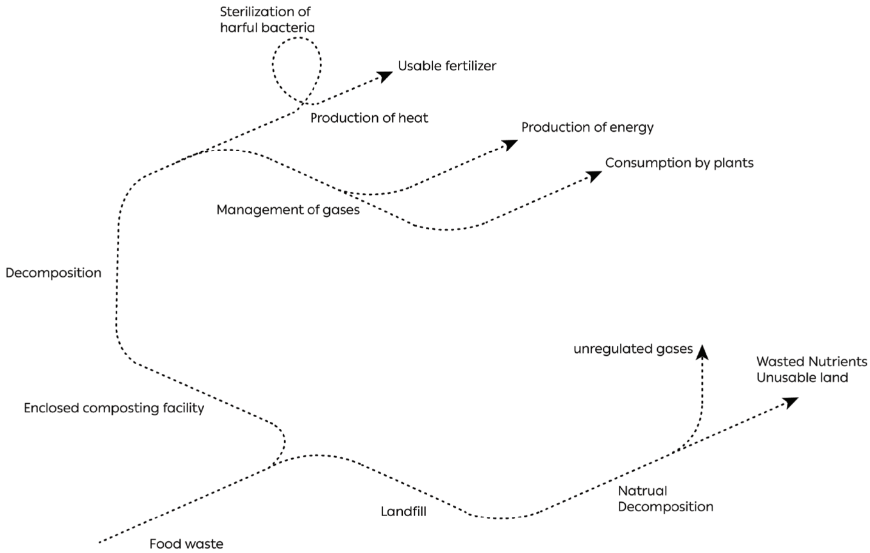


Figure 3.2

There is however another kind of composing that is beginning to become popular in some countries. Anaerobic bio-digesters are a mechanically enhanced form of composting that uses the same anaerobic process present in a landfill.

While these two systems use the same biological process to break down food, their ecological impacts a vastly different. Figure 3.2 illustrates the differences and advantages of the bio-digester when compared to a landfill.

The process of composting used in a bio-digester result in three things: methane gas, heat, and biomass or compost.
The methane generated by the bio-digesters is less diluted than the methane generated in a landfill. This is because the bio-digester is a closed and controlled machine that only produces methane gas. The landfill has aerobic and anaerobic processes within it that dilute the methane with CO2.

The heat generated by the bio-digester can be used to heat other bio-digester units. This increases the efficiency of large-scale bio-digesters. This heat is created by the decomposition of organics and is present in a landfill as well. However, there is no efficient method to

capture this heat.
The biomass or digestate produced by the bio-digester can be used as a fertilizer. This is partially because the waste going into the bio-digester is separated beforehand. Unlike the landfill, the bio-digester only accepts organic waste. The organic waste in the landfill is unusable because it has been mixed with other waste.

The other reason the digestate can be used for compost is it has undergone a kill step. This is where the temperature is increased high enough to ensure that any harmful bacteria like E. coli are killed. If digestate does not undergo a kill step, this harmful bacteria could end up in someone's garden or food. [12]

We can see there are plenty of benefits that come with bio-digesters. However, they do have their shortcomings as well.

Bio-digesters are an expensive investment. The Detroit Zoo's million-dollar bio-digester can only process 500 tons of manure per year. This is a small chunk compared to the thousands of tons of organic waste produced by the city of Detroit each year.

Additionally, these machines are built for a specific scale. If there is not enough organic waste to run the bio-digester, it becomes useless. Similarly, if there is too much organic waste the biodigester cannot just expand or speed up its process. It must undergo another expensive expansion.

This is where the landfill shows its benefits. The landfill works at any scale. It can accommodate varying amounts of waste. The construction and operation are much cheaper than a bio-digester. This allows for expansion much cheaper than that of the bio-digester.

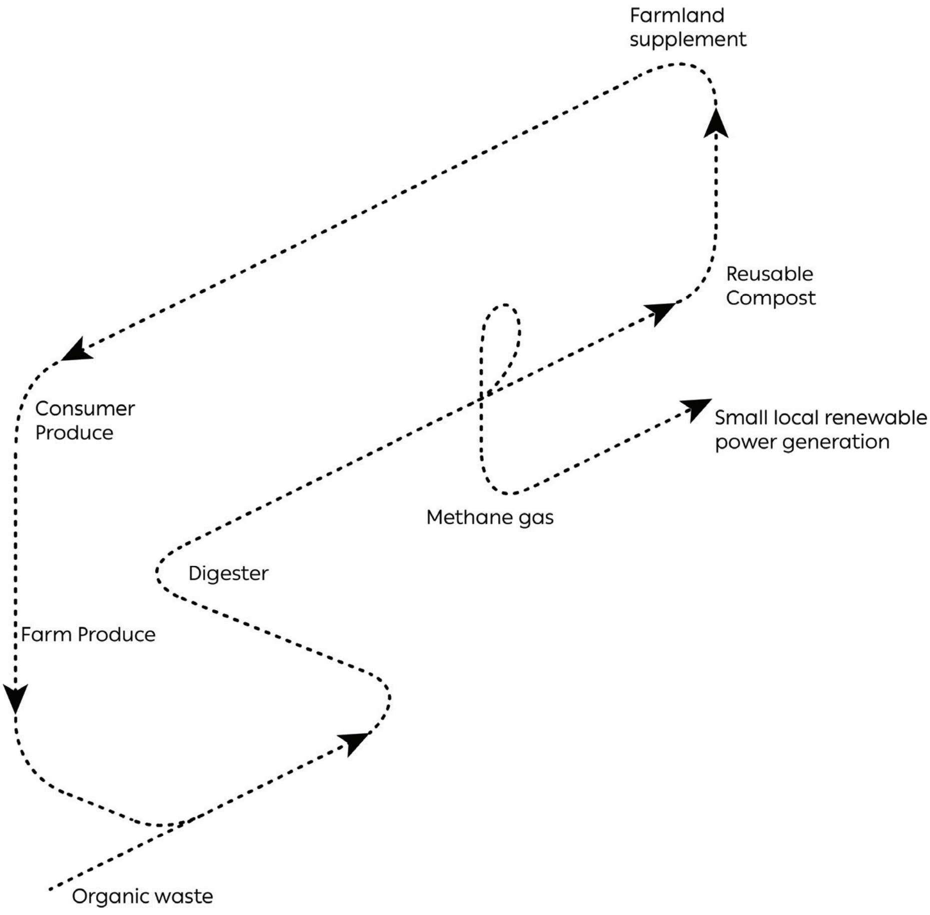

Farmland
supplement
Reusable
Compost
Consumer
Produce
Small local renewable
power generation
Methane gas
Digester
Farm Produce
Organic waste

Figure 3.3

Some of the most robust ecosystems are those that are self-supporting. One benefit of a bio-digester is it takes a step towards creating a closed-loop system.

The purpose of the closed-loop is to allow for the reuse of resources as shown in Figure 3.3. The compost that is produced by the bio-digester can be reused as a soil supplement, or for soil remediation, or as a fertilizer.

As a fertilizer, the compost recycles nutrients back into the soil. These nutrients were originally extracted from the soil by farms and distributed as produce. The digester returns these unused nutrients back to farms to be reused. This closed-loop is a step towards achieving sustainable food production and waste management.

Urban Environments

Different types of urban environments play a key role in the formation and the type of waste ecosystem. By analyzing urban environments we begin to understand why the waste ecosystem is structured as it is. With this knowledge, we can begin to understand how to design in a way that works with our urban environments.

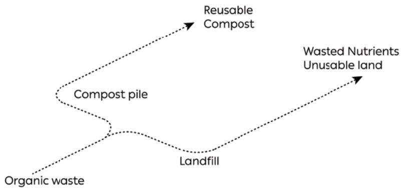


Figure 4.1

Small Urban Environments

These urban environments are categorized by their remote location and small population. These environments are typically small towns with a population ranges up to 5,000 people.

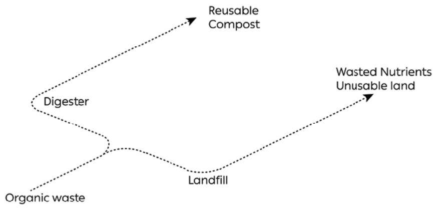


Figure 4.2

Medium Urban Environments

These urban environments can be regional hubs for many smaller environments. These are usually large towns or small cities. Their population ranges up to about 60,000 people.

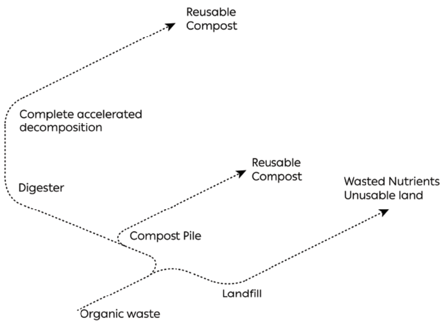


Figure 4.3

Large Urban Environments

These environments are typically large cities. They can act as hubs for small and medium urban areas. Their population has no limit.


URBAN

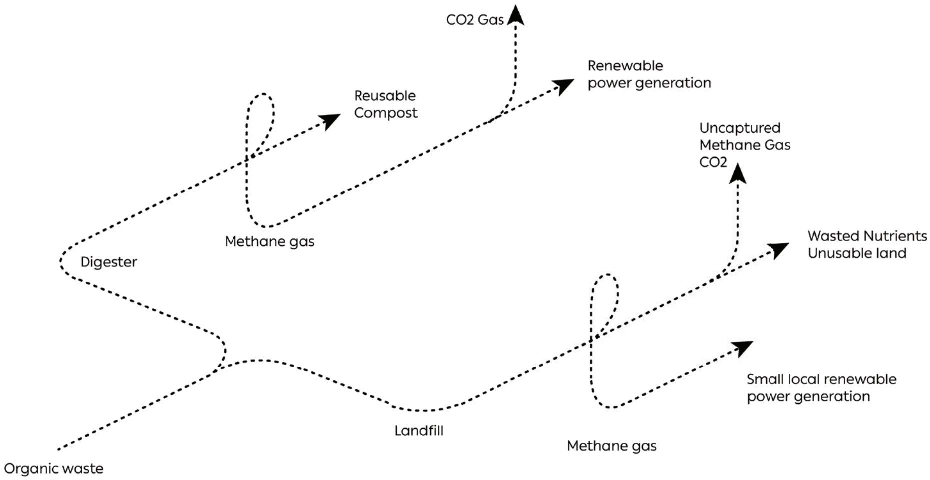


Figure 4.4

Large urban environments are distinguished by a large population. These urban centers produce enormous amounts of organic waste. Due to this fact they require systems that can accommodate large amounts of volume. Figure 4.4 illustrates the different solutions available in these environments.

Landfills become most efficient at this scale due to their size. They generate enough revenue to sustain the implementation of green practices like methane capture.

Composting becomes unmanageable at this scale due to the intense area it would require.

These can be some of the best environments for anaerobic bio-digesters. The large population justifies the high initial investment.

Medium urban environments have a population size large that can support most waste management options. Figure 4.5 illustrates the waste management solution available. Landfills work well with these environments if they are also supported by neighboring communities. It is possible to support a bio-digester in this sized environment but the profit will not be high enough to attract a large company.

Landfills are work in these environments and depending on their size, might have methane collection systems.

This is close to the maximum size a composting operation could handle. However, this may benefit the composting operation. Due to the scale, the revenue would pay for the necessary maintenance associated with composting.

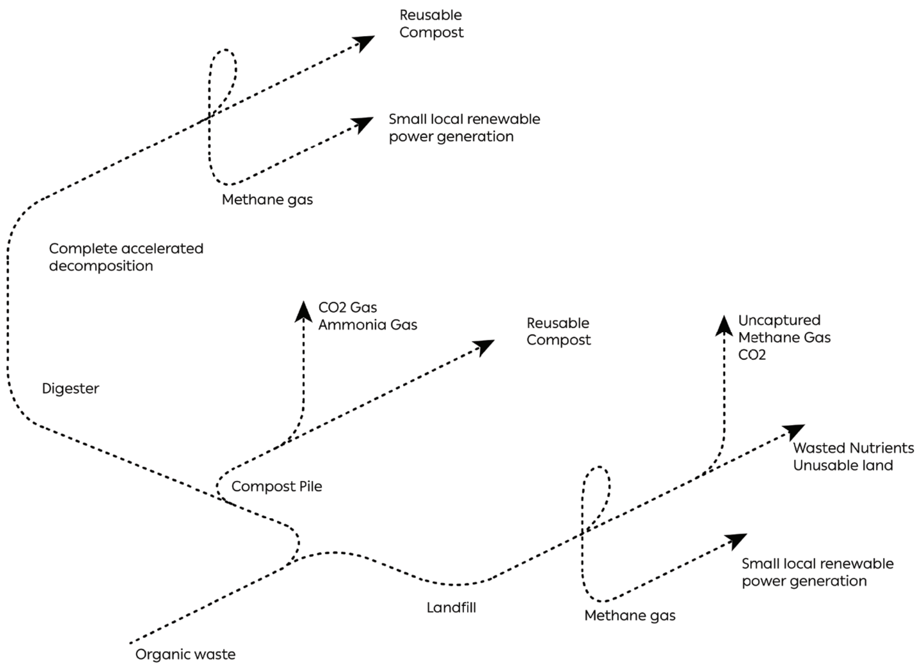


Figure 4.5

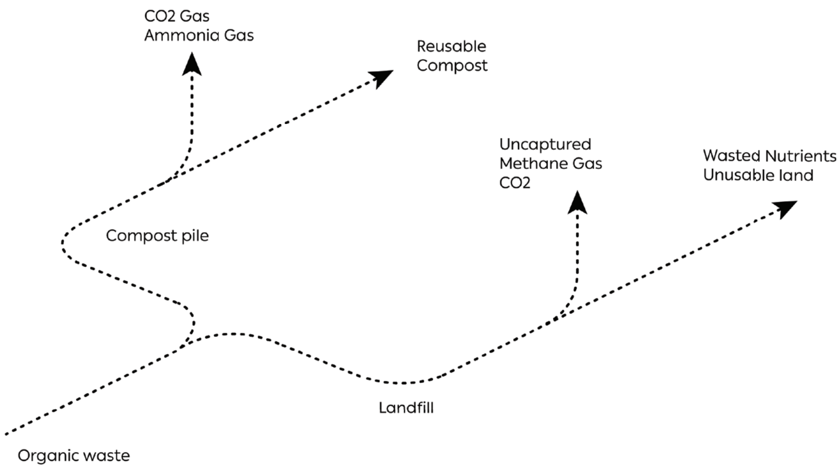


Figure 4.5

Smaller urban environments are often isolated and lack the population required to sustain any large-scale operation. Additionally, the local government may be financially strained by any attempt to manage their own waste.

These communities may contribute to a regional landfill instead of paying for their own.

Bio-digesters can work in small-scale areas but the cost far outweighs their benefits. Such an investment might never pay for itself.

Composting is viable at this scale as shown in Figure 4.5. However, effective and ecological composting requires observation and maintenance. If small communities cannot afford to manage their compost, it might be advantageous to send it elsewhere.

Northern Michigan Ecosystem

Two Dominant Environments
Our Waste Ecosystem
Our Recycling Ecosystem
Future Staging
The Composting Hub.

Two Dominant Environments

Northern Michigan is comprised of a few medium-sized urban environments that are supported by many smaller towns and villages. Because of the unique geographic location of northern Michigan and its distance from any large cities, we must understand how these smaller environments can take part in green waste management strategies like composting and bio-digesters.

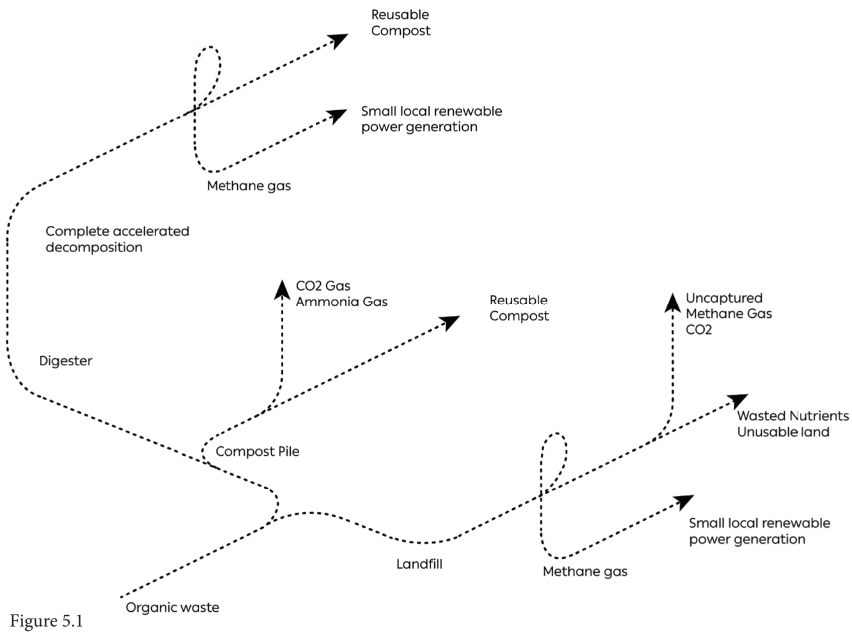


Figure 5.1

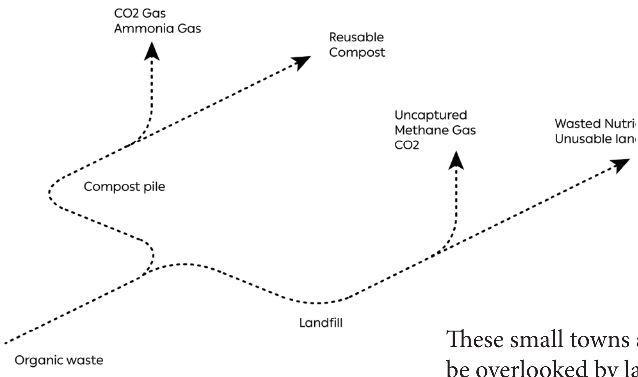


Figure 5.2

These small towns and cities will be overlooked by large waste management companies. They don't hold enough potential to attract these corporations and they are too far to be used as satellite locations.

However, these communities have adapted to their location and have found strategies to increase their economy of scale.

Our Waste Ecosystem

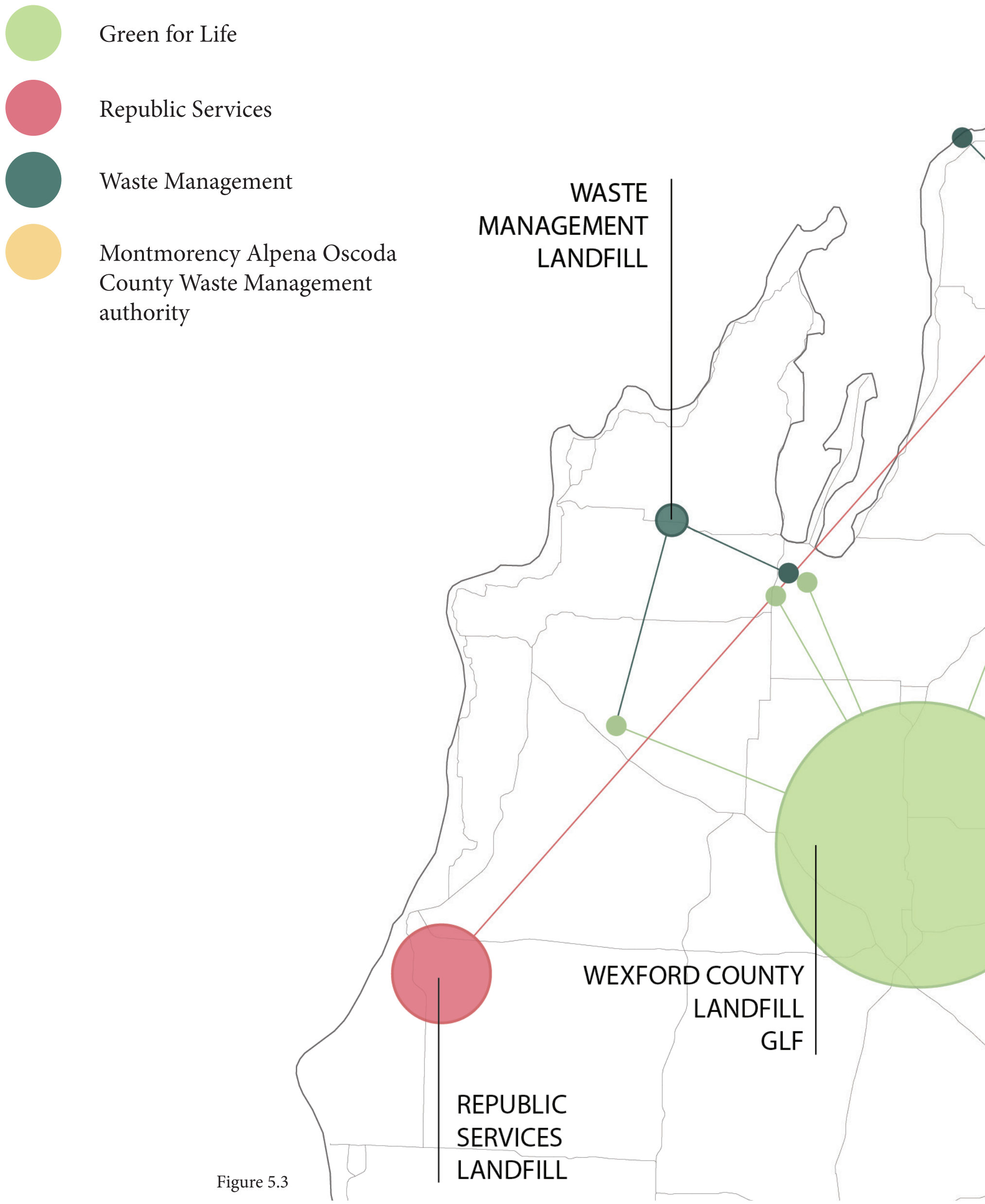
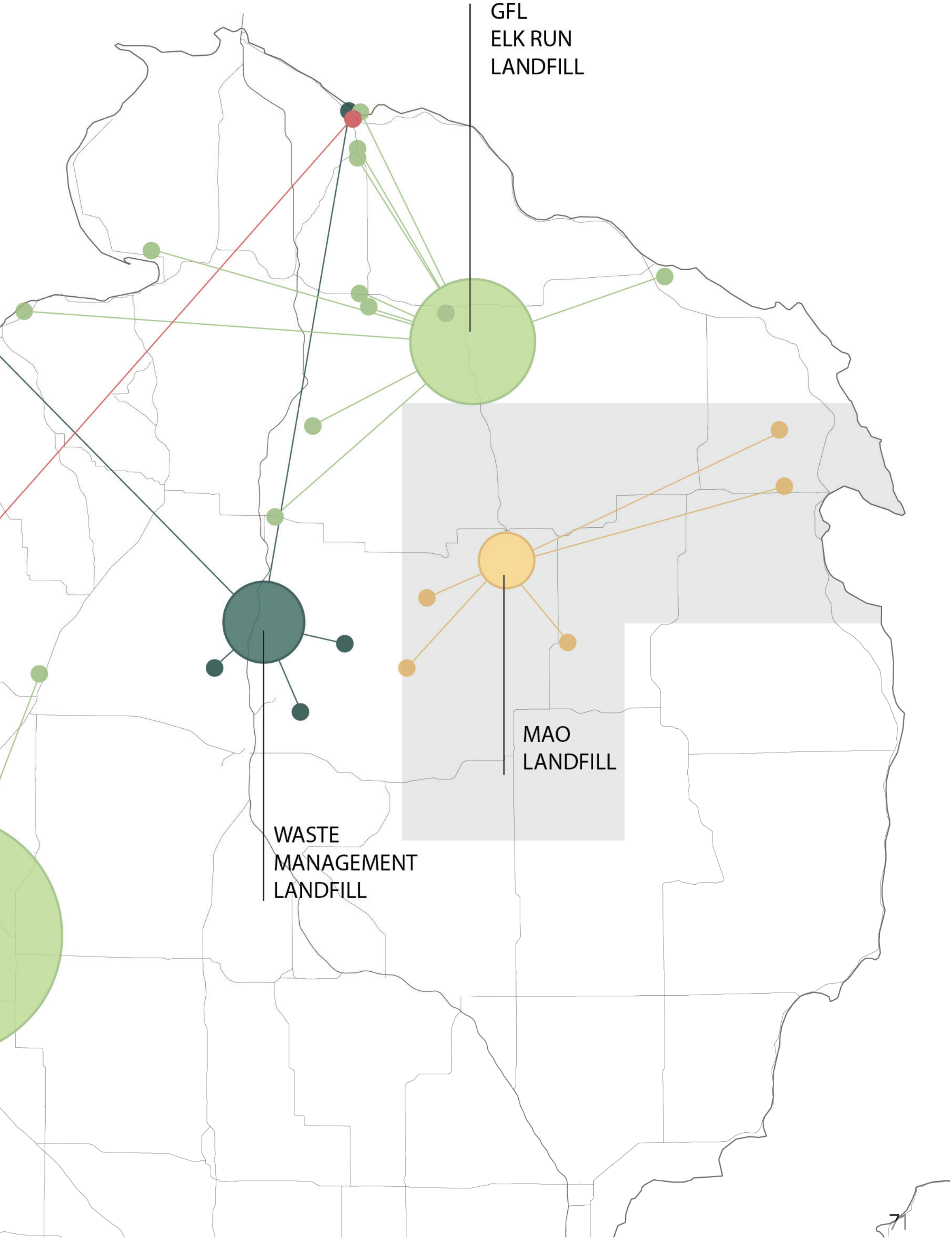


Figure 5.3


GFL
ELK RUN
LANDFILL
MAO
LANDFILL
WASTE
MANAGEMENT
LANDFILL

For most communities in northern Michigan, waste is collected via roadside bins and is taken to a transfer station. Some smaller communities ask that residents drop their waste off at a compactor or transfer station.

The transfer station is where waste is prepared and loaded for long-distance travel. Almost every community has a waste transfer station somewhere close. This station saves money for the organization collecting the trash.

From the transfer station, the waste can travel directly to a landfill or to a Material Recovery Facility (MRF). This facility sorts the trash, separating plastics, paper, and metal that can be recycled. The remaining waste is sent to the landfill as shown in figure 5.4.

For most of northern Michigan, waste is collected by private companies. These companies make money by collecting and disposing of trash. Any costs incurred between the pickup and the disposal of the trash is money lost. Because of this, the companies have placed their transfer stations and MRFs in strategic areas to minimize costs. Material recovery facilities generate extra revenue because the reclaimed materials can be sold.

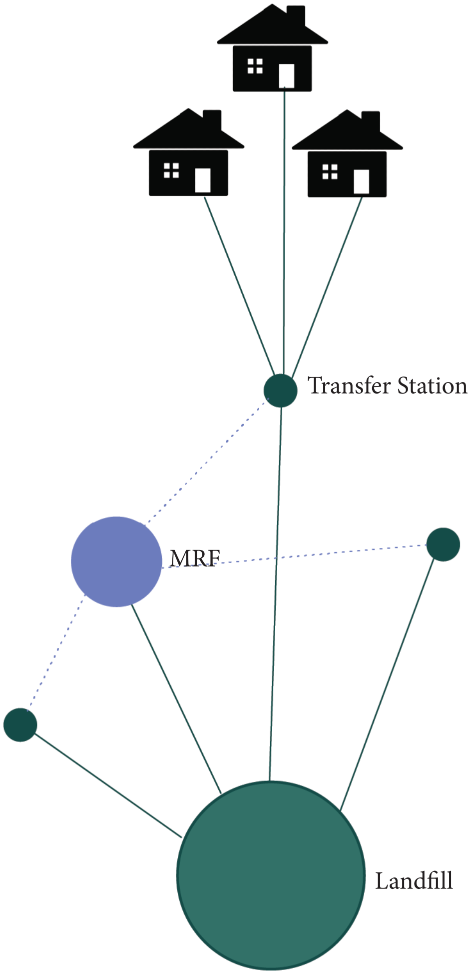


Figure 5.4

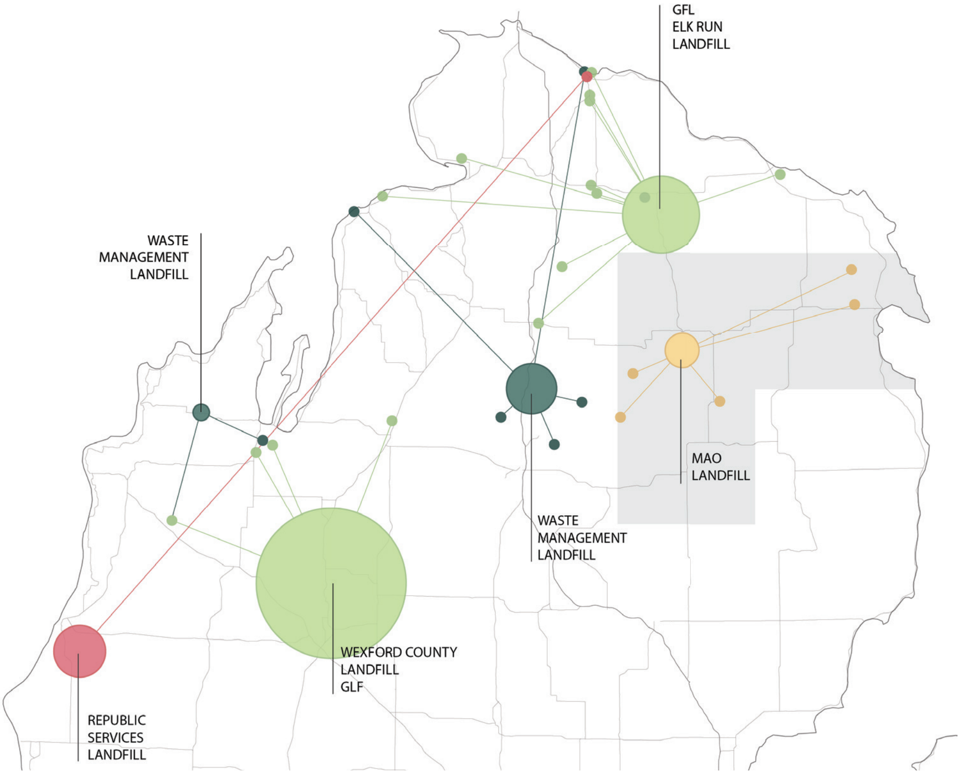


Figure 5.3

This begins to shed light on why the northern Michigan waste industry looks the way it does in figure 5.3.

Let us use Green For Life (GFL) as an example. GFL owns two separate landfills in northern Michigan. This allows them to serve a broad area while saving money because the company does not have to ship the waste as far. These additional savings allows GFL to have the lowest collection prices in the region.

Republic Services has some of the highest prices because they are forced to ship their waste over long distances. These are fundamental aspects of the trash industry.

There is one public waste management entity operating in northern Michigan. The Montmorency, Alpena, and Oscoda county areas (MAO) have joined together to pay for their own waste management. This requires more public funding, but it can become a source of revenue in the long run.

Our Recycling Ecosystem

Material Recovery Facility (MRF)

Transfer Station

Montmorency, Alpena, Oscoda counties

Emmet, Cheboygan, Presque Isle counties

Leelanau, Benzie, Grand Traverse, Kalkaska, Crawford, Ostego, Antrim, and Charlevoix counties

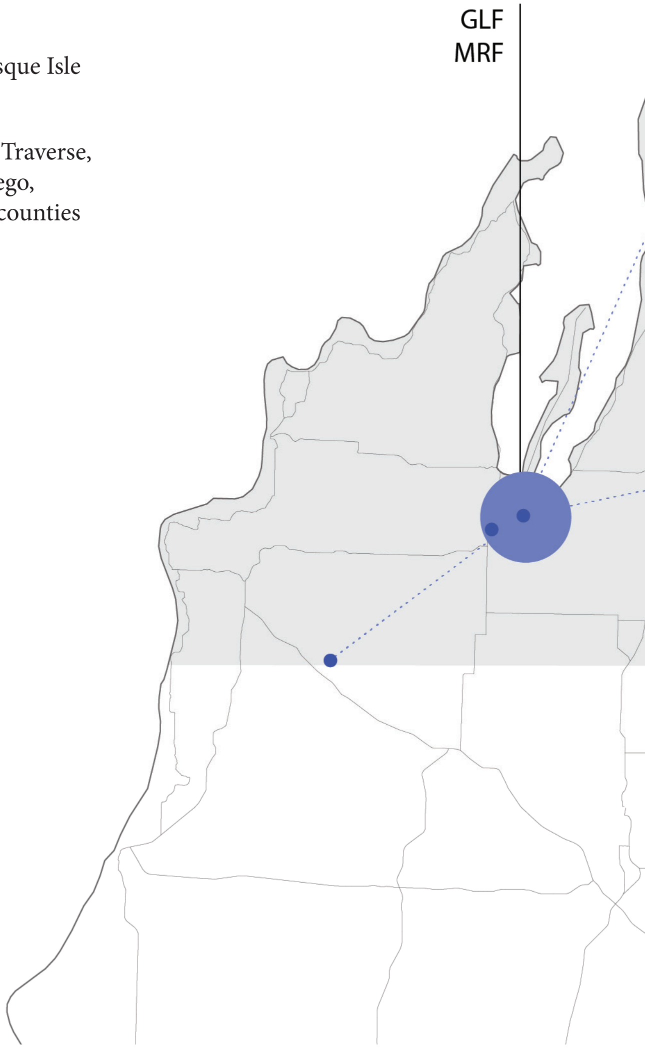
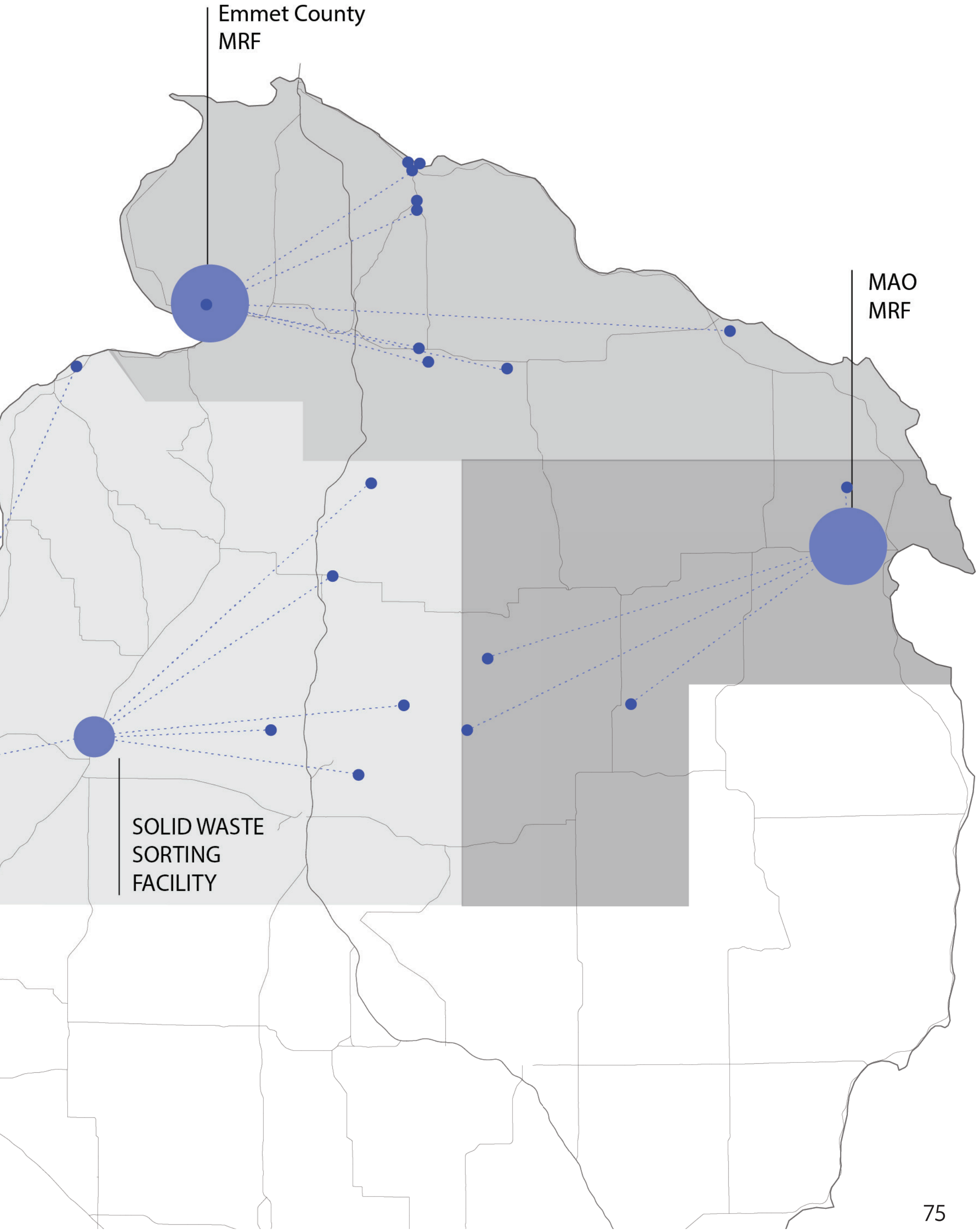


Figure 5.5


Emmet County MRF
MAO MRF
SOLID WASTE SORTING FACILITY

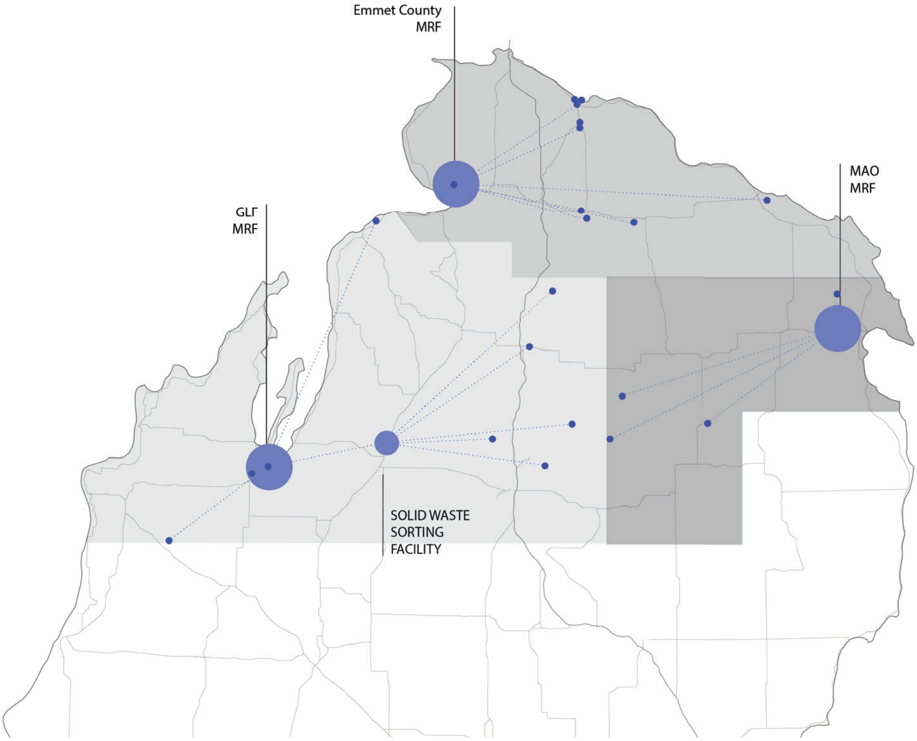

Emmet County
MRF
GLF
MRF
MAO
MRF
SOLID WASTE
SORTING
FACILITY

Figure 5.5

Recycling in northern Michigan functions similarly to the waste management system. Material Recycling Facilities (MRF) benefit from the same transfer stations and economies of scale that waste management companies do. However, there are some community-driven differences.

The first is the occurrence of community-driven recycling and intercounty cooperation. Emmet, Cheboygan, and Presque Isle counties work in unison to increase their recycling rate.[13] This relationship, shown in figure 5.5, increases the economy of scale for the Emmet County MRF, allowing them to invest in more recycling infrastructure. The recycling collection system works separately from the waste management system. Here recyclables are deposited by residents at drop-off locations. They are later shipped to the Emmet county MRF.

The MAO county group works similarly and all waste is collected by the county.

The remaining counties are serviced by GFL who collects recyclables and ships them to the Traverse City MRF. This facility has one of the largest economies of scale because it serves the most people.

The Emmet county MRF is the only facility that collects organic waste. [14] This waste usually comes from local restaurants and initiatives to promote composting. The MRF composts this organic waste in a field next to their facility. This small composting operation is the same size as the entire sorting and recovery facility. Because of the intense area required to compost these operations are uncommon.

However, they do have economic benefits. Anything these public recycling facilities have to send to the landfill costs money. By recycling organic waste, they remove an expense and create another source of revenue. This does come with additional maintenance costs associated with analysis and turning over of the soil. In a large-scale operation, the compost can be sold to local farmers.

The GFL MRF does not have the space required to support a large composting operation, and neither does the MAO MRF. This suggests that there is an opportunity to create a separate entity in the waste disposal and recycling ecosystem.

Future Staging

Local and regional composting provides a sustainable, low cost closed loop system.

Some large municipalities implement methane collection from organic waste.

United States introduces incentives for methane collection from organic waste.

Commercial Companies implement methane collection in large urban environments

This diagram is a hypothetical timeline of the future of organic waste management. It argues that future incentives will allow commercial companies to be investing in green technologies like bio-digesters.

In this scenario, large urban environments would be the first areas that companies invest in this green infrastructure. From here they would spread out to neighboring cities. However, they will most likely not extend these services into rural areas because of the lower population.

Preexisting and presorted compost sites can connect to larger methane collection infrastructure.

Commercial companies begin to connect to satellite cities.

Small towns and cities are left out because of their low potential.

These areas would remain excluded from this new infrastructure until local governments took action and invested in strategies to connect them to this new green infrastructure.

The upper two events signify the implementation of organic waste collection and construction of composting facilities. These facilities will allow these smaller areas to connect to these larger companies leading the innovation.

The Composting Hub.

Figure 5.6 illustrates a conceptual new step in the waste ecosystem. This composting facility would provide a dedicated spot in the waste stream to reuse organic waste and move the region towards a closed-loop ecosystem.

This facility focuses on the composting and care of organic waste. Mismanagement of composting results in imperfect compost that could have dangerous pathogens. By creating a dedicated location and business to oversee the composting we ensure a safer quality of compost.

This facility would also provide multiple benefits to the community. Access to local fertilizer and locations to deposit organic waste would be increase awareness. Many communities have small compost piles at their local transfer station. However, these small operations are usually left uncared for. The resulting compost cannot be sold to the community. Many community members might not even know of its existence. This larger and centralized operation would ensure that the smaller community's organic waste could be properly cared for and accessible for purchase.

This increased awareness would also extend beyond the local community. It is almost impossible for large privately owned waste management companies to access every small community's composting pile. This would require intensive investment from the company. Additionally, there are much safer routes to collect organic waste. Large urban environments produce significantly more organic waste and are much easier for a company to keep track of. By uniting these smaller communities and organizing the composting operations, this facility would allow large companies to reach out and establish collection programs in rural areas.

This facility would serve as a temporary location for composting with the expectation that it partner with a larger company that can invest in technologies like bio-digesters.

This facility would also take a step towards changing the narrative on organic waste. Currently, organic waste is thought of as trash. By creating a separate location for processing and a new resource for communities we allow people to see organic waste as a resource. This is very similar to plastic and metal recycling. By giving people the option of a second bin for recyclables, they begin to understand their plastic waste has potential and can be reused.

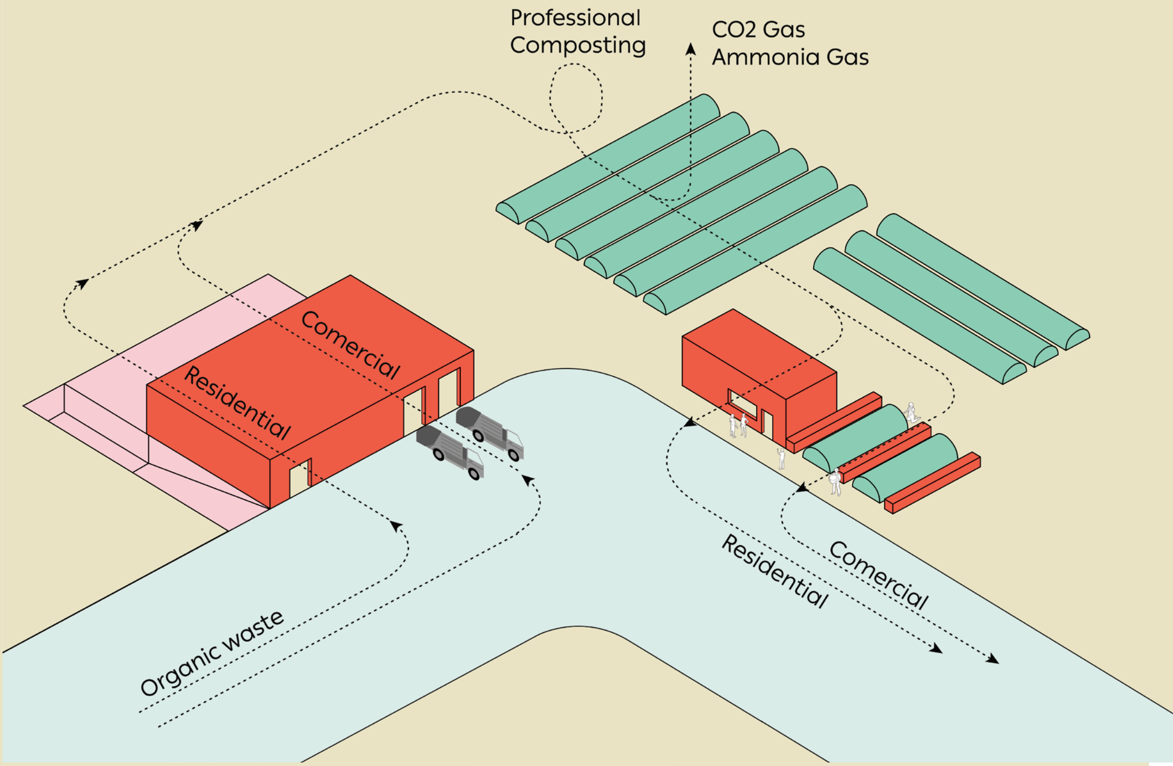

Professional
Composting
CO2 Gas
Ammonia Gas
Comercial
Residential
Organic waste
Residential
Comercial

Figure 5.6

Another change would also be made at the smallest community level. Small rural communities often don't have garbage trucks picking up trash in roadside bins. Instead, they have a local compactor or drop-off area like the one shown in figure 5.7, where residents bring their trash. These deposit areas can vary from a hole in the ground to a compactor and loading station.

In small communities like these, it would be beneficial to implement a separate area for the collection of organic waste. This change does not have to be expensive as many of these communities don't have spare change lying around. In communities with simple loading areas and piles of trash, it could be as simple as a second pile for your organic waste. In more affluent communities it could be a simple as a separate door where organic waste is deposited.

These changes will provide the separation of organic waste from regular waste. They will inform the community members that they may choose to participate and separate their organic waste.

The emphasis on the separation of organic from regular trash is to encourage the sub-conscience concept that organic waste is not trash. A separate collection area implies that organic waste is different.

These smaller communities deserve architectural changes because they interact with their waste collection. Most larger communities in northern Michigan utilize roadside pickup services. An architectural intervention might not be the best solution for these communities. Their participation in organic waste recycling might entail a different color garbage bag or a separate roadside bin.

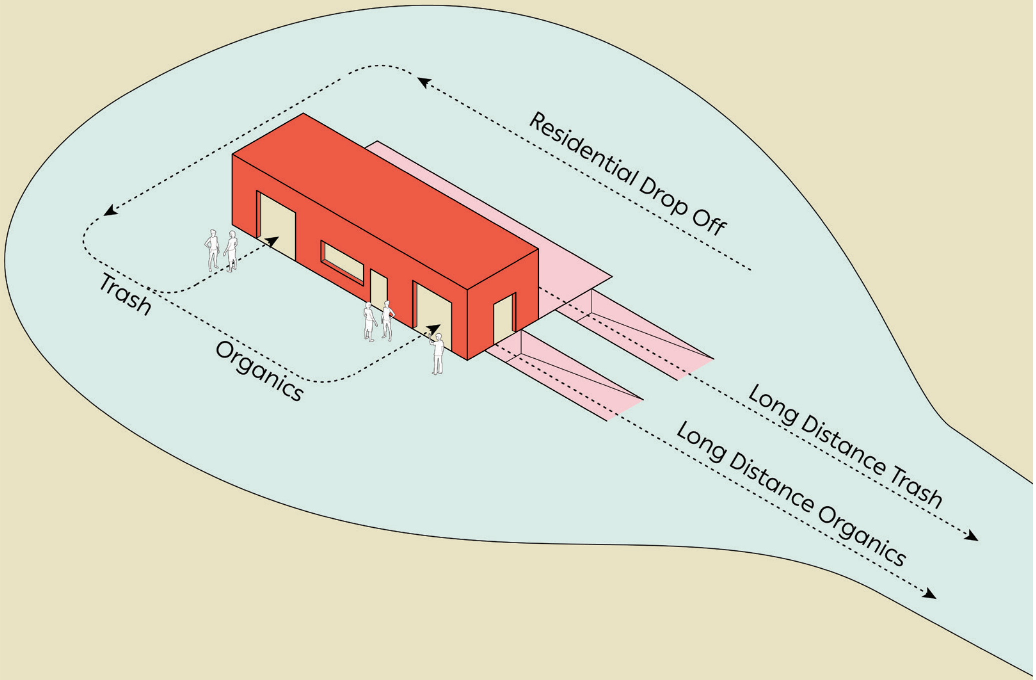

Residential Drop Off
Trash
Organics
Long Distance Trash
Long Distance Organics

Figure 5.7

Figure 5.8

These proposed facilities seek to change the public image of composting. Figure 5.8 illustrates the current perspective of residents and businesses on composting.

Currently composting is viewed as an auxiliary method of recycling. The companies that are currently composting do so in a limited capacity. Their composting takes place in the back of their parking lot and is only rarely advertised. These resources might be used by local residents and contractors who try to support green business, but they are not viewed as a primary source for fresh dirt or fertilizer. Figure 5.8 shows the disregard and low priority of today's composting operations. Figure 5.9 illustrates an operation where the act of composting is treated as a priority. Seeing an organization passionately displaying

Figure 5.9

their composting enforces the idea that composting is important. Hiding compost behind a building only implies that it is not something we should be concerned with.

Many of these composting operations can produce odors and be unpleasant. This is most likely the reason these operations take place out of sight. However, it is possible to display the importance of these systems while considering the local residents. These facilities would need to be located outside urban areas where there is ample room to compost.

Reflection

Conclusion
Closing Thoughts

Conclusion

The human ecosystem is different than any other natural ecosystem. Conforming to nature is usually not our easiest path, especially in the waste industry. And making changes to a system that affects everyone's lives is even more difficult.

However, it is important that our society continues to grow. We must be able to view our own practices through the lens of another to understand our shortcomings. This thesis has been an exercise in putting ourselves in nature's shoes and asking how we should change our waste ecosystem.

I believe these proposed changes to our infrastructure implement environmentally friendly practices in a sensible manner. By providing communities with the choice to embrace these ecological practices, this proposal becomes less controversial. Over time the benefits of these solutions will begin to be seen and these practices will become sensible solutions instead of stiff regulations which many communities might view as invasive.

Closing Thoughts

This thesis began on a very different track, with completely different intentions. It was my hope to understand the greenhouse and explore the different ways they could exist in our current urban environments. My goal was focused on creating dependable sources of local food production. However, along that journey, I realized that organic waste was enabling these greenhouses and had much more potential than heating a greenhouse.

This exploration was very informative. I would typically shy away from public involvement but this exploration has shown me that without that involvement, nothing will change. I believe it is critical that architects, planners, and designers are involved in the design of our waste management system. Food production can be spurred by demand, but there is no demand for sustainable waste management. Without the effort to find and develop solutions that work with our communities, our waste ecosystem will remain inefficient and unsustainable.

Works.

List of Abbreviations

CO2	Carbon Dioxide, a greenhouse gas.
MAO	Montmorency Alpena Oscoda Tri County region
MRF	Material Recovery Facility
GFL	Green For Life, a Canadian Waste Management Company

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Fig 4.1 Author’s Own
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