Section 6. BECS, Biochar and the converging ecological and social crises

The concept of using large-scale biomass with carbon sequestration, as well as a vast expansion of 'carbon sink plantations' for climate mitigation relies on a reductionist understanding of the current planetary crisis and as such is fundamentally flawed.

Greenhouse gas concentrations in the atmosphere, which are being rapidly increased primarily by fossil fuel burning but also by ecosystem destruction and agro-chemical use, are seen as susceptible to human influence – not just through reducing or stopping emissions (which of course is essential to survival) - but by manipulating the biosphere. The aim is to force an already dangerously degraded biosphere to do what nature has never been able to do; to sequester and retain billions of tonnes of atmospheric carbon, not over thousands of years but within decades. Despite the overwhelming evidence that industrial agriculture and industrial forestry are rapidly depleting the biosphere, soil and freshwater worldwide at an ever faster rate, it is proposed that both these can be expanded further and that this will somehow make the biosphere considerably more productive than it has ever been before.

Those who advocate such proposals appear to view climate change, and specifically, dangerously high atmospheric concentrations of CO_2 not only as the single greatest threat which we are facing, but as a crisis which can be seen in isolation from the much wider accelerating destruction of the biosphere and of all the earth's life support systems. They disregard the fact that ecosystems have, throughout the planet's history maintained the conditions under which life can exist. This includes regulating the carbon and nitrogen cycles, rainfall, storm patterns and to a considerable extent cloud formation, as well as maintaining healthy soils, regulating the freshwater cycle, and providing habitats for all species. What they ignore is the fact that biodiverse ecosystems maintain the conditions, including a climate, which is amenable to life on earth. Reductionist thinking however diminishes ecosystems to the concept of 'biomass' or 'carbon sinks', seen primarily for their capacity to convert atmospheric carbon into a stable form for storage whilst, ideally, at the same time delivering usable 'products'. This simplistic view of climate mitigation (carbon sequestration accounting) pays scant recognition of the vital role played by species diversity in driving the biochemical processes involved in maintaining ecosystems and thus the conditions for life.

Biodiversity is thus seen primarily as a future victim of climate change, not as a natural 'buffer' against catastrophic climate change. In reality, biodiversity is the immediate victim of a combination of direct habitat and ecosystem destruction caused largely by industrial agriculture and industrial forestry, nitrogen overloading and other forms of chemical pollution, freshwater depletion, the introduction of invasive alien species, and increasingly climate change. Without healthy ecosystems we cannot sustain agriculture and human survival.

6.1 Ecosystems Regulate the Climate

Ecosystems, including healthy soil, hold considerably more carbon than the atmosphere at present. When they are destroyed, not only is the carbon that was stored in the ecosystem released, but also the capacity for future sequestration is lost.

However, this is only one of many ways in which ecosystems regulate the climate. Tropical forests for example play a crucial role in maintaining concentrations of the free radical, hydroxyl (OH^-).[145] Hydroxyl plays a particularly crucial role in stabilising the earth's temperature by breaking down methane as well as various pollutants such as sulphur dioxide. Methane is 25 times more powerful as a GHG than CO_2 when averaged over the IPCC assessment period of 100 years. However methane in fact takes just 12 years to break down making its potency compared to CO_2 skewed downwards. Reduce the IPCC assessment period to 20 years (a more relevant period in relation to climate tipping points) and methane becomes 72 times more powerful than CO_2 as a GHG. Hydroxyl thus represents an even more important negative climate feedback than the IPCC data at first sight suggests. If global hydroxyl concentrations were to suddenly decline, for example because of large-scale tropical deforestation or ecosystem collapse, the additional global warming resulting from the accumulation of methane could be catastrophic. In fact, some scientists are concerned that the recent increase in atmospheric methane levels follows a pattern which suggests that it may be partly caused by declining hydroxyl levels.[146]

Ecosystems, and in particular large contiguous old growth forests, play a crucial role in regulating the rainfall cycle over large areas. The Amazon forest, for example, has been shown to recycle up to 80% of its rainfall through evapo-transpiration, around 6 tera tonnes ($6x10^{12}$) of water vapour a year. This recycling of the original rains takes place up to six times from East to West as storm clouds are drawn by a gradient of convection from the Atlantic seaboard, across 4000 Km to the Andes before being carried north across the equator via the Hadley Cell. It is widely accepted that this massive evapo-transpiration engine depends entirely upon a large enough area of contiguous forest: break the forest canopy with extensive agricultural plantations and the recycling of rains could break down, threatening the whole forest. Daniel Nepstad, senior scientist at the Woods Hole Research Center, has warned:

> *"The nightmare scenario is one where we have a 2005-like [drought] year that extended for a couple years, coupled with a high deforestation where we get huge areas of burning, which would produce smoke that would further reduce rainfall, worsening the cycle...While some climate modellers point to the end of the century for such a scenario, our own field evidence coupled with aggregated modelling suggests there could be such a dieback within two decades."*[147]

Evapo-transpiration: Forests play a key role in regulating rainfall systems and storm-tracks; jrscience.wcp.muohio.edu

About half of the rainfall received by the Amazon forest is exported to an area that extends from Argentina to the US Midwest. New research suggests that the Amazon forest also plays a major role in the energy transport, and therefore rainfall and storm tracks, across a large part of the planet. Science writer Peter Bunyard, reporting on studies by Pedro Silva Dias and Roni Avissar, states:

> *"Teleconnection is the name given for such transfers of energy by means of rainfall to the United States, to South Africa and towards Europe from Amazonia and it comprises relatively slow-moving moist masses of air that, like a slowly moving train, push their way northwards and southwards out of the Basin, carrying their precious cargo of water in the form of water vapour. In effect, we are talking of water that is absolutely essential for the growth and survival of crops fundamental to the needs of the United States, to Argentina, the Northeast of Brazil and even South Africa."*

Furthermore, the Amazon rainforest, has been shown to produce small organic particles – isoprenes and terpenes - which play an important role in cloud formation and in increasing the Earth's albedo, i.e. reflectivity.[148] Other tropical forests, and indeed other ecosystems, including marine plankton, play a similar role. Old growth boreal forests have recently been shown to also release terpenes.[149]

Ecosystems other than tropical forests also play a crucial role in regulating rainfall and temperatures. According to a study by University of Queensland scientists, the destruction of native vegetation has played a major role in recent droughts. They suggest that the 2002-03 drought was 2-3^{o}C hotter because of vegetation clearing and that the same is likely to be true for other droughts.[150] And on a regional level, land-conversion to cropland, particularly using 'C3 crops' such as soybean (which now covers millions of hectares of agricultural land worldwide), has been shown to result in significant regional warming and drying, for example in Mato Grosso, Brazil.[151]

6.2 No Stable Climate Without Biodiversity

The survival of species and ecosystems is therefore entirely interdependent. As species are lost, ecosystems become less resilient and more vulnerable to collapse. According to the 2005 Millennium Ecosystem Assessment:[152]

> *"There is established but incomplete evidence that changes being made in ecosystems are increasing the likelihood of nonlinear changes in ecosystems (including accelerating, abrupt, and potentially irreversible changes)… The increased likelihood of these nonlinear changes stems from the loss of biodiversity and growing pressures from multiple direct drivers of ecosystem change. The loss of species and genetic diversity decreases the resilience of ecosystems, which is the level of disturbance that an ecosystem can undergo without crossing a threshold to a different structure or functioning".*

This 'different structure or functioning' as becomes clear from reading the Millennium Ecosystem Assessment, essentially means ecosystem collapse.

A large variety of studies illustrate the crucial role which biodiversity plays in allowing ecosystems to survive and thus to regulate climate, rainfall, soil metabolism, in other words, to keep the planet habitable. In line with the warnings from the Millennium Ecosystem Assessment, a large number of studies which look at marine as well as terrestrial ecosystems show that when species are lost, the decline in ecosystems can be severe and in many cases abrupt and irreversible.

- A study in Patagonia showed that species diversity correlates with carbon sequestration: The more species of grasses and shrubs which populate an ecosystem, the more carbon is sequestered. This is due to the fact that different plants vary in their root depth, in the form of nitrogen they use and in the timing of photosynthesis, so they can fill different ecological niches.[153]

- A study of deep-sea ecosystems shows that biodiversity losses can lead to an exponential decline in the ability of ecosystems to function which is of serious concern since, as the authors stress "deep sea plays a key role in ecological and biogeochemical processes at a global scale [and]… are essential for the sustainable functioning of our biosphere and for human wellbeing."
- A recent review of the literature on drivers of biodiversity extinction[154] illustrates how ecosystems can unravel when species loss triggers 'chains of extinction', with 'amplifying feedbacks' that can become impossible to stop.

  Examples of this include:
- In Australia, localised extinctions of dingoes have led to an increase in cats, foxes and rabbits which have caused large numbers of marsupial extinctions.
- Overhunting of mammals in tropical forests has led to the local extinction of dung beetles. Dung beetles are essential for seed dispersal and probably for the control of parasites spreading to vertebrates. They also a role in nutrient recycling. Their disappearance, together with the loss of birds and mammals has stopped many trees from reproducing.
- Overhunting of primates, who play an important role in seed dispersal, has been linked to the loss of species diversity in trees.
- A study of different extinction scenarios in a rainforest in Panama[155] concluded that selective logging of tree species with high wood density can reduce carbon storage by up to 70% but also warned that the impact of biodiversity losses on the ecosystem cannot be measured just in terms of carbon storage:

  "Human domination of terrestrial and aquatic landscapes has made us increasingly dependent on a reduced number of species to provide critical ecosystem services. Given uncertainty in both the nature of extinction and the variety of ecosystem services required for human well-being, we may best be able to meet these demands by maximising the pool of species on which we depend."
- One study in the Brazilian Pantanal found that pacu fish play a vital role in the dispersal of seeds, including those of palms. Overfishing of pacu is thus a major threat to the forest.[156]

These studies clearly show that losing any species can put the entire ecosystem at risk, and that species diversity must be a central feature of any approach to mitigating climate change. The destruction of biodiversity and ecosystems go hand-in-hand with climate collapse, as is illustrated by analysis of the current mass extinction already underway.

6.3 Vanishing Frogs: Lessons From an Unfolding Mass Extinction

Dead yellow-legged frogs in Sierra Nevada, California, killed by chytridiomycosis, a fungal disease responsible for amphibian deaths in large parts of the world. *Photo by Vance Vredenburg, www.sciencedaily.com/releases/2008/08/080812135654.htm*

Amphibians are amongst the most successful and adaptive classes of animals on earth. They have been around for around 350 million years and have survived at least three mass extinctions, including the End Permian Extinction, which wiped out around 70% of all species on land and is believed to have been the most catastrophic of all previous extinctions. Relatives of modern frogs evolved 190 million years ago and survived the mass extinction event that killed the dinosaurs.

Yet amphibians are now declining, and extinctions are occurring across the world, much faster than amongst birds and mammals. The very survival of amphibians as a class is uncertain. As David Wake, co-author of a recent paper in PNAS warns: "There's no question that we are in a mass extinction spasm right now. Amphibians…made it through when the dinosaurs didn't. The fact that they're cutting out now should be a lesson for us".[157]

According to the Global Amphibian Assessment, over 160 species have already become extinct in recent years and decades, and a further 32% of all amphibian species are threatened with extinction. The true figure could be even higher because for 22.5% of amphibian species there is not enough information to assess their extinction risk, but many of them may be threatened, too. Habitat destruction and fragmentation are widely seen as the cause of most amphibian declines worldwide, but not the only one: Frogs, toads, salamanders and caecilians are dying in great numbers even in well protected rainforests and wetlands, far from sources of pollution. There have been many reports of seemingly healthy populations suddenly dying out. Field biologist Martha Crump described seeing golden toads in the Montverde cloud forest in Costa Rica in 1987: "There must have been a hundred male golden toads. They were this brilliant golden orange, just sitting there like little statues." She saw around 1500 of them during that breeding season. The following year, only ten were found and none of them bred. In 1989, the last single golden toad ever was spotted and the species has been declared extinct. Twenty out of fifty species found in the same area disappeared at the same time. A fungal disease called chytridiomycosis is widely believed to have been the immediate cause of extinction, although it had not been identified at the time and so cannot be validated. Biologist David Wake describes the fungus which causes chytridiomycosis as "the most devastating wildlife disease ever recorded".[158] It may have been implicated in the first ever reported 'mysterious' mass deaths of amphibians – that of boreal toads in the Colorado Rocky Mountains in the 1970s.[159]

According to the conservation alliance Amphibian Ark:

> *"Where Bd [the fungus that causes chytridiomycosis] thrives, generally moist cool habitats, 50% of amphibian species and 80% of individuals can be expected to disappear within 1 year.[160]*

Many scientists believe that the fungus can only kill such large numbers of frogs because they are already vulnerable to disease. Climate change, pollution, particularly from agro-chemicals and increased UV-B radiation due to ozone depletion have been implicated as the underlying causes of the deaths. Others believe that mass deaths, at least in lower Central America and in the Andes, could be explained solely in terms of a newly introduced disease spreading in a wave-like pattern, typical for epidemics, without any other factors playing a role.[161] There is indeed strong evidence that chytridiomycosis was spread from Africa through international trade in frogs and toads[162] – but there is equally strong evidence that the spread of the pathogen was facilitated by the vulnerable state of amphibian populations.

The idea that amphibian populations are more vulnerable is supported by their susceptibility to other pathogens such as Ranaviruses or trematode parasites. A global mass extinction event amongst one of the earth's oldest and most adaptable classes of animals clearly suggests that something very fundamental is going wrong and chytridiomycosis is only one of the factors. In 2007, a study by Steven Whitfield et al.[163] revealed 75% declines of reptile and amphibian populations in a lowland rainforest. Chytrid fungus was not found in the area, nor does it affect reptilians, and the forest had not been diminished by logging or deforestation. Pesticides, which elsewhere have been shown to drift over large areas, were ruled out as a cause of the declines because populations of the same species increased in nearby abandoned cocoa groves, though soil and water were not actually tested for pesticides. The authors concluded that climate change was the most likely cause of the declines: More dry days and higher temperatures had reduced the amount of leaf-litter in the rainforest on which many reptiles and amphibians depend. Clearly, climate change is a major threat to amphibians, in large part because they depend on ample and clean freshwater for breeding. The 20 species which disappeared from Monteverde forest, for example, did so after the driest year on record in Costa Rica, during which breeding pools had dried up too quickly for tadpoles to develop. Yellowstone National park too is experiencing massive amphibian losses; John Varley former chief scientist for Yellowstone, commenting on a recent study said "Everybody can identify with the loss of glaciers, but in Yellowstone the decrease in lakes and ponds and wetlands has been astounding… some wetlands that were considered permanent ponds are no longer there". http://www.sciencedaily.com/releases/2008/10/081028184830.htm Global warming has been shown to cause more dry days during the dry season and also to alter cloud cover in a way which could also favour chytrid fungus.[164] Droughts and heatwaves will undoubtedly decimate remaining amphibian populations in many parts of the world. For example Mediterranean countries are rich in amphibian species and climate change is projected to result in increasing desertification.

Agrichemical pollution and ozone depletion have also been shown to decimate amphibian populations on a scale that puts their global survival at risk. Introduced invasive species and other forms of pollution further exacerbate the losses. The evidence linking agrichemicals to amphibian deaths is solid and widely accepted. A large number of pesticides and herbicides have been shown to kill amphibians even in low concentrations, lower than those found over ever larger parts of the planet. Chemicals that have been implicated include organophosphates such as chlorpyrifos, malathion and diaznion, endosulfan, carbamates, paraquat, atrazine and a surfactant used with glyphosate. Even where pesticide exposures are not directly lethal, they sometimes cause lethal malformations and interfere with reproduction and behaviour in agricultural areas: These chemicals are difficult to contain and are easily blown over large areas, for example from the San Joaquin Valley to the top of the Sierra Nevada mountains and to Yosemite National park in California.[165] While most of the discussion of amphibian extinctions in the Monteverde forest has focussed on possible interactions between climate change and chytridiomycosis, nobody appears to have studied the possible impacts of pesticides which could have been transported into the forests by wind, given that many including some that have been banned in Europe and North America and known to kill amphibians, are used in the vicinity. Fertilisers, which pollute freshwater over large areas are also known to kill amphibians. For example, a study in Oregon found that levels of nitrite in water permitted as 'safe' for fish killed all five species that had been studied.[166]

Ozone depletion has substantially increased UV-B radiation. UV-B radiation has been shown to harm amphibians, causing cancers promoting reproductive defects and inhibiting immune system functioning, killing tadpoles, affecting their growth and development, and causing adult amphibians to go blind.[167]

A very recent report by Peter Hudson, co-author an independent research study, confirms "We are facing a cataclysmic global decline in amphibians caused primarily by the effect of a fungus that was historically not important, but the emergence of which might be associated with climate change, along with the use of herbicides and pesticides," Hudson explained. "The bottom line is that there doesn't seem to be one single explanation for the massive amphibian declines. It could be a mix of other factors." [Peter Hudson et al. Penn State University www.sciencedaily.com/releases/2008/11/081112113708.htm]

6.4 Biodiversity in Meltdown: the Lessons for Climate Change Mitigation

As extinction waves are spreading rapidly across the world's amphibian populations, it seems clear that the causes are multiple and include habitat destruction, agrichemical use, climate change, ozone depletion, and the trade and movement of animals across continents. Even without climate change impacts, the remaining factors leave little room for optimism about the future of amphibian and other biodiversity. As a recent paper on the drivers of global extinction states: "Conservation actions which only tackle individual threats risk becoming half-measures which end in failure, due to uncontrolled cascading effects."[168]

Amphibian extinctions, while they have been particularly well studied are by no means unique: Global reptile populations are far less well monitored yet there is evidence that they may be at an even greater risk of global extinction, for many of the same reasons. As ecologist Whitt Gibbons warns: "The disappearance of reptiles from the natural world is genuine and should be a matter of concern. Current evidence suggests that these declines constitute a worldwide crisis".[169]

Pollinator declines are widely acknowledged and pose a major threat to ecosystems and to human survival. About one third of all plants, including two-thirds of the most important food crops depend on pollination. The recent collapse of large numbers of European and North American honey-bee colonies has been given particular attention, though other pollinators are also in less well studied decline. The key to pollination and thus to the survival of both natural ecosystems and agriculture is species diversity.[170] This diversity is disappearing fast: A 2006 study found that bee species in the Dutch countryside have declined by 67% since 1980 and those in the British countryside by 52%. Wildflower species have declined simultaneously.[171] Epidemics of new diseases, climate change, agrichemical use, alien invasive species and the destruction of ecosystems and agricultural biodiversity are all believed to be contributing to the pollinator extinction crisis – a scenario very similar to that of amphibian extinctions.

Such massive biodiversity losses are reducing the capacity of ecosystems to regulate the climate, water cycles, soil fertility, and other systems essential for life. Most climate change mitigation policies recognise that unmitigated climate change will wipe out biodiversity but they fail to recognise the core implication: that there can be no stable climate and no capacity for resilient ecosystems and therefore resilient agriculture in the face of climate change without biodiversity.

The authors of a recent study on climate change and species extinctions, Rik Leemans and Bas Eickhout show: "Even small magnitudes of climate change will impact species, ecosystems and landscapes considerably. With the already ongoing high rate of climate change (i.e. larger then 0.2^{o}C per decade), a decline in biodiversity and many ecosystem services will accelerate soon."[172] This is particularly concerning because the Earth's landmass will almost certainly continue to warm at a much faster rate than 0.2^{o}C per decade quoted in the study. In the last decade (1998-2007), compared to the previous decade (1988-1997) for example, global surface land temperatures rose by more than 0.4^{o}C. There is also evidence that only half of all ecosystems and only 36% of forests will adapt to global warming of just 0.1^{o}C per decade over a century. Faster warming will trigger far more widespread ecosystem collapse. Only 30% of ecosystems and 17% of forests are expected to adapt to warming of 0.3^{o}C per decade over a century, according to Leemans and Eickhout. Clearly, most ecosystems and thus most species will not be able to adapt to ongoing warming at the present rate. Hence, any presumption that we can avoid abrupt and self-reinforcing climate change impacts by only gradually reducing emissions in the future is false, especially given the time-delay between changes in greenhouse gas concentrations and global temperatures. This means we are already locked into very significant warming.

In the light of what we know about the current vulnerability of the earth's life support systems, and the knowledge that climate change will make these systems more fragile, the notion that we can make the biosphere more productive over a period of decades and in the process draw down atmospheric CO_2 appears not simply dubious but extremely dangerous.

Some climate models predict that global warming of 3-4^{o}C will warm and dry the Amazon basin to such an extent that large-scale forest die-back will be triggered. This level of warming could be reached by mid-century. Yet there are already signs that the rainfall cycle over the Amazon basin is at or close to the point of breakdown. A process of savannisation has already been observed in parts of the eastern Amazon. Each of the last four dry seasons has been exceptionally dry over large parts of the forest and different adjacent areas. Those impacts are difficult to explain other than in terms of regional rainfall changes linked to deforestation and selective logging. Even without a die-back scenario, the Amazon forest is being destroyed at an accelerating rate: In the 12 months up to August 2008, the deforestation rate in the Brazilian Amazon rose by 64% compared to the previous year according to Brazilian government figures. During August 2008, deforestation was at least 228% greater than during the same month the previous year. Large-scale infrastructure plans, linked to the escalating global demand for agricultural commodities, including for agrofuels and wood, will further accelerate the destruction. Given that up to one third of all terrestrial species are thought to live in the Amazon basin, mass extinctions are highly likely well before climate change alone would threaten the survival of the forests.

Elsewhere in the tropics and subtropics, monoculture expansion, industrial logging and other forms of industrial exploitation are also destroying ecosystems far in advance of serious climate change impacts. Brazil's Cerrado, the world's most biodiverse savannah, for example, is being destroyed twice as fast as the Amazon forest, largely for monoculture plantations of sugar cane, soya and eucalyptus.[173]

Other tropical biomes are similarly affected. In South-east Asia, one study predicts that habitat loss, largely through deforestation alone will cause the extinction of 79% of all vertebrate species, most of them (over 4000) being endemic to the region.[174] Malaysia and Western Indonesia are home to at least 15,000 endemic plants and over 200 threatened endemic mammals, birds and amphibians. Yet the United Nations Environment Programme expects that the habitat of most of those species, 98% of the lowland forests of Sumatra and Borneo (the two islands studied by UNEP) will have been destroyed, largely due to oil palm plantation expansion and illegal logging, with similar rates of destruction and likely species losses in other parts of the region, including in West Papua and Papua New Guinea. At the same time deforestation the oxidation and burning of peat stores beneath much of this forest will continue in parallel and add massively to warming.

Meantime, most extinction scenario studies focus on the impact of agricultural expansion rather than agricultural intensification. Yet, as we have seen, agrichemicals play a major role in current extinctions, including of amphibians and pollinators. The loss of biodiversity in soils – soil microbes, worms, insects – through industrial agriculture has barely been studied in its own right but is linked to the greatly increasing soil erosion and humus depletion rates.

As we have seen in the discussion about amphibian extinctions, the most devastating impact on biodiversity comes not solely from climate change or habitat destruction or pollution but from multiple destructive impacts happening simultaneously – i.e. from the converging crises. As biologist David Wake has said about frog declines: They "have really been hit by a one-two-punch, although it's more like a one-two-three-four punch". The same is true for other species and for ecosystems. And the 'punches' described by David Wake do not necessarily just add up – they can also reinforce each other and thus lead to even more catastrophic extinctions. This has been shown in a recent study of rotifer zooplankton in a controlled environment. Over-exploitation, habitat fragmentation and warming each led to population losses which could eventually lead to extinction. However, if the three impacts were combined then the rate of population losses were over 50 times faster.[175]

Amphibian declines demonstrate why we cannot strive to protect biodiversity solely by protecting some areas, whilst maintaining or even increasing pressures on adjacent lands. Impacts from industrial agriculture, such as pesticide use for example have been shown to extend over such large areas that the concept of maintaining separate protected areas as 'biodiversity havens' lack plausibility.

In summary; implementing misguided climate change mitigation strategies which are based on or coupled to industrial agriculture and forestry are thus likely to accelerate the ecological and climate systems breakdown already well underway and risk triggering abrupt, unpredictable and irreversible collapse.

6.5 Agro-biodiversity, cultural biodiversity and climate change

We have shown in Section 5 why “climate change mitigation” strategies which depend on industrial monocultures, including those which involve industrial bioenergy production, will inevitably lead to the displacement of very large numbers of people and to the loss of food sovereignty and livelihoods.

Small farmers, indigenous peoples, other forest and rural communities already suffer the greatest impacts of climate change and, increasingly, the negative impacts of so-called ‘climate change mitigation’ strategies, such as agrofuels, large hydro power and carbon trading schemes. As we have seen, pressures on communities particularly on the global South (but also indigenous peoples and other communities in many countries of the North) could increase many-fold if so-called 'carbon negative' bioenergy was adopted by governments as another tool for 'climate change mitigation'.

This is more than a humanitarian disaster. Not only are the livelihood of communities destroyed but also their culture and their knowledge and experience of living in harmony with nature, of biodiverse sustainable farming, and of living without reliance on fossil fuels. This means that the very knowledge and community technologies most needed to try and prevent climate and ecological collapse are being destroyed.

The concept of biochar as a global soil conservation strategy disregards the many locally adapted sustainable farming and soil conservation methods which communities have developed over long periods. This approach to soil conservation mirrors the ‘Green Revolution’ approach to agriculture, where ‘experts’ promoted one set of ‘solutions’ to farmers, as ‘superior’ to traditional farming practices. Diversity and adaptation to local climate, soil and culture continue to be dismissed in favour of allegedly ‘science-based’ large-scale solutions, no matter how tenuous the scientific basis actually is.

The legacy of the Green Revolution includes not just the environmental destruction linked to industrial agriculture described above and the displacement of tens of millions of people, but also the loss of a much of the world's crop varieties, developed by farmers over thousands of years. According to a report by the Forum for Food Sovereignty, “More than 90% of crop varieties have been lost from farmers' fields in the past century and livestock breeds are disappearing at the rate of 5% per year”.[176] As we have seen, policies based on maximising short-term bioenergy yields will favour industrial monocultures and thus further erode crop varieties, whilst the shift from pastoralism to industrial livestock feedlots will accelerate and further reduce varieties of livestock breeds. Agro-biodiversity, however, will be increasingly essential if humans are to adapt to and survive the degree of climate change to which we are already committed. The continued loss of this diversity will further undermine food sovereignty and food security and threaten the survival of ever larger numbers of people.

A ‘biochar revolution’ would inevitably be led by those companies who hold the patents and have access to funding, and would accelerate the industrialisation of global agriculture and forestry. Successful soil conservation strategies such as inter-cropping, permaculture, composting, the retention of crop residues, fallow periods are likely to be sacrificed for a 'one size fits all solution'. Fallow periods, essential for protecting soil in many non-industrial farming systems already lead to land being classed as 'abandoned' or 'degraded' and thus earmarked for conversion to plantations – a trend likely to accelerate with further bioenergy expansion.

As we have shown above, there can be no stable climate without biodiversity. The survival of biodiversity, however, depends directly on cultural diversity, as Jelson Oliveira of the Pastoral Land Commission in Brazil discusses:[177]

"Genetic diversity is very closely tied to the ethnic diversity of our peoples; it is not by coincidence that countries such as Brazil, that possess the greatest diversity in plant life, also have the largest number of ethnic groups...The more pluri-ethnic a people are, the greater are their chances to live together in a sustainable manner with natural resources, because their tastes and imagery contribute to saving seeds, plants, and animals."

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Section 7. Towards an adequate response to the converging crises

The current debate about climate change is dominated by responses which reflect dangerously reductionist thinking. Climate tends to be viewed in isolation from the rest of nature. The debate on climate change is reduced to a debate about numbers and about numerical 'targets'. 'Emission reduction scenarios' are being discussed in a 'pseudo-scientific' debate, which fails to take account of macro-interrelationships. This is heightened by our lack of knowledge of how earth systems will respond to even the current atmospheric and ecosystem changes, let alone those caused by geo-engineering interventions. This discourse reflects a widespread inability to think holistically, to see patterns and interconnectivity within the natural world. A reductionist discourse and understanding of the wider planetary crisis results in reductionist 'solutions' which exacerbate the very crisis they are meant to address.

Virtually all of the 'solutions' which are being forwarded in the mainstream debate involve merely ***reducing*** fossil fuel burning and/or the ***rate*** at which we destroy the biosphere, or moving to a 'fossil fuel free' ***growth*** economy. Some rely on patently dysfunctional market mechanisms, such as trading in 'ecosystem services'[178], or carbon trading. The fact that carbon trading has been a monumental failure, and in many cases resulted in a net increase in emissions appears not to dent the enthusiasm of those who promote it.

Other proposed 'solutions' include planetary geo-engineering, which generally involve sacrificing biodiversity and further disrupting poorly understood earth systems. These include changing the composition of the atmosphere, cloud cover or manipulating the biosphere in the hope that we can lower the planet's temperature. Such interventions, as we have seen, are dangerous and unproven. By threatening biodiversity and ecosystems – a primary, negative climate feedback – we increase the risk of not only triggering runaway warming but also destroying the planet's ability to recover from a mass extinction event. Such a runaway scenario could be described as 'beyond catastrophe'; without the powerful negative feedback provided by ecosystems (a situation which planet earth has never previously faced), oceans would warm releasing dissolved CO2 and eventually the ocean water itself would begin to vaporise. Water vapour, a powerful GHG represents a potent positive feedback which would raise temperatures inexorably. Because of the inhospitable nature of such a hot planet, and atmospheric similarities with Venus, this situation has been termed a 'Planet Venus' scenario and would result in a permanent end to life on earth.[179]

At this late stage, where the signs of earth systems failure are evident all around us, we need as a primary response to search for ways of living which cause no further harm to the planet. Alongside this we need to find ways of allowing ecosystems to heal and to increase in resilience.

The following three most urgent questions are central…and hardly ever raised in the mainstream climate discourse:

- How can humans actually live without further accelerating climate and ecological collapse?
- Insofar as is possible how can we undo some of the damage which humans have caused to give life on earth the greatest chance of survival?
- How can we bring about the necessary social and economic changes to make such a transition possible?