Walter Jehne; The soil carbon sponge, climate solutions and healthy water cycles
https://youtu.be/123y7jDdbfY

Transcription

I have split the talk into bitesize chunks, so you don't have to read all at once, just like if you watch the video, there are handy pause moments as he goes from one topic to another. I find this gives you time to soak in and digest the information.

0:00-0:40

Didi Pershouse did the first part of the talk, which I have not included as she's written a work book
"Understanding soil health and watershed function" free download https://soilcarboncoalition.org/learning/Soil_Health_and_Watershed_Function.pdf
which goes into her work in detail.

Here are the most important points, and Walter will refer to the bread analogy later:

Plants drink in CO_2 from the air and water from the roots to create life. Carbon is everywhere, in the microorganisms in the soil, in the animals, in the plants.

Water, soil and climate are interconnected.

Using a flower and bread analogy- when you have a mound of flour (representing the mineral soil particles) on a plate and pour on water, it runs off and you get a drought in the middle where the flour has not absorbed the water, and a flood around the edge where the water has run off. Compare this to pouring water onto bread- the bread acts as a sponge, the only difference is that biology (yeast) has changed the structure of the flour. The same is the case for soil. If you'd like to see this on the video, it's at 4 minutes 15 seconds in.

It's not true that if you till the soil it will make it more absorbent. This is shown with a model called "the infiltration vs runoff and erosion in rain simulator", shown in the workbook.

The main speaker is Walter Jehne, a soil biologist in Australia.

He works with Healthy Soils Australia which has 1000 farmers members who are regenerating the soil to help fix the water cycles and cool the planet.

"New Climate Solutions- we are going to be talking about hydrology,
95% of the heat dynamics of the blue planet is governed by water. It's a whole process and influence that we have in a sense ignored in the last 60 years of climate debate because we've been so focussed on the CO2 rise and the symptoms of that, and what do we have to do to address that.

Water and the natural process drives the hydrology and heat dynamics of the planet- can we look at these and see if they can be part of the solution?

Where do we humans have agency- as in, what can we do, what are the practical points of influence? One of these things we can influence is the sponge. How do we regenerate the earth soil carbon sponge? It enables all the biosystems, the water and food we depend on, and enables us to actively cool the planet.

We've all seen Charles Keelings chart from 1958-
CO2 started at 280ppm in 1958 and is now 406ppm

It goes up in a zigzag. Every winter we were emitting carbon, and every spring summer we were drawing it back down, from the air, into bio systems.
We have a deficit of 10 billion tonnes of carbon every year that wasn't being drawn back down.
It's that accumulative deficit that causes the CO_2 rise.
CO_2 is a greenhouse gas which does about 4% of the heat dynamics of the planet. By increasing it we are accelerating the greenhouse effect.

We know the effect is serious.
We have Insident solar radiation: that is solar energy that's beaming down on the earth all the time.
On average at the top of the troposphere, that's 342 watts per square meter.
To keep a stable climate we need 342 watts going back out.
Otherwise the climate heats.
It's not, because now we now have increased the greenhouse effect of our atmosphere we have only 339 watts per square meter reflected back out. There's about 3 watts per square meter that's being retained, or warming. It's significant because it's it's warming the planet, but we are talking about less than 1% of total radiation.

What role does water play in this?

In 1978 Jimmy Carter asked scientists to give him the grounding of what we have to do to fix climate change.

The scientists did a lot of their work on the CO_2 increase. They were well aware that 95% of the heat dynamics is governed by water, but they excluded water from their analysis because:

1. Water is so dominant on earth they believed we humans cannot have possibly altered it enough to have an effect

2. Because water is so variable in time and space, in different habitats and seasons, it's impossible to model mathematically and work out scenarios etc.

So they focussed on CO_2, and water wasn't seriously considered. Svante Arrhenius did these calculations originally in 1896, showed warming due to CO_2 alone was only about 0.2 degrees centigrade when you double the CO_2, so they integrated a water vapour feedback effect as part of their modelling process.
Simply what happens is as you increase the temperature, the amount of water vapor in the atmosphere increases. Air at a higher temperature can hold more water. This is included as a secondary feedback. But they've never looked at water as an independent factor.

Because of this analysis, for the last 40 years we've been focussed on CO_2. In 1988 the United Nations Convention on Climate Change was formed to prevent dangerous climate change happening. All nations in words committed themselves to it. Out of that they formed the IPCC, Intergovernmental Panel of Climate Change, the scientists have been looking at the consequences and impacts of the rising CO_2 increase, again leaving out the hydrological processes because they are too complex and difficult to model.

When we are talking about new solutions for climate change, we are really trying to step outside this narrow band and see what else we can do.

In 2005 they found it's not just the rise in temperature but the dangerous weather events that's accelerating and happening more. These extremes are already impacting populations and food production. Hurricanes, storms, flooding, droughts, systemic aridification of large areas and wildfires and sea level rise.

All of these impacts are hydrological. These positive feedback loops are already happening and accelerating.

In Australia and Mediterranean areas, the Hadley cells (where hot air rises from the equator and descends to the north and south), because of the heating of the planet these have expanded north and south by 300km, so the intensified heating has forced the other cooler moist Hadley cells further towards the poles. Australia has seen a 20% decrease in rain fall, and a 30% reduction in stream flow and so is aridifying- the same is happening in the Middle East, California etc. Farmers farming the Fertile Crescent in Syria for the last 10,000 years have abandoned their farms because their soils and hydrology has collapsed. This migration into urban areas has resulted in social collapse and crisis too.
This systemic aridification is one of the serious fundamental consequences of climate change that's already occurring.

In 2015 the IPCC pulled down a general agreement to get to net zero carbon emissions. Can we get our emissions to equal the drawdown each year? To do that there has been a big move towards how we can draw down carbon back into soils and biosystems, as carbon sinks.

Yes we have to do this. Yes we have to continue to reduce our CO2 emissions. This has to continue. No one for a minute is suggesting we don't have to do this. But the power is can we accelerate that drawdown of carbon back into the biosystems. Every year 120 billion tonnes of carbon is drawn by green plants back into the biosystems in spring and summer. But that's not good enough. Because every year 130 billion tonnes of carbon is emitted, which is where we get the 10 billion ton deficit.
We can increase this, because at the moment the residual bio system that we have, ie the land surface still covered by green photosynthesising vegetation, is perhaps half of what it was 8,000-10,000 years ago.

The UNEP (United Nations Environment Programme) data shows we've done so much degradation of forest and grasslands we've created 5 billion hectares of man made desert and wasteland over that 8,000 years. The issue is can we increase the drawdown of carbon by regenerating that biosystem. A lot of what we will be talking about is how we do that, and how can we enhance that.

0:40-0:59 This section includes the best description of soil formation and soil carbon I've seen.

There's a bigger problem however.
Because although that may be able to drawdown CO2 and flatline them, it won't bring the CO2 back down to pre industrial levels. In order to do that, we may have to do another 10 billion tonnes per annum to draw back heritage/legacy emissions. So the target may be 20 billion tonnes of carbon per year. The good news is yes we can do that. We can do that by land regeneration, by extending the areas but also the longevity of production of green growth. None of this is possible unless these biosystems have water. In order for the plants to grow to draw down the carbon, they need water from the soil. The whole take home of whether we can draw down that carbon is, yes-but we must regenerate the soil carbon sponge, in order for the plants to get the water they need. We don't need to bring water in, we need to build up the sponge so that when it rains the water is retained in the landscape rather than washing away or evaporating.

Where is the rain, and what happens to every raindrop?

Another problem is that even if we are able to draw down 20 billion tonnes of carbon per year, and we could get to negative net emissions, even that's not good enough. Because the oceans contain 30,000 billion tonnes of carbon, and as we draw down more carbon from the air, the oceans re-equibrilate some of the carbon that they have been absorbing from all of our emissions over the last 8,000 years back into the air. It's a buffered equilibrium system. It may take 100 years, or 1000 years of drawing down before the CO_2 levels get back down to preindustrial levels, or before human intervention.

The oceans contain dissolved CO_2 which are making them acidic.

We are already experiencing extreme climate events, the Napa Valley burnt last winter which is unheard of in a temperate zone, the Californian water cycle is on the brink of collapse, we don't have 100 years or 1000 years to sort out the problem, we need to balance the system now. It's not just regenerating the earth's soil carbon sponge, but how do we naturally, safely, cool regions and the planet.

It's very audacious, how do we bring it back to the debate as a grass roots, practical reality. How do we practically and safely cool the planet- that's the challenge we've given ourselves.

This has been to set the context of what we are about. We've already said why we have to do it, so the next question is what do we have to do? And how do we do it?

The easiest place we can go to for answers is to say what did nature do? How did nature create this biosystem? How did nature create natures hydrology, how did nature create the earths natural cooling? We were 342 watts in, 342 watts out, stable for hundreds of millions of years. How did nature do it?

We can look at all the evidence, it's very clear. We can go back to 420 million years ago. Then we had oceans and we had rock. Dry, arid, hard rock. No life on land. There was complex multicellular life in the oceans after the Cambrian explosion, but that life depended on nutrients leaching from the rock into the oceans and that was a limiting factor on ocean life. Life is pretty aggressive and competitive so life said, hey if I can get onto that rock to get those nutrients I have a competitive advantage. It did just that. It grew tubes of psytoplasm with enzymes to solubilise essential nutrients. These are our fungi. These drove life processes further. Fungi are just like us, they are heterotrophs; they can't fix their own sugars, they can't make their own energy- only plants and algae can do that, and some bacteria.

They needed to form a relationship, or symbiosis with something that could give them sugars. In the ocean there was plenty of blue green algae. So these fungi and these algae got together and formed a lichen. We see lichen all over the planet still, dissolving rock, or buildings, concrete, wood, cars- whatever it is lichens are biodegrading it, breaking it up, having lunch.

These lichens in growing and moving on, leave behind organic detritus. That organic detritus can hold water, it contains a mixture of minerals, organic materials, and that enabled plant life to evolve from lichens to mosses to ferns to Cyclades to gymnosperms to angiosperms, and about 50 million years ago, grasses.

Parallel with that plant evolution of course we had the herbivores, insects and everything that was feeding on those biosystems.

The process of pedogenesis, of soil formation (soil is simply a mixture of mineral particles and organic detritus) enabled life to extend across the 13 billion hectares of ice free land in this planet. 100 million years you had a planet which was in the Carboniferous period, with lush deep forest, deep organic soils, all teaming with life. In fact so teaming with life that the drawdown of carbon got carbon levels in the atmosphere down to 100ppm. Compare that to when life started on land it had been 7-8,000 ppm by the Carboniferous period nature had drawn all that carbon in. This is where we get all our coal and fossil fuels from.

What we had with soil formation 420 million years ago is same story now, everyday, think of this as exactly what happened on the Great Plains, and after the last Glaciation, this is it.

Basically if you just have hard rock or solid rock or compacted soil, or stardust! 4.6 billion years ago we had supernovas created stardust created the planets out of these rocks. These rocks are made of nutrients, be it phosphorus, calcium, zinc, magnesium. This is what the earth rock was like 420 million years ago.

You put a drop of water on that, and just how Didi showed us with the flour, it just runs off. What life did, (just as Didi showed us with the bread as the sponge, with the whole pedogenesis process) lichens grew on this rock and solubilised it. This resulted in exactly the same mineral particles, (we haven't lost any, although some may be broken up into clay micelles), but there is space inbetween them. In this space there is organic detritus- figuratively think of this as like carbon bed springs between the particles. And what happens with springs? You can bounce on it- it's a sponge.

It goes from a rock, which has the bulk density of 2.6-3.5g/cc (this is a weight per unit volume) to healthy soil which has a bulk density of 1.2g/cc.

Healthy soil is made up (66%) by voids, which can be filled up by air. Nature has taken sunlight, CO_2, water; and created carbon through the plant/microbial processes and added them to this mineral matrix; it's made a healthy soil just out of mineral particles and the organic carbon plant detritus or "bed springs".

What is powerful about soil, and what is the depth of our whole sponge discussion is; now 66% of the volume is available for infiltrating and retaining water. This can now sustain living plant growth for far longer. It can now vastly increase the availability of nutrients. In rock we have all the essential nutrients for plant growth, but they are locked up, unavailable, inaccessible. In a healthy soil the phosphorous, calcium, zinc, is all exposed for microbial activity. So the bio productivity of that soil increases exponentially simply by creating these surface exposures. Just by having the voids.

Because there are voids in the soil the root ability increases. Plant roots can grow and proliferate and penetrate. Instead of 6 inches they can go down to 6 feet/20 feet! So the volume of soil resource is now available for plant growth and the drawdown of carbon we talked about earlier is exponentially increased.

The whole bio productivity of these healthy soils, the resilience of those soils, the capacity to infiltrate, to buffer, to extend life vastly increases. This is what nature did to create the bio system, to create the hydrology, and in a very simple form that's all we have to do. We use plants, we use microorganisms. With photosynthesis the plants and microorganisms together create stable soil carbon, which is the organic detritus or bed springs between the soil mineral particles.

This is how the earth ran 95% of its heat dynamics and its natural cooling. For us it's very simple. If we want to draw down 20 billion tonnes of carbon per year, if we want to rebuild this sponge, we have to copy nature.

So how do we copy nature?

0:59-1:16 This section discusses how modern industrial agricultural practices are harming our soil.

How do we copy nature?

It's as simple as A B C

(Again it's better if you watch the video really for the diagrams, this is at 59:50. Walter draws a cross from a horizontal and a vertical line. A is top left, B is top right, C is bottom right.)

It's all about plant growth.

A is for Agriculture
Both in terms of field cultivation but also in terms of urban agriculture, we'll come back to that later. In agriculture we have been dominant because we live above the ground and we've been all about maximising yield weight. And we are still in that game.

What we don't recognise because we only live above the ground, we only see the 30% of the biomass that's on the tops of the plants. What we tend to not see is the 30%+ that is on the root systems. If we go to our bluegrass prairies you've got root:shoot ratios of 5:1, so already 80% of the biomass is down under, not above ground. The point is we see things above the ground and we miss some of these very important things. 30-40% of the nutrients are exudated out from the roots as sugars and amino acids etc, and these are critical for feeding this microbial ecology that drives the formation of healthy soil. These support a vast population of fungi, bacteria, Protozoa, earthworms, the whole life in the soil. There is 10x the weight of animals in healthy soil than there is animals or humans living above it. All those organisms are driving the solubilisation, fixation, access, uptake, cycling of nutrients, constantly driving the energetics and productivity of those systems. The fungal hyphae, 25,000km per cubic meter of healthy soil! That's twice the diameter of the earth per cubic meter! The soil is a living microbiome.

What's important about the weight of yield above ground- that's fair enough, but what happens to every gram of carbon that's been fixed by photosynthesis? Not how much we produce, but what happens to it?

There's only two things that can happen to that carbon. Only two things for the last 420million years.

It can either (B) burn (or oxidise) back to CO_2

Or it can turn into Stable Soil Carbon (C)

It can either oxidise or turn into bed springs.

Our future management of biosystems is all about B C ratios. How much to we let burn, and how much do we fix into our soils.

We talked a minute ago about the tall prairie grasses with the root to shoot ratio of 5:1, they are putting 80% of the carbon they fix into the soil, building a healthy sponge, a healthy soil. If you were on the Great Plains 9,000 years ago you would have had glacial outwash till- clays, rocks, gravels, swamps, just mineral wasteland. In the space of that 9,000 years, that bluegrass, pumping carbon into bedsprings, that has created some of the worlds most productive soils. 10 meters of beautiful prairie soils, able to retain the rain, extend longevity of growth, maintain massive populations of herbivores, a resilient productive biosystem. Until we can along, but that's another story.

We come along, and in trying to grow things better, not trying to be rude, we had a More On agricultural strategy.

First we CLEAR
We BURN
We CULTIVATE (ie tillage, ploughing)
We over FERTILISE

We IRRIGATE
We can FALLOW (leave the land bare)
And perhaps worst of all we can add BIOCIDES

All these things (in excess) do the same thing: they oxidise carbon back into the air. They burn off the bed springs, reverting soil back to a compacted, impervious rock, like the flour demonstration we had at the start, with lower productivity.

The tragedy is in our agriculture, we've invested 40% plus of the net value of our agricultural production into these inputs that are actually driving this CO2. Of course a lot of the CO2 comes from our fossil fuel use, but for the last 6,000 years, well before we were using fossil fuels, we've been oxidising carbon from the landscape. We used to have 8 billion hectares of primary forest on this planet, we've cleared 6.3 billion hectares. Some of it has regenerated such as in the New England area of North America, and the north east, so we've now got only 3.5 billion hectares of forest on this planet.

We burn every year 350 million hectares of forest. 10% of that residual forest.

Every year we burn 2 billion hectares or grassland and crop stubbles and rangeland. All driving CO2.

When we cultivate the land we expose it to ultraviolet radiation which kills the microorganisms and it oxidises carbon.

We add excessive fertiliser; every gram of excess nitrate fertiliser for example we add to the soil, as in a compost process, oxidises 30g of carbon. That's just the biological composting reactions.

We irrigate and restrict the fungal growth, stopping different organisms growing, restricting the bio productivity.

Fallow is just starvation. If the fungi haven't got exudates they can't grow. Everything just sits in a resting dormant phase until plants come back again.

If we add biocides it's just killing all these things outright.

So we've done an enormous amount of damage. Conversely, what regenerative agriculture is all about, we can focus on "C", and the question is how much of these roots and these root exudates can we turn into humates? Humid acid, humus, (effectively a composting type process) how do we maximise that? And with the fungal networks, the 25,000km of fungal network, that as it moves on it leaves it's cell walls that turns into the compound GLOMALIN.

GLOMALIN and humates together form the glue that hold soil aggregates together and create bedsprings.

Question from the audience:
How much CO2 in a healthy soil is put back by bacteria?

Answer: the fungi do most of the work but we aren't scoring: we need a healthy zoo down there. A lot is also stored by bacteria.

For the plant matter, the stubble and the plant material that we haven't harvested as grain, nature evolved these very clever things, called mobile biodigesters. They are trying to get the plant material back into the soil. These mobile biodigesters are called Ruminants. Their stomachs are full of bacteria, which digest the cellulose into fertiliser. They create the optimal bacteria condition to convert these cardboard litters, because if we didn't do that, all this litter goes up as fire.

Audience: we see this in California, they got rid of their “mobile biodigesters” and you have all this kindling which sets fire.

Walter: yes, if it’s not eaten, it’s going to burn. But there’s a lot more ecological advantages because these herbivores are moving around, they are breaking up surface soil, they’re spreading biofertiliser, so the wise integration of herbivores, particularly in grasslands, critically important.

Grasslands evolved 50 million years ago, to exist only in a symbiotic association with herbivores. If not those grasslands will burn and the whole biosystem crashes back to desert. It’s a knife edge ecological balance, and the important thing is we manage all these things and we can manage B and C beautifully through smart, ecological, regenerative agricultural practices.

Question; but what about methane?

1:16-1:27 This question that sidetracks Walter is very interesting.

Walter: these are very important questions.

You, me, anyone with a gut, produces methane. Because we’ve all got anaerobic bacteria. Anaerobic bacteria produce methane: CH_4. But because these herbivores create green grass- as I said they are the critical thing to keep the ecological health of those grasslands and stop them from burning- that green grass (nature’s really clever) produces transpiration. Or water vapour H_2O.

When sunlight hits water vapour, it photo-oxidises and produces hydroxyl ions OH^-, and hydrogen ions that form bicarbonate ions HCO_3. These hydroxyl ions are free radicles, they are aggressively oxidative. And they will turn that methane rapidly into CO_2 and water.

We've got this process where a healthy green pasture will produce about 100x the hydroxyl radicle photo oxidation than the herbivores grazing it have the potential to produce. There's also methanotropes in the soil, but that's just icing on the cake.

Methane has been 700 parts per billion (ppb) in the atmosphere for the last 10 million years plus. We had massively higher numbers of natural grazers, if you look at the buffalo, wilderbeast, springbox, in the past but levels of methane had stayed constant in the atmosphere.

Recently they went up to 1700 ppb. That was due to Russian oil and gas fields, the Yeltsin and the USR breakdown not having any maintenance for 10 years and the fugitive emissions were prolific. They've now gone up to 2300ppm and it varies from place to place. And some nations have been fracking! In fracking the fugitive methane emissions are prodigious."

(If you'd like to read more about this, this article is a positive step in recording huge methane emitters by satellite, so can help us put a stop to this in the future. Hopefully https://www.aljazeera.com/news/2022/10/26/new-nasa-instrument-detects-methane-super-emitters-from-space?fbclid=IwAR2jny8PzE4CJ2XIxReMSDDyMglQdJX1CVuiw_R9TygZjpM6G8CYtSmTjJw)

Walter continues:

"But there's a putsie in this game. Called cows. Cows can take the blame- hey we look and yes, a cow does produce methane, we, you, me produce methane, but cows can be vilified, but the point is these cows are maintaining these healthy green pastures. Maintaining that photo-oxidation potential, particularly at high latitudes. The real issue of methane that's not in the literature, is that our methane hydrates that are sitting in high latitude sedimentary, ocean sediments on continental shelves, they are bubbling up. The Russian arctic is now like lemonade with methane coming up and the tundras are releasing methane.

Previously, to our knowledge, methane has caused mass extinctions. A big methane burp is one of the most dangerous things we face in this extreme climate. And the only thing that's going to save humanity or other life on earth from a methane burp, is cows. If the cows are there, producing enough sustainable green pasture, enough photo-oxidation, enough hydroxyl radicles we've got that balance. We've got 100x the hydroxyl ions from green pastures compared to the methane from the cows. So we're playing Russian roulette.

Question: What causes a mass extinction from methane?

Walter: it's not so much breathing it. It's 100x more potent as a greenhouse gas. I don't know exactly but there have been times when we've had big geological outpourings of methane it's the warming feedback.

Audience: I just want to point out that these biodigesters that are walking around: we don't want to keep them in feedlots. They need to be near grass!

Walter: oh no! Absolutely no question at all, these animals are designed to eat cellulose, not starch. They produce more methane on starch and you also don't want to eat the meat from them because the bad lipids are so high- don't touch them!

Question: Should we be taking ruminants out to the arctic tundra?

Walter: Not necessarily. The Laplanders herd vast herds of raindeer, in Canada they herd vast herds of caribou, all I'm saying is nature already has these mobile biodigesters in position, we just have to start respecting them and understanding just how powerful all this is. If we let those tundras dry and burn as we did in Canada, northern Alberta 2 years ago, it's disastrous, not just for burning but also for the methane story.

Didi: There's also something that Walter hasn't addressed yet that's going to effect the cooling of the planet, we haven't got there yet- let's go there!

1:27-1:38 This is where it starts getting really interesting!

So what we've been talking about in a sense, this whole picture of what are our new climate solutions, how do we step outside of the tunnel, the black hole we've created for ourselves with the CO2, and open new windows and new opportunities by embracing this hydrological dimension?

We've gone through "why", we've gone through "what", we've gone through "how"- it's all about rebuilding the earth's soil carbon sponge. Actually, let me backtrack, I got sidetracked.

We said the critical thing is the balance between B and C- but we've left a whole field free here. In nature there is never a vacuum, never vacancy."

(Remember the diagram with the horizontal and vertical line crossing? The horizontal line represents the ground level. A is in the top left quarter, B in top right, C in bottom right. A space bottom left is still blank.)

“There’s another thing - “ D” is for dividends. This is important for agriculture because this is where we are going.

If we put carbon into the soil in “C”, for every gram of carbon we put in the soil, we can hold 8 grams of extra water. You can see that from the spring, the bedsprings, from the voids, we can massively increase the water retention, infiltration and so longevity of green growth.

That’s the important thing to understand. From all the “green revolution” stuff where I started research- I didn’t tell you what I’d been doing, but when I started as a researcher it was all about how do we increase the yield of plants. And we’d do genetics and fertiliser etc and if we could get a 30% yield response we’d get a new white coat and a new clip board and line up for a Nobel prize!! Big stuff! But basically at best we could do 30-40%.

But if we increase the longevity of green growth, so when it rains we have a sponge - instead of the soil drying, instead getting 10 days worth of growth we have 100 days worth of growth now, we’ve increased the longevity of growth with the soil carbon sponge, we’ve increased the green growth 1000%. The multiply effect of extending green growth, drawdown, productivity and resilience is powerful.

So 1g of carbon = 8g of water

Every gram of carbon we put in the soil massively increases the biofertility of the soil, as we’ve explained, as those nutrients become available.

80% of the fertility of soils isn’t about how many nutrients in that soil in total, it’s about the availability of those nutrients. It’s about the microbial solubleisation, fixing, access, uptake, cycling of those nutrients. So the whole business about fertility is about the microbial activity in the soils, not how many agricultural More On's we put on.

Every gram of carbon we add massively increases the root ability of the soil, and the volume of soil the roots have access to. This increases disease resistance, resilience and productivity.

The point we are making with "D" is simply by increasing bedsprings we can drive up productivity as nature has, massively. Nature has rainforests on sand dunes in Queensland, where I was working when I was working with the CSIRO*- the worlds most productive terrestrial ecosystem effectively on crushed glass with next to no nutrients in it, but every molecule is moving 1000x faster and giving that productivity, because of the microbial activity. It's not how many, like that quote by May West: "it's not the number of men in my life but the life in my men"! (Laughs from the audience) Another one from president Roosevelt "A nation that destroys it's soil, destroys itself". Does that balance out and get us away from May West?

* (The Commonwealth Scientific and Industrial Research Organisation is an Australian Government agency responsible for scientific research)

The point being though that this is the way that nature drives productivity. Not by trucks putting fertilisers on, not by inventing biocides, not by cultivating; simply by increasing soil carbon. More powerfully, because of these dividends, we negate the need for all this More On stuff. Why do we need it when we have carbon bedsprings? Our innovative farmers and getting 100% yield but 300% of the quality, the nutritional integrity in their food with less than 20% of the inputs, less than 10% of the risk, 300% reliability, 500% natural capital soil regeneration value. These are dividends.

The whole basis of regenerative farming, taking agriculture from the 19th to the 21st century, is all about rebuilding healthy soil, a healthy sponge. Because without that sponge we have nothing, desert.

Now we can forget all about that and we go into the really important stuff.

Because once we have a sponge with water in it, we have the capacity to grow biosystems, the longevity of green growth, and we have transpiration. For every gram of water that transpires, it has to go from a liquid to a gas. And to go from a liquid to a gas, every gram needs to have 590 calories of energy, in its latent heat of vaporisation. Simple physics.

So 590 calories of energy has to be taken from this soil surface, from where this water is, and from the vegetation, so we can't avoid but to cool this surface. That heat of course goes up, and as that water condenses, that heat gets released and most of it goes back out to space. Nature has driven the hydrological cooling of the planet by these latent heat fluxes. Even now with half the green vegetation on this planet, the residual vegetation we talked about: 24% of the incident solar radiation (you know that 342 watts coming in) some 85 watts per square meter is constantly taken back up through these latent heat fluxes. That green vegetation is constantly taking 24% of that incoming energy that's striking the surface, and taking it back out to space.

<u>So with a 5% increase in green, with transpiration, we can affectively negate 3 watts per square meter. Roughly. How do we cool the planet by 3 watts per square meter? Simple we increase transpiration by 5%. And we are running at half of what there was 8,000 years ago.</u>

Audience comment “when you think about all the bare ground that’s out there not doing any transpiration, bare ground is what’s killing you!”

Walter; “yes we‘ll come to that!”

Audience comment “In the upper Midwest, they stopped leaving land fallow, and a study of that shows that just that one thing- covering that land all year round with green things, dropped down the watts per square meter by a factor of 6 watts per square meter! That’s double!”

Walter “Yes, I live in a city called Canberra, which is Australia’s natural capital, it was designed and built from 1913 onwards by Marian Mahony Griffin and Walter Burley Griffin won a prize for making a landscape city, it was a leading city for the 20th century of what urban future habitats need to look like. And Canberra initially was an arid, dusty, dried out sheep paddock- and they built an urban forest and really created a whole new forested environment, it’s now 7 degrees centigrade cooler on a hot summers day than the adjacent new suburbs 2km away. All because of latent heat fluxes. In Canberra we have a grassroots movement called “Cool Canberra” and it’s all about planting trees, about porous pavements, about the sponge, infiltration, to keep these latent heat fluxes.

And it gets better, so let’s keep going…”

1:38- 2:09 This is now about how we can influence water cycles by growing plants, especially in arid areas, to reduce climate change and the affects of climate change.

So we’ve got this water vapour rising up, condensing into clouds, into droplets and releasing the heat. We end up with masses of cloud micro droplets. But these are far too small to fall out as rain so they sit up there as hazes and clouds. They form these nice white fluffy things. Dense, high albido clouds reflect that incident solar radiation directly back into space, it doesn't even get to the earth surface. You know when a cloud comes over you're reaching for another jumper. It's significantly cooler. 50% of the earths surface is covered in dense clouds at any one time. Or it certainly used to be: it's getting less. These on average reflect 120 watts per square meter back to space, about 1/3 of the incident solar radiation. A 2% increase in cloud will offset 3 watts per square meter.

Cloud can only happen if we get microdroplets. This can only happen if plants are transpiring water up into the air. This can only happen if we have the soil carbon sponge. We can bring it back to the sponge because it's the fundamental driver but it's also what we can influence, it's our point of agency. A B C D is what we can do. Every square meter, every acre, every region, every nation. Grassroots empowerment of action.

So that's clouds, and we've talked about the sponge being critical, but that's not good enough just having clouds, we also need rain. Because if we have a dry sponge it's desert; no good. It takes about 1 million of these cloud microdroplets to make a raindrop which can fall with gravity. There are 3 things that allow this to happen; they are called precipitation nuclei, rain can't just occur by itself, it has to be precipitated by precipitation nuclei.

1. Ice crystals are very important in high altitudes and high latitudes, and frontal rain.
2. Over the ocean you need salt. Salt is hydroscopic, so it sucks up water, so it coalesces these droplets. It's salts we use for cloud seeding; we use silver iodide to create artificial rain. We use planes to drop atomised silver iodide into particular types of cloud and we consistently get 20-30% more rainfall through that process.

3. But by far the most important thing in inland areas and tropical warmer areas, is bacteria.

There is certain bacteria, and Louis Pasteur wrote about them in the 1870's; called them aerobactor origines because he found them in the air, but he didn't know what they were doing there.

Bacteria are by far the most effective at nucleating clouds into raindrops. Atomising bacteria to seed clouds is very sophisticated and until recently we weren't able to do that. But these are produced in nature! What nature does, and certain forests; (we've got this from a whole load of studies in the Amazon) - basically the trees aren't just transpiring water vapour, it's also putting up bacteria! So half the rain in the Amazon is actually driven by these bacteria, it goes up and transpires every day, and at 4.30pm you can set your watch on it, it comes down in a thunderstorm. Every day you have this hydrological cycle taking heat from the surface, dissipating it up and returning rain back to the sponge.

Vast areas of forest have been cleared; we've talked about the 8 billion hectares of primary forest that we've cleared 6.3 billion hectares of, so what have we done to our rain!? This is a question again, by regenerating landscapes, can we start restoring these hydrological dynamics? Because these are critical if we are to start refilling this sponge. It all comes back to cooling. Powerfully, natural, simple, safe processes that cool regions and the planet.

Question from the audience:
What scale does this small water cycle operate on?

Walter: the small water cycle is where you have a canopy and transpiration and condensation operates within this small space. We're talking about planetary, global dynamics of clouds and rain.

Audience comment
I think in the Amazon they've tracked about 5 different types of water cycle?

Walter
There's 5x more rain in the Amazon if you measure how much is in those tin cans that are filling every afternoon, compared to what flows out of the river. Because every day, that cycles round and round through these processes.

Audience comment:
Each one of the water cycles extends the influence of the Amazon further.

Audience question:
You've talked about bacteria as nuclei, but what about dust?

Walter:
Dust does not produce precipitation, it's a haze nuclei. Very small particles, aerosols, dimethalsols, James Lovelock's stuff, they are creating haze droplets. We haven't gone into the whole atmospheric physics of these hazes, but yes they are sitting up there. We've now got pollutant brown haze from Cairo to Beijing, basically just sitting there heating and aridifying the landscape, killing the people because of the pollution effects. In that context they are very damaging, very negative. They have to be condensed, coalesced into clouds and then raindrops to get them out, but that process isn't happening. Certainly dust from the Sahara, Saudi Arabia, is driving that whole blanket of haze, but let's not go there because there's a whole other chapter of atmospheric physics; these hazes both absorb incident solar radiation in the liquid phase causing global dimming, but they are also the key thing that keep the water vapour in the atmosphere that drives the water vapour greenhouse effect. But we'll come to that in a second.

Audience question
What about viruses in the atmosphere

Walter:
It's a zoo up there; that's what Pastor did, he made a broth, and said this broth has got contaminated by a living thing, bacteria, microorganisms, he did a clever experiment. He took the tube of the broth from the flask, and heated the broth and bent the tube down so that the tube wasn't open to the air so it didn't go off. You can still go to a museum in Paris where this experiment is still there as an uncontaminated broth. He concluded there must be organisms in the air that are causing this. So that's where the "air biology" became a big deal and he went up to the top of Mt Blanc and found it also had aerobacta. They went up in balloons to 20/30,000 ft, collected air, and. There's even aerobacta there. The air is chocka block with spiders and pollen spores, viruses, bacteria, it's a zoo.

Question from the audience
I'd like to ask about the Hadley Cells?

Walter:
Yes let's get back

We've the point of all that is yes we need rain, we can cool the planet but it all depends on the sponge. Someone made the point previously that there's a vast difference where we have a land system with grass, trees and green vegetation, and where we have bare surface.

Where we have plants and latent heat fluxes cooling the surface, rarely does this get above 20 degrees Celsius. Not just because of the latent heat flux but also because of albido cloud shading and covering effect. But we know with a bare surface and the soil, asphalt, roads or whatever, regularly gets up to 60 degrees Celsius.

Certainly in Australia. It’ll melt your shoes. The indecent solar energy comes in, heating these systems, and how much is actually taken back up? There’s a vast difference. But there’s a simple law of physics; the Stefan–Boltzmann equation, that the earth is a black body radiator. It’s like a stove. Stefan said the re radiation from a black body is proportionate to the constant x 4th power of the temperature in degrees kelvin. That means temperature x temperature x temperature x temperature.

So when we have two different surfaces, one at 20^C and one at 60^C, we get a massive, massive increase in the re radiation of heat, infra red energy, from this bare, hot surface. Now, the punchline is we all know that, but what we don’t recognise is there are 3 variables that control both the natural and the artificial greenhouse effect.

The first factor is how much re radiation there is.
The second is how much of that is absorbed by water vapour molecules
The third is how much is absorbed by CO2 molecules.

The point is we’ve completely ignored in all our climate models the effect of land management, bare soils, and (this first point) the re radiation in driving the greenhouse effect. Completely ignored it.

There are up to 40,000 parts per million of water vapour in the air, in humid hazes, we know there is 406ppm CO2. We know that each water vapour molecule because of its molecular structure can absorb 8x more heat than a CO2 molecule. 590 calories in comparison to about 72 calories. And yet we’ve only concerned about CO2 and it’s going to take up to 1000 years to fix that. So we’re saying domesday, it’s all over, we can’t go forward.

Here, we're saying there's a new solution to climate change. Because we can control the re radiation and it controls 90%+ of the greenhouse effect. We can control water vapour because we've just gone through that with the rainfall, induction, transpiration etc. And yet we are focussed on CO2. We need this because it's the building blocks for building bed springs. We need to build bedsprings by drawing down carbon, to build the soil carbon sponge.

Let's get real. We've got a climate crisis, climate extremes, we've got 10 years, so let's start talking to the elephant in the room. Because we can do this. We can reduce the bare earth and increase the vegetation. And whether we do the latter instead of the former is exsticential.

Question from audience:
Can water really absorb more heat than CO2?

(Do watch the video for the blackboard at 1:56 to explain this: I can't explain it by text!)

Walter
We're talking about empowerment. Through our land management we have an enormous capacity to both cool the planet and avoid these dangerous extremes we are facing.

There's another thing- that when we re radiate a lot of heat from these bare, dry, hard surfaces, this heat is just energy, so it creates a very high pressure dome, a heat dome! So if we look at a country, and let's look at America, because I'm here!

You've got the west ocean, the costal strip, the coastal range, then the Central Valley, then the Sierra Nevada valley then Death Valley, then we go onto the western plains. If we take the Central Valley and we clear that valley (California) of vegetation, we create a high pressure heat dome over that landscape, like a mountain of hot air. We have cooler, moist, low pressure air from the ocean flowing in. But it's got no chance whatsoever to be able to push this high pressure heat dome out of the way. (Do check out the video at 1:58 to see the topographical diagram on the blackboard.) We are desertifying regions and climates from our land management. We are governing where it is hot, dry and re radiating and creating these high pressure heat domes.

If you look at Australia, we used to have the Australian monsoon. The Indian Ocean is the worlds biggest evaporation basin, so we've got a lot of low pressure humid air there. But because we've created this desert over central Australia, very rarely do we get this humid air coming into central Australia, so we remain and reinforce a desert. 6,000 years ago lake Ayre was a freshwater lake 25m deep. Central Australia was a savannah, grassland, with gallery rainforests along the creeks. By burning and land degradation, no one blaming anyone, the point is we create this high pressure heat dome, and we prevent this humid air flowing in. Same as in The Central Valley in America.

So we have a profound effect.

By contrast, in the Amazon, because it's got low pressure forest vegetation; it's continually sucking more moist air into it, driving that rainfall. Except over the last 30 years in Eastern Brazil and in Balize we've done a lot of degradation, a lot of burning, and for the first time we are breaking down that heat flow. For the first time also we've had a hurricane form in the south Atlantic. Never been recorded before in history. Because of that low pressure air being able to go, by being sucked into the land, it's building up, building up until it becomes hurricane intensity.

Question from the audience;

Does this mean that if you want to reduce the strength of hurricanes and rejuvenate the land, that the areas near the coast are very important, like if you wanted to choose which area to regenerate?

Walter;
We don’t want to play god, which area is best- we do all of it, as much as we can. But I agree if you have an arid area near the coast you are going to have a buffer or preventative zone. These are pretty big continental powerful forces. There’s an old Chinese proverb “when’s the best time to plant a tree? The answer is 20 years ago. When’s the second best time to plant a tree? Now!” There’s wisdom there. We’ve got to do every square meter, every area, every courtyard, every balcony, every nature strip, every guerrilla gardening, every farmer, so that’s what we are facing.
But you’re right, in this coastal range we’ve been burning these coastal forests. There used to be beautiful oak shelter woods on that range (west coast of North America). They’ve been largely degraded over a long time by the Spanish, then by overgrazing and fire, the question is has that prevented humid air from flowing into the central valley? Certainly we know that the sequoia sempervirens which is the coastal forest, they get 70% of their moisture from fog/ dew harvesting from these onshore humid air flows. But then it stops. Previously, Lewis and Clarke 1812, 1815, asked how much did that humid air extend? Because we know that the Central Valley was this absolute garden of Eden paradise of wetlands and green pastures and rivers- beautiful; ducks, geese, you name it!

Question from the audience;
What about the orographic effect?

Walter
The orographic effect is when you have a mountain range and the air has to rise. It obviously then cools as it rises, then you get ice crystals. So the precipitation as snow on the Sierra Nevada is an

orographic effect. The heat domes create their own mountains in effect.

Audience question;
What about desalinisation? And getting that fresh water from the ocean into the land?

Walter
Well, desalinisation takes a massive amount of energy to turn that saltwater because you have to put it through a reverse osmosis membrane, the question you have to ask is what's the lifecycle cost! The cost of that energy in terms of carbon pollution etc.

Same audience member
What I mean is the major aridisation is based on change of the Hadley cells, that's part of the global dynamics. Therefore what are you going to do in that region where you're not getting rain?

Walter
Ok, so not for me to do, for us all to do, but yes, as I said there are humid hazes, air flows, all the deserts of the world have rivers of water flowing across them constantly in the air; 4% moisture content. Nature used to harvest a lot of that water through these processes. I don't think it's a question of desalinisation because the volumes of water compared to these natural systems is inconsequential, but the point is what have we done to the land system that has prevented that condensation of that 4% moisture content of those air flows. So in the Middle East can we rehydrate deserts? That's what we are talking about in Australia, can we rehydrate arid areas by creating vegetation that created the conditions for this condensation?
"What about rivers"
Desalinisation is used to keep people alive, the 2 lietres of water we need minimal although we use 150 listers each because of showers

and stuff, but there's no way we can desalinate enough water to grow the food we need and certainly not these ecological hydrological processes, but 71% if the planet is ocean, another 3% of the planet is covered with lakes, so there's plenty of water on the blue planet, it's just a matter of what have we stuffed up, and what can we restore.

Audience: we need to wrap up

Walter
This has been good this discussion and we aren't quite finished with this whole thing, but..

The bottom line is there are new opportunities that we can use to naturally cool the planet, to address climate change, but also to secure the water, the food and the biosystems, and the social stability that depends on that. There's 7 missed meals between social stability and chaos. This all depends on water and food, for example looking at Syria. So this is critically important. As Mark Twain said, "whiskey is for drinking, water is for fighting over". It's true, that's what's going to happen. But the point is these natural processes give us the opportunity to secure endless, safe water. There's plenty of water on this planet, but we just have to come to respect it and rebuild the cycles.

The point of agency and the point of this whole discussion is about regenerating the earth's soil carbon sponge. By drawing down that carbon and adding bedsprings between those soil particles, we can do it, practically, rebuild the sponge, ABC etc. we can restore healthy biosystems and a healthy future for California and for all of us.

Resources and references for landscape renewal

This video shows some of the amazing things that are happening world wide, with particular focuses on the Loess Plateau Watershed Rehabilitation Project in China.
https://youtu.be/TYHVQssoDEs

Fantastic news from Australia! "146 million US dollars in total will fund this project… 50 million hectares are expected to be provided for"
https://www.warpnews.org/human-progress/australia-sets-aside-30-of-their-landmass-to-protect-unique-species/

Conservation biologist M. Sanjayan, PhD, CEO of Conservation International and former lead scientist of The Nature Conservancy reviewing Allan Savory's work in restoring grassland in Africa (2015, 2 mins.)
https://youtu.be/XfPpC258ZwM

Allan Savory's work explained
https://returntonow.net/2017/11/30/cows-can-turn-desert-back-grassland-save-planet/?fbclid=IwAR38bud8trnSOPHQOwfmTkh_gxrY5-rJk07Eak50hz8BBszeNM4rza2OHRA

Grazing revolution- a radical plan to save the earth: book by Allan Savory
https://www.goodreads.com/book/show/19403078-the-grazing-revolution

Trees for the Future is a charity giving the knowledge and the tools to create a forest garden, to farmers in desertifying areas of Africa. With the shelter from trees (which also provide food) they can grow annual crops and have food not just for themselves but to sell at the local market. Here is a more developed example https://youtu.be/xu-jCvUMsXs and another just starting out https://youtu.be/

bHVhM6cCWdI and specifically about reversing desertification, there's this webinar which is so hopeful for our future https://youtu.be/qdsZHYflqKo
This charity do carbon offsetting as well as just simple donations https://trees.org/

I'm sure there are many more great examples of how we are trying to turn back desertification, if you know of any please do let us know.