Carbon Farming to Address Climate Change

Various strategies on global and national levels to address the rising threat of catastrophic climate change have failed to achieve the necessary reduction in greenhouse gas levels. They have led instead, directly and by default, to continuing increases in the levels of carbon dioxide, methane and nitrous oxide. It is established fact that forestry and farming are the cheapest and most effective routes to taking carbon out of the atmosphere and sequestering it in soil, trees and buildings using wood in construction. These are effective greenhouse gas removal strategies that are cheap and effective. Instead of actively pursuing these low-cost options we continue to degrade our soils, deforest or degrade forest carbon sinks and implement government policies in respect of biofuels and farming that accelerate the rate of increase in greenhouse gas levels. We have wasted a decade when we could already have been halfway back to 1850 greenhouse gas levels.

At the Oxford Real Farming Conference in January 2018 Patrick Holden of the Sustainable Food Trust asked Michael Gove, who was on the platform with Zac Goldsmith, if Britain remained committed to the 4 per 1000 proposal. The answer was ‘Yes.’

This paper addresses the question of ‘how?’

The 4 per 1000 (‘Quatre pour Mille’) proposal originated from Stéphane Le Foll, France’s Agriculture Minister from 2012 to 2017. Britain is a signatory and a Forum and Consortium member. 4 per 1000 states that, if farming and forestry could increase soil organic carbon by four parts per thousand, that would be enough to totally offset the annual 16 billion tonne increase in greenhouse gas levels.

In 2015, the French National Assembly, in response to that, set a €56 a tonne carbon tax that comes into effect in 2020. When everyone has to budget €56 a tonne for every net tonne of carbon dioxide emitted, they will likely choose to purchase tax-reducing offsets from farming and forestry, who can supply them at lower cost. ‘4 per 1000’ is a modest and achievable target.

**CARBON REDUCTION POLICIES HAVE FAILED SO FAR**

**Carbon Capture and Storage**

HM Govt has spent over £1.5 bn supporting CCS, the idea that you can capture CO2 emissions and bury them securely in the the ground. Nothing has worked so far, except the unproven PetraNova 2 plant in Texas, where the CO2 is used to push more oil out of exhausted oil wells. If CCS were to work it would cost at least €70 per tonne CO2 stored, with no guaranteed technology to ensure that the CO2 will stay in place. CCS requires fossil fuel inputs of at least 50% higher per kWh than energy generation without CCS.
Voluntary Carbon Trading
The voluntary market has created credits for 1 billion tonnes of CO2 in the past 10 years. That’s about .02% or 1/500 of emissions over that period. The European Climate Exchange and the Chicago Climate Exchange both went bust in 2010 when EU political decisions led to a gross oversupply of carbon allowances, driving the carbon price down from €20 to €0.70 per tonne CO2. Ethical investors lost money.

Biofuels
The EU Renewable Transport Fuel Obligation and the US Renewable Fuel Standard Programme both require mixing corn ethanol, rapeseed oil, palm oil or other combustible food-derived fuels with petrol or diesel. This has led to nitrate pollution and soil erosion and it is questionable whether it has any impact on fuel emissions. Corn ethanol production uses 1.2 - 1.4 litres of gasoline to supply the energy to produce 1 litre of ethanol, thereby increasing, not decreasing, emissions.³ 7 million tonnes of the world’s annual palm oil production of 66 million tonnes is burned to fulfil EU member state obligations. There are entire plantations of trees on otherwise useful land in North America that are harvested and pelletised to be burned as fuel in power stations such as Drax in the UK. The result has been substantial increases in particulate pollution with consequent impacts on human health. Wood burning emits more CO2 and more particulates than equivalent coal burning and contravenes the 1956 Clean Air Act that aimed to reduce smoke pollution in the UK.

The political process has singularly failed to reduce emissions. It has also failed to use the cheapest and most effective form of carbon removal - sequestration in soil and in trees. Instead it has focused on expensive high-tech alternatives while simply burning food and forests.

The 4 per 1000 initiative suggests that markets may do better, were there a ceiling price for carbon.

WHAT IS A CEILING PRICE?

The Government (and eventually governments in unison globally) can set a ceiling price for carbon that requires all emissions of CO2 to be paid as part of a company’s tax bill and to be declared as part of its annual returns. If a company can purchase carbon offsets for less than the ceiling price then it will do so, saving money and encouraging carbon sequestration and reduced emissions. A tax like this can be applied ‘upstream’ by being charged to the primary producers of fossil fuels, concrete, steel, wood pellets and energy.

HOW EFFECTIVE IS FARMING AND FORESTRY?

How challenging is the 4 per 1000 target? Some organic and regenerative farmers have increased soil organic carbon annually by as much as 7 parts per 1000 ⁴ The Rodale Institute have recorded sequestration in long term trials that show sequestration of 6
tonnes CO2 per annum in a corn/vegetable/wheat rotation and pasture results of 9 tonnes CO2 per annum, both per hectare.\(^5\)

Forests can sequester 11 tonnes CO2 per hectare per year.\(^6\)

Only individual farmers and foresters can make the thousands of micromanagement decisions necessary to manage our wide variety of soils and landscapes. They can then harvest the ‘downstream’ income for their carbon sequestration. No centralised administrative scheme can ever weigh and balance all the options. Historically outcomes have been worse than no intervention at all.

**WHAT IS A REALISTIC CEILING PRICE?**

Given that Lord Nicholas Stern has estimated that every tonne of CO2 emitted today will cost us £150 in the future and other worst-case estimates run as high as $1000/tonne, the French price of €56 (or a sterling equivalent of £50/tonne) is a modest valuation of the real cost of emissions.

What would happen if there were a £50 per tonne CO2 price? On a global level, farmers and foresters would take action to reduce greenhouse gas levels by an annual amount well in excess of 4 ppm. This would be enough to get us back to 1850 levels in 25 years. The UK can lead on this by example.

**HOW WOULD FARMING AND FORESTRY RESPOND?**

**Reduced inputs**

If nitrates, pesticides and herbicides included their embodied carbon cost in their pricing they would become uneconomic in many applications. Farmers would reduce inputs. A tonne of ammonium nitrate has a carbon footprint of 5.6 tonnes of CO2e. The £240 cost of a tonne of nitrate fertiliser would more than double. Nitrous oxide emissions and water pollution from run off would diminish.\(^6\)

**Pasture and Field Management**

Farmers would increase soil carbon by the use of grass leys and compost. They would minimise tillage and grow green manures to keep ground cover all year round. A wildflower meadow, even when cut for hay once a year, can capture and store 3 tonnes of carbon, or 11 tonnes of CO2 per hectare annually\(^8\). Grass species would be selected that are deep rooted and are the most efficient at storing carbon in pasture soils. These would replace nitrate-hungry annual ryegrass species.

**Biochar**

Carbon from straw, sawmill waste and forestry arisings can be converted into biochar and added to the soil to permanently enhance fertility and increase the carbon in the soil ‘carbon bank.’ Biochar is 80-90% pure carbon and can stay in the soil for centuries. One tonne of biochar incorporated into soil permanently sequesters 3 tonnes of CO2, whilst increasing soil fertility by enhancing the soil microbiome. The Royal Society has called for the use of biochar in place of fuel wood in their Sept 2018 report on Greenhouse Gas Removal.\(^9\)
Afforestation and land use change
Farmers would plant trees and hedgerows on former biofuel land and would practice agroforestry and alley cropping.

No more biofuels
We would stop burning forests in power stations like Drax. Trees would be worth more alive than dead. Farmers will find other break crops to replace rapeseed.

Increased use of wood in architecture
Wood would replace steel and concrete in buildings and homes. Steel and concrete together are responsible for 10% of global annual GHG emissions. Wood is carbon negative. Modern cross lamination technology means wood can equal or exceed the strength, resilience and load bearing capacity of concrete or steel.

No more CCS
The £1.5 billion that the Government has given to support carbon capture and storage research would be the last such payment.

End of peat use
Peat use would end overnight as peat would become uncompetitive with sustainable growing media such as coconut coir, composted green waste and composted bark. Peat bogs would become more profitable if left alone to become carbon sinks, sequestering 1-3 tonnes CO2e annually. Coconut coir CO2 emissions in horticulture are equal to peat but take place over 10 years instead of 2 years. Coconut trees and plantations are a carbon sink and already produce nutritive energy-rich food of which coir is a by-product.

Improved rivers and fisheries
The sea would be more productive. Reduced fertiliser use and reversal of soil erosion would herald the end of harmful algal blooms.

Soil is the world’s most important and valuable commodity. With a realistic carbon price, we would not suffer the resource misallocation of agricultural subsidies embodied in the Common Agricultural Policy.

WHAT’S STOPPING 4/1000?

Greenpeace have a lot to answer for here. 12 years ago they and other NGOs successfully campaigned against paying the same price for carbon saved by trees as for emissions avoided from wind or solar. Andy Tait, their head of biodiversity said: “These proposals offer countries the chance to buy their way out of reducing emissions through forest protection. If relatively cheap forest credits were easily traded with other carbon units, they could ‘flood’ or otherwise destabilise the markets.”

We have wasted a decade when forestry could have been taking billions of tonnes of carbon out of the atmosphere, solely because it is a so much more effective and inexpensive tool than wind and solar.
There is a huge amount of money going into various technologies to reduce emissions. Investments in infrastructure for wood pelleting, biofuels manufacture, CCS have created a network of vested interests which see the much cheaper sequestration of carbon by farming and forestry as a competitive threat. Wind and solar are getting cheaper, but are nowhere near as competitive as 4/1000.

Money has been poured into supporting wind energy. Every tonne of CO2 saved by onshore wind costs €162, from offshore wind £267. Combined Cycle Gas Turbines (CCGT) have half the emissions of coal fired power stations and make it much harder to justify subsidies to wind or solar. How do these costs compare to forest carbon?

**FOREST CARBON COST**

A regenerating degraded tropical forest can profitably generate CO2 savings for a cost of less than £5/tonne. Management costs for forestry are minimal: planting, initial weeding, then thinning after 7 and 14 years, thus few of the annual costs associated with arable farming. Pasture and arable farmland can sequester CO2 for less than £20/tonne. Exact figures vary depending on land use type, soil type and climate. Sequestering carbon in the soil or in forests is always significantly cheaper than reducing emissions. So why do we continue to see deforestation and forest degradation? Why do we lose 31 football fields per minute of productive agricultural land entirely due to farming methods that need take no account of carbon emissions?

The answer is that for decades there has been a prevailing view that the biggest problem was industrial pollution. We saw a high price of carbon and adequate regulation as a means to force industrial polluters to eliminate pollution. This has failed. Forest credits are the cheapest way to mitigate climate change. It was feared that forest credits would bring down the price of carbon and reduce the incentive to reduce emissions from energy, industry and transportation. Clearly this was unrealistic economics because a tonne of carbon emitted has the same impact however the mitigation occurs and a free market will always go for the most efficient option. However, vested interests have successfully lobbied to have a two-tier carbon price, one that undervalues the carbon saving from CO2 sequestration and one that generously rewards technological approaches that can reduce CO2 emissions. This approach can only work if government policy controls pricing.

This policy has failed. Emissions are still rising globally, by 16 billion tonnes CO2e annually. Changing land use that takes full advantage of the power of photosynthesis now must come to the fore. The societal benefit of carbon greenhouse gas reduction is the same, whether it comes from reduced emissions or increased sequestration. A tonne of CO2 is a tonne of CO2 whether it is emitted into the atmosphere or removed from the atmosphere. The ‘Social Cost of Carbon’ i.e the price our grandchildren will pay for our profligacy, is at least £150/tonne, so reducing carbon dioxide is a real bargain.

**HOW DOES A CARBON PRICE AFFECT FOSSIL FUEL PRICES?**

A barrel of oil represents 118 Kg of carbon dioxide emissions. At £50 per tonne CO2, the carbon dioxide emissions from one barrel would increase the oil price by £8/barrel, or $10
per barrel. The oil price was $110 a few years ago and has risen from a low of $30 to current level of $80 in the past year. This has had minimal impact on fossil fuel use.

If the market price of carbon dioxide is lower than £50 the impact on the oil price will be commensurately lower.

**WHAT WOULD BE THE ROLE OF THE CITY?**

The Government need not be involved in the carbon market. It simply creates a law and a tax price that requires all emissions to be paid for or offset by an equivalent amount of sequestration. This then takes carbon dioxide out of the hands of government and puts it, like any other valuable commodity, in the hands of the markets.

If Shell, Exxon, Tata, British Steel and other primary emitters were paying £50 tonne for their emissions, then the market would drive up the price for offsets. That’s the supply side of the equation. What would the demand be? Fossil fuels and industry emit 33 billion tonnes a year. At £50/tonne that would be more than £1.5 trillion. From a City of London trading point of view, that’s a commodity market with a nominal value double that of petroleum and 3 times that of coffee. If Britain leads on this by example then the financial hub for carbon, the ‘gold’ of the future, could be London.

The City of London has the depth of liquidity and the reputation for integrity that a $1.5 trillion global carbon market will need to succeed. This is a great opportunity for London as a global financial centre to benefit from a carbon market supported by law.

As every tonne of carbon dioxide emitted will have a ceiling cost of £50 tonne and it is possible to sequester carbon at a lower cost than that the flow of cash into sequestration will be transformative. Pillar 1 subsidies can fall away without impacting on land values. Rural economies will be invigorated. The complexity of agricultural subsidies will be simplified and will help remediate the misallocation of resources that current CAP policy encourages.

Auditing and certification of carbon sequestration represents an opportunity for the carbon certification industry.

**WHO WILL PAY?**

Emissions should be counted as far up the supply chain as possible. Refineries, power stations, coal mining, transportation and livestock farming would purchase carbon. This would impact on pricing, but in practice the carbon tax is simply charging a fraction of the actual societal cost of emissions. At £50/tonne CO2 the price of lamb would increase by £2 Kg, the cost of beef by £1.35 Kg, the cost of cheese by 90p per Kg and the cost of petrol or diesel by 5p per litre. Organically produced lamb, beef and cheese would be less expensive than the non-organic alternative.

**WHAT ABOUT CHEAPER IMPORTS?**
The European Environment Bureau interpret WTO and GATT rules on Carbon Border Tax Adjustments to conclude that any country that prices carbon can impose a commensurate tax on imports to compensate if the supplier country does not have an equivalent carbon pricing regime.

**WHAT IS THE GLOBAL SCALE?**

Carbon sinks are primarily forests, fields and meadows

The world has 1.5 billion hectares of arable land

The world has 4 billion hectares of forest and woodland

The world has 5 billion hectares of grassland

That’s a total of 10.5 billion hectares that have the potential to play a part in carbon sequestration.

Every year the earth sends 36 billion tonnes of CO2 into the atmosphere, comprising 33 billion tonnes from industry and fossil fuels and 3.5 tonnes from deforestation and land degradation.

But 20 billion tonnes of these emissions already come back to Earth.

Every year 9.5 tonnes are absorbed by the sea and 11 tonnes are absorbed by forests and soils. That leaves a net annual increase of 16 billion tonnes.

The 4 per 1000 initiative can achieve its goals in 2 ways:

1. By stopping the emissions from deforestation and land degradation (3.5 bn tonnes)
2. By increasing the capture of carbon dioxide by forests and soils by 8.5 bn tonnes.

If carbon is priced then the 3.5 billion tonnes lost to deforestation and degradation would soon end.

The remaining 8.5 bn tonnes works out at approximately 1 tonne per hectare of woodland, pasture and arable land

Can farmers, foresters and pasture managers achieve 1 tonne CO2e per hectare? At a bare minimum, yes.

**An example of Soil Organic Carbon dynamics**

La Vialla, a family farm in Tuscany, comprises 1440 hectares including arable, pasture, woodland, vines and olives. They are a microcosm of the global distribution of land use
types. Their soil is silty/sandy. The University of Siena⁴, using IPCC methodology, has
calculated their annual carbon cycle for the past 8 years.

Their calculations show that 4.24 tonnes of CO2e per hectare have been captured every
year for the past 8 years.

Across the global estate of forests, farms and pastures of 10.5 billion hectares that
translates to an annual capture of \(4.24 \times 10.5 \text{ bn}\) = 44 billion tonnes CO2 per annum.

In other words, the annual increase of 16 billion tonnes CO2e per annum could translate
into an annual decrease of 28 billion tonnes per annum. As emissions are 33 billion tonnes,
a £50 tonne carbon price globally would enable such a decrease, reversing greenhouse gas
levels with the urgency that is required.

Then we could take a measured approach to the burning of fossil fuels because farming and
forestry would still be taking far more carbon out of the atmosphere than fossil fuel burning
contributes.

The world is not like La Vialla. Some farms have richer soils, some have poorer soils, the
rainfall in Tuscany is pretty average, every farm and woodland is different.

One illustrative example: the carbon footprint from La Vialla’s poultry fertiliser amounts to
35 tonnes CO2e compared to, were they to use chemical fertilisers, 409 tonnes CO2e.

**WHAT ABOUT PERMANENCE AND FAIRNESS?**

**Permanence**
One criticism of soil and forest sequestration is that is can be reversed, whereas a tonne of
avoided CO2 emissions is eternal. A farmer can plough up the soil, a forester can chop
down the trees and then much of the carbon captured is released back into the
atmosphere.

**Fairness**
A farmer who has degraded soil or woodland can instigate quite rapid increases in soil and
forest carbon. If a conscientious farmer has already built up substantial levels of carbon-rich
organic matter in their soil or has mature woodland then they will find it harder to increase
it incrementally to the same degree.

The threat of hurricanes, forest fires, floods and earthquakes can also affect carbon storage.

**2-PART PAYMENT FORMULA**

A 2-part payment can address permanence, fairness and unforeseen upsets

1. A payment for the annual increment of CO2 as measured in organic matter
2. An annual ‘interest’ payment at, say, 10% of the amount of carbon held in the soil ‘bank.’

An insurance ‘no claims bonus’ for not losing any carbon can also apply. Farmers would need to insure against loss of carbon due to flood, earthquake, drought or other extreme events that might disrupt their carbon store. The no claims bonus would be an additional benefit to the landowner.

The market will of course focus on the cheapest carbon, i.e. forestry. However insufficient supply means that there will have to be a motivating price to reward other sources such as pasture, arable, tree crops, agroforestry and vines. The cost of agroecologically-produced food would come down and the cost of industrially-produced food would go up. No longer would price be a barrier to eating food that is rich in nutrients, low in pesticide residues and which delivers tangential social and environmental benefits.

Most people recognise that low impact farming is better for human health and environmental health, but the higher price has always been the deterrent to widespread adoption. Human health, biodiversity, a more welcoming countryside and the end of land degradation and sea pollution are additional benefits.

**Time to Incentivise Soil Organic Carbon**

Soil Organic Carbon sequestration, including forest soil sequestration and sequestration in wood is a cheap and effective way of reducing greenhouse gas levels. Compliance with Paris COP 21 targets is challenging if we are solely dependent on technological solutions aimed at emissions reductions. Using up precious soil and forests for the production of biofuels is wasteful, uneconomic and does nothing to help mitigate climate change. The above outline shows how economic incentives to maximise soil and forest sequestration of carbon dioxide can be an effective and low-cost solution to achieving greenhouse gas reduction.

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1. [https://www.4p1000.org/](https://www.4p1000.org/)
2. [https://cleantechnica.com/2017/06/12/petra-nova-leading-ccs-power-station-provide-model-australia/](https://cleantechnica.com/2017/06/12/petra-nova-leading-ccs-power-station-provide-model-australia/)
5. [https://rodaleinstitute.org/assets/WhitePaper.pdf](https://rodaleinstitute.org/assets/WhitePaper.pdf)
6. [http://www.fao.org/docrep/005/ac836e/AC836E03.htm](http://www.fao.org/docrep/005/ac836e/AC836E03.htm) [https://www.forestry.gov.uk/forestry/infd-889hsz](https://www.forestry.gov.uk/forestry/infd-889hsz)
7. [https://www.researchgate.net/publication/51997325_The_European_Nitrogen_Assessment_Sources_Effects_and_Policy_Perspectives](https://www.researchgate.net/publication/51997325_The_European_Nitrogen_Assessment_Sources_Effects_and_Policy_Perspectives)
8. [http://wildflowerturfblog.wildflowerturf.co.uk/2012/09/14/does-a-wildflower-meadow-offset-your-carbon-footprint/](http://wildflowerturfblog.wildflowerturf.co.uk/2012/09/14/does-a-wildflower-meadow-offset-your-carbon-footprint/)
BUSINESS AS USUAL

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- FARMING: 10 billion tonnes CO2
- FOSSIL FUELS & INDUSTRY: 27 billion tonnes CO2
- LAND SINK: 10.9 billion tonnes CO2
- OCEAN SINK: 9.5 billion tonnes CO2

TOTAL ANNUAL INCREASE IN GREENHOUSE GAS LEVELS

+17 Billion tonnes

£50 PER TONNE CARBON PRICE

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- FARMING: 5 billion tonnes CO2
- FOSSIL FUELS & INDUSTRY: 27 billion tonnes CO2
- GRASSLAND: 20 billion tonnes CO2
- FOREST: 6 billion tonnes CO2
- OCEAN SINK: 9.5 billion tonnes CO2

TOTAL ANNUAL REDUCTION IN GREENHOUSE GAS LEVELS

- 20 Billion tonnes