‘Landscapes’. This 4-piece series explores the obsession inherent in the romantic landscape of recreating the world and simultaneously being part of it.

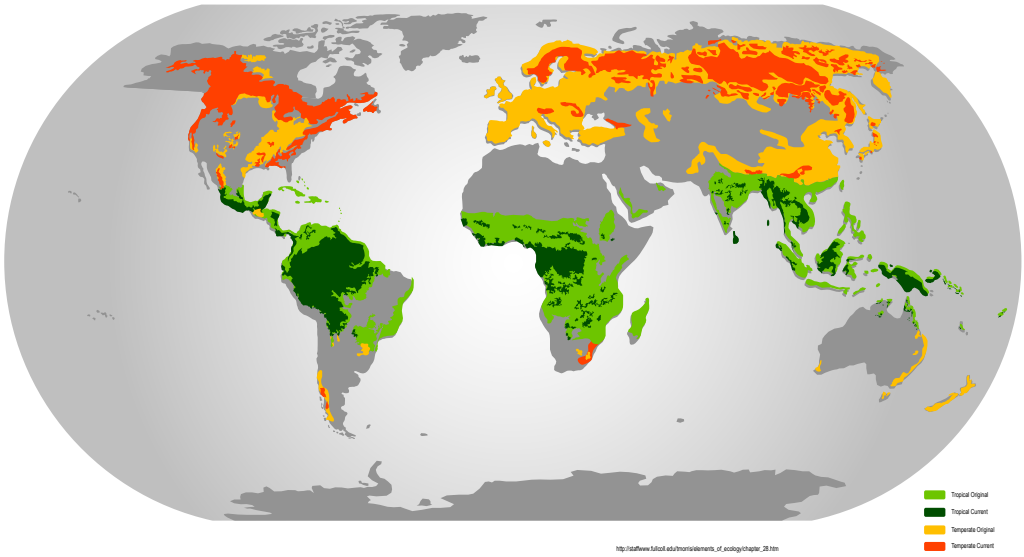
Clip-On Architecture: Tropical Deforestation and Potential Solutions to the Climate Crisis

Vanessa Keith

“One of the primary causes of global environmental change is tropical deforestation...” (Geist & Lambin, 143)

“Perhaps the easiest and most beneficial way to reduce emissions would be to stop the destruction of tropical forests...estimates suggest that up to 20 percent of human greenhouse gas emissions come from deforestation in the tropics.” (Lynas, 297)

TEMPERATE AND TROPICAL FOREST COVER: PAST AND PRESENT



Introduction: The Tabula Rasa City

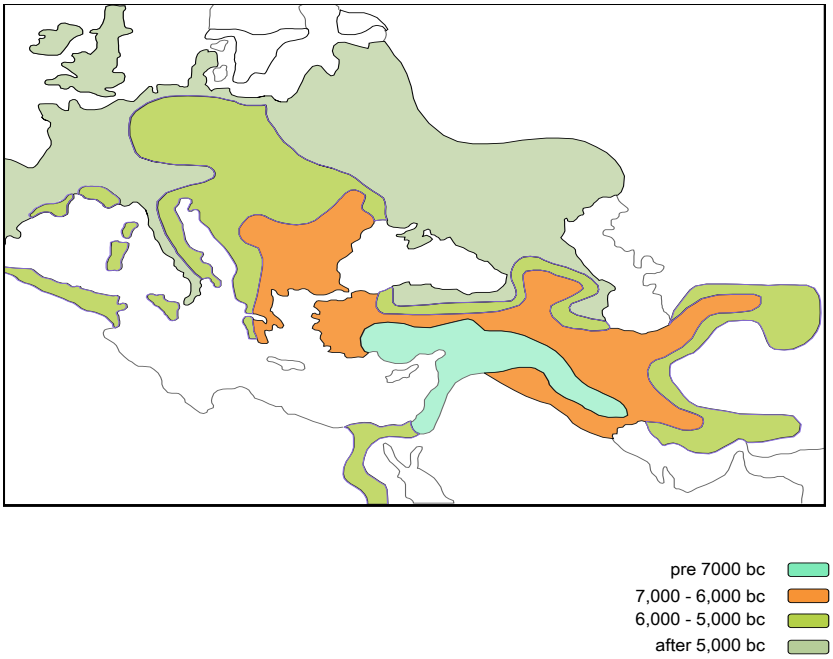
Much of the literature related to the role of the built environment in climate change has focused on new technologies and new ideas which might be implemented in new buildings. Tabula rasa eco-cities trumpeting their green credentials and high levels of environmental sustainability are being planned in the U.S., China, and Abu Dhabi, among other places, and green is the word of the day. Treasure Island in San Francisco will be transformed from a military base to become a community of some 6,000 new apartment buildings for 13,500 residents by 2020. Dongtan, a new city planned for Chongming Island on the outskirts of Shanghai, is currently an alluvial wetland and the future site of a 500,000 resident community which will reach full size by 2050. And Masdar in Abu Dhabi, is an eco-project designed for a community of 30,000 which is scheduled to be completed by 2016.

Arup, the designers of Dongtan, have projected that it will recover, recycle and reuse 90-100% of all the waste it generates. Electricity will be provided solely by biomass and wind power. Masdar aims to be the first city with zero waste produced, zero carbon emissions and zero fossil based power, and Treasure Island aims to return 300 of its 450 acres to parks and local farming, and to obtain 50% of its power from renewable sources. (Biello, 68) Despite these ambitious plans for new cities, one might ask, with all the city fabric which currently exists, why build at all, and most especially on such a massive scale? Is starting from scratch the only way? And are these new green cities as sustainable as they purport to be? For its part, Dongtan has received the 2007 Greenwasher Award from Ethical Corporation Magazine, which calls the project a modern day Potemkin village, and as such, likely never to be realized.

The thirst for utopia and starting anew appears to be nothing new. Our relationship with the planet has been one of altering the natural world to suit our needs, from the time we first picked up crudely fashioned tools. Deforestation "is not a recent phenomenon; it is as old as the human occupation of the earth, and one of the key processes in the history of our transformation of its surface." (Williams, xxi) The desire to expand ever outward, the thirst for the frontier, the unconquered lands, the uncharted waters, thus seems to be a fundamental part of being human. The early spread of agriculture in Europe, and the deforestation which accompanied it, is a process which started some time prior to 7,000 B.C. Contrary to previous notions of agricultural development, early farming was an activity which sprouted up independently in different areas of the world:

"Much early thinking revolved around the idea that there were centers of agriculture and domestication, spread widely throughout the world...However, the concept is now discredited. The pathways to agriculture have been several, and they were often followed independently in geographically separated populations." (Williams, 37).

THE SPREAD OF AGRICULTURE IN EUROPE



Source: A.G. Sherratt, "The Beginnings of Agriculture in the Middle East and Europe," in The Cambridge Encyclopeadia of Archaeology, [Cambridge University Press, 1980], 102-11), also in Killeen.

So even in its earliest days, it appears that human alteration the landscape was a bottom-up event, rather than something centralized and disseminated from the top down. In terms of its current manifestation, satellite photos documenting the Brazilian Amazon show the same peculiar fishbone pattern that is the result of piecemeal deforestation over and over. Brazilian Amazonia has the highest absolute rate of deforestation and forest fragmentation in the world, and as such has been extensively studied. (Armenteras et. al., 354) Unpaved and often unofficial roads branch out from new roads, with the parts between the spines gradually thinning until the entire area is cleared.

1975

1986

1992

2008

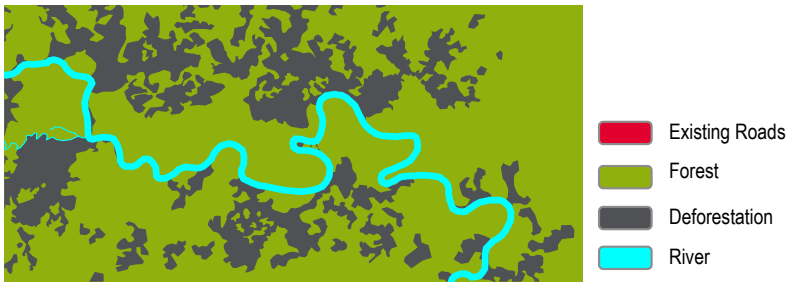
Source: NASA/Goddard Space Flight Center Scientific Visualization Studio

Source: Google Earth

Deforestation Over Time:
As seen in NASA satellite images of Rondonia, Brazil from 1975-1992, clearing along the side of new roads in the forest have a tendency to fan out, creating a fish bone pattern. This new pattern in the forest appears directly after the construction of the first road. By 2008, Rondonia is a vast area void of forest with fish bone patterns continuing to expand northwards.

Deforestation Along Rivers:
Deforestation along the Caqueta River in Colombia follows an amoeba pattern. As the city sprawls further down the river natural barriers influence its shape and size.

Deforestation Along Roads:
Deforestation in Rondonia, 2008. Here continued felling and clearing of trees has almost entirely eliminated the areas of forest between the strips of cleared forest seen in the satellite images above.



"Modern highways are the **most important driver** of deforestation in the **Amazon**." (Killeen, A Quiet Storm, 22)

Why and how does it happen? Is there some fundamental pattern at work, somehow hardwired into our systems as human beings which makes us repeat the same steps over and over? Jared Diamond points to the deforestation which doomed early civilization on Easter Island as an example of our blindness; a 'landscape amnesia' which allows us to gradually adapt to changing circumstances without noticing the change until it's too late. (Diamond, 426) Back to the present again, the seemingly insignificant actions of individuals, a tree here, a tree there, have turned into something much larger. This pattern can now be seen from space, but the individual parts of this pattern don't see the whole. Steven Johnson points to the silk weavers of Florence, who are still located on the same street as they were 1000 years ago, as an example of emergence:

"Like any emergent system, a city is a pattern in time. Dozens of generations come and go, conquerors rise and fall...and beneath all that turbulence, a pattern retains its shape...The world convulses, sheds its skin a thousand times, and yet the silk weavers stay in place...that continuity has much more than sentimental value, and indeed it is more of an achievement than we might initially think. That pattern in time is one of the small miracles of emergence." (Johnson 104-05)

The silk weavers thus form part of a dynamic human pattern which outlasts and supercedes both the lives and the individual will of the members of the community. The pattern is a collective phenomenon, an emergent behavior. (Johnson, 106) It is also an example of the city as a human construct in its ability to learn and adapt to changing circumstances over time. The solution, then, would appear to have something to do with examining the factors at play which encourage this behavior and setting out to change them. While it is obvious that some top down decision making is involved in creating the conditions which allow access to the rainforest, much of what happens afterwards would often appear to be the workings of many individual decision makers.

Deforestation

Tropical forests are critical to the debate regarding climate change and what is to be done, as they are a key factor in regulating global precipitation, as well as significant because they absorb carbon to a greater degree than forests in the temperate zones. (Lynas, 297)

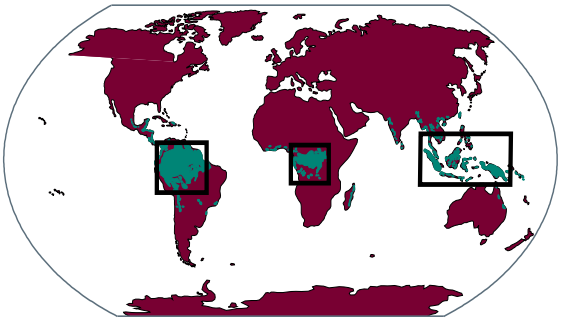
"The Amazon Basin literally drives weather systems around the world. The tropics receive two-thirds of the world's rainfall, and when it rains, water changes from liquid to vapor and back again, storing and releasing heat energy in the process. With so much rainfall, an incredible amount of heat is released into the atmosphere, making the tropics the Earth's primary source of heat redistribution." ...

""Deforestation does not appear to modify the global average of precipitation, but it changes precipitation patterns and distributions by affecting the amount of both sensible heat and that released into the atmosphere when water vapor condenses, called latent heat..."

"Associated changes in air pressure distribution shift the typical global circulation patterns, sending storm systems off their typical paths." And, because of the Amazon's location, any sort of weather hiccup from the area could signal serious changes for the rest of the world like droughts and severe storms."

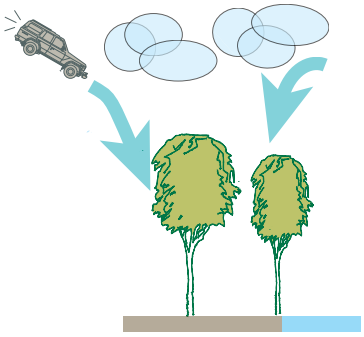
http://earthobservatory.nasa.gov/Newsroom/view.php?id=28106

TROPICAL FORESTS OF THE WORLD



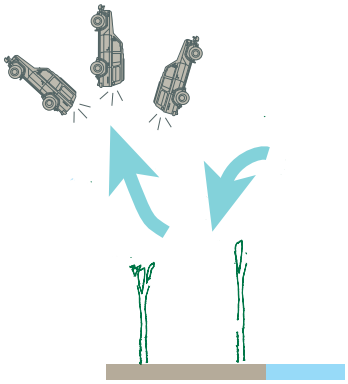
("Tropical Deforestation Affects Rainfall in the U.S. and Around the World, Nasa Earth Observatory: <http://earthobservatory.nasa.gov/Newsroom/view.php?id=28106>)

BEFORE DEFORESTATION



In one year, 1.5 acres of typical rainforest absorbs as much C02 as a typical SUV produces in the same amount of time.
www.ecoclicknetwork.com

AFTER DEFORESTATION



Tropical deforestation leads not only to a reduced amount of CO2 absorbed from the atmosphere as well as an increased release of CO2 into the atmosphere from the forest's above ground biomass, estimated to contain around 76 gigatonnes of carbon. (Killeen, 57)

It is estimated that the Amazon rainforest absorbs approximately 28% (7.34 billion metric tons) of carbon emissions from the burning of fossil fuels every year.

Tropical rainforests are the planet's defense against global warming. Deforestation is one of the greatest sources of carbon dioxide which is the principal cause of global warming. "If converted to cattle operations, rainforest land yields about $60 per acre. If timber is harvested, the land is worth around $400 per acre. But if its renewable and sustainable resources are harvested, the land could yield an average of $2,400 per acre."

Each acre of rainforest prevents 75,000 to 100,000 pounds of carbon dioxide from being released. http://www.ecoclicknetwork.com/devEco/MoreEcoFacts.cfm

"Eventually, plants will absorb **less carbon through photosynthesis than is released by soil respiration,** turning the **Amazon** ecosystem into a **net source of carbon** and further exacerbating **global warming**." (Killeen, A Quiet Storm, 26)

There are many factors underlying deforestation, and the literature would appear to agree that it relates to a combination of different factors, rather than one key driver. The agents of deforestation are small subsistence farmers, ranchers of cattle and other grazing animals, loggers, and large scale agricultural companies or plantations. (Angelsen & Kaimowitz, 74) Larger scale actors usually create patterns which resemble bigger scars on the landscape caused by massive clear cutting of forests for logging, commercial farming or strip mining. Though frightening in the scale of their actions, these actors are usually easier to pinpoint than the largely anonymous small scale cutters of trees, whose collective impact may be potentially greater. Often, the two are linked:

"...cattle ranchers may obtain access to lands by deforesting but also by inducing landless peasants to do the job for them. With the possibility of having their land legally acquired through occupation, and subsequent sale of property to cattle ranchers, landless peasants can be effective - and dependent - agents of deforestation. Some logging companies are known to supply local populations with power saws and then buy their production of logs, often obtained illegally from protected areas, thus expanding the area deforested."(Contreras-Hermosilla, 6)

Thus the immediate causes of deforestation involve microeconomic decision making on the part of these agents, often in response to larger macroeconomic forces which are either a global phenomenon or the result of government policy.

Immediate Causes of Deforestation

- **A jump in prices for agricultural products.** This stimulates deforestation because when the agricultural sector is more profitable, it is more likely that the local population and migrants will shift their resources into agricultural production. Higher rural wages decrease forest clearing, because they make farming more expensive. (Angelsen & Kaimowitz, 81, 84)

- **An uptick in the market price for a land intensive crop.** This may lead farmers to clear more land to cultivate one crop over another, and has been seen in Cameroon, where an increase in the market price of plantains caused many producers to shift from cocoa, a less land intensive crop, to plantains, which led to more forest clearing. (Angelsen & Kaimowitz, 83) The rising demand for palm oil, which recently emerged as a leading biodiesel fuel, poses a huge threat to tropical forests everywhere; indeed, demand for biofuels may increase forest clearing far beyond the most pessimistic scenarios predicted by conservationists. (Brown, 89, Killeen, 38)

- **Cattle ranching.** This leads to greater clearing of land to create pastures for grazing. (Geist & Lambin, 145) The excessive number of sheep, cattle and goats on the planet also contribute to soil erosion as they remove vegetation and "their hoofs pulverize the protective crust of soil that is formed by rainfall." (Brown, 161) Overplowing, overgrazing and overcutting drive desertification and are intensifying as human and livestock populations grow. (Brown, 97) Brown suggests that in addition to limiting the numbers of grazing animals, we should also keep them in restricted areas bringing the forage to them.

- **A shortage in off-farm employment.** This usually leads to an increase in deforestation, as do lower wages. This is because much of the primary forest clearing activity is done by subsistence farmers. (Angelsen & Kaimowitz, 73)

- **More roads = more deforestation.** This is because more roads create a multiplication of edges and thus more access to pristine forest areas. Indeed, "Most studies show that forest clearing declines rapidly beyond distances of 2 or 3 kilometers from a road" (Angelsen & Kaimowitz, 85). The fishbone patterns discussed earlier would appear to prove this hypothesis.

Underlying Causes of Deforestation

- **Government Policy that encourages migration into previously unpopulated areas.** This is an underlying cause of deforestation and can be seen in the example of Singapore, which has lost half of its indigenous animal species and 97% of its original forest cover as a result of deforestation. (CIA: The World Factbook, 2008) In Singapore, government policies initially aimed at moving the majority of the population outside the city center to outlying areas in order to make way for redevelopment as a commercial and business hub, are largely responsible as an underlying cause of the resulting pressure on natural areas. (Ooi, 456)

- **Pro-Deforestation State Policies.** This can encourage forest clearing through the granting of tax credits, low taxation or incentives for cash cropping and legal land titling. In these cases a growth of pastures and commercial crops is often seen along with an expansion of the road network. (Geist & Lambin, 147)
- **Greater External Debt.** This may lead to higher levels of deforestation because international lenders sometimes enforce policies which encourage agricultural and forest product exports and the liberalization of trade as a condition for the granting of loans. (Angelsen & Kaimowitz, 90)

- **Technological Changes.** This can lead to more forest clearing if the new technology increases crop yields without raising the amount of labor or capital needed for farming. (Angelsen & Kaimowitz, 91)

- **Increased ease of access to forests and markets where goods may be sold.** This accelerates forest clearing because the development of commercialization encourages still more deforestation and the modernization of the agricultural sector, encouraging shifting cultivators to become sedentary cash croppers and subsistence farmers. (Geist & Lambin, 149) What's more, the more fragmented a forest becomes, the more edges it has, the easier it is to access, which also accelerates the process: "Forest fragments are more accessible than large compact forests, and forests in coastal countries and islands are more accessible than those in continental countries." (Angelsen & Kaimowitz, 85)

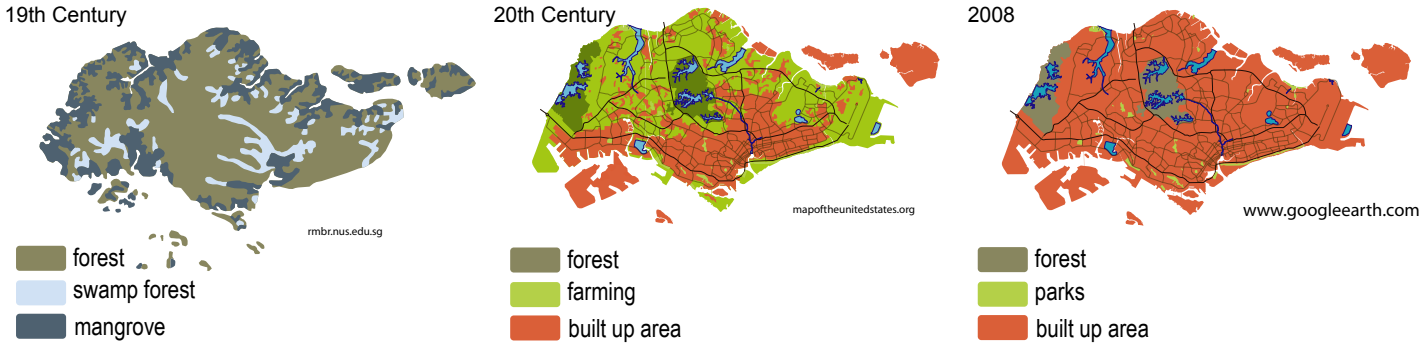
- **Where farmers can gain title to the land by clearing it**, deforestation is more prevalent. Homesteading is often a way to gain property rights to land in places where there is an absence of secure land tenure. (Angelsen & Kaimowitz, 85)

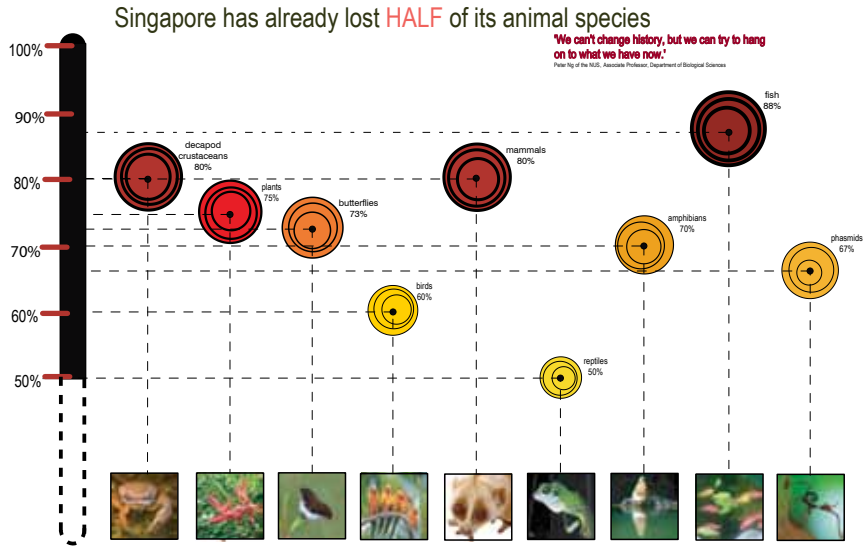
- **Higher Prices for Timber.** This encourages deforestation by making it more profitable. (Angelsen & Kaimowitz, 86)

Subsistence farmers may eke out a living by clearing small plots of land for farming, and those plots may later be consolidated into larger land holdings by commercial farmers or ranchers, who buy the plots and send the subsistence farmers on to repeat the cycle. (Killeen, 24) The farmers invest very little in the land relative to the profit they make from its sale, which is another factor that encourages them to fell trees. Or illegal logging may take place on a small or even on a large scale. Much of logging is done by foreign corporations which exploit forest resources until they are depleted, and then move on to the next location. Brown notes the Chinese logging orgy, spurred by a booming wood products industry, which he feels is "the most devastating development affecting the earth's remaining natural forests" (Brown, 88, see also Diamond, 375). Deforestation in some cases also involves charcoal production for cooking, something which is seen in parts of Africa as well as Haiti, which has only 2%-3% of its original forest cover remaining as a result. (CIA: The World Factbook, 2008)

In Singapore, past government policies encouraged migration of a substantial chunk of the urban population into outlying areas to make way for an enhanced central business district.

DEFORESTATION IN SINGAPORE





"Land-use reorganization has been aimed at first relocating a majority of the population living in the city center to the outer areas of the city-state. The objective has been to free the city center for redevelopment into a commercial hub with hotels, offce, and retail space in order to serve the business community. Another objective of land-use reorganization has been the relocation of cottage and small-scale industries to purpose-built industrial estates outside of the city center." This policy, implemented in 1955, has led to a doubling of the built environment and has caused increasing pressure on natural and reserve areas. (G.L. Ooi, "The Role of the State in Nature Conservation in Singapore," Society and Natural Resources, 15:455±460, 2002; 456)

"The forces driving urban development in Singapore have been relentless in the search for land upon which to build. Demands for land for development of urban facilities and infrastructure, including port and airport, have often been pitched against the call for nature conservation. Arguments are often couched rather simplistically in terms of whether land should be left for the birds rather than to meet the needs of the people in Singapore." Moreover, the people's need for nature may well have been met by the city-state's tree planting and park development program; ironically, the system of parks is costly to maintain, while nature preserves require much less in the way of maintenance. (Ooi, 458)

It appears that, whatever the local cause, deforestation finds its larger origins in the tragedy of the commons (Diamond, 428). Current economic models sadly do not take into account the services provided by forests. As in the case of the destructive flooding of the Yangtze River in 1998, that caused an astonishing $30 billion dollars worth of damage due to landslides, these services may be worth far more money than the lumber in the trees. After the destruction, the Chinese government paid loggers to replant the trees, noting that the flood control service of trees was worth three times the value of cut timber. (Brown, 86, 166)

IIRSA: Infrastructure at the Mega Scale

"View of rainforest at the Araguaia River on the border of the states of Mato Grosso and Goia in Brazil" Online Photograph. Shutterstock, November 12, 2008 <http://www.shutterstock.com> c. Frontpage.

IIRSA (The Initiative for the Integration of the Regional Infrastructure of South America), a massive infrastructure project, is an initiative begun in 2000 by 12 South American nations which aims to integrate the physical infrastructure of the entire South American continent. This will be accomplished via a series of 506 projects totaling $68 billion dollars in investment with projects organized along three lines: transportation, energy, and telecommunications. (www.iirsa.org) IIRSA is a threat to tropical forests, largely due to its highway system which will crisscross the Amazon rainforest with a network of new roads that will provide far greater access to forests than has ever been seen before in the region.

The Amazon is the largest intact tropical rainforest on the planet, and the Amazon River system is the largest freshwater ecosystem in the world, containing nearly 20% of the Earth's freshwater discharge and approximately 3,000 species of fish. (Killeen, 50) It is sufficiently large to have a significant impact on weather systems and precipitation stretching between the American Midwest and the Rio Plata Basin, two agriculturally important regions. (Killeen, 60)

Conservationists are also very concerned about the impact its continued deforestation will have on global climate change. Highways which cut the forest into fragments, multiplying the potential points of entry for human activity, will go through protected and indigenous areas and encourage human migration into previously unoccupied terrain. This, it is believed, will cause a pressure on forests and a sharp increase in deforestation.

While regional integration in South America is a noble goal, the combined environmental and social effects of this mega-project have not been evaluated in their totality. (Killeen, 8) Human infrastructure, in the form of roads and dams, breaks up natural environments into isolated parcels, and threatens the species living there as they cannot move in response to changes in their environment; mass extinctions are well within the realm of possibility. (Killeen, 43-51)

HADLEY CIRCULATION

The long-distance effects “of Amazonian deforestation are modulated by a phenomenon known as the Hadley circulation in which warm air rises at the equator, moves toward the poles, descends at higher latitudes, and returns toward the equator along the surface of the earth...” According to climatologists, as deforestation increases, precipitation will be reduced and temperatures will rise in the Amazon. As a result, these impacts will cause climate change in other parts of the world and global warming will continue at a faster rate. (Killeen, 60)

SOUTH AMERICAN LOW LEVEL JET

Meteorologists have documented a weather system that directly links the western Amazon with the Rio de la Plata basin, one of the most important agricultural regions on the earth. In this system, a major gyre originates with the Atlantic trade winds and passes over the Amazon before curving southward as it nears the Andes to form the South American Low Level Jet. (Nogues-Paegle et al, 6; Marengo et al., 2262)

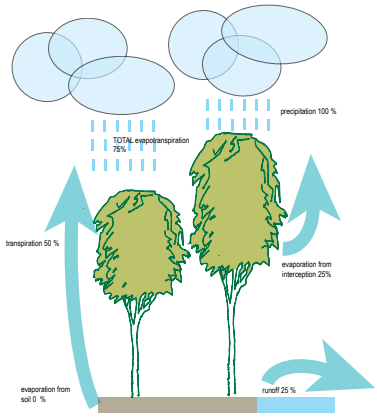
The South American low-level jet is a regional strengthening of a continental-scale gyre, which transports moisture westward from the tropical Atlantic Ocean to the Amazon basin, and then in a southerly direction toward the extratropics of South America. The main recipient of the moisture is the La Plata basin, which “drains a region similar in size to the Mississippi River basin.” (Vera et. al., 63)

The deforestation of the Amazon will have far reaching consequences in terms of its impact on global warming and precipitation in areas far from the forest itself. (Killeen, 60)

IMPACT ZONE OF THE AMAZON RAINFOREST

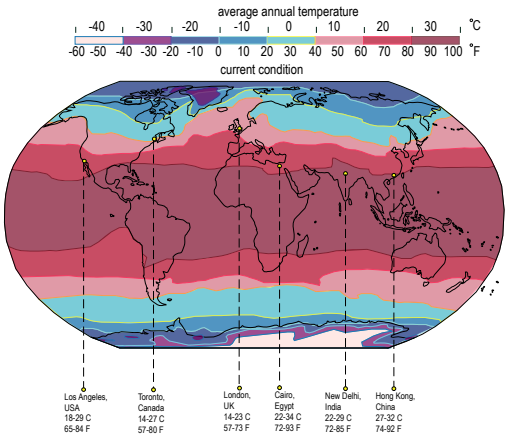
Deforestation in the Amazon severely reduces rainfall from Mexico to Texas and into the Gulf of Mexico most notably in the spring and summer growing seasons when rainfall is essential for agriculture. Similarly, the deforestation of lands in Central Africa affects precipitation in the upper and lower U.S Midwest, while deforestation in Southeast Asia was found to alter rainfall in China and the Balkan Peninsula most strongly. It is important to note that such changes primarily occur in certain seasons and that the combination of deforestation in these areas often increases rain in one region while reducing it in another. (www.nasa.gov/centers/goddard)

RAINFOREST WATER CYCLE

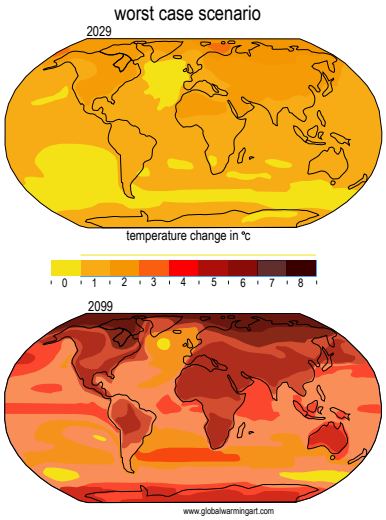


Precipitation in the American Midwest as well as southern Brazil, northern Argentina and Paraguay, all critical agricultural regions, will be strongly affected. (Killeen, 60)

GLOBAL WARMING: +6 C



Average July in Selected Cities

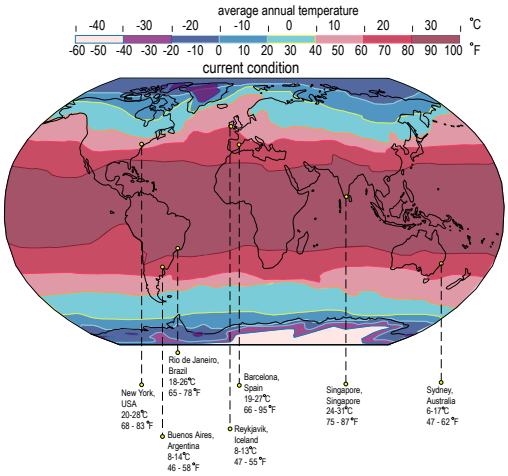


"...hotter oceans would have spawned hurricanes of staggering ferocity, far outdoing anything we see today." (Six Degrees, Mark Lynas, 254)

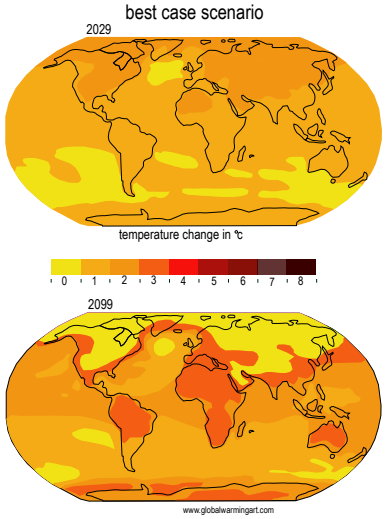
In a world 6 degrees warmer than today **"Super-hurricanes...would have had enough fuel to carry them to the North Pole and back, perhaps even allowing them to repeatedly circumnavigate the globe."** (Lynas, 254)

"...each breath you inhale has more carbon dioxide in it than any breath ever taken by any human before you over the entire evolutionary history of our species." (Lynas, 261)

GLOBAL WARMING: +3 C



Average July in Selected Cities

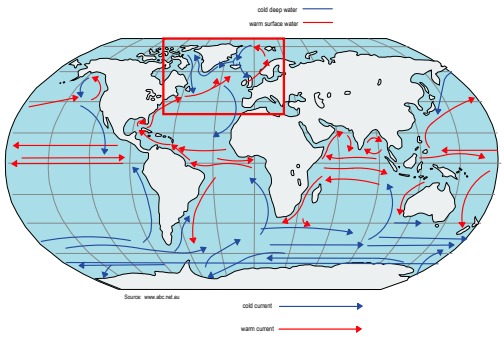


By 2071, Barcelona and Berlin will likely have an average temperature similar to that of North Africa. Paris will be like the South of Spain. (The Guardian, 5/15/07)

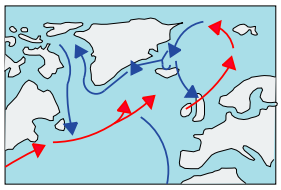
In a world 3 degrees warmer than today **"Evidence suggests that the extent of drying in the three-degree world is going to be far off any scale that would permit human adaptation. ... And for people already eking out a living on the margins of subsistence, the result can be summed up in one word: Famine."** (Lynas, 125)

"Botswana as we know it would drown – not under water, but sand." (Lynas, 127)

SEA CURRENTS AND PRECIPITATION

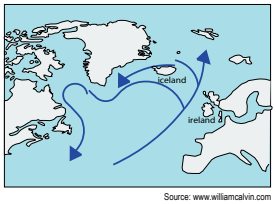


current conditions



potential disaster

In the event of the failure of the northernmost loop of the North Atlantic Current



"We could go back to **ice age temperatures within a decade**...an **abrupt cooling** could be triggered by our **current global-warming trend. Europe's climate** could become more like **Siberia's."** (Calvin, The Atlantic Monthly, January 1998)

The North Atlantic current is an oceanic conveyor belt, **a powerful flow of water the size of around 100 Amazon Rivers,** or the amount of the water contained in all the rainfall on Earth. This current is responsible for the climate in Europe being warmer than it would otherwise be. When compared to locations in North America this becomes plainly evident. Rome, at 42 degrees N is at the same latitude as Chicago, while London and Paris are near the 49 degree N line, which also crosses the Hudson Bay. **Too much melting ice could potentially disrupt this flow, catastrophically altering our climate** and rapidly decreasing average temperatures: " I hope never to see a failure of the northernmost loop of the North Atlantic Current, because **the result would be a population crash that would take much of civilization with it, all within a decade."**

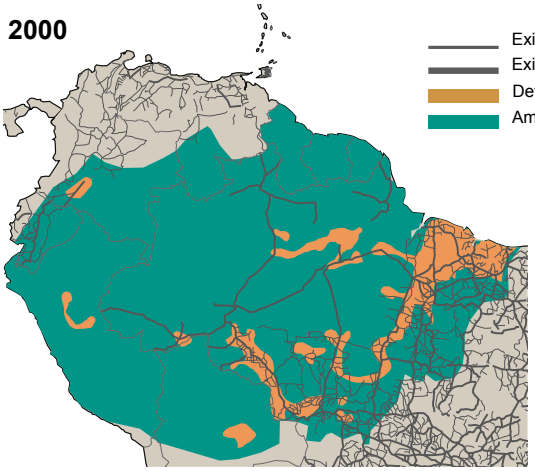
(http://williamcalvin.com/BrainForAllSeasons/Oslo.htm)

THE AMAZON

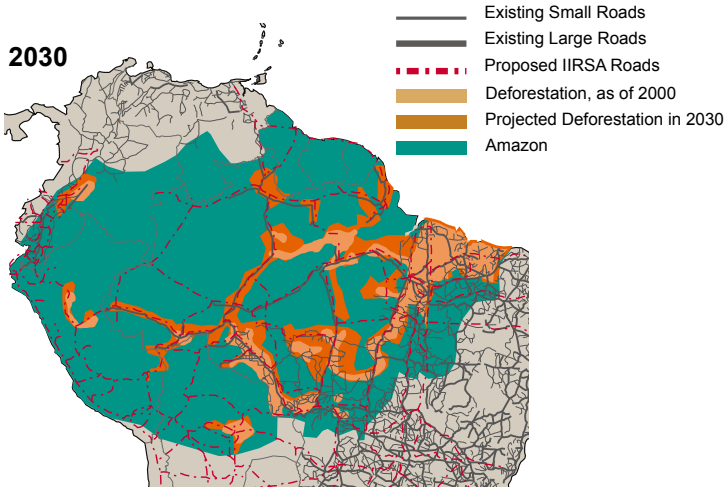
Proposed IIRSA roads will **cut the forest into many fragments,** thus multiplying the number of degraded edge conditions and **creating a fragmented ecosystem.** (Killeen, 60)

IIRSA Combined Action Areas
Source: www.iirsa.org

Amazon Rainforest



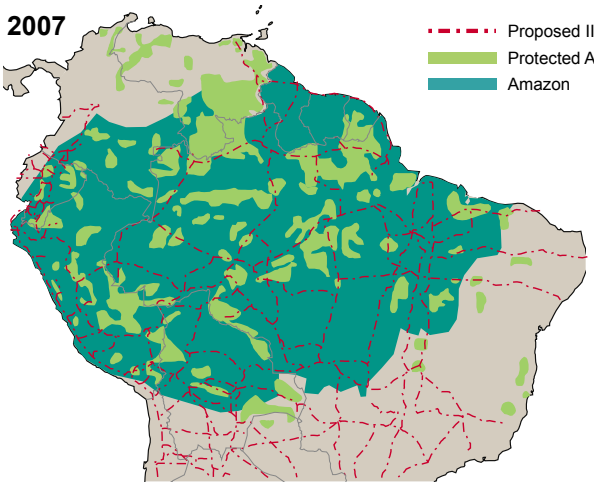
This image demonstrates the correlation between the location of existing roads and the deforestation currently taking place in those locations. While not every road has resulted in forest clearing, there is a strong connection within the Amazon between the pattern of deforestation and the roads. (Based on Killeen, 5)

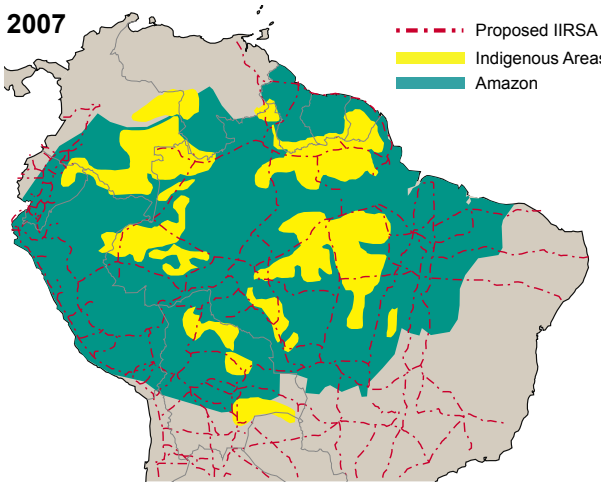


This image presents IIRSA's proposed roads with a projected pattern of deforestation, as estimated to accrue by 2030. (Based on Killeen, 5)

PROTECTED AND INDIGENOUS AREAS WITH IIRSA ROADS

"Analytical and empirical models and studies find that **greater access to forests and markets accelerates deforestation**." (Angelsen & Kaimowitz,85)

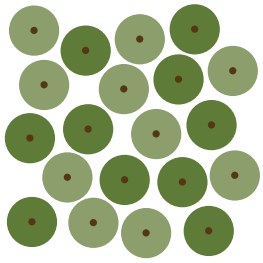




By examining the penetration of projected IIRSA roads into the protected and indigenous areas of the Amazon, it is clear that IIRSA projects will disturb ecosystems and indigenous cultures and affect animal life in South America. (Killeen, 16)

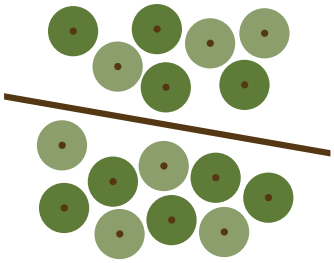
Most of the indigenous people about to be impacted by IIRSA **have no idea that the project even exists.**

DEFORESTATION PATTERNS



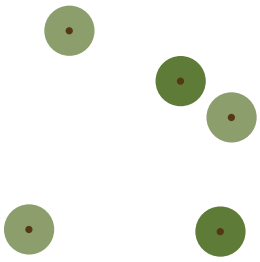
NATIVE FOREST

Forests significantly contribute to regulating the world's climate and are home to a diverse range of plant, animal, and insect species



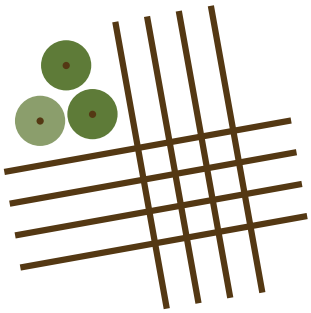
DEFORESTATION IN THE AMAZON

The insertion of roads into the forest divides ecosystems and challenges the diversity of the plants, animals, birds, and insects that live there by dividing habitats. Additionally, roads are often linked to the expansion of industry, agriculture, grazing land, and new towns which all lead to further deforestation.



DEFORESTATION IN HAITI

A combination of logging, unsustainable agriculture, charcoal production, and environmental conditions has led to nearly an entire deforestation of Haiti, with only 2% of the original tree cover currently remaining.



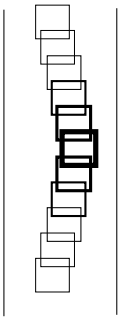
DEFORESTATION IN SINGAPORE

The growth of the city has almost entirely deforested the island, with only a few segregated pockets of forest remaining within the urban sprawl.

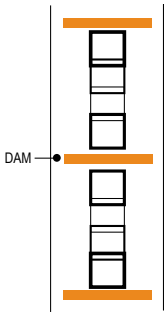
INTERRUPTED ECOSYSTEMS: WHY IS THIS BAD?

AQUATIC ECOSYSTEMS

UNINTERRUPTED



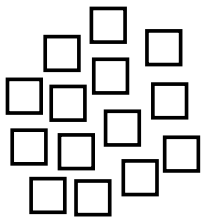
INTERRUPTED

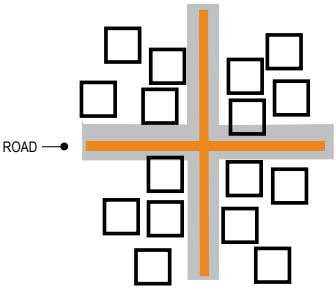


In an interrupted aquatic ecosystem the species are enclosed in an area and are unable to migrate when climate changes. Species can become endangered or extinct if they are not able to adapt to changes in their environment.

Fish Ladder (upload.wikimedia.org)

FOREST ECOSYSTEMS





When roads cross a forest ecosystem they are likely to increase deforestation and human incursions into the area. Moreover, roads are similar to dams in that they effectively block migrations and prevent species from moving in response to climate and other changes.

Animal Underpass (Parks Canada / J. Klafki / September 2006: www.pc.gc.ca)

As deforestation is strongly linked to patterns of individual short term self interest, the question becomes how we can work with rather than against these interests in order to promote a different outcome?

"Landholders will always act to maximize their own economic benefits, and no amount of regulation will successfully alter that behavior... Market regulations take many forms, but the most effective are those based on financial incentives that motivate individuals to choose voluntarily what is in their short-term economic interest." (Killeen, 74)

It would appear that both individual self-interest and our collective and fundamental patterns of inhabitation and colonization of the planet are entirely at odds with the environment. Deforestation equals economic development and progress, and the principal difference between what is happening now, and what happened in the distant past, is the fact that we have reached a crucial tipping point in terms of the ability of the planet to absorb our growing populations and the damage inflicted by our activities. The developing world should not be demonized for arriving late to the table and applying the same formulas for progress which have thus far worked for the rest of the world. Rather, we should begin to incorporate the 'services' provided by tropical forests into our economic equations. Brown notes that:

"Every newly planted tree seedling in the tropics removes an average of 50 kilograms of CO2 from the atmosphere each year during its growth period of 20-50 years, compared with 13 kilograms of CO2 per year for a tree in the temperate regions" (Brown, 167).

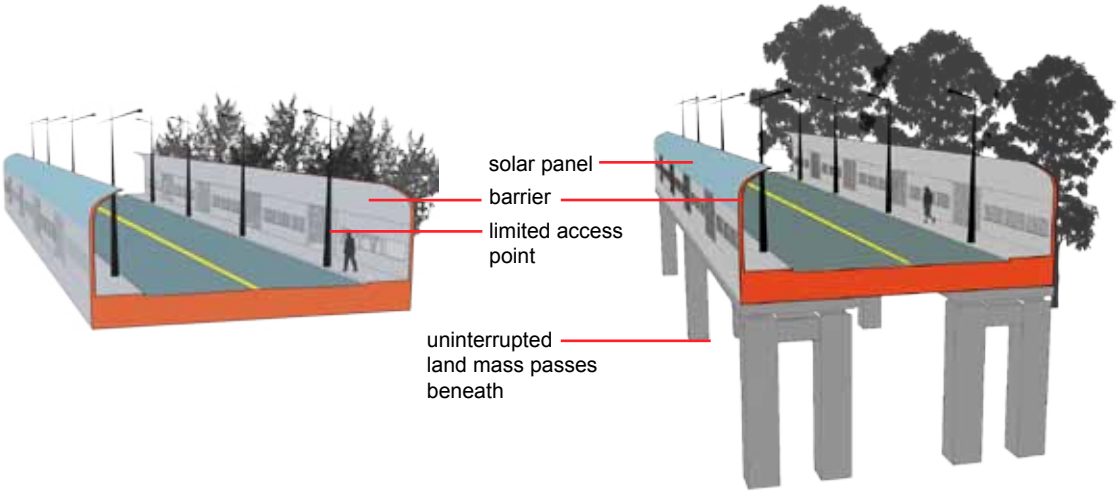
The rainforest has approximately 76 gigatonnes of carbon stored above ground in biomass; if traded in carbon credits on the international market at the current rate of $5-$10 per tonne of CO2, its value would equal between $1.5 and $3 trillion dollars. Without controls placed on deforestation, this carbon, equalling approximately 20 years of fossil fuel consumption, will eventually be released into the atmosphere, making the rainforest a net producer of carbon. (Killeen, 57) Indeed, current estimates suggest that up to 20% of human greenhouse gas emissions come from deforestation in tropical regions, with Brazil and Indonesia being the primary culprits. Stopping deforestation in the tropics "would save the same amount of carbon over the next century as stopping all fossil-fuel emissions for an entire decade" (Lynas, 297). Though the Kyoto protocol doesn't recognize the preservation of existing forest areas as a carbon offset, this idea is well worth exploring. (Killeen 57)The monetization of the services provided by the forest (carbon capture and storage, flood prevention, and the like), could potentially create a system in which those countries who are custodians of the trees are paid 'rent' for the maintenance of their resources.

It is not within the scope of this article to fully examine all the implications of the IIRSA case study. Rather we point to it as another example of tabula rasa planning, this time on a massive scale, that appears to be founded upon the seemingly unquenchable human thirst for the frontier. The main issue underlying the tragedy of the commons is that individuals benefit in the short term from the overharvesting of commonly harvested resources, but suffer collectively in the long term when they are depleted. (Diamond, 428) One solution is for those who share the resource to recognize their common interests and collectively agree to police themselves. This tends to work best in smaller and more isolated homogeneous communities where there is some stake in a common future and the boundaries of the resource and those who exploit it are well known. (Diamond, 429) The government can also enforce quotas, though this may be impractical as the cost of policing the resource may be high. A third solution is to privatize resources, making individuals custodians of them; this practice can be something that emerges from the top down as a governmental initiative. It can also be bottom up as in the case of farmers in Niger who, in the 1980's, noticed that the soil was more fertile and there was reduced erosion when they planted acacia trees in their fields. This practice spread and now there are around 120 million trees on Nigerien agricultural land: "The key to this success story was the shift in tree ownership from the state to individual farmers, giving them the responsibility for protecting the trees." (Brown, 158)

Killeen points to several interesting examples at the macroeconomic or policy level which would appear to hold promise in terms of balancing the needs of economic progress with the environment. In Peru, the petroleum infrastructure is located in remote areas and functions like an offshore platform in the forest by using river transport for equipment and air transport for people. This approach has been much more successful in limiting deforestation than that seen in Ecuador, which has its pipelines running alongside access roads that have often become entry points for tree felling and subsistence agriculture. (Killeen, 30) Moreover, pipelines in Ecuador are sometimes breached by local residents who then claim damages from the oil companies for harm to their lands, making more of a case for keeping pipelines, roads, and people separate. And if they must be built, it might be prudent to construct the roads in such a way as to limit human access, while making under or aboveground crossings for animals in order to as much as possible maintain connected habitats. Limiting roads through pristine forest areas by relying upon air and river transport is one suggestion, as is the need for the carbon storage capacity of forests to be appropriately valued in the economic calculus of the market. (Killeen, 58, 76). By doing so, forested countries could be compensated appropriately for the important role their natural resources play in protecting the health of the planet on the whole.

GREENING OUR INFRASTRUCTURE

"Perhaps the easiest and most efficient way to reduce emissions would be to stop the destruction of tropical forests...estimates suggest that up to 20 percent of human greenhouse hgas emissions come from deforestation in the tropics...Halting this global blitzkrieg...would save the same amount of carbon over the next century as stopping all fossil-fuel emissions for an entire decade." (Lynas, Six Degrees, 297)



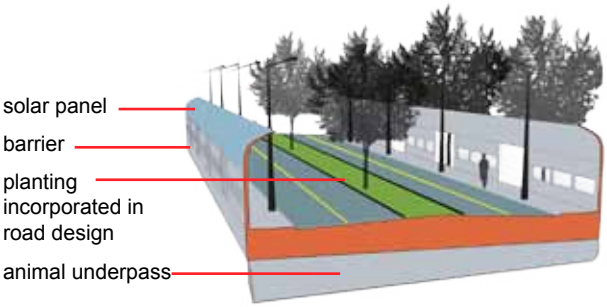
AMAZON BARRIER ROAD WITH CLIP-ON SOLAR PANELS

While it would be better not to construct roads through the rainforest at all, IIRSA is forging ahead. Here we envision a potential compromise solution to the roads proposed by the IIRSA project. If the problem is that roads increase access, it may be worthwhile considering the development of road systems which limit access or have access at specific entry points which are controlled. A barrier of the type shown above still provides a view of the surroundings, and also provides an infrastructure upon which can be mounted solar panels, wind belts, and other sustainable energy generating devices.

AMAZON ELEVATED ROAD

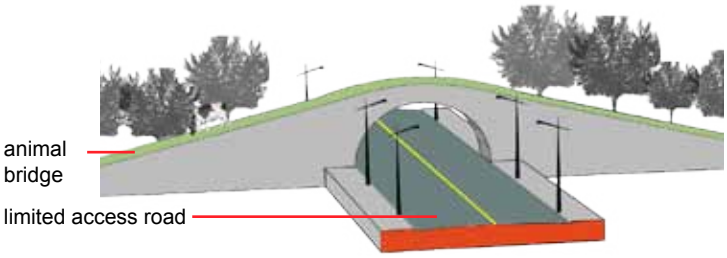
Elevating roads makes access by human beings to pristine forest areas more difficult, and yet still allows animals to migrate and move freely beneath the road surface. While not ideal from a conservation standpoint where leaving such areas entirely alone is best, this represents a compromise solution, given that road construction projects are already planned for the area.

Animal overpasses and underpasses have been used very successfully in Canada: "... Parks Canada has upgraded portions of the highway. This includes dividing and twinning the lanes and installing fencing and wildlife overpasses and underpasses. These crossings allow animals to pass safely over or under the highway. The system has reduced collisions with wildlife by more than 80%. By monitoring the wildlife crossings, Parks Canada has learned that 10 species of large mammals have used them more than 60,000 times since 1996."
<http://www.pc.gc.ca/canada/pn-tfn/itm2-/2006/2006-04-10_E.asp>



AMAZON BARRIER ROAD WITH GREEN STRIP

The roads in the Amazon, or any other road for that matter, provide an opportunity for planting, thus giving back a bit of the surface area taken up by the road. Here a simple underground tunnel allows access by wildlife to the two sides of the road. A barrier which discourages human interventions in the forest also prevents animals from being killed on the road. Wind belts and other technologies can be incorporated into roads, which represent a vast amount of surface area which could be used to generate energy sustainably. It is our belief that we should view all surfaces, whether infrastructure or buildings, as potential sites for the deployment of green strategies. Electric cars at their current level of development can be used for day to day travel and commuting, thus reducing a huge source of greenhouse gas emissions.



ROAD WITH ANIMAL BRIDGE

Similar to the concept of the fish ladder, a device used to aid fish migrations over dams, the animal bridge provides a connective link between the otherwise isolated parts of the ecosystem on either side of the road. This diagram is envisioned as a limited access road with checkpoints, and so has a reduced need for side barriers preventing access to the forest.

<http://www.go-explore-trans.org/images/2007/sept-oct/overpass.jpg>

An Urgent Deadline

"...we do have a short time left to cut back emissions in order to avoid 'dangerous' level of warming and can still aim for a 'safe landing' within the one to two degree corridor. This window of opportunity is very nearly closed, however. ... we have less than a decade remaining to peak and begin cutting global emissions. This is an urgent timetable, but not an impossible one." (Lynas, 270)

Though a few degrees Celsius of warming may not seem all that severe, here are some chilling examples as food for thought. The last ice age, which occurred some eighteen thousand years ago, saw average world temperatures about six degrees colder than those of today. (Lynas, 17) A world six degrees warmer would be something akin to Dante's Sixth Circle of Hell, a world subject to powerful storms far beyond what we are currently able to imagine, including hurricanes able to circumnavigate the globe, and methane explosions which "would dwarf even the most severe modern battlefield weapons" (Lynas, 257). We are already heading toward a likely 1.5 to 2 degrees of warming, and at a likely cost of $15 trillion dollars as it is, so what is to be done? (Lomborg, Times Online, 9/30/08) How can we become more efficient and moreover, how can all that excess carbon be absorbed? Wouldn't it be great if we could just turn on a carbon vacuum cleaner and clean up the whole mess?

Tree as Carbon Vacuum Cleaner

Well, we already have carbon vacuum cleaners, of a sort. They're called plants and trees, and they do the opposite of what we do when we breathe in oxygen and breathe out CO2, or when we take a trip by car to the supermarket. They also have the potential to absorb much of the CO2 we emit year after year, when combined with other sustainable strategies.
Not every tree absorbs the same amount of carbon, and trees in the tropics, as mentioned earlier, absorb more CO2 than temperate trees. However, on average, a tree absorbs approximately 3 kilograms of carbon dioxide from the air per year. Scientists have pointed to the importance of forests in carbon capture. One recent study quantifies it thus:
"Factoring in effects of climate, history and tree type, the researchers developed an equation suggesting that a heavily forested region in northern Michigan could store more than 350,000 tons of carbon per year. With the area population emitting about 573,000 tons of carbon annually, the forests would sequester approximately 62 percent of the region's human-caused carbon emissions -- the equivalent of yearly emissions from about 225,000 cars." ('http://www.sciencedaily.com/releases/2008/09/080908185330.htm')
South Korea is a world model for reforestation. At the end of the Korean War, seeing that the country was largely deforested, the government launched an ambitious replanting scheme on its terraced mountainsides that now sees some 65% of the country's land area covered again with forests. (Brown, 157) The African Union has launched an ambitious plan to plant 300 million trees in a line stretching across the continent in order to combat advancing desertification. China is engaged in a similar fight against the Gobi Desert, and is planting a belt of trees called the Green Wall that will stretch some 2,800 miles (4,480 km) from Beijing to Inner Mongolia. China is also paying farmers to plant trees on their land, with an ultimate goal of covering some 10 million hectares. (Brown, 160) New York City has an ambitious plan to plant a million trees in parks and on streets over the next decade, and there is a plan to make the city sustainable by 2030. Indeed many cities around the world are adopting environmental initiatives independently of their national governments and are participating in the Cities for Climate Protection campaign. (Dow & Downing, 78) Certainly the idea of reforesting for the purpose of carbon sequestration is a worthy one. However, another untapped resource for the application of strategies of efficiency and carbon capture remains the structure and fabric of the city itself.

The Role of the City

The city is a potent generator of carbon emissions when one factors in the distance goods must travel to arrive there, the energy used by the buildings and their many occupants, and the vehicles used to travel between the city and its outlying suburbs. Individual carbon footprints vary greatly depending upon lifestyle, as can be seen in the table on the next page, and the industrialized modern lifestyle may not necessarily equal the highest amount of carbon emissions. It is this writer's belief that, given the seriousness of the timetable for the massive change to our way of life which must take place over the next seven to ten years, strategies which involve a retrofit or a clip-on to our existing infrastructure deserve a serious look. Fossil fuels are a very potent and concentrated form of energy, and it is estimated that we collectively use about "a million years' worth of fossil fuels every year, expressed in terms of the time it took for them to form..." (Lynas, 284) The estimates for how much space must be devoted to the installation of alternative non carbon emitting technologies for the generation of power are staggering. Robert Socolow and Steve Pacala have come up with a system of carbon wedges in order to make this concept easier to understand. (see diagram on following page)

Business as usual is represented by the diagonal line ramping up to 14 GtC/year in 2054, and stabilization is represented as a flat line remaining at 7GtC/year. Each wedge is an activity which starts at zero and ends up equaling a reduction in CO2 emissions of 1GtC/year 50 years from the present. (Socolow and Pacala, 968) Lynas feels that even this is not enough,

HOW MANY TREES = MY LIFESTYLE?

PARIS

A person living in Paris, France who shares an apartment with one other person, and uses the average electricity and propane gas, as well as a small motorbike for local transportation and who takes the train for small trips inside of France, usually eats white meat and in-season food, shops for local products, buys things with little packaging, recycles most of his/her waste, and goes out ocasionally to movies, bars or restaurants would need to plant 8 trees to absorb the amount of carbon generated by this lifestyle.

= 8 trees per capita

NEW YORK

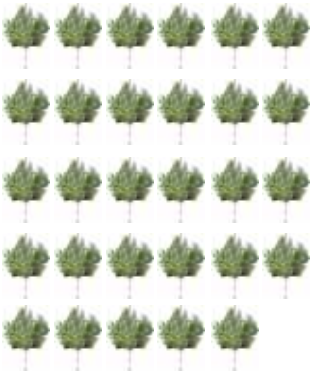
A person living in New York City in the United States in a one person apartment, who uses the average consumption of electricity and propane gas, takes the subway for transportation, taking the bus to Boston 5 times a year and traveling to Chicago and LA by plane once a year, who is vegetarian and eats only organic food, shops for local products, buys things with little packaging, recycles most of his/her waste, and mostly does zero carbon activities would need to plant 7 trees to absorb the amount of carbon generated by this lifestyle.

= 7 trees per capita

MONTERREY

A person living in Monterrey, Mexico in a large house with 4 other people who uses the average consumption of electricity and propane gas, and travels locally by SUV, taking the bus for small trips inside of Mexico and traveling by plane to Mexico City, Playa del Carmen and Paris one time a year, who usually eats red meat, shops for the latest fashions, doesn't ever recycle and owns a car would need to plant 29 trees to absorb the amount of carbon generated by this lifestyle.

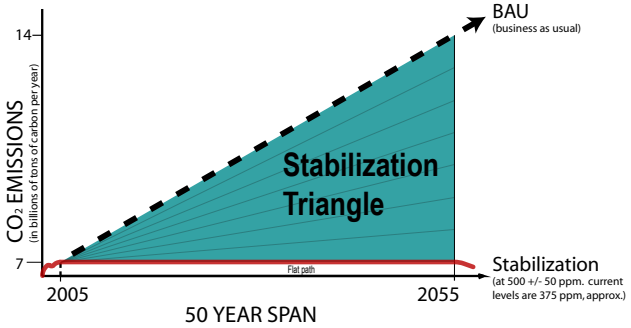
= 29 trees per capita



OFFSETTING CO2: STABILIZATION WEDGES

"Humanity can solve the carbon and climate problem in the first half of this century simply by scaling up what we already know how to do." (Pacala and Socolow, 968)

1 WEDGE = AVOIDS
1 BILLION TONS OF CO_2 EMISSIONS
PER YEAR BY 2055



- We can prevent a doubling of CO_2 if we can keep emissions flat for the next 50 years
- Keeping emissions flat will require cutting projected carbon output by about 7 billion tons per year by 2055
- To make the problem more tractable, Socolow and Pacala divided the stabilization triangle into seven "wedges."
- A wedge represents a carbon-cutting strategy that has the potential to grow from zero today to avoiding 1 billion tons of carbon emissions per year by 2055, or one-seventh of the stabilization triangle.
- Keeping emissions flat will require the world's societies to "fill in" the seven wedges of the stabilization triangle.

Renewables & Biostorage

-Wind-generated electricity
-Solar electricity
-Wind-generated hydrogen fuel
-Biofuels
-Forest storage
-Soil storage

Efficiency & Conservation

-Increased transport efficiency
-Reducing miles traveled
-Increased heating efficiency
-Increased efficiency of electricity production

Fossil-Fuel-Based Strategies

-Fuel switching (coal to gas)
-Fossil-based electricity with carbon capture & storage (CCS)
-Coal synfuels with CCS
-Fossil-based hydrogen fuel with CCS

Nuclear Energy

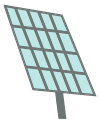
-Nuclear electricity

(Socolow + Pacala "Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies." Science Magazine, 13 August 2004 Vol 305)

"Stabilization at any level requires that **net emissions** do not simply remain constant, **but eventually drop to zero**...To develop the **revolutionary technologies** required for such **large emissions reductions** in the second half of the century, enhanced **research and development** would have to begin **immediately."** (Pacala and Socolow, 968)

stating that Socolow and Pacala's 500 ppm concentration is about 100 ppm too high. It would likely warm the Earth by somewhere between three and four degrees, "probably crossing both the carbon cycle and Siberian methane tipping points in the process." (Lynas, 300) The two tables below perform a calculus of various categories of sustainable strategies and the amount of landmass they require.

STABILIZATION WEDGES QUANTIFIED: DO WE NEED TO GO NUCLEAR?

Alternative Energy	Size required to cover one wedge	Area required if we were to use each alternative energy source to cover all of our energy needs (7 wedges)	Percentage required of the whole world's land mass
 Wind power	= "a wedge of wind power would require a combined area roughly the size of Germany."	357,000 Km^2 x 7 = 2,499,000 Km^2 965,000 Sq.miles	= 5.7 % of the world's total land mass
 Solar energy	= "a wedge worth of PV would still require arrays with an area of two million hectares, 20,000Km^2, or half the size of Switzerland."	20,000 Km^2 x 7 = 140,000 Km^2 54,000 Sq.miles	= 0.32 % of the world's total land mass
 Nuclear power	= a wedge worth of nuclear electricity requires an area of 0.78 square miles, 2.02 Km^2, or the size of Monaco.	2 Km^2 x 7 = 14 Km^2 5.4 Sq.miles	= 0.000032 % of the world's total land mass
 Reforestation	= "new forests would have to be established over an area the size of the contiguous United States."	963,000 Km^2 x 7 = 6,741,000 Km^2 2,602,714 Sq.miles	= 15.5 % of the world's total land mass

(Socolow + Pacala "Stabilization Wedges: Solving the Climate Pro em for the Next 50 Years with Current Technologies." Science Magazine, 13 August 2004 Vol 305)

WHAT IF WE ONLY USED GREEN ENERGY AT CURRENT LEVELS OF CONSUMPTION?

World CO_2 Emissions
TOTAL EMISSIONS (in millions of metric tonnes)

ASIA 7,402.8
EUROPE 6,156.9
MIDDLE EAST & AFRICA 467.1
NORTH AMERICA 6,202.3
CENTRAL AMERICA AND THE CARIBBEAN 484.8
SOUTH AMERICA 731.1
OCEANIA 383.9

TO ACHIEVE CURRENT LEVELS OF ENERGY CONSUMPTION WITH GREEN ENERGY EACH COUNTRY WOULD NEED:

ASIA
5,694,462 SOLAR PANELS OR 3,364,909 WIND TURBINES

EUROPE
4,736,077 SOLAR PANELS OR 2,798,591 WIND TURBINES

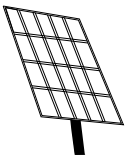
MIDDLE EAST & AFRICA
359,307 SOLAR PANELS OR 212,318 WIND TURBINES

NORTH AMERICA
4,771,000 SOLAR PANELS OR 2,819,227 WIND TURBINES

CENTRAL AMERICA & THE CARIBBEAN
372,923 SOLAR PANELS OR 220,363 WIND TURBINES

SOUTH AMERICA
562,384 SOLAR PANELS OR 332,318 WIND TURBINES

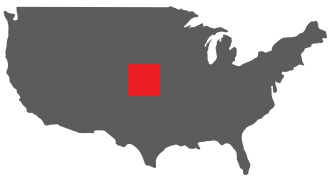
OCEANIA
295,307 SOLAR PANELS OR 174,500 WIND TURBINES



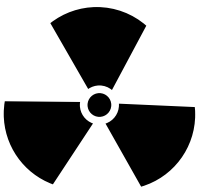
AN AVERAGE SOLAR PANEL SAVES ABOUT 1,300 TONNES OF CARBON PER YEAR FROM ENTERING THE ATMOSPHERE

A wedge of photovoltaic electricity generation would need a 700 fold increase from today's total, covering two million hectares (five million acres) of land, equivallent to .2% of the total land area of the United States.

EACH WIND TURBINE SAVES ABOUT 2,200 TONNES OF CARBON PER YEAR FROM ENTERING THE ATMOSPHERE



for wind power to achieve one wedge, two million one-megawatt turbines would be needed, a 50 fold increase from today's deployment. the turbines would cover 30 million hectares (74 million acres), equivalent to 3% of the total land area of the United States.



NUCLEAR POWER
The energy contained in one pound of uranium is equal to the energy produced by about 1.3 million pounds of coal.

Nuclear power is a very low-carbon energy source, and has a proven track record in electricity generation, however it also raises the spectre of nuclear weapons proliferation and deadly accidents, as well as the still unsolved issue of how to safely dispose of highly radioactive wastes.

http://www.cbc.ca/news/background/energy/sources.html

The City as Usable Surface Area

A densely populated city replicates its ground surface area many times over in the surfaces of the buildings which populate it. I will use the example of New York, a city with which I am very familiar, though the same sort of calculus is applicable to cities across the world. New York City covers some 309 square miles (801 sq km) of land area, much of which is built up. As of the 2000 census, there were 7,679,307 housing units in the five boroughs. (<http://factfinder.census.gov>) A recent New York Times article quantifies the amount of available roofspace in the city alone as 944 million square feet, a mere 11.5% of the total building area the city holds. (<http://www.nytimes.com/2008/08/28/nyregion/28roof.html?_r=1>) Given that the population on the planet is rapidly increasing and due to double over the next 100 years, we may soon need all the available arable land for growing crops, with marginal lands where food crops provide inadequate yields relegated to biofuel crops. (Killeen, 39) As the available space for the necessary green technologies is limited, it makes sense, therefore, to consider the city as the surface for our intervention.

To take our argument further, a hypothetical six story apartment building has a footprint of approximately 2,100 square feet. The vertical surface area available on the facade for the deployment of green technologies using wind and solar power, or green screens for vertical gardening, or water walls for cooling, is approximately 12,000 sf if the building is freestanding, and around 3,600 sf if it is in an infill condition. Add on the roof area, much of which remains unused, and you get 14,100 sf for the freestanding and 5,700 sf for the infill building. Take off a bit of the square footage to account for window openings and the like, but it remains nonetheless a significant amount of available space. Multiply that by the sheer number of buildings occupying any densely populated urban condition and the number becomes more significant still. New York State also has 113,000 miles of highway, another forgotten infrastructure to which clip-ons may be added. (<http://www.atssa.com/galleries/default-file/NY_SHSP_FINAL.pdf>)

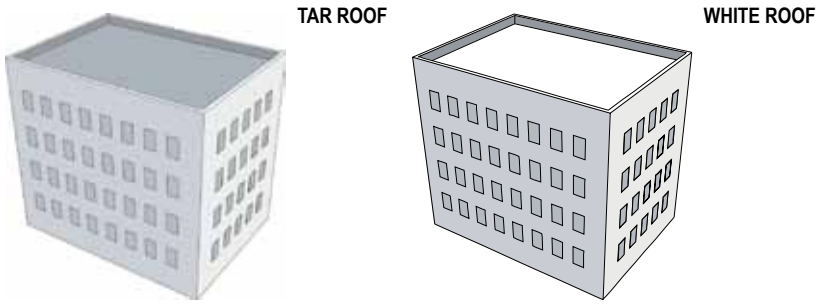
Sustainable Solutions

Even something as simple as painting roofs white, instead of black, has been shown to provide a significant savings in terms of the amount of energy expended to cool buildings, as well as reflecting heat away from the city rather than absorbing it. Indeed, Hashem Akbari, a physicist at the Lawrence Berkeley lab estimates that painting the average American 1,000 sf roof white would offset 10 metric tons of CO2. The urban roofscape constitutes approximately 20-25% of the urban surface area, and paved roads make up another 40%. If all of those surfaces in the 100 largest cities in the U.S. were painted white instead of black, he states, that alone would constitute a fairly significant carbon offset in the range of 44 metric gigatons. (<http://machinist.salon.com/blog/2008/09/12/white_roofs/index.html>)

Many sustainable low-tech options are currently being developed for and by developing countries. Notably, in many cases it takes a relatively small investment to make a huge difference. USAID is working in Kenya to distribute 780,000 solar cookstoves which, as they are more efficient, require less wood, relieving some of the pressure on local forests as a source of cooking fuel. (Brown, 154) Non turbine wind belts are being developed for the market by a team from MIT who, in 2004, got the idea as they were working to solve the energy needs of the local Haitian population in Petite Anse. The belts function by converting the vibration caused by the wind passing over them into energy. (<www.humdingerwind.com>) Other pole mounted wind turbines have also been developed at a scale that is more readily deployable within the confines of the city, and able to harness wind energy coming from all directions. (<http://www.quietrevolution.co.uk/>) Rooftop solar water heaters in China have made a big splash and, at $200 each, they are widely being used in villages which do not yet have electricity. There are around 40 million of these heaters being used in China today. (Brown, 246)

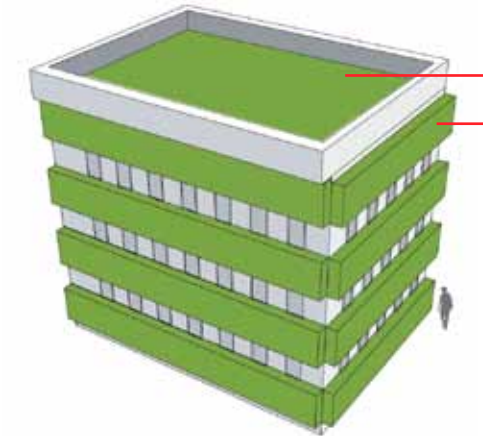
Special gutters are now available for the collection of rainwater for passive heating and cooling, or for the generation of electricity via waterfalls. (<http://www.smartflo.com.au/>) There is great interest in the potential of algae, which can be grown almost anywhere, and is faster growing even than bamboo. Certain types of algae may be as effective in capturing CO2 as trees, and algae is currently being used in a pilot project at MIT where it absorbs 40% of the CO2 emissions from a power plant and is then converted into biofuel. (<http://www.csmonitor.com/2006/0111/p01s03-sten.html>) In-stream turbines for rivers allow for the generation of electricity without the expense and environmental damage that can be caused by large scale dams. The Spiteri Water Pump, a machine which generates electricity when immersed in a body of water by harnessing its latent electrostatic energy, does not need any fuel to operate. It has low operating costs and generates energy 24 hours a day. (<http://www.timesofmalta.com/articles/view/20080601/local/maltese-energy-invention-wins-international-award>) Geothermal energy is another, virtually limitless supply of power from the earth's core that is presently used to heat over 90% of the houses in Iceland, and constitutes more than one third of the country's energy usage. About half of the world's geothermal capacity is concentrated in the United States and the Philippines, with other countries bordering the ring of fire in the Pacific not far behind. (Brown, 253-54)

Greening our cities: Exterior applications



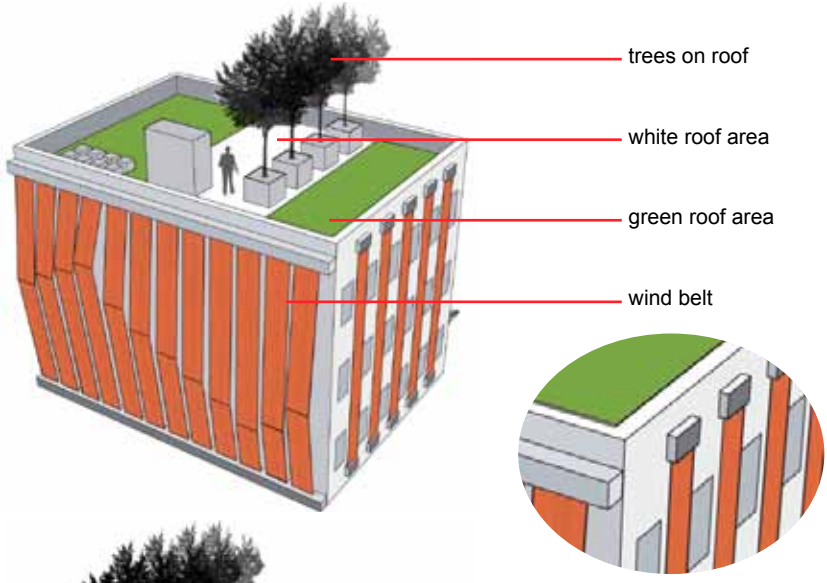
"Hashem Akbari, a physicist at the Lawrence Berkeley lab, just released a study showing that the average American 1,000-square-foot white roof could offset 10 metric tons of carbon dioxide.

According to his data, roofs constitute 20 to 25 percent of urban surfaces, while pavement is about 40 percent. Therefore, if all of those surfaces were switched to a reflective material (or color) in the 100 largest urban areas in America, his calculations show, this would offset 44 metric gigatons of carbon dioxide. That's more than all countries emit in a single year. Further, that's worth about $1.1 trillion at current carbon trading rates."
"Paint your roof white, save the planet." Online article. Machinist. 12 Sept. 2008 <http://machinist.salon.com/blog/2008/09/12/white_roofs/index.html>



GREEN SCREEN

By integrating more trees and photosynthesizing plants within the fabric of our existing cities, we harness the power of plants to absorb carbon from the atmosphere. The surface area of buildings multiplies the ground footprint of the city many times over, making vertical gardening and the integration of growing walls into our buildings an interesting practical solution. The roofscape of most cities is an area that is often forgotten but that could easily be used for the application of green technologies beneficial to all. Greenscreen is a type of metal structure that can be attached to existing walls or used to create freestanding growing walls: <http://www.greenscreen.com/home.html>

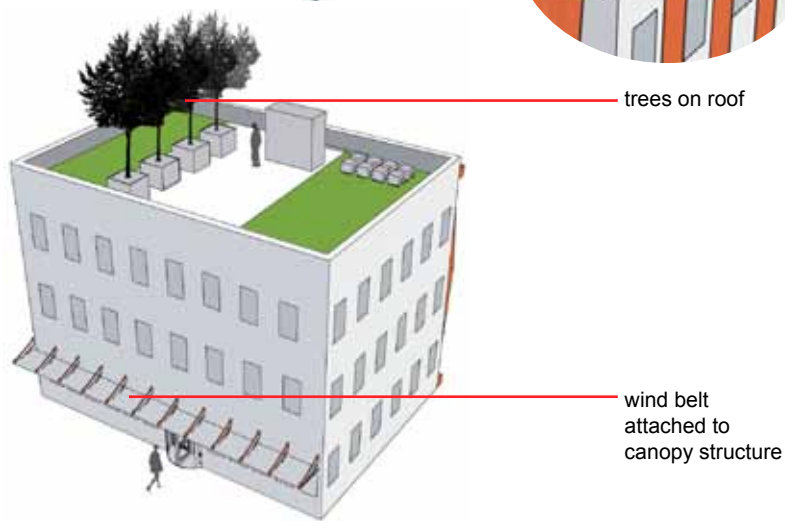


WIND BELTS AND GREEN ROOF

Wind belts are a recent technology which harness the power of the wind to generate electricity. They are relatively inexpensive and suitable for both developed and developing countries and are the first wind technology not to employ turbines: "About the size of a cell phone, the final Windbelt prototype employs a taut membrane that, when air passes over it, vibrates between metal coils to generate electricity."

http://www.businessweek.com/innovate/content/oct2008/id2008106_231604.htm?campaign_id=rss_topStories

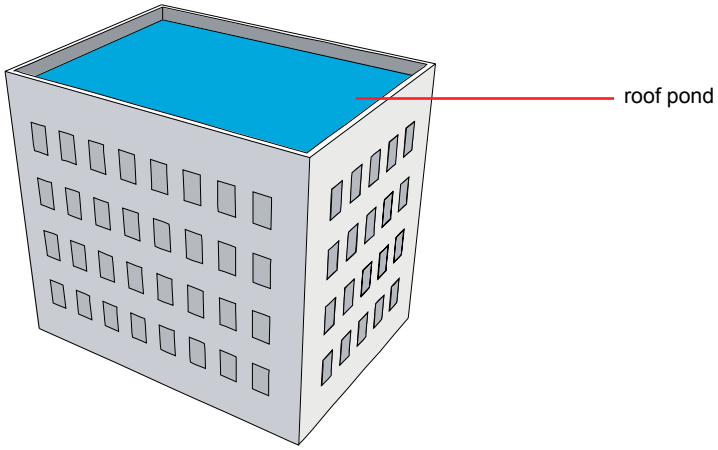
Wind belts could be used on the facades and roofs of existing buildings as a sculptural element, taking advantage of the building envelope as an available surface upon which to attach. Trees may be planted on the roof by using either planters or by using a new Japanese soil substitute, Pafcal, which is much lighter than earth.
http://www.treehugger.com/files/2008/02/alternative-soil.php



WIND BELTS AND GREEN ROOF

Wind belts can also be attached to functional structures such as canopies which are normally used to protect the building entry from rain.

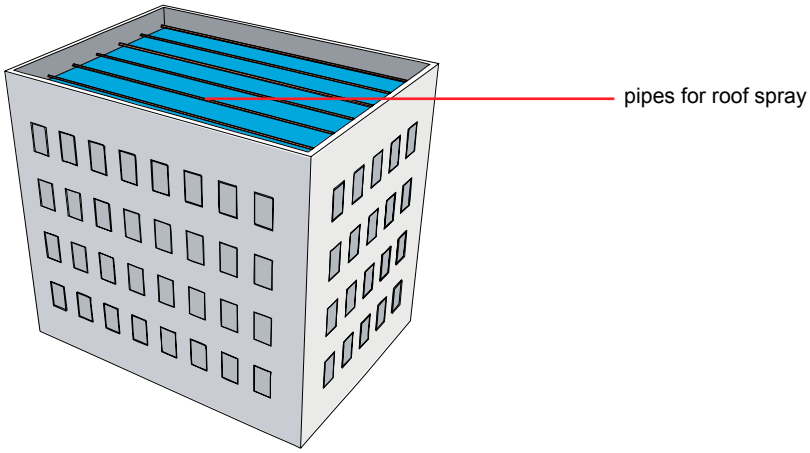
http://www.businessweek.com/innovate/content/oct2008/id2008106_231604.htm?campaign_id=rss_topStories



ROOF POND

Roof ponds can be used for cooling in areas that are warm and not very humid. This technology has a lot of potential, but has been underused to date because of a fear of leakage on the part of architects and clients, however, if properly detailed it is a promising strategy and can help to reduce the heat island effect in cities. Water is placed between two layers of insulating material. The area covered with water should be 85% to 100% of floor area in places with winter temperatures between 25 and 35 degrees Fahrenheit (-4 to +2 Celsius) and 60% to 90% of floor area in places with winter temperatures between 35 and 45 degrees Fahrenheit (+2 to +7 degrees Celsius). Average pond depth is between 3 and 6 inches. Insulating panels cover the roof and are opened during the day in the winter to absorb the heat of the sun, and at night, the panels are closed, allowing heat to radiate to the building's interior. In the summer, the process is reversed.

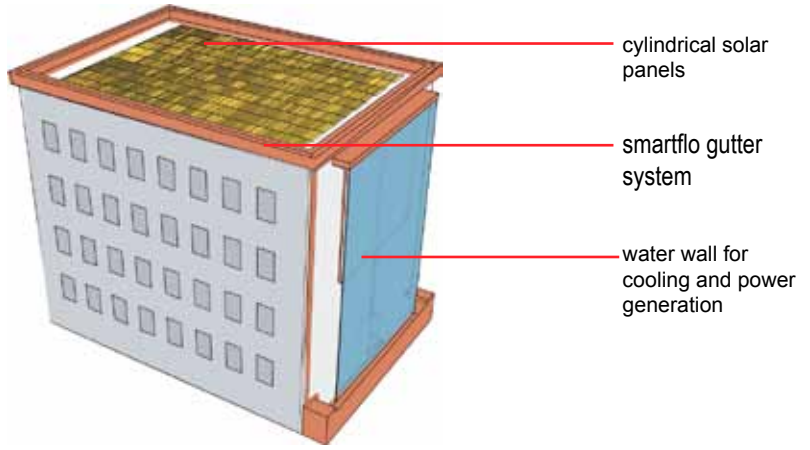
Benjamin Stein and John S. Reynolds: Mechanical and Electrical Equipment for Buildings, Ninth Edition. John Wiley and Sons, 2000. P 224.



ROOF SPRAY

This is another method for cooling which could be employed in a retrofit of existing buildings. It can be used in combination with the roof pond, or independently with the water being stored in a tank. Here water is cooled by spray at night, via evaporation and night sky radiation, and then stored for use during the day in the building's cooling system.

Benjamin Stein and John S. Reynolds: Mechanical and Electrical Equipment for Buildings, Ninth Edition. John Wiley and Sons, 2000. P 379-80.



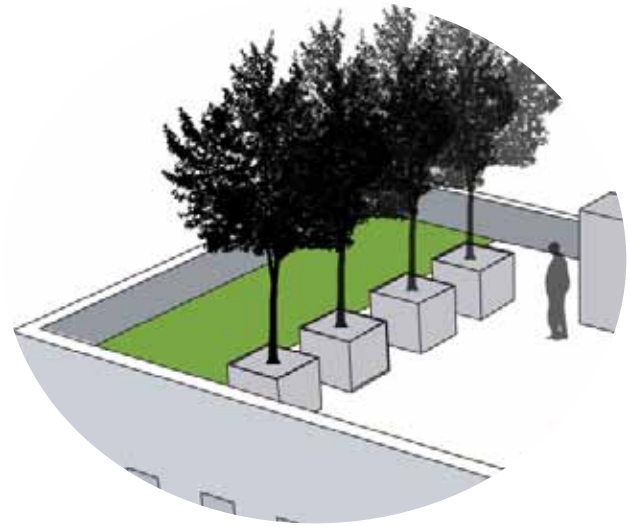
WATER WALL, WATER COLLECTION AND SOLAR PIPE

It is well known that electricity can be generated from fast moving water. Here, we propose that a water wall be added to a blank facade on an existing building as a means of generating electricity. Water can be collected via a system of gutters on the building, and then can be piped and recycled to generate the necessary flow. This water can also be used to flush toilets and for other non-potable applications. In addition, the water provides cooling to the building's inhabitants.
www.http://www.smartflo.com.au/SF_Concept.htm>

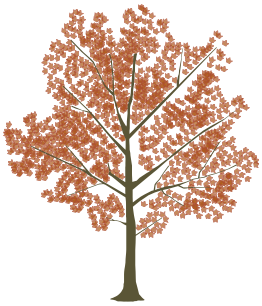
The roof in this scheme is envisioned as a space in which the entire surface area is covered by solar coils. This is a recent development: "Solyndra's panels employ cylindrical modules which capture sunlight across a 360-degree photovoltaic surface capable of converting direct, diffuse and reflected sunlight into electricity. This self-tracking design allows Solyndra's PV systems to capture significantly more sunlight than traditional flat-surfaced solar panels..."

Press Release. Online article. <http://www.solyndra.com/News/Press-Release-01>

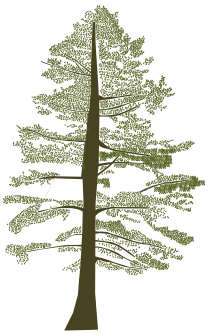
WHY A GREEN ROOF? ESTIMATED CARBON ABSORPTIVE POWER OF TREES



The amount of carbon dioxide or greenhouse gas emissions that a tree absorbs is not the same for all trees. An oak tree in the Midwest absorbs a different amount of CO_2 than a palm tree in Florida or a pine tree in Canada. The absorbtion of carbon dioxide of each tree is different depending on its size, how old the tree is and the type of climate where it grows. However, it is estimated that one tree removes an average of 3 kilograms of CO_2 from the air in one year.



A 25 year old maple tree absorbs 1.1kg or 0.0011 tonnes per year of CO_2. So, over 25 years you would need 36 maple trees to offset one tonne of CO_2. Trees can live for longer than 25 years and subsequently absorb more CO_2.



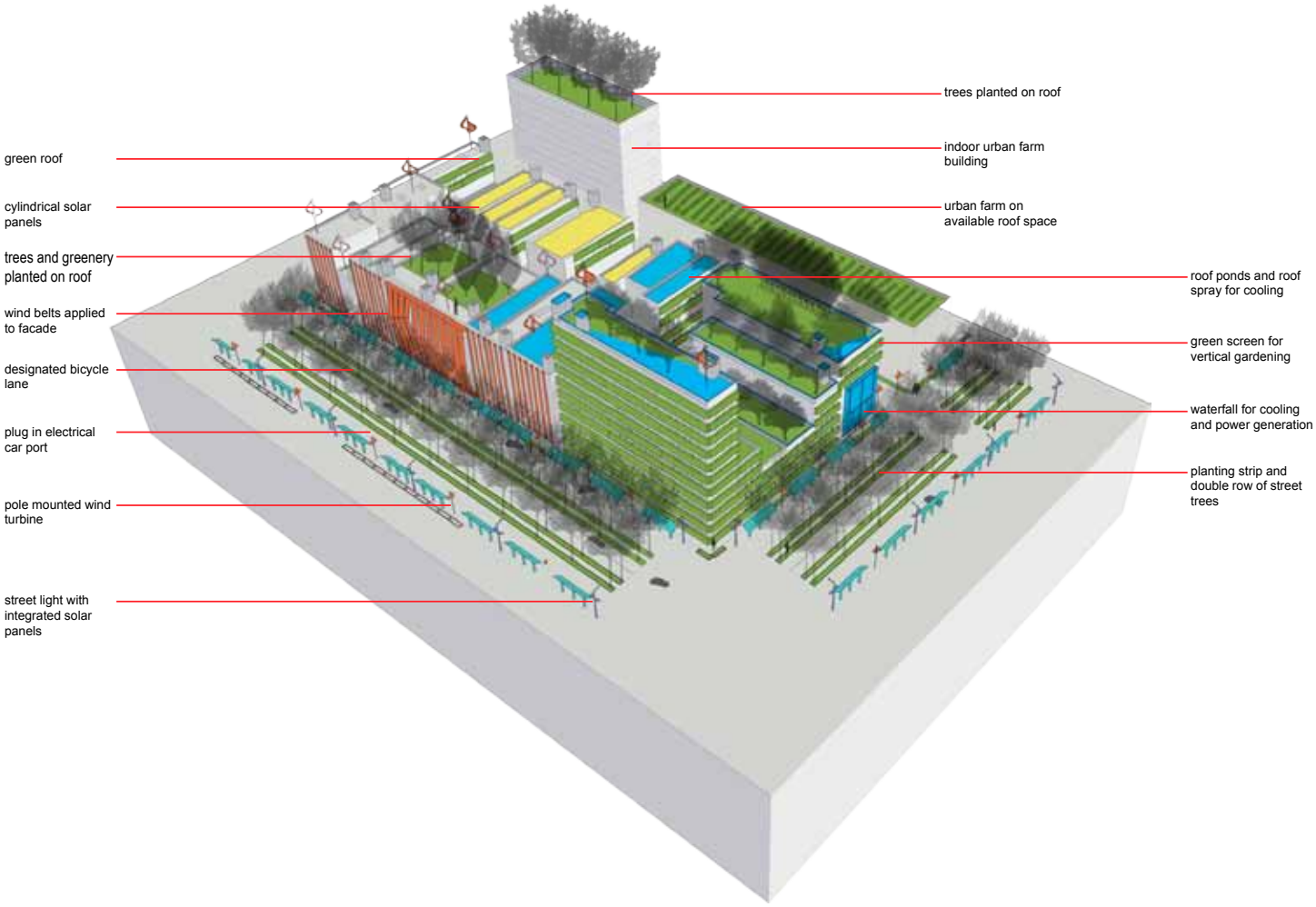
A 25 year old pine tree absorbs 6.82kg or 0.00682 tonnes of CO_2 per year. Over 25 years, you would only need 6 trees to offset one tonne of CO_2.

http://www.erasecarbonfootprint.com/treeoffset.html
and
http://www.savetheplanet.co.nz/carbon-wave-power-whatis.html

Lightweight soil substitutes such as Pafcal are being developed which will allow for roof planting without the heavy loads associated with soil. (<http://www.suntory.com/about/news/2008/10033.html>) Green screens have been developed which can allow vertical gardens to grow up the facades of existing buildings. (<http://www.greenscreen.com>) Urban farming, which could take place in buildings within the city limits, thus drastically reducing the travel distance for foodstuffs, is being explored. Indoor farming does not require fossil fuels for plowing fields and driving harvests to market, nor does it require fertilizer or pesticides, and plants can be grown 24 hours a day. Indeed, “a 30 story farm that covered a city block could feed 50,000 people year round” (Fischitti, 74). Solar modules are being designed that can be attached to light fixtures, (<http:www.dimmer.de>) or which come in rounded tubes and are able to collect more energy from the sun than traditional solar panels, converting direct, diffuse, and reflected sunlight into power. (<http://www.solyndra.com>) So it would appear that Socolow and Pacala are correct in their assumption that all or most of the technology needed to reduce carbon emissions to stabilized levels already exists.

THE CITY AS RETROFIT: CLIP ONS TO THE RESCUE!

What might it look like to see all of these technologies together? There are obviously many things which have not been discussed here that may be applied both within and outside the building envelope, and there are still many issues to research and explore. However, I thought it useful to conclude with an image which visualizes the clip-on city infrastructure at work. Below you see a piece of an existing city to which we have applied some of the technologies discussed above. Large scale urban farming which takes place indoors and on large expanses of roof, green screens to let plants to climb the vertical surfaces of the city, trees which are now able to grow on the city roofscape. Roof ponds and artificial waterfalls for cooling and electrical generation. Solar and wind devices which form sculptural elements in the city, performing a function as well as having an aesthetic. Ports for plug-in electric vehicles which gather energy from photovoltaics. Solar panels incorporated into street poles, and vertical wind turbines which form a rhythm in the streetscape. Bicycle lanes, room for walking and the incorporation of still more trees. It's only a diagram, but perhaps the current dilemma can provide an opportunity to rethink and retool our existing way of life. Perhaps utopia is now.



Research Team: Fay Alkhalifa, Marcus Brooks, Graziela Gimenes, Akiko Hagiwara, Anna Obratzsova, Gabriela Rodriguez, Allison Schwartz.

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