

Re-greening earth

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Throughout Earth's history, climate change has been the driving force in evolution, selecting new life forms pre-adapted to those changes. But the rate of change we are now experiencing has been in fast forward mode for only the last 100 years or so. This has greatly reduced biodiversity in most functional ecosystems, and threatens to reduce even further the total number of species on the planet. Inevitably, this will impact our daily lives and inflict profound negative changes in our status unless we do something to slow it down. The root causes for rapid climate change, for a brief moment in time, were subject to heated debates (mostly politically based). But after all the scientific evidence was gathered and fully integrated, the answer became obvious, even to the most closed-minded industrialist. As Pogo, that well-known comic strip philosopher, once sagely observed: "We have met the enemy and they is us." Health issues, quality of life, and even where we will be able to live as sea levels rise over the next 100 years, are issues that we must face head-on if we are to survive as a species. Do we simply sit on the tracks as the runaway climate train approaches and then mows us all down like a flock of mindless sheep? This is not the way in which we have survived and evolved over the last 100,000 years. I believe that we are still evolving. Creating a problem is one thing, but realizing the causes of the problem, then taking radical measures to correct them are yet another.

Doing something to reverse the effects of a failing agricultural system

on natural systems means to increase our natural capital. This will require a dramatic reduction in our agricultural footprint. While cities have small land use footprints with respect to square meters of land per thousand individuals, their ecological footprint regarding food production is huge. For example, New York City (over 8 million individuals) requires the size of the state of Virginia to supply it with fresh produce and meat products. The top 20 cities in the United States have an agricultural footprint roughly the size of Montana. A radical new approach to life in the big city is what is envisioned: eco-urbanism.

If the trend in urbanization continues at its current rate, nearly 65% of us will be living in cities within the next 20 years. This translates to fewer and fewer farmers. In addition, assuming no catastrophic events, such as an influenza pandemic or another world war, there will surely be another 2.5 billion people on the planet in just another 50 years. That raises an essential question: how will we feed all those hungry mouths? Many agronomists feel that the solution lies in more research, in which improved intensive industrial farming practices carried out by an ever decreasing number of highly mechanized farming consortia could produce higher yields of crops through the scientific application of a new generation of agro-chemicals and genetically modified plants. Even if this strategy succeeds in the short term, it will still require adding a significant amount of new farmland to the equation, nearly equivalent to the size of Brazil. Since

we already farm 80% of the world's terrestrial arable surface (this includes grazing land), this amount of new land suitable for farming simply does not exist. To quote one of America's great humorists, Will Rogers, "Buy land. They ain't makin' it anymore." It is evident that something will have to change radically over the next 10-20 years if we are to avoid starvation on a massive scale.

Another thing to keep in mind is that farming uses large quantities of fossil fuels. In the United States alone, farming consumes some 20% of all the gasoline and diesel fuel burned annually. Green house gasses produced as a direct result of farming are of course a concern, but an even more

immediate one is that the price of food is inexorably linked to the price of fuel, and it has essentially doubled the cost of eating over just the last 3 years.

Agriculture uses some 70% of the available freshwater on the planet for irrigation purposes, and in doing so, renders it unusable for drinking due to contamination with agrochemicals (pesticides, fertilizers, and herbicides) and silt. Some resource experts now value water more than oil, and warn that if current trends in water use continue, it will become priceless – unavailable, that is.

Food experts like Michael Pollan (*The Omnivore's Dilemma*) and recent MacArthur Foundation awardee Will



1. The Living Tower by SOA Architects.

Allen advocate for locally grown food crops within or close to the urban landscape. Consumers seem to also resonate well with the concept of home-grown food, as more and more green markets spring up each summer throughout most US cities to take advantage of nearby farmer's efforts. Unfortunately, this strategy cannot supply food for the entire planet, especially for those regions of the world that are the most challenged with regards to the availability of arable land—sub-Saharan Africa, the Middle East and many parts of Central and South America. Agriculture now occupies a landmass equivalent to the size of South America. It's obvious that by adding another 2.5 billion people,

we will overwhelm the system unless we replace the current method of obtaining our food from soil-based agriculture with something more ecologically sustainable. At the same time, we have great need for ecosystem restoration. Can we do both without further harm to the Earth?

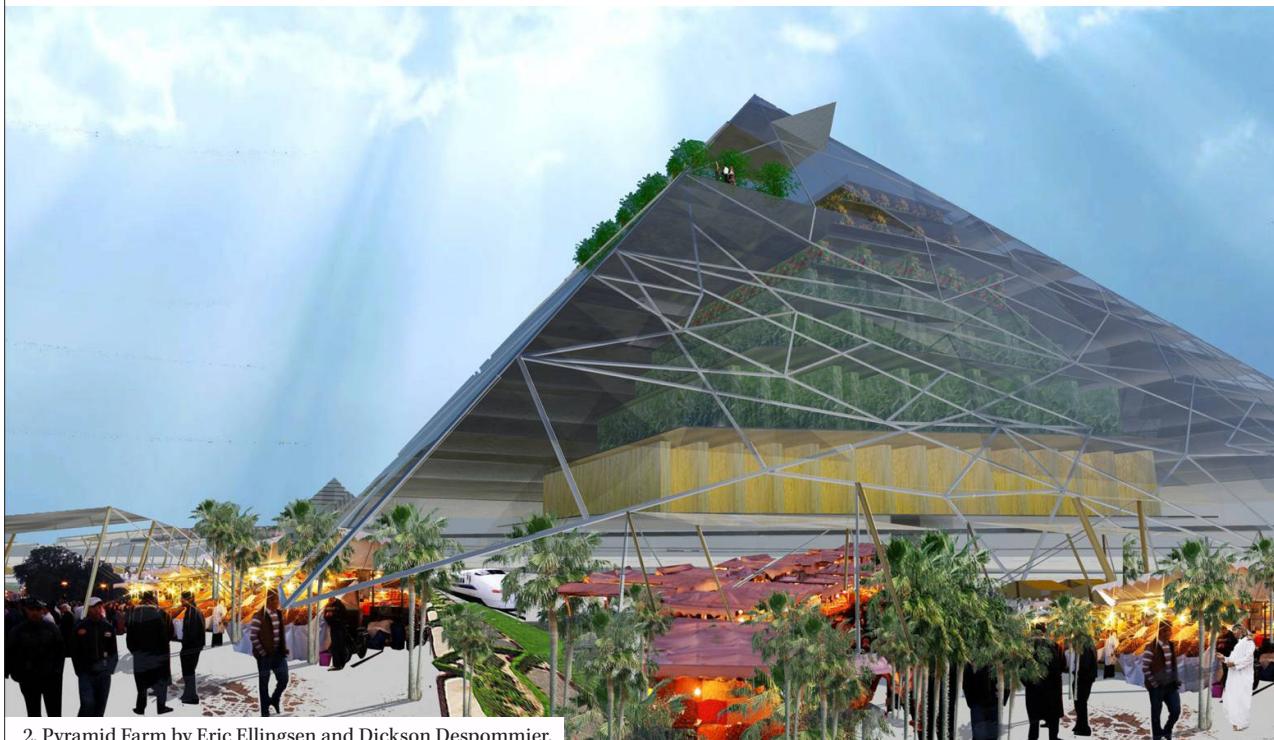
One potential solution to slowing down climate change is to grow most of our food crops indoors and give farmland back to nature, allowing the land to repair itself back into functional ecosystems. If we could replace a significant portion of soil-based farming with indoor hydroponic and aeroponic farming operations within the city limits, then we could

seriously consider the option of returning a significant portion of farmland back to its original ecological function (hardwood forests and tall and short grass prairies). For example, most of the Eastern United States was at one time hardwood forest. It was cut down to make room for corn, soybeans, etc. This has contributed heavily to the rapidity of the climate change escalation.

With the help of my students, I have developed a way of imagining large-scale indoor farming in urban centers. The concept of farming inside tall buildings situated within the urban landscape has been envisioned for some 10 years now. It began innocently enough; with the seven graduate

students in my Medical Ecology class opting for a semester project involving rooftop farming in Manhattan. They worked hard and discovered that there were about 13 acres of rooftop available, and by growing rice they could feed around 2% of that small, densely populated island. They were openly put off by their seemingly trivial result. I tried to mollify the class by reassuring them that they had learned a lot and that by working as a group, they had gained a leg up on most other graduate students in the environmental health sciences. Nonetheless, they were not happy with their result, complaining that their efforts had been in vain. I countered with; "What if we put the crops inside the buildings?" Unfortunately, that was the last day of class, and the students went off along their chosen career paths without the benefit of the next phase of the idea.

Over the following summer, I thought more about the concept and coined the name Vertical Farm Project (VFP). Ten iterations of the class have worked on the project, from 1999 to 2009. I began posting the class projects of the VFP on the internet starting around 2002 (see: www.verticalfarm.com). Since then, the popular press has become attracted to the vertical farm concept, and numerous articles have appeared world-wide. It has received a fair amount of acceptance in the popular press and with environmentally enlightened citizens around the world. This has encouraged me to carry the concept to the next level; namely to the concept stage. I have done so, encouraging all those with meritorious



2. Pyramid Farm by Eric Ellingsen and Dickson Despommier.



CHIVES



PEPPERS



**BRUSSEL
SPROUTS**



TOMATOES



THYME



SPINACH



PEAS



LETTUCE



PEACHES



APPLES



CABBAGE



STRAWBERRIES



CHERRIES



ideas to contribute them to my web site, which they have generously agreed to do. I have been overwhelmed with highly imaginative and beautifully illustrated designs of vertical farms submitted by inspired individuals with the vision generated by our original idea. Many of their designs can be seen on the website, and I continue to post new ones as they become available. In fact, these ingenious designs have been the inspirational stimulus for the next phase of the vertical farm concept, prototyping.

My graduate training is as a microbiologist, not an architect. That means that I rely heavily on architects and engineers for advice regarding construction materials and constraints of design. On the other hand, I bring the perspective of crop security and food safety to bear on the problem of growing crop plants in a confined indoor space. Together, we have evolved a master plan as to how to proceed. Initially, a “playground” version of the vertical farm would be built. In it, researchers will test to the limits of available technologies a variety of strategies for growing food indoors. Water reclamation, waste to energy, lighting, and crop growth monitoring and harvesting will be investigated using a team of experts in agronomy, architecture, engineering, urban politics, automation, and social marketing, among others. Eventually, we will proceed with spawning a variety of VF concepts, all of which will be scalable (restaurants, schools, hotels, apartment complexes, hospitals, etc). Decentralizing food production in a city has many virtues; among them is

the guarantee that we will always have an abundant, robust and safe food supply. I do not mean to trivialize the level of difficulty in bringing all this to fruition. There is no substitute for hard work and clever thinking – or money, for that matter.

Thus, how to establish a realistic, economically viable urban “ecosystem” within the techno-sphere (i.e., the built landscape) is the most important challenge we face today. Establishing criteria for eco-urbanistic behavior will involve connecting disparate, cutting edge technologies in ways yet tried. Fortunately, the invention of radically new and untried methods for things such as pollution-free waste-to-energy strategies and safe gray water reclamation are not necessary, as the ones that we currently have available are more than sufficient. So constructing a totally off the grid community is feasible, even though we have yet to do so. The time is right to incorporate this notion into a real situation to prove once and for all that humans can behave in an environmentally responsible fashion. If we as a society

do not choose to travel down this route to get out of our ecological mess the human condition will surely exacerbate already stressed-out, depleted natural systems, particularly hardwood forests. Increased rates of deforestation to make room for even more farmland would alter the atmosphere in such a way as to eventually (30-50 years into the future at most) spell the end of traditional soil-based agriculture. Even the most dimwitted politician could predict what would happen next if this were to become reality.

In conclusion, the vertical farm will only succeed if we cooperate. The team must include as many talented individuals in architecture, engineering, agronomy, politics, economics, psychology, and microbiology as we can muster in a common effort to relieve the land of as much stress from traditional farming as possible. If all this comes to pass, then balance between us and the rest of the natural world will be achieved and everyone, including Bambi, will rejoice, living long and prospering.



4. The Living Skyscraper: Farming the Urban Skyline by Blake Kurasek.