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Humic Carbon to Fix Extinction, Climate and Health

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Abstract: Climate change due to human activities correlates with undeniable CO_2 increase. Yet, from NASA/IPCC data, shutdown of non-essential business for just six days would enable land plants to entirely fix annual CO_2 excess of 4 Gt carbon C/yr. At 8,580 Gt C, soil contains ten times atmospheric C and eight times that of ocean or forests. Restoring lost soil organic carbon (SOC) in worm-worked humus at 2–5 Gt C/yr is then the only practical carbon capture & storage (CCS) capable of freely offsetting all 9 Gt C/yr anthropogenic emissions and drawing down excess CO_2. As a priority, all resources must be directed towards proven, earthworm-based, organic husbandry to safely combat global threats due to irreversible species extinction, perilous climate change and deteriorating human wellbeing (mental/physical health). Underpinning all three interlinked crises is a relentless, yet largely ignored, erosion of precious topsoil at 2,000 t/s (= 1–3 Gt C/yr). A first recovery step is to vermi-compost all bio-wastes back onto fields as per Howard's "*Law of Return*".

Keywords: soil organic carbon sequestration, climate, organic agriculture, cancer, earthworm, fire

1. Introduction

Carbon accumulation in the atmosphere is currently at a rate of +4 Gt C (+2 ppm CO_2) or +0.5% per year and is manifestly linked to climate change. This is not an economic, chemical, geo-physical nor an engineering problem, rather it is an ecological imbalance attributed to land clearance and burning combined with rate of fossil fuels emissions exceeding the living Earth's ability to reprocess. The UN's latest bulletin (IPCC 2018) [1] predicts a brief window of just 12 yrs – to 2030 – in which to tackle the perils of climate change. A temporary shutdown, as USA partially imposed in 2018/2019, may provide CO_2 emission respite (by -1–2%?) measurable at Mauna Loa Observatory (Figure 1).

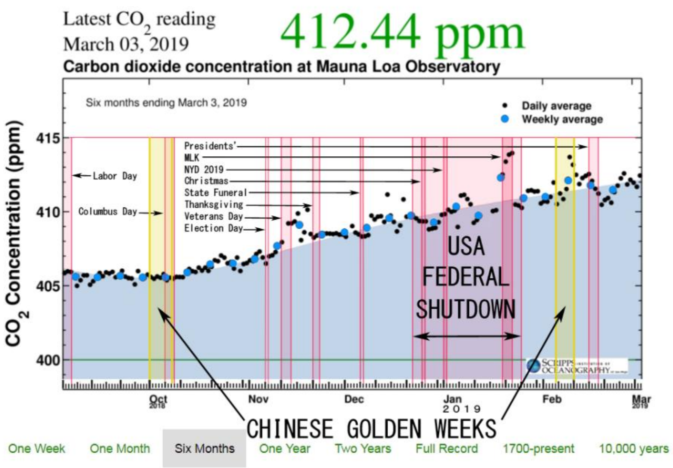

Figure 1. Shutdown (as for national holidays in China, USA, EU, India, Russia and Japan) may be detectable in Hawaii's CO_2 notwithstanding seasonal/local weather, time lag or other emission confounders.

Climate is not the greatest threat, however, as both a loss of biodiversity (due largely to "*conversion of natural ecosystems into agriculture or into urban areas*") and excess synthetic fertilizers (that also deplete soil carbon, as noted below) were flagged as more urgent by Rockström *et al*. (2009) [2]. Most of their nine pillars for survival rely entirely upon topsoil that, based upon UN's FAO data, provides 99.7% of human food (just 0.3% from fish) whilst being relentlessly eroded at a rate of 75 Gt/yr or 2,000 t/second [at mean SOC of 1.3% = 1 Gt C/yr; cf. IPCC have >2 Gt C/yr] (Pimental & Burgess 2013 [3], Blakemore 2018b [4]). Of Project Drawdown's (www.drawdown.org) 100 climate solutions, about 85% are based upon adaptable Permaculture principles and practices (Mollison 1988) [5] that essentially condense to one simple foundation: Saving our soils.

Critical loss of invertebrates (e.g. earthworms or insects) by -50–100% and collapse of dependent food-webs is due partly to climate but most surely to chemicals killing the soil and life therein or thereupon (Carson 1963 [6], Blakemore 2018a [7], Lister & Garcia 2018 [8]) (Figure 2).

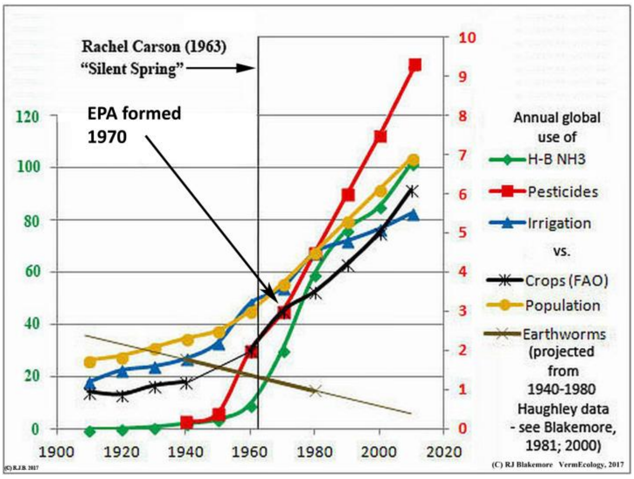

Figure 2. Population rise (yellow, due in part to education, medicine & hygiene) and FAO's commercial crops (black, omitting gardens/farms with higher yields per area & in total) that correlate with irrigation (blue) more than either synthetic fertilizers (green, causing air/soil acidity and C depletion – see Philpot 2010 [9]) or toxic biocides (red, increasing exponentially despite "*Silent Spring*" warning and EPA); earthworm decline is in brown. (Graphic with sources: vermecology.wordpress.com/2017/05/27/slimeless-spring-ii/ 27th May, 2017).

Since Carson (1963) [6], toxic agrichemicals are known to cause death, allergies, cancer, neurological and reproductive problems in test animals and in humans. Farm workers and children are most susceptible with higher induced cancers, Parkinson's and autism rates linked to biocides. One example: the most ubiquitous herbicide, glyphosate, as used in chemical (rather than organic) "no-till", is associated with health and ecological problems (Séralini 2012, 2014 [10–11], Swanson *et al*. 2014 [12], Leon *et al*. 2019 [13], Zhang *et al*. 2019 [14], Gaup-Berghausen *et al*. 2015 [15]). Patented as a chelating pipe-cleaner and a broad antibiotic (US Pat. 7771736), glyphosate's targets include beneficial soil algae and N-fixing bacteria (Pseudomonadaceae e.g. *Azomonas* or *Azotobacter*) and symbiotic Enterobacteriaceae in gut flora of humans, ruminants, birds, honey bees and earthworms.

Ecologically, all three critical problems (biodiversity, climate and health) are interlinked and solvable by the simple expedient of restoring organic farming as advocated by Howard (1943) [16] (who first noted synthetic N fertilizers burning off soil organic C) and Balfour (1975) [17] from the time of agricultural divergence following WW2. The mantras that chemical agriculture is required to "*feed the world*" with "*70% more food by 2050*" are demythologized by FAO data, as discussed below, showing up to 80% of sustenance comes from local family gardens/farms not from destructive and highly subsidized GMO soy, corn, or canola monoculture, and that a predicted population increase of 20–30% requires just 20–30% more food once excessive meat-eating is moderated (UN-HRC 2017 [18]). Neither does organic farming "*require more land*", rather it conserves essential soil moisture (+28.7%), soil organic matter (+50%) and biodiversity whilst saving costs plus providing greater employment and healthier food without overall loss of production (FAO 2017 [19], Blakemore 2015a, b [20–21], 2018a: tabs. 12–13 [4]). National organic action plans, as enacted in the Philippines in 2010, are for countries as diverse as Bhutan, Denmark, Estonia, India, Ireland, Russia and parts of Africa.

Atmospheric carbon increase is primarily at the expense of the soil and its biota (Lal 2001: 533) [22]. This soil idea is not new: Revelle & Suess (1957) [23] proposed it as a cause of Callendar's effect. A global carbon debt due to agriculture is thought to be of 133–153 Gt C from the top 2 m of soil, with the rate of loss increasing dramatically in the past 100 yrs; global decreases in soil organic carbon (SOC) of -40–60% from pre-clearing levels have caused emissions of some 60 to 150 Gt C into the atmosphere (i.e., up to 50% of excess carbon dioxide) and at least 78 Gt lost from the global soil SOC pool due to agricultural land-use conversion with 26 Gt by erosion and 52 Gt by mineralization (Batjes 2018 [24], Sanderman *et al.* 2017 [25], CSIRO 2010 [26]). Australia has been particularly affected and Chan *et al.* (2010) [28] discuss some causes and remedies for SOC loss in pastures and croplands. Köhl *et al.* (2015) [28] show loss of about 5 Gt C from forest soils just from 1990–2015. Blakemore (2018a: tab. 12, fig. 10) [7] charts rapid SOC flux from the earliest non-organic fields at Rothamsted with -60% loss after 175 yrs, but restoration possible in just a few years of re-manuring.

Yet only in 2015 did an international initiative "4 per 1,000" (www.4p1000.org) propose increasing soil carbon by 0.4% from a supposed starting base of 1,500–2,400 Gt SOC. As total SOC is now raised to >8,580 Gt due to terrain (Blakemore 2018b) [4], only 0.1–0.2% extra C may be required. Conserving vibrant topsoil is an implicit aim of both organic farming and of Permaculture that, practiced at both local and broadacre scale, have doable potential to entirely offset the excess carbon associated with climate change within a reasonable timeframe (Blakemore 2015 a, b) [20–21].

This paper further investigates how organic husbandry may redress these most urgent issues.

2. Materials and Methods

Published reports based upon NASA, 4p1000 and UN's IPCC data are reviewed and revised for newly recalibrated land surface areas (Blakemore 2018b) [4]. The photosynthesis formula $6CO_2 + 6H_2O = C_6H_{12}O_6 + 6O_2$ is reversed by respiration and decomposition (mainly by microbes and earthworms), both being forms of slow combustion, with equation $C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O$ (carbohydrate + oxygen → carbon dioxide + water). Photosynthesis operates within temperature constraints, requiring light energy and chlorophyll. Gross primary production is mainly terrestrial by autotrophic vascular plants plus cryptogamic mosses, lichens and biocrust (including land-based microbial 'phytomenon' cf. phytoplankton, as discussed in a supplementary data file - S1). Net Primary Production (NPP) is gross photosynthetic biomass carbon less plant respiration.

Values are herein measured as total carbon rather than CO_2 and rates are Gt C/yr (= Pg C yr^{-1}).

3. Results and Discussion

3.1. Shutdown: Cancel Emissions and Suck Up C

Remission is provided for by NASA (2011) [29] and IPCC (2013) [30] both with gross terrestrial photosynthesis of 123 Gt C and +4 Gt C added to the atmosphere annually; thus 123/365 = 0.33 Gt C/day biofixated, so just 12 days of natural land production accounts for excess (viz. 0.33 x 12 = 4). Although their NPP of 60 Gt approximately doubles this rate, when terrain allowance recalibrates photosynthetic NPP to >218 Gt C/yr, and plausibly to 250 Gt C/yr (Blakemore 2018b: tab. 11) [4], this rate is halved. Therefore, only six days respite offsets excess CO_2 and a fortnight would neutralize most of 9 Gt C annual emissions. Temporary and graceful shutdown is of non-essential business and transport synchronized near each equinox (as happens in China) or, ideally, for a week-long Spring Break (like Japan's "Golden Week") at Vesak or around Rachel Carson's birthday in May corresponding to the northern hemisphere's CO_2 peak (see keelingcurve.ucsd.edu).

Human emissions are 9 Gt C with uptake 4 Gt to the atmosphere and 2 Gt to the ocean so NASA (2011) and IPCC (2013) [29–30] balance a variable net terrestrial sink at around 3–4 Gt/yr. However, NASA separates land respiration vs. decomposition as 60 Gt each (123-120 = 3), whereas IPCC has "*Total respiration and fire*" discrepancy of 118.7 Gt (123-118.7 = 4.3) as shown in Figure 3. Marine NPP photosynthesis is relatively minor, most limited by nutrients and light at depth.

Indeed, IPCC has 3 Gt total marine biota cf. 450–650 Gt land vegetation biomass (now quadrupled to >2,000 Gt C – see Blakemore 2018b: tab. 10 [4]). Ocean is hereafter largely irrelevant for practical carbon consideration as it is already CO_2 saturated (partly with C from erosion!) and its ~2.3 Gt C/yr net passive air-sea uptake is only ~1% of net active air-land exchange of >218 Gt C/yr (Figure 3).

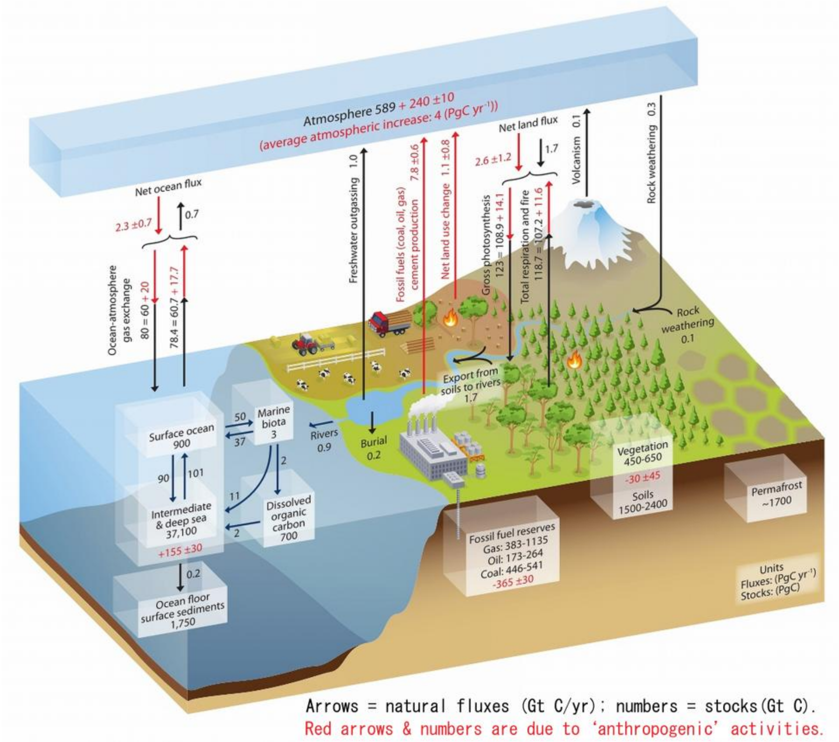

Figure 3. IPCC (2013: fig. 6.1) [30] global C cycle with land sink of 2.6 ± 1.2 Gt C/yr (cf. NASA 2011 has 3 Gt/yr) [29] that may increase with proper organic management and less fire. IPCC allows 1,500–2,400 Gt C in soil, ~1,700 Gt permafrost (max. 4,100 Gt) cf. Schuur *et al.* (2015) [31], while Köchy *et al.* (2015: 361) [32] have 1,700 Gt permafrost and 1,300 Gt elsewhere. This total of 3,000 Gt was used by Blakemore (2018b) [4] in a new accounting for terrain and topsoil to give 8,580 Gt SOC (~1,700 x 2 = 3,400 in permafrost?) with about half the remainder in managed soils. Soil erosion to rivers given as >1.7 is 2.9 Gt C/yr from Tranvik *et al.* (2009) [33]!

NASA/IPCC's [29–30] human contributions of +9 Gt C/yr are <4% compared to revised natural air-land NPP of >218 Gt C/yr (>96%) (Blakemore 2018b: tab. 11) [4] in biomass that, for the most part, is ultimately decomposed or accumulates in the soil at approximately constant rates. Atmospheric accumulation (+4 Gt C/yr) indicates not only excess emission/erosion but also a deficit of photosynthesis and/or a surfeit of respiration/decomposition and combustion.

When terrain is considered, annual leaf-litter of 60–80 Gt C is doubled (ca. 120–160 Gt C/yr), thus all 800 Gt of atmospheric C may be transformed via plant leaves through the intestines of earthworms into rich humus (Darwin 1881) [34] in (800/120–160) 5–6.6 yrs. Upped microbial decomposition in root zones, assuming half NPP of >218 Gt goes below-ground, further halves this terrestrial rate to (800/218) <3.6 yrs. Such values are supported by rapid decline of radioactive ^{14}C isotope from the Cold War atmospheric nuclear tests and by IPCC (2007: 948) [35] giving CO_2 turnover time (= residence lifetime) of about 4 yrs (details are in attached S1 file). Atmospheric C of 800 Gt, if recycled in 4 years or 208 weeks, takes just one week to process about 4 Gt C. Q.E.D.

Current findings of <4% human emissions and 3.6 yr residence time seemingly support Harde (2017) [36] who, with different reasoning, summarized: "*The anthropogenic contribution to the actual CO_2 concentration is found to be* ***4.3%*** *... and the* ***average residence time 4 years***." He also has an adjustment time of 47.8 yrs. A rebuttal paper by Köhler *et al.* (2018) [37] mistakes Harde's findings with outright rejection but accepts "*reasonable approximations for the residence time*". Neither paper considers my new NPP account for land plant respiration, so excess CO_2 – if truly from human activities and leveled in just one week – may be transfer most rapidly into soil organic carbon pools.

Highest in the landed northern hemisphere, atmospheric CO_2 peaks in May and at midnights. Annual progression relates to respiration and decomposition on land until Spring turning point in boreal taiga forests when temperatures rise above 10°C allowing photosynthetic compensation. Disregarding gas fluxes, the most massive and meaningful total C sequestration sink is soil humus.

3.2. Sequestration: Humic Carbon of Organic Farms also Sustains Secure Food Supply

Agriculture utilizes 50% of habitable land with a quarter of this cultivated for crops supplying 83% of human food, the rest being pasture for stock that provide an extra 17% of calories (<0.5% food is from the ocean!); forests (37%), marginal scrub (11%) and cities (2%) occupy the remaining snow/sand-free surface areas (Blakemore 2018b: fig. 4 from OurWorldinData) [4].

Food insecurity is due partly to political inadequacies and partly to waste, but the common situation is 40–80% of global provision is not by industrial agriculture but by local small-holders and home gardeners; so industrialized food provides only 20–60% of the total (Altieri 2008, FAO 2014) [38–39]. Claims of 70% more agrichemical food needed by 2050 are debunked (FAO 2017 [19], Blakemore 2018a: archive.org/details/S1AppendixWormMSRJB in textbox at end of that file [7]).

When trees are cleared, pastures ploughed and plants sprayed with biocides then vital soil biota – microbes, fungi and earthworms that do most biological and physical work – decline and topsoil humus depletes requiring yet more synthetic chemical applications. Poisoned soils, sick children, dead birds, rivers running brown with silt and the air filling with dust from exposed ground are key indicators of collapse. This route to desertification is exacerbated by last-resort grazing of cattle, sheep or goat herds before an inevitable/eventual land abandonment (Mollison 1988) [5].

Permaculture, with appropriate production (e.g. agroecology), defrays toxic and persistent agrichemical/pharmaceutical accumulations whilst rebuilding healthy soils without jeopardizing food security. Harmful synthetic N-P-K fertilizers are replaced with microbial/fungal mineralization from vermi-compost by recycling of all organic 'wastes' (that are currently burned/incinerated or dumped) as per Howard's "Law of Return" [16] or Zero-Waste programs. The doubling of land surface area and of topsoil relief (Blakemore 2018b) [4] likely doubles or quadruples natural microbial nitrogen fixation, as for the extra soil carbon, well above Smil's (2000) [40] N and C totals.

Even with regulated C emissions reduction and synthetic N replacement, the prime imperative is removal of excess CO_2 from the air and the only way to achieve this is via photosynthesis on land with storage in worm-worked humus. In order to process and store more carbon, the requirement (from the photosynthesis equation above) is to increase scope and scale by keeping all soil mantled with foliage for more of the year, e.g. as cover crops and 'green curtains'. Extra photosynthesis is from halting deforestation (such as for GMO soy in Brazil or palm oil in southeast Asia used for cattle feed/biofuels as senseless land/energy misuse) or from reforestation to reverse desertification.

On assumption of initial 1,500–2,400 Gt SOC, the 4p1000's 0.4 % flux to soil from atmosphere was reasoned to give possible sequestration in the top 1 m of global agricultural soils of between +1–3 Gt C yr^{-1} (Zomer *et al*. 2107, Minasny *et al.* 2017) [41–42]. Albeit disputed by Batjes (2018) [24] with at best 1 Gt C yr^{-1}, no study includes new upwardly revised SOC total from Blakemore (2018b) [4] of >8,580 Gt that is accepted by Lal (2019) [43]. With ~3,400 Gt in permafrost and about half (or >2,590 Gt) of remainder in managed soils, +0.1–0.2% SOC gives a new potential +2–5 Gt C yr^{-1} flux.

Organic food production, whilst providing higher yields and greater C sequestration in humic topsoil has many other advantages compared to chemical farming in terms of higher soil moisture content (+28%), greater microbial activity and biodiversity (Blakemore 2015b, 2018a) [4,7]. Reduced pollution (costs of which chemical companies disavow) improves well-being too, as Howard (1943) and Balfour (1975) [17] concluded: "*The health of soil, plant, animal and man is one and indivisible*."

3.3. Survival: Biodiversity for Human Health (as for CBD Aichi Targets https://www.cbd.int/sp/targets/)

The problems of chemical agricultural in critical species extinction, although topical, are not new and were recorded almost 100 years ago from the earliest field experiments at Rothamsted by Morris (1922, 1927) [44–45] who found insects depleted -88% and earthworms all but completely eradicated by synthetic fertilizers (Blakemore 2018a: tab. 1; fig. 6) [7]. Not just the soil invertebrates are affected: Dependent birds and mammals including humans are also impacted (Carson 1963) [6]. Cancer rates from Carson of "*one in every four*", are now >1 in 2 in US (https://www.cancer.gov/). According to their National Cancer Institute (https://seer.cancer.gov June, 2018) causes are just 5% genetic, so 95% are due to chemical pollution and/or lifestyle resulting in the progressive banning of many agrichemicals. As noted, farm workers and children are particularly susceptible to 'weed killers' with cancer, chronic Parkinson's and autism rates alarmingly high and rising (Figure 4).

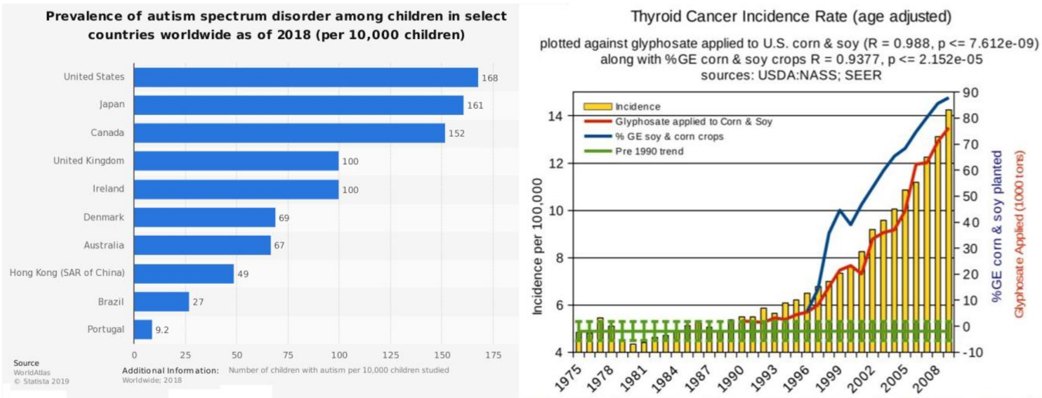

Figure 4. Increasing ASD in children (WorldAtlas Statista 2019) counter-indicates genetic causation; correlation of autism and other now common chronic diseases – e.g. diabetes, cancer, Alzheimer's, MS, IBS – is with glyphosate use and possibly other compounding factors including individual susceptibilities (Swanson *et al.* 2014: fig. 10 [11]; vermecology.wordpress.com/2018/05/27/wormageddon-destruction-in-our-soils/).

3.4. Smoke: A Burning Issue

Achieving 4p1000's extra SOC humus also implies reduction in un-necessary burning. The FAO (AFOLU 2014: 3) [46] has the land use factor accounting for a third of total anthropogenic greenhouse gas forcing, this includes deliberate or prescribed fires in natural forest, savannah, moorland and peats with burning crop-stubble, rice husks or sugarcane trash contributing to this. Forests take 80-100 years to recover from logging or accidental fires (Bowd & Lindemeyer 2019) [47]. More frequent with climate change, fires correlate with areas of soil degradation/erosion (Figure 5).

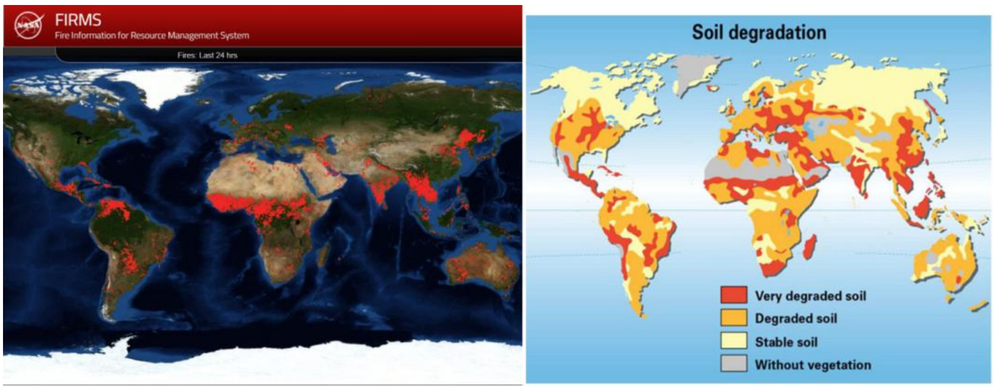

Figure 5. NASA's FIRMS real fire plots closely match UNEP's GRID-Arendal (2005) map of global soil degradation and desertification for which: "*The primary causes are deforestation, overexploitation for fuelwood, overgrazing, agricultural activities and industrialization*". (Source www.grida.no/resources/5507). Note: Vegetation releases ~3.6 kg CO_2 per kg C burnt due to O_2 oxidation formula, it also produces 1.8 kg of H_2O water as steam.

In general, CO_2 released by fire is not budgeted because, IPCC considers it balanced by carbon taken up during plant growth and the emissions as 'carbon neutral' (e.g. IPCC 2014) [48]. If so, this is mistaken in my view as all plants can be mulched and their carbon returned to the soil as compost rather than adding yet more smoke and water vapour (another greenhouse gas) into the atmosphere. This humic SOC aspect of fire is perhaps an important yet undervalued consideration.

4. Conclusions and Summary

A planned one week shutdown (2% of a year and of GDP) offsets annual CO_2 excess allowing natural processes to operate. A second week cancels all human emissions yet is pointless without programs to help farmers transition to organic at any scale to reduce soil erosion and increase humic SOC. Based upon IPCC (2014) [48], an official view is that Natural Climate Solutions (NCS) can provide only about one third of cost-effective climate mitigation alongside aggressive fossil fuel emission reductions (Griscom *et al.* 2017) [49]. Nevertheless, the subsequent 4p1000.org organic humus plan – herein newly revised to add 2–5 Gt C/yr – provides an elegantly feasible method. Soil remains the greatest mystery, yet its known 3–4 Gt sink may be upped by this extra 2–5 Gt from less erosion/burning and more compost/mulching to remediate the current +9 Gt C emissions, thereafter with reasonably rapid CO_2 drawdown. An unresolved issue concerns permafrost cryosols (see Figure 3) of 1,700–3,400 Gt representing ~25–50% of total global SOC at especial warming risk.

Aside from mitigation to remediate climate change, the imperative is to remove noxious agrichemicals/GMOs from the environment as an urgent priority to conserve biodiversity and to protect plant, animal and human well-being. The most practical way is also by restoring organic production that interlinks under a Permaculture umbrella with mutually beneficial issues in energy (e.g. geothermal/trompe), housing (e.g. solar-passive, heat pumps) and transport (e.g. pneumatic cars) themselves requiring separate study (as with Project Drawdown or as proposed by 350.org).

Cities and waterways are not major issues *per se* as each affects only 1–2% of land surface, so forests, fields and prairies are more important; but education of 50% of Earth's population now living in towns is needed for a better appreciation and delight in Nature amidst its rapid, almost irretrievable loss. At shutdown, city folk can visit local gardens or parks for 'forest bathing', WWOOF, relish a beef-free barbecue, hike or run cross-country with friends, contemplate sitting under a tree or planting one as cool shade or sustenance for contemporary travellers and as legacy heritage for our descendents to enjoy. As in Bill Mollison's maxim: "*Grow a pear for your heir*".

Supplementary File S1: Earlier draft with background data on total C storage potentials, nuclear isotopes and tree rings; compares the profound Deep Carbon CoDL project (<20 Gt C) with simple surface biocrust (>20 Gt C), massive CoML with modest CoSI (Blakemore 2012) [50], HANPP and other relevant source information. Sponsored science's abuse/misuse and its turn towards irrelevance or "*Darkness*" is flagged. Available online at: https://ia601502.us.archive.org/23/items/rob_S1/S1.pdf.

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Conflicts of Interest: The author declares none except unpaid association with 4p1000, FAO's GSP and IPBES.

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