A Sustainable Urban Village Model: A Biomimic Design

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Executive Summary

Climate change, loss of biodiversity, and water and food droughts are alarming signals of the urgent need to develop an environmentally and socially sustainable model of urban land use. In contrast to the dominant model, the research-based proposals presented in this paper are based on an integrated approach to the interconnections between regional ecological systems in the urban environment.

The guiding principles of an alternative model can be found in the life cycle of a plant. Plants provide a point of cyclical connection between the soil, water, air, food, waste, and energy, meeting all their needs within a single stationary place. Drawing from the insights gleaned by the study of plants, our model of sustainability offers an innovative method for addressing environmental and social processes in the context of an urban village.

In addition to soil, water, air, food, waste, energy, plants, and the restoration of local ecosystems, this paper examines research pertinent to sustainable transportation, ecology education, human health and well-being, and religion and cultural values—all together, these make up twelve categories that are the foundation of our research, training, and educational programs. Our model of an urban village offers a comprehensive, holistic solutions to address all these components, each of which is examined in further detail in the body of this paper.

The key objective is to create a sustainable urban village model, improved and refined through further research, that can be replicated in various regional ecosystems. At its core, our model uses biomimicry to find solutions for each requirement of our lifecycle. Compared with the current approaches, our solutions are local, biologically intelligent, and require much less energy to implement and ultimately sustain human populations.

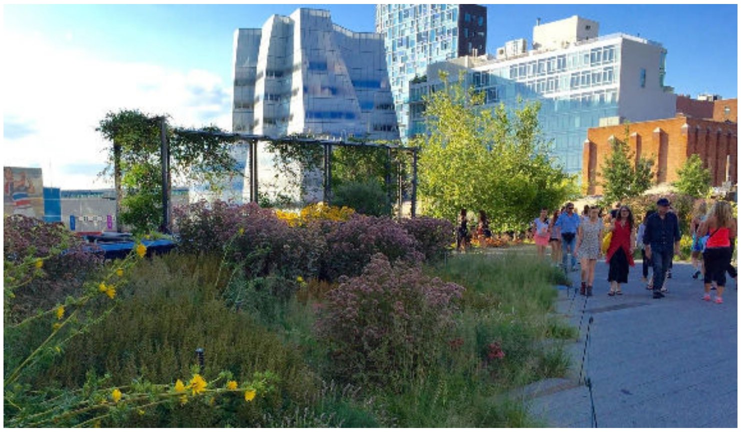
CNGF is implementing the model outlined in this document at the Santa Clara Sustainable Agrihood, located at the former Bay Area Research and Extension Center (BAREC) site for agricultural research. Aspects of this model are also in planning or have been proposed for several other sites in the region, and recent legislation has created extraordinary opportunities to replicate it on undeveloped land across Santa Clara County. For a multitude of reasons, Silicon Valley is an ideal place to lead these efforts and influence others around the world. In the same way that the world has looked to Silicon Valley as a center of technological progress, we believe that now is the time for its forward-thinking leaders to support the development of innovative urban land use models for global sustainability.

The Ecology Model

The California Native Garden Foundation (CNGF) has developed a model for a sustainable urban village based on biomimic design. The guiding principles of our alternative model are to be found in mimicking the life cycle of a plant. Plants provide a point of cyclical connection between the soil, water, air, food, waste, and energy, meeting all their needs within a single stationary place. We think urban planners can actually learn a lot from plants. To develop this biomimicry model, our research examines 10 interconnected categories that comprise the fundamental needs of humanity: soil; air; water; waste; energy; food; terrestrial and marine ecosystems; transportation; environmental education; and human health and well-being.

The High Line Park in New York City, NY. *Source: Alrie Middlebrook*

CNGF is part of a collaborative team that will be implementing an agrihood, to be constructed in the heart of Santa Clara, which will serve as a sustainable urban village that includes affordable housing for low-income seniors and immigrants. We aim to create a new model of urban living that incorporates affordable, medium-density housing within a self-sustaining environment that includes a working farm and offers numerous programs for wellness education. This is a truly innovative project, unlike any other in the United States. The agrihood



The High Line Park in New York City, NY. *Source: Alrie Middlebrook*

will include a working farm, native landscaping, and innovative methods of water conservation and waste management. It incorporates practices that will sequester more carbon, produce abundant food, clean the air, and promote biodiversity, all while being adjacent to six stories of urban apartment buildings. Nearly twenty percent of the 6-acre parcel will be devoted to native gardens, food gardens, walking trails, and a working no-till farm. This document provides an overview of emerging trends and select case studies to illustrate how this model could work.

The City as an Ecosystem

A city can be considered an ecosystem, with various inputs of materials and energy following through its different pathways, including the flow of pollutants. Viewing the city as a an ecosystem can help identify persistent environmental issues, especially how the **reintegration** of management with natural processes can enable increased energy efficiency, resource conservation, and enhanced biodiversity. This will ultimately enable cities and its inhabitants to create a model of sustainability that allows future city stewards to do the same. A biomimic design, modeled after the biological intelligence of a plant's ability to complete its grounded lifecycle, can meet allow people to their essential needs for soil, air, food, waste, native ecosystems, energy, transportation, education, and health and well-being, while using as little energy as possible, reducing infrastructure, and protecting the local ecology.

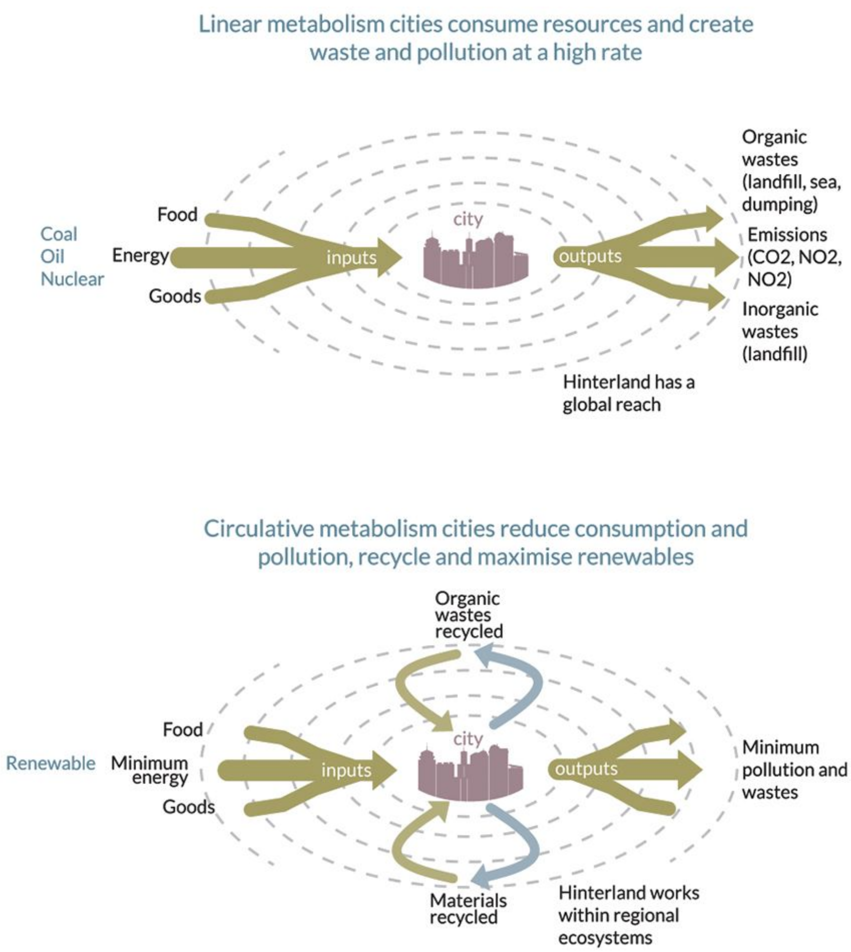
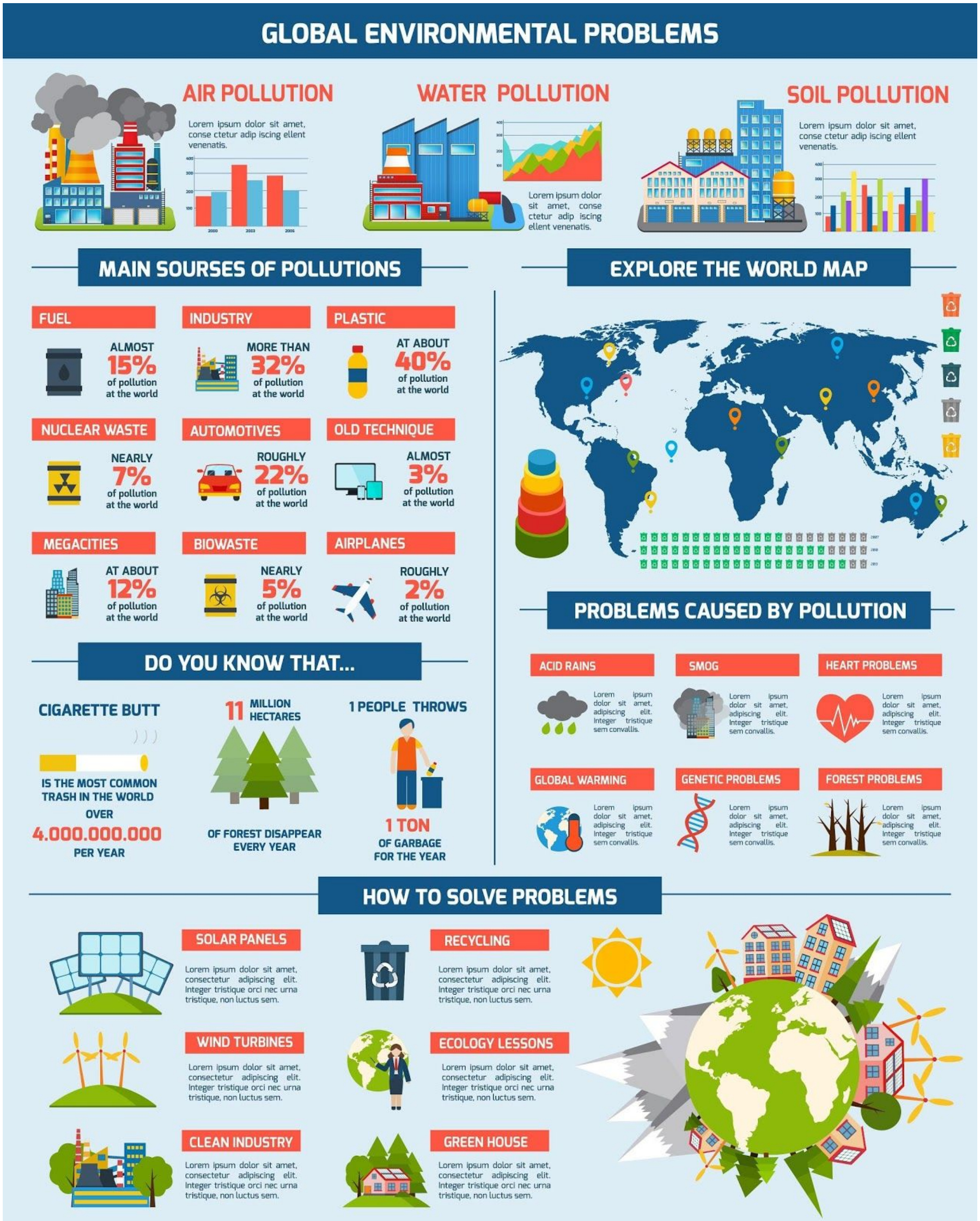


***Figure 1.* Energy models of linear and circulative metabolism cities**

In Figure 1, a **metabolism model** demonstrates how various inputs to the system and **waste outputs** can be used efficiently to fit within the capacities of the local, regional, and global ecosystems. It is an approach that has been developed by academics over the past 30 years (Wolman, 1965; Boyden *et al.*, 1981; Girardet, 1992). With this model, it is easy to specify the physical, biological, and human basis of a city in order to better understand the environmental impacts of cities and highlight opportunities for efficiencies, improvements, and transformation.

Lifecycle of a plant

Just as a plant completes its **lifecycle** from a seed to its full growth intact to its roots, all in the same place, our model aims to provide all life-supporting systems to a human being right where they live. We see the lifespan of a human being as very similar to that of a plant. Plants have a significant role because they just don't provide food and feed us but also house, clothe, medicate, transport, supply, teach, inspire, and entertain us. It is this relationship with the plant communities that can sustain a human cycle for a longer time.


GLOBAL ENVIRONMENTAL PROBLEMS
AIR POLLUTION
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WATER POLLUTION
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SOIL POLLUTION
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MAIN SOURSES OF POLLUTIONS
FUEL
ALMOST 15% of pollution at the world
INDUSTRY
MORE THAN 32% of pollution at the world
PLASTIC
AT ABOUT 40% of pollution at the world
NUCLEAR WASTE
NEARLY 7% of pollution at the world
AUTOMOTIVES
ROUGHLY 22% of pollution at the world
OLD TECHNIQUE
ALMOST 3% of pollution at the world
MEGACITIES
AT ABOUT 12% of pollution at the world
BIOWASTE
NEARLY 5% of pollution at the world
AIRPLANES
ROUGHLY 2% of pollution at the world
EXPLORE THE WORLD MAP
DO YOU KNOW THAT...
CIGARETTE BUTT
IS THE MOST COMMON TRASH IN THE WORLD
OVER 4.000.000.000 PER YEAR
11 MILLION HECTARES
OF FOREST DISAPPEAR EVERY YEAR
1 PEOPLE THROWS
1 TON
OF GARBAGE FOR THE YEAR
PROBLEMS CAUSED BY POLLUTION
ACID RAINS
Lorem ipsum dolor sit amet, adipiscing elit. Integer tristique sem convallis.
SMOG
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HEART PROBLEMS
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GLOBAL WARMING
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GENETIC PROBLEMS
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FOREST PROBLEMS
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HOW TO SOLVE PROBLEMS
SOLAR PANELS
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RECYCLING
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WIND TURBINES
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ECOLOGY LESSONS
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CLEAN INDUSTRY
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GREEN HOUSE
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Creating a New Model

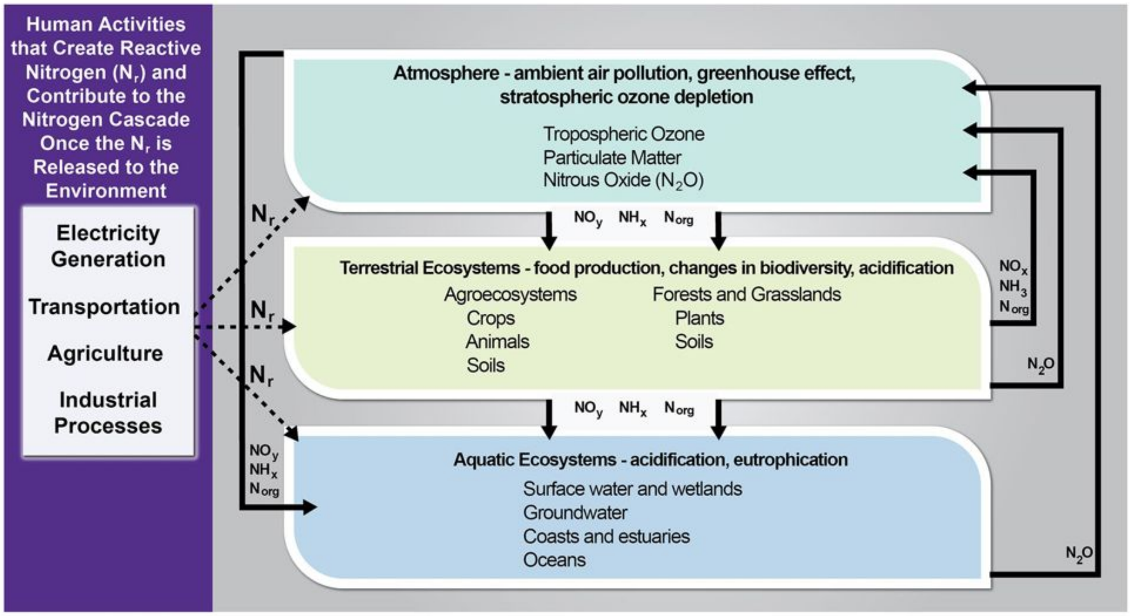
Our sustainable urban village model depends on insights from the cultures of indigenous people depends along with innovative scientific methods like **metagenomics**. We must build on the newest technologies in order to provide solutions to the challenges of sustainability. These solutions can credibly measure and communicate sustainability and business benefits, manage change, and successfully implement new approaches. In order to provide these technological solutions, we need to understand how we can successfully develop, demonstrate, and put forward the needs and adoption of these new approaches. Thus, an appropriate model will be the one that (1) defines scope of our work; (2) prioritizes the impacts we need to curb and (3) conducts the necessary assessment that would measure and monitor results.

- Development: Understand how to apply technology to solve sustainability challenges
- Demonstration: Credibly measure and communicate sustainability and business benefits
- Adoption: Manage change and successfully implement new approaches

Macro v. micro solutions

- Micro solutions based on ecological model/**mutualism**, cooperation, and **synergies** of **microbiology**
- Natural cycles
- Some of the examples how natural cycles have been disrupted by human intervention

Biogeochemical Cycles



Use of phosphorus fertilizers in agriculture has greatly transformed the phosphorous cycle in United States. Even though phosphorus do not directly affects the climate but it does indirectly increase carbon sinks by fertilizing plants. Similarly, human induced nitrogen fertilizers alter the nitrogen cycle. Disruption of nitrogen cycle has greatly affected atmospheric concentrations of the three most important human-caused greenhouse gases: carbon dioxide, methane, and nitrous oxide.

How Forest Systems Renew Themselves

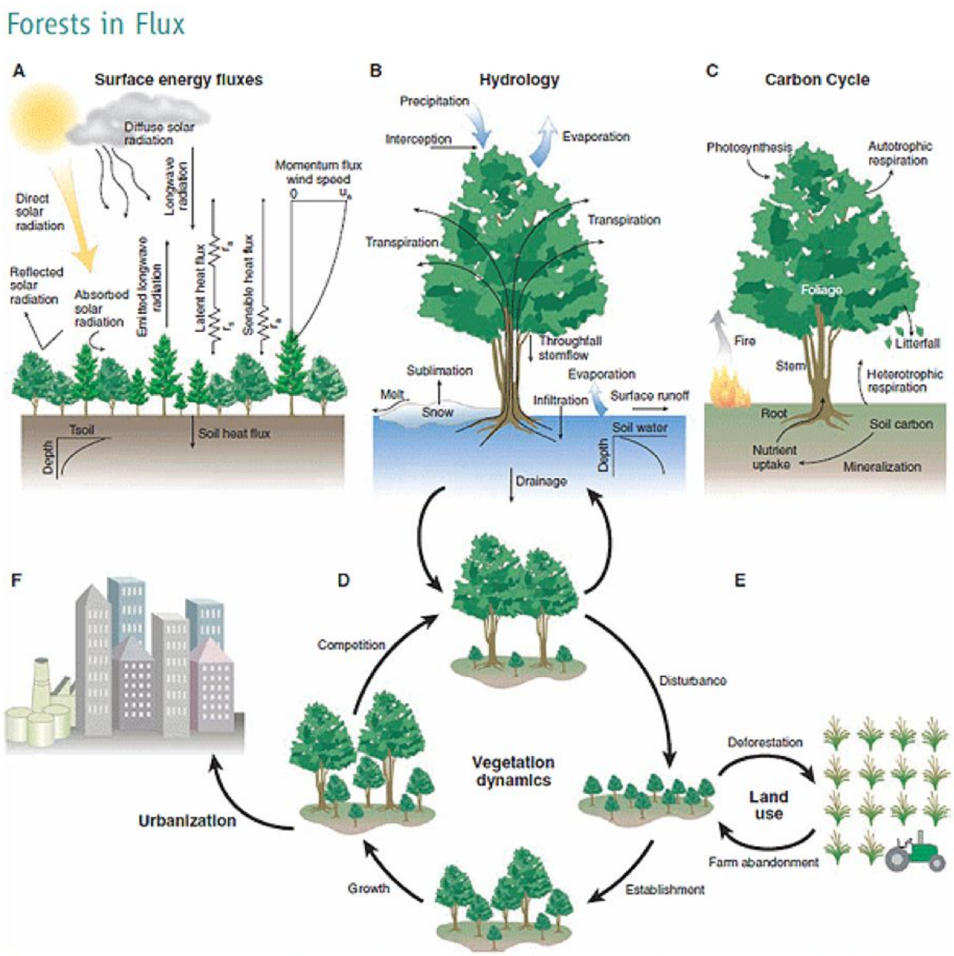


Fig. 2. The current generation of climate models treats the biosphere and atmosphere as a coupled system. Land surface parameterizations represent the biogeophysics, biogeochemistry, and biogeography of terrestrial ecosystems. **(A)** Surface energy fluxes and **(B)** the hydrologic cycle. These are the core biogeophysical processes. Many models also include **(C)** the carbon cycle and **(D)** vegetation dynamics so that plant ecosystems respond to climate change. Some models also include **(E)** land use and **(F)** urbanization to represent human alteration of the biosphere.

Forest Ecology Model

Conservation and restoration

For the first time in Santa Clara Valley, in California and in America, a working farm and community gardens are the prominent open space features of a multi-generational medium density, low income senior, affordable and market rate urban village. A 32,000 sq foot regenerative farm is heralding a paradigm shift in urban land use. Incorporating rural elements that sequester more CO2, produce abundant food, promote biodiversity and clean the air is a revolutionary use of land adjacent to 6 stories of urban apartment buildings.

Nearly 20% of the 6 acre parcel is devoted to native gardens, food gardens, walking trails and a working no till farm. This project will provide the residents an opportunity to experience daily life next door to a village farm, a vineyard, an orchard and walking and hiking paths that connect all four corners of the neighborhood.

The townhouses and apartments, designed with contemporary architectural materials like wood, concrete and glass will show a direct link to California farm life by the use of natural materials in the housing, incorporating common materials like rusted steel trellis', galvanized cattle troughs for planters, core 10 rusted steel facade raised beds, painted sheet metal, and natural gravel and decomposed granite walking trails and paths. The organic farm and nature friendly landscape will dictate both the horizontal and vertical growing spaces.

Floor to roof vine covered rusted steel trellis' will thrive where sun streams into courtyards. Other garden influenced courtyard features will be tall, colorful art walls with seeds and flower themes. There will be an open and spacious entry plaza with iconic sculpture food towers. They'll be filled with many varieties of fruits and vegetables, nutritious, colorful and reaching toward the sky.

A sunken amphitheater for performance venues, a u-pick veggie patch and giant, colorful California poppy shade sculptures fill the plaza. Fun things to do in comfort and pleasure await all villagers and their guests. A farmers market will be a weekly occurrence. Farm trucks can drive on natural permeable gravel, park their produce filled trailers and find many customers.

A multi-purpose barn will include a food demonstration kitchen, meeting and classrooms, and assembly area for CSA boxes, a machine and wood shop, exhibition space, a walk in refrigerator and storage. Behind the barn, next to the farm a vine cover walkway will house the chicken and rabbit hutch.

Families with children who live in nearby neighborhoods like Mid-Town and Santana Row can walk to agrihood. There will be an active play area built over a nature preserve that is adjacent to the farm. There will be climbing structures, rope bridges and look out towers. A hiking and dog walking trail will take you on a tour of the farm. You'll see pigmy goats, composting and vermicomposting production areas, greenhouses, and even a resting area for farm workers that is a giant bee hive. Many garden groups and senior, veteran farmers, school children and residents can grow their own fruits and vegetables in the galvanized metal farm troughs and raised planters. They can take a break at the nearby pop up kitchen that looks like a remodeled shipping container. On warm summer nights they can dine under a rustic trellis covered with grapevines. Fundraising farm to table events can take place under the arbor light twinkling and the sounds of live music filling the air.

Restoration of Local Ecosystems

When we define **disturbance** as an ecological term, it is as an abrupt change to an ecological system that alters the biomes in that system. This may cause radical shifts that bring death to organisms or an immediate alteration in their spatial patterns. Agriculture, mining, and urbanization are among the **anthropocentric** driven disturbances that have radically disturbed local ecosystems.

Garden for Ghana plot in Yamoransa, Ghana. ***Source: Alrie Middlebrook***

In our natural world, disturbances also cause abrupt changes to local ecosystems. Fire, floods, volcanoes, and earthquakes are natural disturbances that greatly alter local ecosystems. By observing how ecosystems recover from natural disturbances, we are able to utilize **ecological modeling** to help us repair manmade disruptions, like agriculture and extraction methods such as mining, drilling, and major construction projects that dramatically alter local ecology. Therefore, when we design and build cities, our understanding of local ecosystems and how they restore and recover after natural disturbances can help define and rebuild future **indigenous landscapes** and urban farms or cities (Holling, 1986; Pickett et al., 2001; Chapin, Matson, & Vitousek, 2011).

Garden for Ghana student leader, standing by one of 100 native trees recently planted, with foreground highlighting trash problem in Africa. ***Source: Alrie Middlebrook***

Regional and local ecosystems are made up of local plant communities, which, in turn are comprised of millions of organisms that are defined by **complex microbial networks** that support and interact with each other across species populations. Beginning with soil microflora and fauna, like bacteria, fungi and **nematodes**, all life systems, within an ecosystem are dependent on the networks that define their species interacting with the networks of other species. Plant community evolution has a very long time line. Most plant communities on our planet have been successively completing their life cycles for millions of years within relatively small local ecosystems. A meadow, a woodland, a wetland will each contain some unique plants that many times may not be found in another plant community 100 miles south or north, especially when a natural barrier like a mountain or a large body of water separates them. All plant communities and ecosystems are defined by local conditions. These may be soil chemistry, distance from an ocean, distance from a fault line, altitude, aspect, precipitation, and distance from the equator. The more specific you can define a local plant community, especially one that has been disturbed by a man made action, the more accurate we can be in renewing or restoring that system.

Disrupting local plant communities results in many dire consequences, the most detrimental being CO2 emissions increases, loss of biodiversity, disruption of climate regulators, killing of pollinators, polluted air, loss of fresh clean water, loss of topsoil and destruction and massive kill off of soil microbes. Armed with science based tools and methods that enable us to restore complex local ecologies and plant communities, once planted, we can also follow specific protocols for the long term stewardship and management of these systems.

Erosion of hillside in Yamoransa, Ghana. ***Source: Alrie Middlebrook***

The United States Green Building Council has recently purchased the Sustainable Sites Initiative, which is a rating system comprised of over 200 benchmarks for sustainable urban land use (Kibert, 2016). The corporate headquarters for CNGF, located at 76 Race St. in San Jose, is a site certified and recognized by USGBC. Ours is the only site in Santa Clara County and one of only seven certified sites in California. Among the criteria are several points that can be earned by using locally native plants, by sourcing local plants from regional native plant nurseries that operate sustainable business models and by eliminating invasive plants from your gardens. Research shows that once re-introducing native plant communities into disturbed soils has been accomplished, the soils gradually return to naturalized soils' microbial networks which, along with the native plant community network, is then able to return the benefits and services to the local ecosystems (Loreau et al., 2001; Reynolds, Packer, Bever & Clay, 2003; Bever et al., 2010).

Mixed Evergreen Native Plant Community, High Sierra, California. ***Source: Alrie Middlebrook***

1. Soil Health and Soil Building

Approximately half of the planet's topsoil has been lost during the past 150 years (Montgomery 2007; Morgan 2009). In addition to the loss of fertile land, the consequences of erosion are numerous and ruinous. Soil organisms are highly sensitive and closely linked to vital ecosystem functions, including water storage, carbon sequestration, decomposition and nutrient cycling, detoxification of toxicants, and suppression of noxious and pathogenic organisms (Doran & Zeiss, 2000; Van Bruggen & Semenov, 2000; Doran, 2002). Soil erosion is a serious problem because **terrestrial ecosystems** protect numerous life forms and produce all of our food, either directly in agriculture or through the regulation of **marine ecosystems** (Baldock, Masiello, Gelinas & Hedges, 2004; Chapin III., Matson & Vitousek, 2011).

Native oak woodland and chaparral garden in Stanford, CA. ***Source: Alrie Middlebrook***

One of our other important goals is to facilitate a clearer understanding of the importance of healthy soils and soil building practices. Direct field experience by keen observers can inform the adoption of healthier practices. Alternative models can be documented and tested against traditional methods, measuring outcomes and benefits like improved human health, enhanced biodiversity, greater carbon sequestration, and ultimately higher crop yields and plant health.

Native grassland, chaparral and vineyard in Fremont, CA. ***Source: Alrie Middlebrook***

Despite its crucial role in the ecosystem, soil has not been valued or protected in urban land use models. Soils are regularly paved over with impervious materials and/or compacting large areas, practices which kill trillions of beneficial soil **microbes** and prevent soils from serving as living **biomes (**Fierer et al., 2012; Ramirez et al., 2012). In urban environments, leaf litter and other organics are routinely removed from the surfaces of soil and grass, counteracting the natural processes that occur in any forest ecosystem. Then gasoline is wasted in order to carry organic material to landfills. Many harmful chemicals and debris continue to be used in construction, and toxic materials are frequently dumped in low-income neighborhoods and industrial areas in cities. These activities result in **phytotoxicity** and contaminations of soils. They also perpetuate soil degradation and destruction among future generations, who never learn about soil's vital role in creating healthy people and a sustainable environment.

Soil erosion on farmland caused by disrupting soil systems networks. *Source: indianapublicmedia.org*

The application of **metagenomics**, a new science that was originally developed to aid **biomedicine**, will eventually transform the science of all organisms, including agriculture, forestry, and **microbial forensics** (National Resources Council, 2007). But progress will be slow. The growing body of scientific understand will reveal how soil and plant biomes function, with their communities of microbes cooperating extensively to perpetuate life while suppressing trillions of potentially harmful pathogens.

Native grassland and oak woodland garden in Livermore, CA. *Source: Alrie Middlebrook*

Our team has made several crucial observations during 30 years of designing, building, and maintaining native gardens. After planting a native garden with regionally appropriate native plant species that evolved together as a **plant community--oak woodland** and **grassland** in Santa Clara County, for example--we would continue to remove many invasive species from the garden over the next 4-5 years. We also found that **invasive species**' ability to germinate in naturalized soils was greatly reduced. Gradually, the native gardens we planted would be populated by more native species, especially if there were other native grassland or oak woodland gardens in close proximity. These plants germinated naturally without being planted.

Our hypothesis is that the microbes of the individual plant species in the plant community create a strong network with the **soil microbiology**, which prevents non-native or invasive species from germinating in the soils. This has happened in our gardens so many times that we can predict that disturbed site soils will be restored to a naturalized soil state if we steward the garden and continuously remove invasive species. This phenomenon happens in a relatively short time. Therefore, we can predict urban garden and farm outcomes by following these important steps to reestablishing terrestrial ecosystems. The benefits are increased biodiversity and more CO_2 sequestration, water conservation and cleansing, and ultimately improved food production. By accumulating our collective knowledge of regenerating local native plant communities, we can then apply these findings to conservation farming practices in urban environments.

Native grassland and oak woodland garden in Almaden, CA. ***Source: Alrie Middlebrook***

2. *Air*

More than 1.6 million people, many of them children, die from air pollution every year. Millions suffering from the effects of polluted air may experience debilitating diseases, reduced productivity, and shorter life spans . The leading causes are radiation, methane, cooking with firewood, **pesticides** and **insecticides**, air conditioners and refrigerators, smoke from industries and factories, automobile use, smoking cigarettes and other tobacco products, **deforestation**, and **industrial agriculture** (Pope III et al., 2002; Borrego et al., 2006; Anderson, Thundiyil, & Stolbach, 2012).

Many of these sources of air pollution are linked to the industrial production of food. Growing and processing, the byproducts of eliminating waste from consumed foods, transportation food miles, clearing land for agriculture, and industrial agriculture models are major contributors to global pollution levels. The evolution of **chemically dependent agriculture** since 1945 has allowed large **monoculture** farm models to define our **global landscape**. As much as two-thirds of the sources of air pollution could be reduced if our food system was transformed from large-scale, global industrial farms to one which includes more regional, small sustainable farms (Matson, Parton, Power, & Swift, 1997; Foley et al., 2005).

Smoke from factories and industrial areas have a global impact, and this type of air pollution is inextricably linked with water pollution. Emitting heavy metals from coal burning power plants can impact the health of people who live on other continents, along with marine species in far away oceans. For example, heavy metals and other pollutants from Chinese factories are emitted into the atmosphere and then carried by wind and weather patterns to California, eventually arriving in the oceans to disrupt marine ecosystems and planet cycles like carbon, nitrogen, and phosphorus (Cheng, 2003; McConnell & Edwards, 2008).

Large acreage monocropping agriculture increases air pollution.

It is possible to substantially reduce air pollution by adopting an interconnected approach that shifts our food models to small regional farms, located near denser housing and open space. We also need to take a more regional approach to the foods we grow and eat. When our regionally-based diet includes more perennials native to local ecosystems or those that are similar--for example, the comparable ecosystems of California and the Mediterranean, or tropical West Africa and tropical South America--we create ecological solutions which are rooted in conservation and sustainability. In these time-tested models, pollution levels are negligible.

Today if you eat a single taco in San Francisco, all the ingredients (beef, corn, tomatoes, lettuce, onion, peppers, oil and spices) add up to 7,000 food miles. Now, imagine preparing a similar dish in an urban Agrihood with its own farm. An **Agrihood** is an urban land use model where food is grown and consumed locally, just as a plant makes its own food while rooted in the ground. In this model, significantly less energy is used to produce and transport food, thereby creating a more sustainable ecosystem that also sequesters more carbon.

Use of pesticides contributes to air pollution.

One such community is Ceres, a four hectare environmental park in Melbourne, Australia that was built on a landfill site 30 years ago. At Ceres, they collected data to measure food miles and greenhouse gas emissions. They filled a typical supermarket grocery basket with foods that were popular and commonly available, but not necessarily sustainable. The total distance for all the modes of transportation required to fill this grocery cart was 70,803 km or three trips around the world. Their estimate of the total greenhouse gas emitted from just the food trucks transporting on roads was 16,989 tons of CO2--the equivalent of 4,247 cars driving for one year. This was only a preliminary study but the numbers indicate a need to conduct more studies where CO2 emissions and food miles can be linked and quantified (Caraher & Carey, 2003; Stacey, 2008).

The Ceres example demonstrates how carbon emissions and food miles can be measured and quantified. In the same way that the polluting, wasteful practices of our current food system can be calculated, it will be possible and necessary to measure and quantify the benefits of our alternative model. What if consumers could make choices based on food miles, CO2 emissions, and pollutants emitted? What if there were costs identified with each mile? Costs to society, health care, lost productivity or even the collapse of food systems due to the ravages of climate change that greatly diminishes farm production. These are a few categories that are directly connected to the 10 causes of air pollution worldwide. Armed with data and studies that link cause, cost and long term outcomes to present day food systems pollution may persuade the government and the development community to rethink how cities can thrive in the future as pollution-free zones.

3. Water

There is a water crisis worldwide, exacerbated by global climate change. The crisis is borne out by extreme weather events that produce prolonged periods of drought, followed by flooding, tidal surges, and hurricane events. At the same time, infrastructure built in the developed world 70 to 100 years ago used lead pipes which have corroded and contaminated the drinking water (Lee & Schwab, 2005; Gray, 2008). There are also asbestos pipes still in service. In America, at least 10 million people drink water conveyed by pipes containing lead (Brown & Margolis, 2012). Massive infrastructure projects cannot be completed without government, private, and community support. For example, New Jersey is addressing its aging infrastructure in 21 cities by creating New Jersey Future, an alliance comprised of state and local jurisdictions, supported by the Johnson and Johnson Foundation and the Geraldine Dodge Foundation, and other non-government and local entities (www.njfuture.org)

Erosion control and bioswale before and after photo/rendering for Garden for Ghana, Yamoransa, Ghana. *Source:* Shaohua Jiang, CNGF intern

To replace infrastructure we must address water supply, **wastewater**, and **stormwater**. Since we are at a critical juncture due in large part to climate change, any solutions must be sustainable and greatly reduce CO_2 emissions. Considering the lessons learned from these developments, our goal for the future of cities is to eliminate as much infrastructure as possible (Pahl-Wostl et al., 2008). When we carry water in pipes, especially long distances over hilly terrain, we use enormous amounts of energy produced by fossil fuels. In fact, the largest use of electricity in California is to move water. Finding ways to conserve, reuse, clean and replace water, close to where rain falls, is the driving goal of water management. Currently the methods we use to clean water, handle waste, and reuse water are greatly dependent on costly infrastructure and fossil fuels (Gleick, Wolff, & Cushing, 2003; Hanak, 2011).

If we examine how a plant uses water, it wisely collects all water from every surface, and it stores water in its structure and directs and holds water in the root system, as the plant's system requires. These strategies per individual species took millions of years to develop and are appropriate for the regional conditions which prevail where each plant species originates. Our water management should strive to be as efficient as a plant's, and plants operating in networks as plant communities. Our urban village model can benefit especially from examining plants native to California, which endured extensive periods of drought through the millennia.

Ultimately, if reason is to prevail, our solutions will be biomimic. For example, using the Agrihood model as a case study, 100% of storm water can be captured on the 6-acre site. Some of it is stored for later use, and some is cleaned and used for **controlled-environment agriculture**, like Aquaponics farms which could be installed on roof tops of low income senior apartments. Some storm water is diverted to low impact developments or green infrastructure features like parking lot **swales**, **constructed wetlands,** and **rain gardens**. Other downspout water is directed to landscape features or **porous paving** sites to flush grit from particle spaces and improve drainage. Landscaping can use drought tolerant regionally native plants to conserve water and improve **soil hydrology**. Some food plants in the working farm can be native, perennial drought-tolerant foods as well as food plants selected from other drought-prone ecosystems compatible with California's Mediterranean climate.

Fresh water for household use can be reused as greywater for irrigation, rain gardens or constructed wetlands, ultimately returning to underground storage. Wastewater treatment can be greatly reduced by building small, efficient on site waste management models. Today's wastewater treatment wastes a lot of water and fossil fuels, using it to break down **biosolids**, then conveying it to the ocean or routing it to purple pipes for non-potable use.

Oroboros aquaponics farm, Half Moon Bay, CA. ***Source: Ken Armstrong***

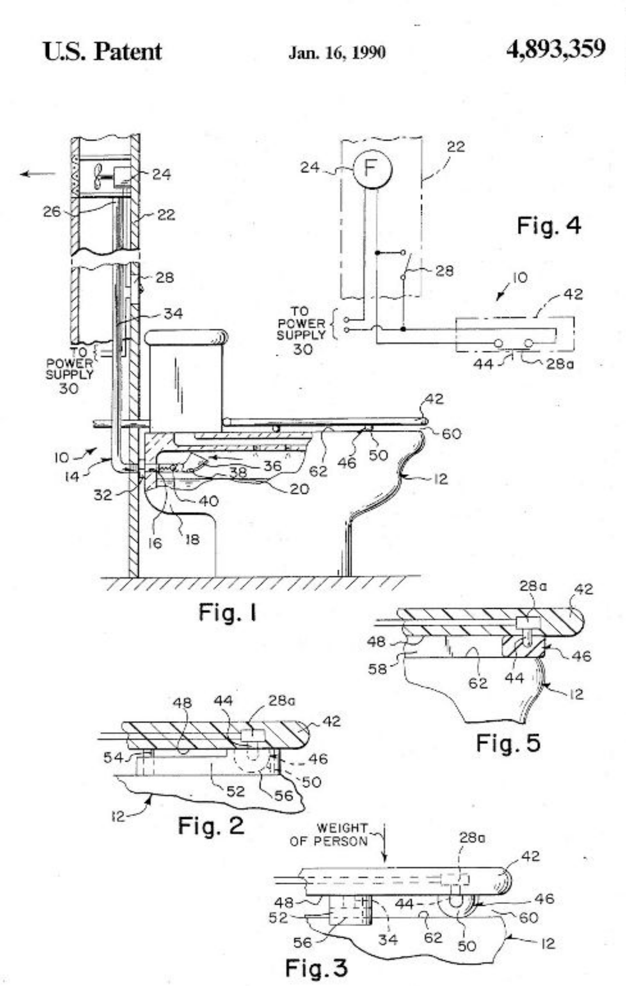
Nanyang Technological University in Singapore has developed highly efficient No Mix vacuum toilets that require 90% less water to flush, separating the fluids from the biosolids and converting the solid waste to energy for cooking and heating. Urine contains nitrogen, phosphorus, and potassium. The water in urine is processed onsite and can be used as greywater for irrigation, or seasonal rain gardens, and then returned to the underground aquifer. Once converted, the remaining chemical components can be stored and used for fertilizer on the Agrihood farm (Lim & Wang, 2013; Rajagopal et al., 2013).

Wang Jing Yuen, Director of The Residue and Resource Reclamation Center at NTU, stated, "The ultimate aim is not only for the new toilet system to save water, but to have a complete recovery of resources so that none will be wasted in resource scarce Singapore." These models and others like them in Africa, Korea, and the United Kingdom do not rely on costly infrastructure to handle and reuse waste. Instead, they mimic plant function and efficiency, onsite where the entire community--both plants and humans--benefit.

4. Waste

Early archeological records from the Han dynasty indicate that humans were making compost 2000 years ago. Recipes were found listing human waste, animal waste, straw, ash, etc. Some consider the beginning of the environmental movement to have been in 1739, when Benjamin Franklin led an effort to petition the Pennsylvania Assembly to stop waste dumping in Philadelphia. For the most part, steps have been taken to manage waste only when it has smelled bad and fouled the air.

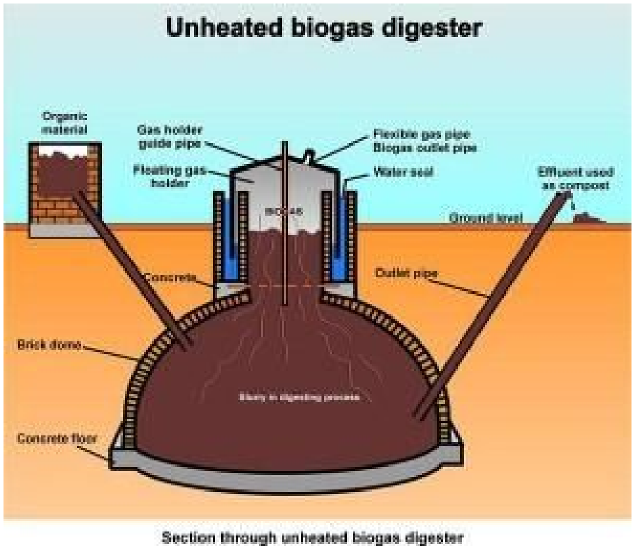
For millennia, handling waste efficiently was an afterthought. There was very little planning for waste management and waste programs were reactionary. Some Innovation was introduced for incinerators and compactors, but as the records demonstrate, time after time people were put off by the fumes, the noxious odors, and debris that emanated from the burning of waste to foul the air or cover the land with layers of ash and soot. They filled landfills with unsorted waste, compacting it and covering it, which resulted in methane gas plumes (Louis, 2004).



No-mix vacuum toilet drawing. ***Source: US Patent Office***

No one understood the chemistry of decomposition nor recognized the value of decomposing microbes, who have the ability to return trash to compost in a relatively short time. There were no electronic microscopes to study microbial behavior. In the 19th Century, the separation of human waste from other wastes was dictated by public health laws, disease outbreaks, and unpleasant odors permeating city neighborhoods.

Today, hauling waste or moving waste away from where people live continues to be the dominant means of waste management. Although there has been some progress, we are still incinerating and filling up landfills. In 2012, the EPA noted that Americans produced 4.38 pounds of solid waste per person each day, and we recycled 34.5 percent and incinerated 12%. The rest went to landfills (Finnveden, Johansson, Lind, & Moberg, 2005; Worrell, Vesilind, & Ludwig, 2016).



Detail of typical digester.

There are viable alternatives to managing waste by moving it great distances, utilizing fossil fuels at each step of the process and wasting most of the energy that could be converted to food or fuel. Instead, we could use cheap sources of waste that are easily and efficiently converted and used on site. We are using great amounts of energy in inefficient methods for handling waste, generating low returns as large waste management companies profit from this wasteful model at each step of the process.

In school we learn about the carbon cycle. There is no waste, only decomposers. The technology already exists to recycle and reuse waste onsite, utilizing microbes to convert waste to compost and methane gas for heating and cooking. A university in Singapore has developed a two chambered vacuum operated toilet that requires only ten percent of the water of traditional toilets, and converts liquid and solid waste to fertilizer and biogas. Likewise, a village in northern Sweden has developed a system to convert urine waste into nitrogen- and phosphorus-based fertilizers (Hanæus, Hellström, & Johansson, 1997). Other nations which lack infrastructure are installing biogas designs in buildings instead of sewer lines.

Biogas installation ICTC building, Yamoransa, Ghana. ***Source: Alrie Middlebrook***

Why should Silicon Valley, a world leader in technology innovation, continue to use toilets that require between 9.1 and 18.8 gallons per person per day? This is the time for ecological leadership. We need to develop models that utilize microbiology to return waste to energy for onsite use.

It is possible to utilize available resources that can grow food and convert energy for the people who have produced the waste and are a part of the cycle of renewal (Costi et al., 2004; Morrissey & Browne, 2004; Cheng, 2009; Seadon, 2010).

5. Energy

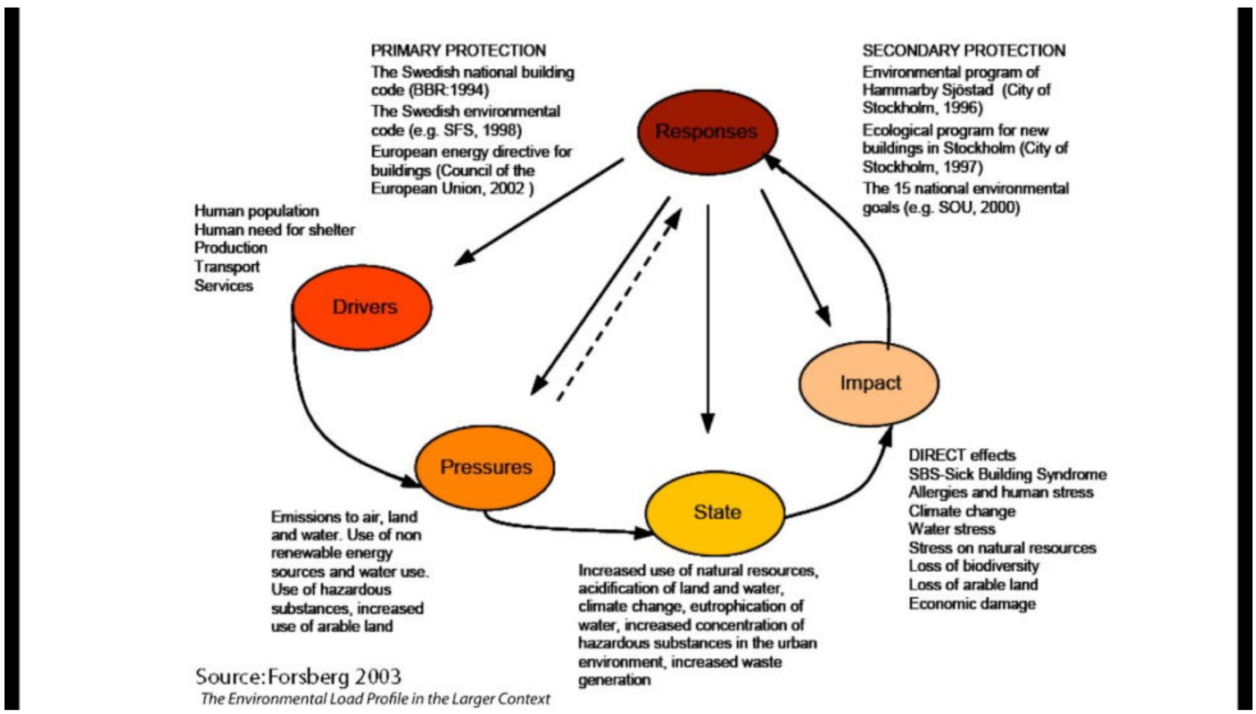
Humans have been using unsustainable methods of creating energy since the start of the Industrial Revolution. As means of transportation were developed for a growing global population, the car culture became a key feature of Western societies. Our extraction-based economy has led to accelerated environmental destruction. While combusting fossil fuels adds greenhouse gases to the atmosphere and contributes to climate change, it is our ever-increasing need for fossil fuels that demands more drilling. This in turn demands a growing need for fossil fuels and causes more environmental disasters, like offshore oil spills.

Possibilities for sustainable regional energy solutions abound if we attend to local ecology. The growing use of renewable energies includes regional solutions for individual ecology models, offering many highly promising answers to our fossil fuel problem. Significantly, renewable energy sources have served the unique purpose of empowering individuals to take part in the monopolized supply of energy, particularly on a local scale (Chu & Majumdar, 2012; Pearson, & Foxon, 2012)

In central and northern Texas, for example, the use of wind turbines among farmers and cattle ranchers has achieved a consensus of support in their communities (Swofford & Slattery, 2010). Wind turbines have become affordable enough to cover the initial installation costs, and farmers and ranchers can sell excess electricity to the local power company through the grid. This zero-effort means of drawing income is highly appealing to these undercompensated staples of our livelihood. It is much more sustainable to use these kinds of locally supplied sources of energy, as people did for centuries before the Industrial Revolution and birth of the fossil fuel industry. The long-term movement toward efficient and sustainable energy answers is inspiring. The auto industry continues to improve in fuel efficiency and greenhouse gas emission removal techniques. The costs of installing solar and wind power-harnessing technologies continue to decrease, making it a more viable solution for everyone from individual homeowners to businesses and government institutions.

Aside from methods of electricity production, other sources of energy are currently available and proliferating where regionally applicable. Such an example exists in Africa with the increasing usage of biogas capture and conversion. Biogas Energy Solutions, based in Nairobi, Kenya, installs custom-made biogas capture systems for individual clients that are appropriate for their biogas source. They have conducted research, created a multitude of prototypes, and successfully developed systems for biogas sources such as human waste, elephant dung, and avocado waste. Innovative, specialized energy sources like that of Biogas Energy Solutions have already been created, and they will continue to aid in our pursuit of a fossil fuel-free energy future that supports local ecology everywhere (Kiplagat, Wang, & Li, 2011; Nzila et al., 2012).

Bold, innovative solutions are necessary for the cities of the future to be more environmentally and socially sustainable (see http://thesolutionsproject.org/). One "ecodistrict" in Sweden is attempting to address these interconnected issues in ways that future cities might emulate. Hammarby Sjöstad ("Hammarby Lake City") is a sustainable, mixed-use development adjacent to the Swedish city of Stockholm. The project presents a model of sustainability in its redevelopment of a declining industrial district into housing, commercial areas, and recreational space. The unique features and strategies for sustainability at Hammarby include innovative transportation methods and urban planning; biogas production from waste; power generation from trash; installed photovoltaic arrays; solar hot water tubes; centralized vacuum tube recycling collection; storm water remediation; green roofs; brownfield cleanup; and public education about environmental issues (Johansson & Svane, 2002; Iveroth & Brandt, 2011; Iveroth, Vernay, Mulder, & Brandt, 2013).



The Hammarby Model

6. Regenerative Food Systems

Our current practices of industrial agriculture have done tremendous damage to our global environment and its citizens, as we noted in the previous sections on soil, air, and water. This model that produces most of the world's food is not sustainable (Bird & Ikerd, 1993; Grey 2000). The CEO of Central and West African operations for the International Fertilizer Development Center (IFDC) predicted that it can only last 50 more years, at best (Tilman et al., 2002).

Consistent with most of the solutions outlined in this paper, we believe future sustainable solutions will mimic biological models and relate more to micro habitats within complex ecosystems than current models do. These types of carbon farms are currently being promulgated by other organizations, including Regenerative International, The Savory Institute, African Center for Holistic Management, Threshold Foundation, and Schmidt Family Foundation. Our objectives in creating this model are:

1. Reduce CO2 emissions.
2. Restore and enhance biodiversity
3. Restore local ecosystem services.
    a. Conserve water and improve soil function.
4. Reintroduce locally native edible and medicinal plants as candidates for inclusion in the models.
5. Connect the models to schools and universities, featuring lesson plans and garden projects that teach children about their local ecology and sustainable food production skills.
6. Connect food to water conservation, reuse, and cleansing.
7. Connect food to waste and create waste management programs that are safe and cost effective, modeled after life cycles.
8. Help develop other revenue generating cottage industries based on the regen farm model.
9. Produce healthy nutritious food with many diverse choices.

Our regenerative farm model draws from several disciplines as well as shared knowledge about successes and failures from around the world (Francis, Harwood, & Parr, 1986; Lightfoot, 1990; Pearson, 2007; LaSalle & Hepperly, 2008). This model incorporates lessons taken from many practices: the local ecology where the farm is located; soil microbiology; regional organic farming models; indigenous cultures food systems; conservation agriculture; controlled environment agriculture; permaculture; data from successful regional farms; working with consultants from those farms; and successful models we or others have created here and in other global ecosystems.

The key components of our regenerative farm model includes the following:

- No till
- Polyculture
- Continual planting and harvesting:
    - Mediterranean rotations 3 times per year
    - Tropical rotations 5 times per year
- Improved seeds and plant selections
- Composting and vermicomposting teas and foliar feeding
- Human waste composting systems, and biogas converters
- Over planting, reduced spacing, and planting configurations
- Mulching, continuously, so that soil is never left exposed to the light or high temperatures
- Drip irrigation, including subterranean irrigation
- Native plant **hedgerows** for insect management, pathogen reduction, and the restoration of soil microbiology
- Introduction of native grasses for improved hydrology and water management

The selection of food and medicine plants to be grown are:

- **Comfort foods**
- **Superfoods**
- Drought tolerant foods
- **Perennial** food and medicinal plants
- Native edible and **medicinal plants** (Ancestral plants)
- Edible, medicinal native and tropical trees (a food forest with native grasses and perennials as understory)
- No **GMOs**

Our overarching objective is to supplement the typical diet that is overly reliant on complex carbohydrates, like corn, wheat, and rice, with multiple plant sources of nitrogen-fixing legumes and fruits such as yams, sweet potatoes, plantains, avocados, etc.

Regeneration farm model in Yarmoransa, Ghana.
One of 15 garden plots under development since 2013 in "Garden for Ghana" Program.
Source: Alrie Middlebrook

Harvesting orange-fleshed sweet potatoes from one of the garden plots in Yamoransa. Source: Alrie Middlebrook

Food forest, erosion control and vegetable gardens in Yamoransa.
Source: Alrie Middlebrook

Singing Frog Farm, a no-till farm in Sebastopol, CA.
Source: Alrie Middlebrook

Cojimar, a regenerative farm in Cuba utilizing no-till methods and vermicomposting tea as fertilizer.
Photo by Alrie Middlebrook

Aquaponics harvest at Oko Farms, Brooklyn, NY.
Photo by Alrie Middlebrook

Oko Farm sign in Brooklyn, NY.
Photo by Alrie Middlebrook

8. Sustainable Transportation

Transportation is at the core of the mounting crisis that stems from unsustainable energy use and carbon emissions. The U.S. Environmental Protection Agency estimates that more than one-fourth of current **GHG** are a direct result of transportation (US EPA, n.d.). While industry shifts toward an information economy that pollutes less, the share of carbon emissions caused by transportation continues to increase.

Our auto-centered transportation system is a result of the dominant models of urban planning which prevailed after World War II. This model divided commercial, residential, and recreational spaces into separate zones, making it virtually impossible for people to carry out their daily activities without using a car. The U.S. government expended huge sums for the construction of highways and new suburban housing developments, while city centers were left to decline. The end result was a sprawling network of mass produced suburbs which were designed first and foremost around the demands of automobile traffic (Gottdiener, Hutchison, & Ryan, 2014; Macionis & Parrillo, 2004).

The future of transportation is most evident in the preferences of the Millennial generation. One recent study by the U.S. Public Interest Research Group revealed that the average number of miles driven by 16 to 34 year-olds declined by 23 percent between 2001 and 2009 (Dutzik, Inglis, & Baxandall, 2014). In comparison with older generations, Millennials are the least likely to drive and the most likely to use public transit, walk, and bicycle (McDonald, 2015). Today, they are also more often using ridesharing services for their car trips. All of these trends point to the same conclusion: people are likely to become increasingly less attached to the ideal of private auto ownership, and there will be a growing demand for quality public transit, ridesharing, and cities friendly to pedestrians and bicyclists (Badger, 2014).

Instead of more highway construction or technological fixes like electric vehicles, our land use model offers a comprehensive approach which recognizes how transportation fits within the natural and social environment of urban life. The objectives of our approach are to design a transit system that can reduce carbon emissions and enhance biodiversity, but also to reconnect people socially and environmentally so that they gain a better understanding of their interdependence with ecology. Whereas postwar urban planning focused on moving cars as efficiently as possible, our model prioritizes access and mobility for people. Drawing upon the insights of **Transit-Oriented Development (TOD)**, we suggest that access to quality public transit must be situated in cities where a mixture of housing, office, and retail spaces are connected by walkable and bicycle-friendly streets (Calthorpe, 2010).

There is growing evidence to suggest that many people prefer to live in this kind of high-density urban environment (Gottdiener, Hutchison, & Ryan, 2014). An increasing number of well-educated professionals are choosing to live in cities instead of the suburbs, leading to a crisis of affordable housing (Freeman & Braconi, 2004; Schwartz, 2014). In cities where the expanding public transportation has been linked with downtown revitalization—Portland, San Diego, Chicago, San Francisco, New York, Washington, DC—the numbers of people who use public transit, ride bicycles, and walk instead of driving has increased significantly (Calthorpe, 2010, p. 83). In many of these urban neighborhoods, land values and rents automatically increase with closer proximity to public transportation.

Rather than looking to high-tech, large-scale, futuristic fixes to our current transportation problems, our model incorporates locally scaled solutions that draw from the lessons of the past. Prior to the auto-centered "**urban renewal**" of the postwar years, many American cities contained effective public transportation systems which utilized streetcars and light rail trains. In the words of urban designer Peter Calthorpe "The next revolution in transit may not be high-tech; it may be old-fashioned rail updated to be environmentally clean, scaled to the modern metropolis, and styled to new sensibilities" (2010, p.85).

Bio-Bus powered by biofuel.
Source: Geneco.uk.com

Bicycle-powered vendor cart in Portugal.
Source: Alrie Middlebrook

Vendor truck at a farmers market in an urban landscape.
Source: Internet Stock Photo

9. Ecology Education

The future of our planet's health depends on the ability to educate young people in methods of environmental stewardship. Typically, public schoolyards are not designed to offer this sort of environmental education outdoors on a regular basis. This is not an education that students can get by reading a textbook or sitting in a classroom—they need to get outdoors and engage directly with our planet's cycles, reconnect with nature, and engage in project based, hands-on learning (Bogner, 1998; Smith & Williams, 1999; Johnson & Mappin, 2005).

The Environmental Laboratory for Sustainability and Ecological Education (ELSEE), CNGF's largest initiative, is an outdoor teaching garden that can be customized for 10,000 public school sites in California. ELSEE was created to close the gap of **eco-literacy** in California schools and give children the outdoor learning laboratory missing from the educational system. It aims to restore urban open spaces by creating school gardens that reconnect children with the rich history of biodiversity, innovation, and renewal in Santa Clara Valley. The ELSEE model is adaptable to any region of California. Our prototype meets over 200 benchmarks for sustainable urban land use as recognized by the United States Green Building Council, and it is the only **certified site** in Santa Clara County.

While disadvantaged communities and low-income areas frequently lack recreational and green spaces, wealthier communities enjoy an abundance of well-serviced green spaces. ELSEE strives to bring environmental education to students in these underserved areas. Its main objective is to provide the physical, psychological, and economic benefits of sustainable land use which sequesters more carbon, increases biodiversity, and reconnects children with the local ecology. These outdoor educational efforts dovetail with our Sustainable Organic Farm Training (SOFT) by offering young people opportunities to apply their skills and knowledge in practices of environmental stewardship.

Since ELSEE was established in 2009, its programs have been partially implemented at 85 partner school and non-profits. ELSEE has expanded throughout the region and its underserved communities, working directly with public, private and charter schools such as Downtown College Preparatory, San Jose Conservation Corps and Charter Schools, San Jose Unified School District, Eastside Union School District, and Live Oak School District in Santa Cruz. Our capacity to work with schools in **disadvantaged economic communities** creates opportunities to convert schoolyards into urban open space and build **green space equity**.

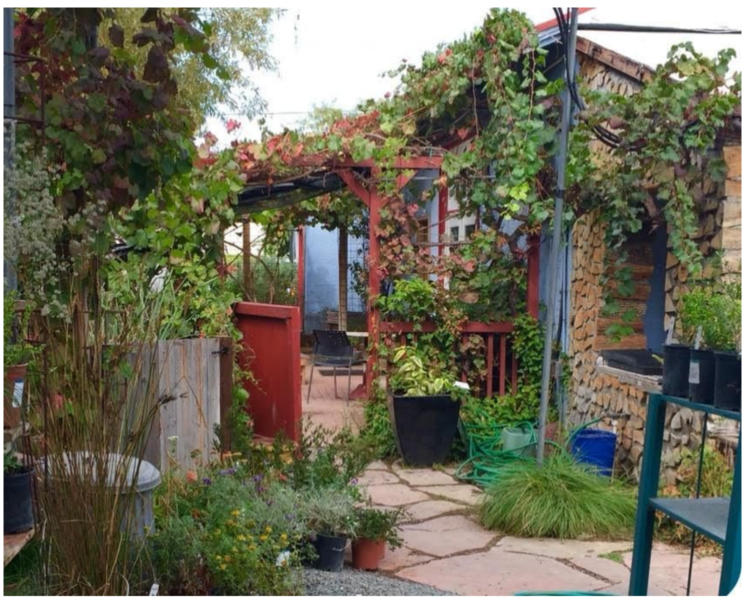
Class field trip Aquaponics lesson at ELSEE flagship garden, San Jose, CA.
Photo by CNGF staff

Big Red Food Tower, class field trip at ELSEE flagship garden.
CNGF staff photo

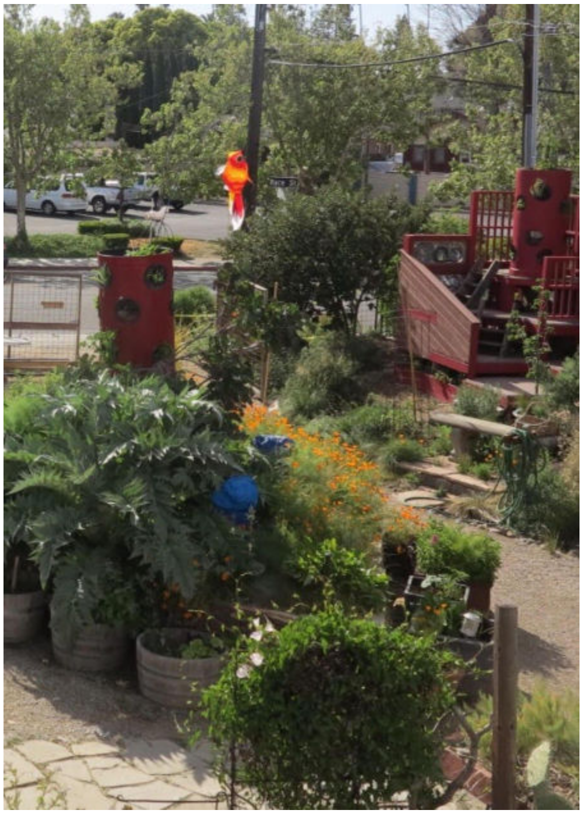
Outdoor nature game, class field trip at ELSEE flagship garden.
CNGF staff photo

A lesson on the evolution of chickens, while touring Dino Coop at ELSEE flagship garden.
Photo by CNGF staff

Food towers in Mariposa Meadow, ELSEE flagship gardens, San Jose, Photo by Alrie Middlebrook



CNGF Nursery at Corporate Headquarters, Middlebrook Center and ELSEE Flagship gardens, San Jose
Photo by Alrie Middlebrook



ELSEE Flagship Teaching Garden in the Spring, 2014.
Photo by CNGF

10. Human Health and Well Being

A city's built environment poses many complex challenges that relate to ecology, social structures, and physical and mental health. Many urban planners and communities continue to be unaware of the full consequences of environmental factors for public health, despite research indicating that chronic diseases like heart disease, obesity, and asthma result from the ways we design, build, and sustain our environment (Agyeman & Evans, 2003; Srinivasan, O'Fallon, & Dearry, 2003; Tillman & Clark, 2014). A growing body of evidence also suggests that many mental health problems—anxiety, depression, attention deficit disorder, substance abuse, aggressive behavior—are exacerbated by poor urban planning and inadequate housing (Evans, Wells, Chan, & Saltzman, 2000; Guite, Clark, & Ackrill, 2006; Maas et al., 2006). Substandard housing, overcrowding, and unhealthy living environments have had especially harmful effects on low-income populations, minorities, seniors, persons with disabilities, and immigrants. Consequently, these communities typically suffer from higher rates of respiratory disease, developmental disorders, chronic illnesses, and mental illness (Bashir, 2002; Krieger & Higgins, 2002; Jacobs, Kelly, T., & Sobolewski, 2007).

The links between social, physical, and mental health and well-being demand an integrated, comprehensive approach. Rather than attempting to treat these problems in isolation from one another, our model considers how they are interconnected in the built environment. Healthy air quality, biodiversity, and nutritious food can not only enhance physical and mental health, they also foster the kind of social cohesion necessary to maintain sustainable communities. Environmental education is a crucial component in our model. Education is essential for passing on the knowledge needed to improve upon these practices, but also for enabling people to overcome a sense of disconnection from nature and each other. The future of sustainability depends on our ability to foster social, physical, and mental health, and to educate people about the interdependency between them.

There are numerous methods for measuring and quantifying the benefits of a sustainable urban environment for human health and well-being (DeVries, 2003; Mailer et al., 2006). The collection and analysis of statistics on community health, such as stress levels, physical health and illness, would provide us with a basis for replicating this model in other communities. To measure the extent of social health, it is possible to conduct surveys that can assess the levels of community engagement in physical exercise and other recreational activities. Improvements in physical, mental, and social health and well-being can be documented to support our socio-ecological approach to urban sustainability, and to further improve upon our model.

Concept rendering of Santa Clara Agrihood by Jonathan Davis Architect
and Middlebrook Gardens Design Studio Labs. 2015 Win-6, Client: Kirk Vartan.

Street in Camden, NJ with no vegetation or designated open space.

Peacemakers International Gardens, Chene Street, Detroit, MI.

Spiritual Ecology

Achieving sustainability will necessitate a whole new series of practices and lifestyle changes, but those changes will be in vain without an accompanying change of values and consciousness about nature. The prevailing mindset of industry and science has been characterized by an extractive domination over the planet's resources—drilling for oil, clear cutting, mountaintop removal, etc. There is no reciprocity in this relationship to nature, no concept of stewardship or regeneration. The bounty of life is objectified into things to be used and then thrown "away" (Kempton, Boster, & Hartley, 1996; Foltz, 2003). We have an economic standpoint which suggests that we can keep growing infinitely, and that growth is good and necessary. What climate change is showing us is that this independence was always an illusion--one cannot simply take and use nature without some kind of blowback. The future will demand that younger generations are educated and taught to value our interdependence with nature.

The spiritual traditions of many indigenous peoples, on the other hand, value the interconnection between human beings and species habitats around the world. The human species is not seen as separate or superior to animal, plant, and mineral bodies. Insofar as it regards the physical world as sacred, the wisdom of **indigenous cultures** is upheld as an antidote to environmental exploitation (Kinsley 1995; Salmon, 2000; Grim; 2001). **Spiritual ecology** is the name given to this alternative set of values and socio-political structures that preserve intimacy with the earth and its sacred nature (Sponsel 2012; Hahn et al., 2013). The collective wisdom of indigenous environmental stewardship, accumulated over thousands of years among countless generations, offers a time-tested model for maintaining viable communities within a sustainable environment.

Spiritual ecology involves a wide range practices in which religious, cultural, and environmental understandings and experiences are intertwined. Various traditions offer a spiritual vision that connects humanity, the planet, and the divine in ways that transcend the Western dualities of human/earth, heaven/earth, mind/body (Hunter & Toney, 2005).These ancient beliefs intersect with contemporary movements in recognizing the unity and interconnectedness of all of creation. Spiritual ecology is perfectly compatible with our model derived from the life cycle of a plant, in which the spiritual and intellectual needs of humanity are interdependent with the needs of nature.

**"Master basket weaver Abe Sanchez gathering *Juncus textilis*,
one of the four predominant plants used for basket weaving by southern California Indians."**

CNGF hike at Berry Creek Falls, Big Basin State Park, CA. ***Source: CNGF staff***

SULRI Monitoring and Data Collection

The Sustainable Urban Land-use Research Institute (SULRI) will involve collaboration with researchers from four leading universities CNFG has collaborated with: Stanford, Santa Clara University, San Jose State University, and the University of California, Santa Cruz. SULRI will be a center for the research and development of ten key categories that comprise sustainable urban land use: soil; air; water; food; waste; native plants; alternative energy; alternative transportation; human health and well-being; and environmental education. These categories represent all the requirements necessary for humans to complete our life cycle. In a nutshell, initiatives within these categories could provide solutions to the needs of people in a sophisticated manner using the resources right where they live.

The second function of SULRI will be a monitoring and reporting division, primarily operated by college interns who will study the users living in or using these models for learning, or in other ways benefitting from direct contact with these healthy land use models. Data collection and measured outcomes will provide critical information to measure the effectiveness of the **Best Management Practices (BMPs)** and **Low Impact Design (LIDs)** that will be implemented. We will assess each of the categories using quantitative and qualitative data analysis, which will be conducted at SULRI, in collaboration with a Technical Advisory Committee. These results will serve as a preliminary step to further research under each category. The various research projects will follow an objectives strategy, including projected specification of measurable outcomes, establishment of timelines and checkpoints, definition of appropriate metrics, and development of analytic tools. One key outcome of this research will be the development of testable hypotheses.

We are building this institute in Silicon Valley with a large network of allied farm to table partners: Veggielution, Full Circle Farm, Valley Verde, La Mesa Verde and San Jose Conservation Corps. The recent approval of urban Ag incentive zones (AB 551) by the Santa Clara County Board of Supervisors, and a capacity to build a local food system model adjacent to a market that generates 20 million visitors a year, puts us in an ideal position to influence and educate a large population. With our local farm partners network, we are committed to creating a sustainable, local food system that builds community, improves access to healthy food, and teaches residents to cultivate their own fruits and vegetables. Zack Lewis, the former Executive Director of Garden2Table, has been involved with Santa Clara County to identify vacant land in San Jose and the potential impacts of implementing AB 551, exploring how to incentivize the development of urban agriculture projects on privately owned vacant land.

SULRI is working with technical advisors to propose research projects for the Agrihood and other sites that will introduce and fund technologies in the ten categories. The following table lists our technical advisors:

Technical Advisory Committee		
S.No.	**Name**	**Designation/Areas of Specialty**
Consultants		
1	Bob Abrams	Principal Hydrogeologist, Jacobson James & Associates (Agency Consultant)
2	Elias Aklaku	Waste management and biogas consultant, Biogas Engineering Limited, Kwame Nkrumah University of Science and Technology
3	Ken Armstrong	Aquaponics consultant, Ouroboros Farm
4	Guillaume Baraslou	Domaine Baraslou ecological landscape architect, Narhonne Languedoc, France
5	Kofi Boa	Director, Center for No-Till Agriculture, Ghana
6	Les Chau	Principal Hydrogeologist, AMEC Foster Wheeler (Agency Consultant)
7	Deeksha Chopra	Environmental consultant
8	Josiah Clark	Consulting Ecologist, Habitat Potential
9	Ann Dwan	Information Technology Consultant
10	Jim Honnibal	Hydrologist, AMEC Consultants (Agency Consultant)
11	Paul Kaiser	Agroecologist, Regenerative farmer and no-till specialist, Singing Frog Farm
12	Zach Lewis	Urban Planner, former CEO, Farm to Table
13	Del Mecomb	Propagation specialist, Suncrest Nurseries (Agency Consultant)
14	Alrie Middlebrook	Native plant specialist, Hedgerow ecologist, Middlebrook Gardens
15	Vicki Moore	Founder/Education director, Living Classroom
16	Lawrence Ray	Consulting Ecologist
17	Linda Rohleder	Invasive species specialist, Lower Hudson PRISM
18	Sara Rosenberg	Center for No-Till Agriculture, Ghana
19	Frank Rosenblum	Civil engineer, President, Underwood and Rosenblum, Inc.
20	Katharine Rondthaler	Forge Organic Garden manager, Center for Sustainability, Santa Clara University
21	Kendall Sager	Beekeeper, Kendall's Bees
University Professors /Ph.Ds		
1	William Armaline	Director, Human Rights Program, San Jose State University
2	Emily Creegan	Applied Soil Science Ph.D. candidate, California State Polytechnic University, Pomona
3	Lucy Diekmann	Postdoctoral Fellow, Department of Environmental Studies & Sciences, Santa Clara University
4	Michael Fallon	Director, Center for Community Learning and Leadership, San Jose State University
5	Rick Flores	Graduate Student, Environmental Studies Department University of California, Santa Cruz
6	Marjorie Freedman	Professor, Nutrition, Food Science and Packaging, San Jose State University

7	Leslie Gray	Professor, Department of Environmental Studies & Sciences, Santa Clara University
8	Wang Jing-Yuen	Associate Professor, School of Civil and Environmental Engineering, Nanyang Technological University
9	Ed Mauer	Professor, Civil Engineering Department, Santa Clara University
10	Rachel O'Malley	Professor, Environmental Studies Department, San Jose State University
11	Jessica Schweiger	Urban Agriculture Program Manager, University of California Cooperative Extension
12	Lynne Trulio	Department Chair, Department of Environmental Studies, San Jose State University
13	Xiouhau Yang	Controlled-environment agriculture specialist, Horticulture PHD
Leadership and Community Outreach		
1	Jamie Chen	Organizing Manager, La Mesa Verde, Sacred Heart Community Service
2	Nasim Hashemi	Entrepreneurship & Risk Management Consultant, Founder of Freshness Farms
3	Karita Hummer, LCSW, BCD	Co-Founder and Clinical Director, Family Alliance for Counseling Tools and Resolution
4	Elizabeth Kaiser	Marketing and Distribution Consultant, Singing Frog Farms
5	Phillippe Kradolfer	Director, Church of Latter Day Saints, Accra, Ghana

SOFT Training Program

Our Sustainable Organic Farm Training (SOFT) program will focus on teaching young, potential urban farmers how to build, manage, and sustain a regenerative urban farm. This training will provide its participants with both fundamental knowledge and an applied science of the urban **regenerative agricultural** techniques. The project is meant to address modern forms of environmental degradation in urban areas. Conventional agriculture is a leading cause of environmental destruction and the loss of biodiversity (Hole et al., 2005). To counteract this, we want to popularize agricultural practices that are sustainable and regenerative.

The SOFT program serves as a platform for developing a sustainable urban agricultural network in Santa Clara County that can be replicated worldwide. It aims to create science-based urban farming solutions that can be studied and monitored. The best practices which emerge from our research can be taught to future urban farmers, who can then replicate local regional models. Once they are trained, farmers can return to their own communities and create new urban farming networks, which can continue to be studied and improved. Disseminating these practices will contribute to a productive, sustainable society and a more habitable environment (see our SOFT Curriculum below).

If American ingenuity, scientific investigation, and skilled documentation can help solve global food crises in the face of climate change and diminishing resources, then alliances like ours in Silicon Valley and Ghana can complement traditional farming methods. It is a model that is appropriate everywhere from urban farms in **developed countries** to village farms in **developing countries**. Our SOFT program will foster exchanges between students from Africa, the United States, and Europe (especially Southern France) to study how our model functions in each ecosystem. All the results will be documented, and findings will be presented to each community for knowledgeable exchange, feedback, and ongoing improvement.

The motives behind the regenerative farm training program in Africa are to restore their local ecology for more production of nutritious food, especially for school children, and to reduce poverty by creating jobs in the community. Developing a regenerative farm and providing SOFT training would help restore their local soils, improve erosion control, counter deforestation, and develop a food forest comprised of native ancestral trees for food, medicine, and habitat value**.** The program will also teach **ecosystem services** to children and young groups. The ongoing farm training program will be a part of the SOFT Training replication, a first step for the regenerative farm training in Africa.

Our Garden for Ghana project, based in the village of Yamoransa, provides crops for eating as well as medicinal purposes, erosion control, and ecological restoration. Yamoransa was chosen because UCC (Cape Coast University), the top university in Ghana, is only 20 minutes away. Professor Kofi Awusabe Asare, former head of the Population Studies and Public Health department, has been taking students there for community service projects since 2009.

This project is based on a garden model. Working with our community partners has optimized the model to fulfill Ghana's needs by adjusting for local conditions--for example, soil management, nutritional and medical needs, crop management, and regional ecology. Yamoransa is the pilot case in Africa for the implementation of these gardens, with the goal of sharing experiences and outcomes so that the model can be developed in other areas. One reason for the project's success is the commitment of local and global partners to work together in achieving common goals. People from many different backgrounds are planning, digging, composting, planting, and teaching together in order to make a difference.

In addition to our partners in Africa, we are affiliated with international collaborators who can leverage their own resources to participate in building regenerative farm models, where SOFT training programs can be established and scientific data can be collected and analyzed. Another potential partner is Les Vignobles de Villenouvillette in Nevian, France. This family vineyard and Chateau is in Languedoc, Southern France, a well-known wine growing region. France is experiencing a prolonged recession and young people are leaving France in search of work. To establish a SOFT program in this economically depressed area could provide job opportunities and stimulate the economy. It will also allow American students and interns to study the ecology of another region: the soil types, native food and medicinal plants, superfoods, and drought-tolerant plants. Students and interns can investigate what performs best in local soils and how French farmers cope with the weather conditions of this Mediterranean microclimate.

SOFT Curriculum: Our **S**ustainable **O**rganic **F**arm **T**raining (**SOFT**) program will focus on teaching potential young urban farmers how to build, manage and sustain a regenerative urban farm. The program will offer seven courses that combine in-class-training and hands-on experience in the field. Course materials will include illustrations, demonstrations, a resources guide (print and web-based) and assessment questions. Through interactive learning, the program aims to deliver the deep rooted scientific knowledge and skills demanded by the complexity of technological and economic challenges in the global agricultural industry of today and the future.

Social and Environmental Issues in Agriculture: Giving and understanding issues both social and environmental that affect modern/urban agriculture.

- The development of U.S. agriculture

- Environmental issues in modern agriculture
- Social issues in modern agriculture
- Sustainable agriculture and sustainable food system

Organic Farming Skills and Practice: This course will utilize the expertise of our team of advisors along with top industry leaders to teach cutting-edge topics in the field of agriculture and ecology. Through the topics in this class, students will be able to build a solid base of knowledge to explore and understand regenerative farming model, practice and techniques.

- Biodiversity and its importance
- Developing a regional food model
- Selection of food crops (native edibles, medicinal, super foods, perennials, drought tolerant)
- Plant materials
    - Greenhouse management
    - Propagation
    - Transplanting and direct seedling
- Soil management
    - No-till cultivation
    - Selecting and using cover crops, mulching
    - Making and using composting (e.g. vermicomposting)
- Water management, watershed protection and stewardship
    - Irrigation- principles and practices
    - Drip irrigation and subterranean irrigation
    - Stormwater reuse and greywater
- Integrated pest management (e.g. native hedgerows for pollination and pest management)
- Weed management -mulching, native grasses and wildflower)
- Waste management- Manage waste on site with innovative technologies
- Organics, made onsite

Applied Soil Science: These topics will give broad understanding of soils and how they can be affected by farming practices.

- Existing site soils, natural, cultural and history of site, indigenous uses
- Soils and soil physical properties
- Soil chemistry and fertility
- Soil biology and ecology

- Managing soil health and building soils
- Reading and interpreting soil test reports

***Basic Scientific Method*:** This course aims to provide the students with the basic tools for critical thinking and experimental design that can be used to evaluate different farming techniques and help them make sound data-driven decisions when building their regenerative farm model.

- Make your observation
- Design your experiment: sample size, control and randomization
- What does the data say?
- True or False: scientific claims in the media
- Protocols for publishing and sharing data and outcomes

***Agriculture in the Cutting Edge*:** It's an exciting era for agriculture. While the field has not experienced a revolutionary change for a long time, it has now attracted some of the brightest minds to work on the biggest problems we are facing as a species. The topics in this class aim to give the students a survey of the exciting technological advancement happening in Silicon Valley and beyond that can be directly and indirectly used in their own farming practices.

- Big data and agriculture
- CEA: controlled environmental agriculture (hydroponics, aeroponics, aquaponics)
- Precision Agriculture
- Drones anyone?

Entrepreneurship and Risk Management: The course will teach students essential skills and effective strategies for working in and managing farms, and for starting new ones. The content is designed to engage and inspire, students will learn by doing and from some of the best in the field.

- Cultivating entrepreneurial mindsets towards regenerative farming
- Women and agricultural enterprises and business models
- The economics of running a regenerative farm
- Building business models
- Creating demand through traditional and social media
- Scenarios (to understand common biases and pitfalls) and forecasts (to know possibilities and probabilities)
- Negotiation with traditional farming practices (building bridges)

Community Relations, Education and Local Markets: Topics in this class will cover strategies for implementing effective behavior change programs for promoting environmental sustainability using community oriented framework. Topics will include but are not limited to:

- Start the conversation: educate the young minds, new and traditional farmers
- Community outreach strategies
- Marketing principles to promote regenerative farming models
- Developing networks, educating the public, replicating successes
- Distribution chains, farmer's markets, CSA's and social events

We are proposing to offer two programs through SOFT. These programs will be fee-based including scholarships for disadvantaged communities and other special needs communities, and fellowships:

- Two-year academic degree associated with university partners at SULRI
- One-year associate degree accredited with community colleges

Conclusion

Our key objective in this paper has been to substantiate the science behind our sustainable urban village model, which is hased on the connections and interdependence between life cycles. The model outlined here will be implemented at the Santa Clara Sustainable Agrihood, located at the former Bay Area Research and Extension Center (BAREC) site in Santa Clara. For this project, we are actively engaged in developing meaningful collaborations with the city of Santa Clara, Core Companies, Santa Clara University, San Jose State University, Stanford, and the University of California at Santa Cruz.

We have developed a network of partners representing over one hundred local non-profits, corporations, local businesses, and government leaders. This network includes research partners and technical advisors who will establish a high bar of scientific research for our model village and farm. But these projects cannot be fully realized without the support of local, state and national collaborators--we must attract additional grant funds to design and build the land use models described in this document.

We are also seeking additional corporate partnerships that can support the development of new urban farms and village models, and we believe that these initiatives will be championed by leaders in Silicon Valley. Known today for its startup innovation and technology, the Valley was one of the world's leading agricultural regions during the roughly one hundred years from the Gold Rush through the first half of the 20th Century. Today, through the Urban Agriculture Incentives Zones (AB551), there are nearly 3000 acres of undeveloped land in Santa Clara County that developers are now financially incentivized to turn over to urban farmers for a minimum of five years for the purpose of creating regenerative farm models.

Thus far, our sustainable urban village model is either being proposed, in planning, or under development for implementation at Santa Clara Sustainable Agrihood; Full Circle Farms, an 11 acre urban farm in Sunnyvale on property owned by Santa Clara Unified School District; a proposed ELSEE garden laboratory on the campus of the San Jose Conservation Corp and Charter Schools; and a storm water management model schoolyard with an ELSEE lab at Downtown College Prep Academy and 15 other high schools in the region. At the same time, we are building a strong network of urban farm partners to conduct research. These include the O'Donohue Family Stanford Educational Farm; the University of California, Santa Cruz, Center for Agroecology & Sustainable Food Systems; Veggielution; Sacred Heart's La Mesa Verde Gardens; the gardens at Valley Verde; and The Forge Garden at Santa Clara University. In addition to the corporate gardens of Apple, Google, Facebook, Levi Center, eBay, and others, our region has enough urban agriculture models underway to begin monitoring, undertaking research projects, and planning a regenerative farm training program. These are all compelling reasons to act now with others to champion these ideas and enable more real projects to emerge in Santa Clara County, where outcomes can be studied by our Institute, college students can be engaged in their communities, and young people can be trained to design, build, and manage these models in California and worldwide.

In conclusion, we are seeking:

- opportunities to present our model to other groups;
- grant partners and sources who will help fund these innovations in Silicon Valley;
- to engage volunteers, especially skilled professionals, who will mentor students, volunteer in gardens, make presentations, and serve on technical committees and grant writing teams;
- to develop partnerships with local developers so that technology to reduce infrastructure and CO2 emissions is available to them, and its implementation is supported by planners and code enforcements of local jurisdictions;
- long-term meaningful government and corporate partners who will champion this level of environmental stewardship as we, likewise strive to do with our community of urban gardeners, schools and local non-profits.

To mimic nature is to to bond closely and form networks that are impenetrable and support the renewal of life above all else. Following this model of nature, we have a better chance of success in Silicon Valley than anywhere on Earth. The time is now. The place is here. And we are well underway.

Santa Clara City Council meeting about the Agrihood.
Photo by Alrie Middlebrook.

CNGF co-sponsored event, Watershed Gardening,
held at San Jose Conservation Corp Charter School.
Photo by Alrie Middlebrook.

Panel at SCU to discuss Agrihood project. Representatives from SJSU (William Armaline), Dept of Human Justice CNGF President (Alrie Middlebrook), Open Space Authority Board Chair (Dorsey Moore), City of Santa Clara Vice Mayor (Teresa O'Neill), and Core Development Agrihood Project Manager (Vince Cantore). Photo by CNGF staff.

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Glossary

Acidification: Most commonly in the ocean, a chemical process that occurs when carbon dioxide is absorbed by the ocean and reacts with seawater to create acid, severely changing the chemistry of the ocean and potentially destroying aquatic ecosystems
Agrihood: neighborhoods which integrate large-scale food production into residential areas, giving new meaning to the phrase “mixed-use development.”
Agroecosystems: An ecosystem that that functions as a unit of agricultural activity, including both living and nonliving parts
Altered ecology: Changing of the natural ecology which can lead to drastic changes in an ecosystem
Ambient air pollution: Concentrations of particulate matter and greenhouse gases in urban areas emitted by households and cars, which is poor for human health
Anthropocentric: regarding humankind as the central or most important element of existence, especially as opposed to God or animals.
Aquatic ecosystems: An ecosystem located in a body of water
Atmosphere: The group of gases that surround the Earth or another planet, for Earth making it possible to support life
Best Management Practices (BMPs): acceptable practices that could be implemented to protect water quality and promote soil conservation during forestry activities
Biodiversity: The diversity of living organisms from terrestrial, marine, and other aquatic ecosystems, including variation within a species or ecosystem, and between species or ecosystems
Biogeochemical cycles: The movement of chemicals through the biotic and abiotic components of the Earth and its atmosphere
Biomes: a large naturally occurring community of flora and fauna occupying a major habitat, e.g., forest or tundra.
Biomimic design: Design inspired by biomimicry
Biomimicry: The process of looking to nature in its models and elements, to derive inspiration in order to solve human problems (*e.g.* the Wright brothers studied pigeon flight to design the first airplane)
Carbon Sequestration: The process of living organisms (particularly plants and microorganisms) absorbing carbon, decomposing, and returning it in the soil, which ultimately removes carbon dioxide from the atmosphere
Certified Site: The urban property is recognized as having met certain benchmarks for sustainable urban land use that were developed by the Sustainable Sites Initiative which is a part of the United States Green Building Council. Sites receive rankings and can be certified based on the number of benchmarks that have been met
Chemically dependent agriculture: Industrial agriculture as practiced today is dependent on chemical processes like Haber-Bosch, which is the main industrial procedure for the production of ammonia. This process produces about 500 million tons of fertilizer every year which helps feel 40% of the world's population. Since its invention, chemical companies have developed pesticides, insecticides, disease and pest resistant seeds, etc for agriculture, primarily since 1950

Comfort foods: food that provides consolation or a feeling of well-being, typically any with a high sugar or other carbohydrate content and associated with childhood or home cooking
Complex microbial networks: Soil systems are made up of trillion of microbes, representing thousands of individual species operating in synergistic networks to sustain life. When soils are disturbed by natural events or humans and other animals, these networks are disrupted and different outcomes are predictable and observable
Constructed wetland: an artificial wetland created for the purpose of treating anthropogenic discharge such as municipal or industrial wastewater, or stormwater runoff
Controlled-environment agriculture: a technology-based approach toward food production, with the aim of providing protection and maintaining optimal growing conditions throughout the development of the crop
Deforestation: the action of clearing a wide area of trees
Developed countries: sovereign state that has a highly developed economy and advanced technological infrastructure relative to other less industrialized nations
Developing countries: a poor agricultural country that is seeking to become more advanced economically and socially
Disadvantaged economic community (DECs): a result of the complex interplay between the characteristics of residents living in a community (e.g., unemployment, low income) and the effects of the social and environmental context within the community (e.g. weak social networks, relative lack of opportunities)
Disturbance: A temporary change in environmental conditions, such as extreme climate events, that cause huge changes in an ecosystem
Eco-literacy: the ability to understand the natural systems that make life on earth possible. To be ecoliterate means understanding the principles of organization of ecological communities (i.e. ecosystems) and using those principles for creating sustainable human communities
Ecological footprint: The impact of a person or community on the environment, typically measured in the amount of land needed to sustain their natural resource use
Ecological modelling: the construction and analysis of mathematical models of ecological processes, including both purely biological and combined biophysical models
Ecosystem: A community of biological beings interacting with one another and their physical environment
Ecosystem services: The multitude of benefits that humanity gains from ecosystems. Ecosystem services are regularly involved in the provisioning of clean drinking water and the decomposition of wastes
Ecovillage: A community whose inhabitants live by sustainable principles and who attempt to leave the smallest ecological footprint possible
Eutrophication: Often caused by fertilizer-tainted runoff, a process whereby an excess of nutrients are discharged into a body of water, causing plant life to explode and use all of the oxygen, leaving no oxygen in the water for animal life and a “dead zone” in its wake
Flow/cycle: The movement of energy or food in a system
Global Landscape: Agriculture now takes up 40% of the Earth's land surfaces. This has drastically altered the global landscape, especially since 1950, creating a great reduction in biodiversity and loss of habitat and species.

GMOs: The abbreviation for genetically modified organism whose genome has been altered by the techniques of genetic engineering so that its DNA contains one or more genes not normally found there
Grassland: a large open area of country covered with grass, especially one used for grazing
Green space equity: equality of access to green and open spaces across socioeconomic groups
Greenhouse gas (GHG): A gas that absorbs infrared radiation and contributes to the greenhouse effect in the Earth's atmosphere

> **Carbon dioxide:** A common gas produced by burning organic compounds and respiration which absorbs shortwave solar radiation
> **Ammonia:** A chemical that dissolves easily in water and is often used to make fertilizers
> **Nitrogen dioxide:** Considered one of the most potent GHGs for destroying the ozone layer, this gas is produced by the burning of fuel, primarily in cars and other forms of transportation
> **Ozone:** A gas heavily present in the ozone layer of the atmosphere, which absorbs most of the ultraviolet rays from the sun and makes Earth habitable

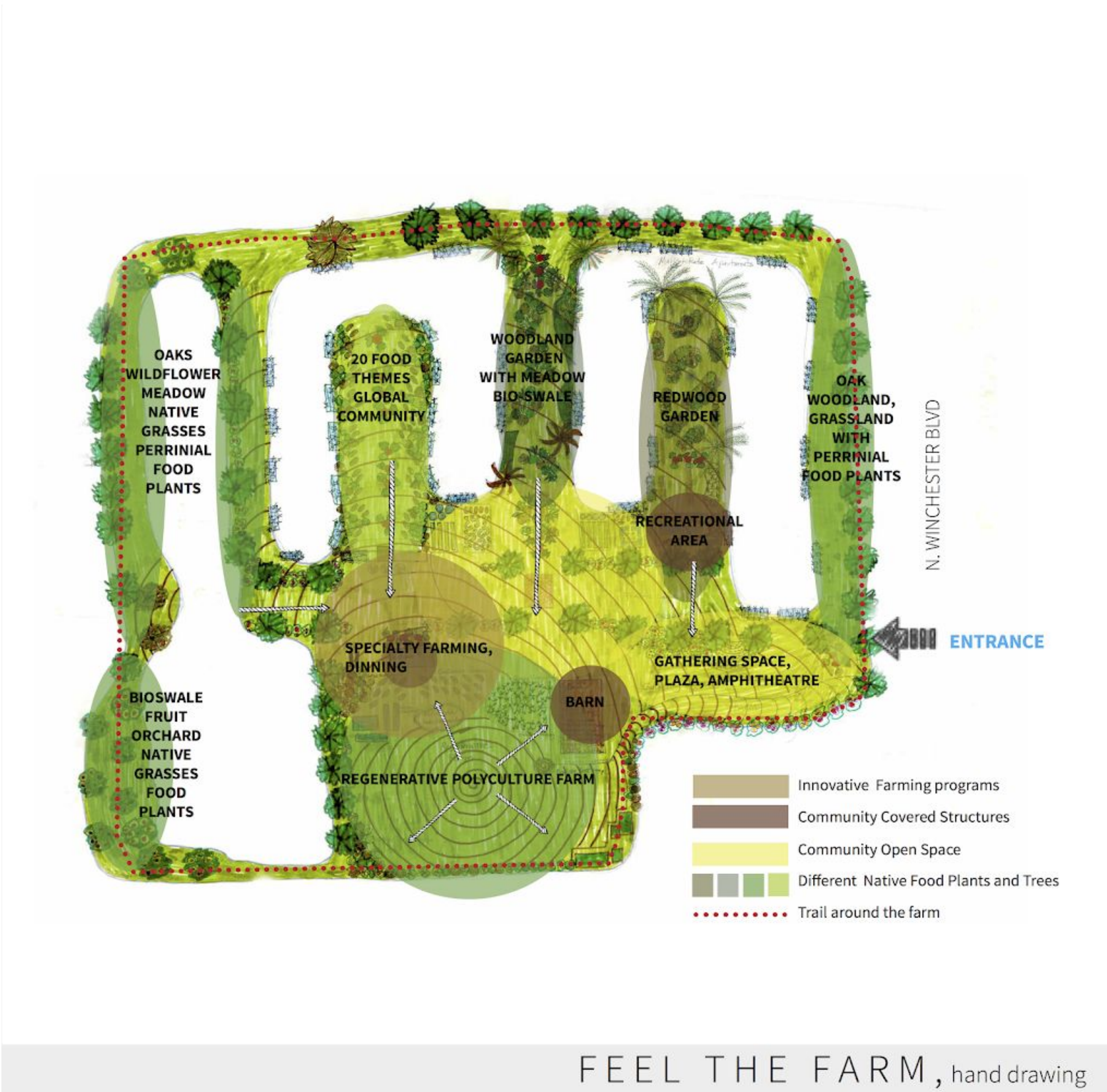
Hedgerows: a hedge of wild shrubs and trees, typically bordering a road or field
Hydrologic cycle: The movement of water through various forms, from vapor in the atmosphere to land or water through precipitation, and eventually back to the atmosphere through evaporation
Indigenous cultures: ethnic groups who are descended from and identify with the original inhabitants of a given region, in contrast to groups that have settled, occupied or colonized the area more recently. Groups are usually described as indigenous when they maintain traditions or other aspects of an early culture that is associated with a given region
Industrial agriculture: a form of modern farming that refers to the industrialized production of livestock, poultry, fish, and crops. The methods of industrial agriculture are technoscientific, economic, and political
Infrastructure: Ecosystem that functions naturally and supply services to people such as water conservation and regulation or beneficial soil formation
Indigenous culture: The culture of a group of people who have historical ties to a certain territory and are often culturally distinct from those in political power
Indigenous landscape: the use of native plants, including trees, shrubs, groundcover, and grasses which are indigenous to the geographic area of the garden
Insecticide: a substance used for killing insects
Internal currency: A system of money used in a particular region or location
Invasive species: species that is: 1) non-native (or alien) to the ecosystem under consideration and. 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health.
Lifecycle: The series of processes and changes an organism undergoes during its life, including reproduction
Low Impact Design (LIDs): a land planning and engineering design approach to manage stormwater runoff. LID emphasizes conservation and use of onsite natural features to protect water quality
Macro vs. micro solutions: Micro solutions are geared to a specific group of people, while macro solutions are designed for all citizen
Marine ecosystems: Marine ecosystems are among the largest of Earth's aquatic ecosystems. They can be contrasted with freshwater ecosystems, which have a lower salt content
Medicinal plants: a plant that has similar properties as conventional pharmaceutical drugs. Humans have used them throughout history to either cure or lessen symptoms from an illness

Metabolism model: A model to describe and analyze the flow of energy and materials within and around city ecosystems
Metagenomics: The study of the dynamic relationships between the molecules that define living communities and the biosphere and how to manage them at the molecular level
Microbes: a microorganism, especially a bacterium causing disease or fermentation
Microbial forensics: relatively new field that can help in solving cases such as: bioterrorism attacks. medical negligence. outbreaks of foodborne diseases.
Microbiology: The branch of biology that deals with microorganisms, often organic matter in soils
Monoculture: the cultivation of a single crop in a given area
Mutualism: A relationship characterized as beneficial to both organisms involved
Nanyang Technological University: a publicly-funded autonomous university in Singapore. NTU is consistently ranked amongst the world's best universities in all of the major college and university rankings and is regarded as one of the top 2 universities in Asia
Native/indigenous ecosystems: ecosystems that are the result of only natural processes that experience virtually no human interference
Nematode: a worm of the large phylum *Nematoda*, such as a roundworm or threadworm
Oak woodland: a plant community found throughout the California chaparral and woodlands ecoregion of California in the United States and northwestern Baja California in Mexico.
Particulate matter: All of the solid and liquid particles in air that are hazardous, including both inorganic and organic particles
Perennial: A plant that lives for two years or more. Perennial food plants can produce food for multiple years. Examples are apples, grapes, almonds, collards, artichokes, sorrel, sweet potatoes and edible lupines.
Pesticide: a substance used for destroying insects or other organisms harmful to cultivated plants or to animals
Phytotoxicity: a chemically induced skin irritation, requiring light, that does not involve the immune system. It is a type of photosensitivity
Plant Community: a collection or association of plant species within a designated geographical unit, which forms a relatively uniform patch, distinguishable from neighboring patches of different vegetation types
Porous paving: a range of sustainable materials and techniques for permeable pavements with a base and subbase that allow the movement of stormwater through the surface
Rain garden: a planted depression or a hole that allows rainwater runoff from impervious urban areas, like roofs, driveways, walkways, parking lots, and compacted lawn areas, the opportunity to be absorbed
Regenerative agriculture: a practice of organic farming designed to build soil health or to regenerate unhealthy soils
Reintegration: An effort to reestablish pre-existing connected relationships among ecosystems in cases where human activities have disrupted these relationships
Socio-ecological system: A system composed of humans and nonhuman life forms in a spatially determined setting
Soil hydrology: all of the components of water related to irrigation and drainage, percolation and recharge to groundwater, capillary rise, root and plant water uptake and release, evaporation from soil and plants, and transpiration

Soil microbiology: the study of organisms in soil, their functions, and how they affect soil properties
Spiritual ecology: an emerging field in religion, conservation, and academia recognizing that there is a spiritual facet to all issues related to conservation, environmentalism, and earth stewardship
Stratospheric ozone depletion: A steady decline of the ozone layer in the stratosphere, most significantly in the polar regions, of about 4% since 1970
Stormwater: surface water in abnormal quantity resulting from heavy falls of rain or snow
Sulfur dioxide: A pungent and toxic gas created when sulfur is burned and oxidizes
Superfoods: a nutrient-rich food considered to be especially beneficial for health and well-being
Sustainable land use: The use of land that promotes a symbiotic relationship between humans and the environment through practices that integrate land, water, biodiversity and other ecological factors to aid humans while also providing long-term sustainable ecosystem services
Swale: a low place in a tract of land, usually moister and often having ranker vegetation than the adjacent higher land
Synergies: Supplemental; the interaction of two organisms which makes an overall greater impact than they could have made individually
Terrestrial ecosystems: is an ecosystem found only on landforms. They form a community of organisms and their environment that occurs on the land masses of continents and islands
Transit-Oriented Develoopment (TOD): a type of community development that includes a mixture of housing, office, retail and/or other amenities integrated into a walkable neighborhood and located within a half-mile of quality public transportation
Tropospheric ozone: Ground-level ozone that is a harmful air pollutant
Urban landscape: Anthropogenic space, often in the context of studying the relation of living things with one another in an urban setting
Urban renewal: the redevelopment of areas within a large city, typically involving the clearance of slums
Waste outputs: The output of material left over from production that has no market value
Wastewater: water that has been used in the home, in a business, or as part of an industrial process

Appendix A

Santa Clara Sustainable Agrihood



*Owner's landscape & ag program document


A selection of communities represented in Santa Clara County
Korea
Japan
China
Cambodia
Vietnam
Philippines
Mexico
Brazil
India
France
England
Spain
Italy
Scandinavia
Germany
Russia
Turkey
Greece
North Africa
South Africa
The Senior courtyard gardens are thematically connected to the community gardens in the plaza.
International Gardens for the Community. Themed container gardens and raised beds.
Art Walls + Vertical Trellis from floor to roof in 3 courtyards
Vertical Food Towers
Woodland Garden with Meadow Swales
Redwood Gardens
Bocce Ball Court
Vertical Aquaponics Farm
Oak Trees
Native Meadows with Perennial Foods
Street Vendors, Tasting, Container Gardens, Aquaponics farms on roofs
Gathering Space Open Plaza, Amphitheatre
Regenerative Farm + Orchard at Plaza Entry
Native Grasses with Perennial Foods
Oaks, Meadows, Fruit, Nut Trees
Aquaponics
Bio swale, Orchard, Dog park
Hiking Trail Around Agrihood
Greenhouse, Vermicomposting, Potting
Native Hedge Rows
Active Play Habitat Garden/Storm Water Retention
Grape Vineyards
Container Gardens for community
Beehive Rest Stop
Market Rate Apartments
Low Income Affordable Apartments
Market Rate Town Houses
Market Rate Town Houses
Market Rate Town Houses
Market Rate Town Houses
Barn Community Building
Chicken Coop, Run
Regenerative Farm
Pigmy goats, composting, Storage Shed
VETERNS ADMINSTRATION OFFICE
N. WINCHESTER BOULEVARD
N
The Bee Book

Appendix B

Existing Ecology-Based Communities

The model and concepts we are trying to establish are not entirely new, as its various components have already been planned, adopted, or developed in the U.S. and other countries. We briefly examine some of these to provide insights into how this model will encourage collaboration, community, and healthier, sustainable land use. Some of these examples that show how ecology-based communities have succeeded, and our model is based on a similar approach to promoting sustainable land use practices.

Hammarby, Sweden: Hammarby Sjöstad contains 11,000 apartments, housing an estimated 25,000 residents. There is a roughly even split between tenancy and tenant ownership. The development includes a comprehensive system of new public transport links, leisure facilities, municipal services, commercial entities, and green public spaces. The Hammarby model is unique in its integration of energy, solid waste, water and wastewater for homes, offices and other activities. Planned as a blueprint for cities of the future, the system also incorporates stormwater, rainwater and meltwater. Domestic refuse is separated into different chutes and the various fractions are then transported by vacuum to containers at a central collecting station. Sustainable public transportation is offered with electric trains, biogas powered buses, and commuter boats. Hammarby Sjöstad is served by a modern public transport system, the Tvärbanan light railway, along with new bus services and a ferry service on Hammarby Sjö lake, between the district's southern and northern points. Car pools are open to residents and people working in the area.

Findhorn, Scotland: The grandfather of all **ecovillages** established in 1962, Findhorn was founded by Peter and Eileen Caddy and Dorothy Maclean, who lived in a small caravan while supplementing their skimpy income with an organic vegetable garden. This community grew out of their personal quest to survive, living together and collectively growing food. They believed in the spiritual power of the plants, the soil, and the place that guided their gardening for a very long time. Now established as Findhorn ecovillage and a related educational foundation, it has some 450 resident members and is the largest intentional community in the United Kingdom. It is said to have the lightest **ecological footprint** as compared to any other community in the country (with half the average use of resources and half the environmental impact) and also has been awarded the Best Practices Award by the United Nations Center for Human Settlement.

Auroville, India: Auroville was founded in 1968 in South India with the spiritual objective of embodying the ideal of human unity. Auroville's philosophy of **biomimicry** is an expression of spirit which has made it a world-class leader in compressed-earth building methods, harvesting of rainwater, plant-based sewage treatment, and solar and wind energy.

Willowsford, Virginia: Located in the heart of Loudoun County in Virginia, Willowsford is a 4000 acre community that has four distinctive yet interconnected villages. The land is divided in two, with one half designated to remain as open space under the stewardship of the non-profit Willowsford Conservancy. Some 300 acres of the remaining portion is used to cultivate varieties of vegetables, herbs, fruits, and flowers, and to raise several breeds of livestock. The produce from these farms is distributed to the community through the CSA program and Farm Stand.

Dancing Rabbit, Missouri: This ecovillage spans 280 acres in the rolling hills of northeastern Missouri. With the main focus on ecological sustainability, they are constructing new buildings and planning a community structure that includes a long term plan for 500 to 1000 people. This new structure will be based on renewable energy sources (*e.g.* solar and wind) for power and vehicles, along with alternative materials for constructing and building homes, like straw bale and cob. In addition, they emphasize locally produced organic food and a self-contained economic system, including bartering and **internal currency.**

Appendix C

Sustainable Sites Initiative

Below are the benchmarks for the USGBC rating system which measures the sustainability of an urban property. These benchmarks must be met in order to qualify as a certified site.

SITE SELECTION

1. Select locations to preserve existing resources and damaged systems.
2. Limit development of farmlands
3. Protect floodplain functions
4. Preserve wetlands
5. Preserve threatened or endangered species and their habitats
6. Select brownfields or greyfields for redevelopment
7. Select sites within existing communities
8. Select sites that encourage non-motorized transportation and use of public transit

PRE-DESIGN ASSESSMENT

9. Conduct a pre-design site assessment and explore opportunities for site sustainability
10. Engage users and other stakeholders in site design.

SITE DESIGN WATER

Protect and restore processes and systems associated with a site's hydrology

11. Reduce potable water use for landscape irrigation by 50% from established baseline (this is a minimum requirement).
12. Reduce potable water use by 75% or more from established baseline.
13. Protect and restore riparian, wetland and shoreline buffers.
14. Rehabilitate lost streams, Wetlands and shorelines.
15. Manage stormwater on site.
16. Protect and enhance on-site water resources and receiving water quality.
17. Design rainwater/stormwater features to provide a landscape amenity.

18. Maintain water features to conserve water and other resources.

SITE DESIGN-SOIL and VEGETATION

Protect and restore processes and systems associated with a Site's soil and vegetation

19. Control and manage known invasive plants found on site.
20. Use appropriate non-invasive plants.
21. Create a soil management plan.
22. Minimize soil disturbance in design and construction.
23. Preserve all vegetation designated as special status.
24. Preserve or restore appropriate plant biomass on site.
25. Use native plants.
26. Preserve plant communities native to the Eco-region.
27. Restore plant communities native to the Eco-region.
28. Use vegetation to minimize building heating requirements.
29. Reduce urban heat island effects.
30. Reduce the risk of catastrophic fire.

SITE DESIGN–MATERIALS SELECTION

Reuse/recycle existing materials and support sustainable production practices

31. Eliminate the use of wood from threatened tree species.
32. Maintain on-site structures, Hardscapes and landscape amenities.
33. Design for deconstructing and disassembly.
34. Reuse salvaged materials and plants.
35. Use recycled content materials.
36. Use certified wood.
37. Use regional materials.
38. Use adhesives, sealants, paints, and coatings with reduced VOC emissions.
39. Support sustainable practices in plant production.
40. Support sustainable practices in materials manufacturing.

SITE DESIGN–HUMAN HEALTH AND WELL-BEING

Build strong communities and a sense of stewardship

41. Promote equitable site development.

42. Promote equitable site use.
43. Promote sustainability awareness and education.
44. Protect and maintain unique cultural and historic places.
45. Provide for optimum site accessibility, safety and wayfinding.
46. Provide opportunities for outdoor physical activities.
47. Provide views of vegetation and quiet outdoor spaces for mental restoration.
48. Provide outdoor spaces for social interaction.
49. Reduce light pollution.

CONSTRUCTION

Minimize effects of construction related activities

50. Control and retain construction pollutants.
51. Restore soils disturbed during construction.
52. Restore soils disturbed by previous development.
53. Divert construction and demolition materials from disposal.
54. Reuse or recycle vegetation, rocks, and soil generated during construction.
55. Minimize generation of greenhouse gas emissions and exposure to localized air pollutants during construction.

OPERATIONS and MAINTENANCE

Maintain the sight for long-term sustainability

56. Plan for sustainable site maintenance.
57. Provide for storage and collection of recyclables.
58. Recycle organic matter generated during site operations and maintenance.
59. Reduce outdoor energy consumption for all landscape and exterior operations.
60. Use renewable sources for landscape electricity sources.
61. Minimize exposure to environmental tobacco smoke.
62. Minimize generation of greenhouse gases and exposure to localized air pollutants during landscape maintenance activities.

63 Reduce emissions and promote the use of fuel-efficient vehicles.

MONITORING and INNOVATION

Reward exceptional performance and improve the body of knowledge on long-term sustainability

64. Monitor performance of sustainable design practices.

65. Innovation in site design Additions to prerequisites and credits.

URBAN FOOD PRODUCTION UTILIZING ECO-AGRICULTURE METHODS

Produce some organic foods on site that are organically grown.

66. Grow and harvest native edible foods that are integrated into restored regional plant communities on site using Eco-agricultural technology.

67. Grow and harvest organic foods in raised beds, over-structure or on architecture structures using Eco-agriculture technology.

68. Grow and harvest annual and perennial food crops utilizing vertical farming technology.

69. Produce animal protein onsite with aquaculture technology and/or raising chickens/rabbits or other small fowl or mammals.

70. Establish edible mushroom cultures within regional native plant community gardens on site utilizing principles of Eco agriculture.