

Walter Jehne Presentation 2018---Edited Transcript
Cooling Earth's Regions Through Water Cycle Restoration
Soil Health and Land Use As Points of Agency

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Introduction – Rehydrating landscapes; Regenerating Biosystems; Regional Cooling

I'm really a soil microbiologist from Down Under. Most of my time I spend just quietly 'underground,' doing work there. I'm working with a little group called Healthy Soils Australia – in Australia. Groups of farmers—very, very innovative farmers from all different industries and all different regions. We've got about a thousand farmers involved in this in Australia, but they're really leading some very clever solutions, both regenerating the land, but coming to re-hydrating arid landscapes, and of course naturally, safely cooling those regions and the planet.

I wanted to share all that experience, but also what's happening globally at a bigger level with you, and really come to the topic of today: new climate solutions. A bit of a pun on solutions because we're going to be talking about hydrology and basically how 95% of the heat dynamics of the "blue planet" is governed in a sense by water. It's a process and a whole influence that we've, in a sense, ignored in the last 60 years of climate debate because we're so focused on the CO₂ rise and the symptoms of that. Of course, what do we do to address the CO₂? Water is the key process that naturally drives the hydrology and drives the heat dynamics of this planet. Really, the question is: can we actually look at those processes and see if they are part of the solution.

It all comes back to what Didi talked about, because at the end of the day, where do we humans have agency? What is it that we can do? Where are the practical points of influence? Of course, that is that simple word: "the sponge." How do we regenerate the Earth's **soil-carbon sponge**?¹

In terms of take-home messages, that "sponge"—the regeneration of the sponge—which is our key tool, our key point of agency. But it also enables a whole *regeneration of biosystems*, gives us the water, the food, the biosystems, the social stability we're going to fundamentally depend on in the next 10 years and beyond. But also allows us to naturally and safely cool regions of this planet. In a sense, that's the new "climate solution" we want to talk about.

CO₂ Problem of Increasing Heat Retention and the "Greenhouse Effect"

Let's get into some of the details of that. We've all known for the last 60 years, and we've all seen pictures of the curve **Charles Keeling**² set up in 1958. That's CO₂ over time, and basically CO₂ goes up—it's 406 parts per million now. It started at 280.

What Charles Keeling showed wasn't just that CO₂ was going up, but that it was going up in a quite clear pattern where every winter we were emitting carbon, and every spring and summer, of course, we were drawing down carbon from the air back into biosystems. So we had this constant springtime/summertime drawdown and then winter emissions. The point was that we had a "deficit" of some 10 billion tons of carbon per annum every year. And basically it's that deficit—that accumulated [drawdown] deficit—that was causing the CO₂ rise.

For the last 60 years, that's been our whole focus in our climate and global warming discussion. Clearly we have CO₂ rising—no question whatsoever. CO₂ is a greenhouse gas. We know it does about 4% of the heat dynamics of this blue planet. It's a major or partial contributor to the natural greenhouse effect, and certainly by increasing it, we are accelerating that greenhouse effect.

1 soil carbon sponge - healthy soil with high organic matter content that can absorb and hold large amounts of water, supporting plant growth and helping regulate climate

2. Keeling, Charles - The scientist who starting in 1958 measured carbon dioxide levels in the atmosphere, creating the famous "Keeling curve" that shows CO₂ rising over time.

We know that effect is serious because if we draw the Earth, we know that we have **incident solar radiation**³—that's sunlight coming in to the Earth all the time. On average, at the top of the **troposphere**⁴, 240 watts per square meter – constant heat energy coming into the top of the troposphere. Basically, to keep a stable climate, it's just simple physics and simple climatology that we need 342 watts going back out. Obviously, otherwise our climate heats.

But now, because we've increased the greenhouse effect—the retention of heat by this planet—we only have 339 watts per square meter going out. So there's about 3 watts per square meter which is being re- tained by the Earth because of this enhanced, abnormal greenhouse effect. So it's a 3 watts per square meter warming, which is really what the “global warming” is about. It's significant because obviously it's changing the climate, but we can see that it's less than **1%** of this incident solar radiation.

It's important to understand that context because, hey 1%—we may be able to do something about it. But of course, here we're talking about heat dynamics, but we've got to now translate: here's the CO2 increase; how do they relate, and what other factors may be involved? Of course, we're raising that proposition for **water**: what role does water play in this? But we'll come to that as we go through in more detail. 6:33

Analyses of Rising CO2; Excluding the Water Variable; 1978; 1988; 2005 and the IPPC

So we've already set the scene because we've got 10 billion tons of carbon every year that's adding to the atmosphere. In 1978, President Jimmy Carter basically said, “Look, I'm getting this warning from scientists legitimately,” and he issued a reference to the Scripps Oceanographic Institute in San Diego and Los Alamos to say, “Do the analysis and tell me what is the consequence of this greenhouse warming? What are the risks to America? What are the impacts to America and globally? Really give me a reference, give me the grounding—where do we have to be and what do we have to do?” So that was Jimmy Carter in 1978—40 years ago.

Of course, these institutes diligently did that work, but they defined **their analyses** very much on the basis of this CO2 effect. Now, they *should* have said, “Okay, we've got this *symptom*, we've got the CO2 increase—obviously it's abnormal—so *how do we look* at the greenhouse effect of that CO2 rise?” They were well aware—climatology 101 right from the '40s, '50s—95% of the heat dynamics of the blue planet is driven by water. But they basically **excluded water** from their analysis for two reasons:

First, because water is so dominant, they assumed that humans could not possibly have influenced that aspect of the world's heat dynamics to have had this effect.

Second, because water is so extremely variable in time and space, location and seasons, it's impossible to model mathematically in the reference that the President had given them. (Can you *mathematically* model and define scenarios and consequences of what would happen?)

The point is that they basically focused on that CO2 component of the greenhouse effect, assuming that *that* was the key problem and *that's* what we were having to address. Because of this analysis, though, really, for the last 40 years, the world has been focused in that linear concept of the CO2 greenhouse effect and what is its consequences in global warming.

Shortly after, in 1988, the UNFCCC—the United Nations Framework Convention on Climate Change—was formed and took on a global reference to say, “Look, we must prevent dangerous “climate change”

3 incident solar radiation - the amount of energy from the sun that reaches Earth's atmosphere or surface, measured as the power hitting each square meter.

4. troposphere - the lowest layer of Earth's atmosphere where weather occurs and where most of the greenhouse effect takes place.

happening,” and all nations in words committed themselves to it. Out of that, they formed the IPCC—the Intergovernmental Panel on Climate Change. And for the last 40 years, those scientists working in the IPCC have been basically doing this sort of analysis: looking at what are the consequences, the impacts, the scenarios from this rising CO2 increase. But very much focused on the CO2, leaving aside a lot of the hydrological and other factors. Again -- too complex and too difficult to model. 10:10

So for the last 40 years, we have looked at this problem from very much that CO2 angle. When we’re talking about new solutions in climate, we’re really saying: can we step outside with the elephants and **start asking questions from the other perspective?**

2005 Study of Dangerous Weather Extremes--Systemic Aridification

Because 10 years ago, actually in 2005 – 13 years ago - **Schellhuber**, Joachim Schellhuber and a whole group meeting at the **Hadley Centre**⁵ did a new analysis and said, “Look, it’s not just the CO2 rise that’s a problem. It’s actually the dangerous extremes in climate that are already accelerating, and happening well in advance of the 2100 scenarios that the IPCC analysis had given warnings about.”

These extremes were already impacting seriously on populations and food production—and they’re quite severe. We’ve talked about them: the hurricanes, the increased storms – Irene, Sandy -- the flooding and the damage all over the world. But also the droughts as a consequence -- the aridification, the systemic aridifications of large regions, the increased wildfires, and of course sea level rise.

The point about all of those factors—all of those impacts—they’re all hydrological. They’re all driven by water, either the *excess* or the *absence* of it, triggering things like fires and droughts. The analysis was very clear: these extremes, these positive feedbacks -- dangerous feedback loops -- were already accelerating, particularly in countries like Australia and in fact all Mediterraneans like California, the Middle East, the Mediterranean [Ocean], South Africa.

Hadley Cells and Aridification in Tropical Heating Zones

We’ve had a process —if we think again, there’s the Earth, there’s the equator, you’ve got the heating, and we’ve got these **Hadley cells**⁶ which cause hot air to rise from the tropical heating zones. Of course, it rises up and descends as dry, hot air. Because of the heating of the planet, this is expanded both northward and southward by some 300 kilometers. So the intensifying heating from this whole greenhouse effect—from this 3 watts—is already causing that.

Of course, this extra heating has forced the cool, moist **Ferrell cells**⁷—which really drove the rainfall in Mediterranean climates, the reliable winter rainfall—forced that further towards the poles in both cases. **13:26**

As a consequence, from 1975 already, the southwest of Western Australia was already aridifying, with a 20% decrease in rainfall and 30%, 40% decrease in streamflow soil recharge—because again, it was rainfall but also evaporation factors. So we were aridifying. The same thing applied here in California. The whole

5. Hadley Centre - A major climate research center in the UK that studies weather patterns and climatic change, particularly known for climate modeling and predictions. Part of the UK Met Office (Meteorological Office) the national weather and climate service.

6. Hadley cells - Large atmospheric circulation patterns near the equator where hot air rises and then descends as hot, dry air, creating desert conditions in certain regions.

7. Ferrell cells - Large-scale air circulation patterns in Earth’s atmosphere that bring cool, moist air to mid-latitude regions like California and the Mediterranean.

southwest of the US, again under that aridification. Same thing in the Middle East, Spain, right across to Syria—basically has been aridifying. Of course, we're already seeing the consequences.

In the last 15 years, we've had farmers who've been farming the Fertile Crescent in Syria, for example, for the last 10,000 years, abandoning their farms, moving into Damascus—Aleppo, because their soils' hydrology—everything has collapsed. Can't grow food anymore -- moving into these urban concentrations, and of course we know as a consequence we end up with social crisis.

So this **systemic aridification** is just one of those fundamental consequences of these climate changes that are already occurring. So the whole point—that was 2005—dangerous climate extremes (DCE). And it's these extremes that become the really dangerous consequences. In a sense, that's the world we're now facing: intensifying dangerous climate extremes. And the issue is: what can we do about it? 15:30

2015 Paris Agreement and Goals of Net-Zero; Drawdown Deficit; Residual Biosystem

Finally, in 2015, after lots of political work and false starts with Kyoto etc., the IPCC and **Christiana Figueres**⁸ in Paris was able to pull down a general agreement to say, "Let us all agree to try to achieve zero net carbon emissions." So in the **Keeling curve**⁹, they're saying, "Can we actually try to get back to neutrality where our emissions and our drawdown of carbon offset each other and we end up with near zero net?" That's very laudable.

Of course, to do that, there's been a big agreement and move: how do we increase the "drawdown" of carbon back into the biosystem, back into soils and carbon sinks? Of course, yes, we have to do that. Of course we have to continue to try to reduce the amount of emissions. Definitely, that has to continue—nobody is for a minute suggesting we don't have to reduce our emissions. 16:44

But the point is: can we actually accelerate that drawdown of carbon back into the biosystems? Every year, some 120 billion tons of carbon is drawn down by green plants back into the biosystem. But it's not good enough, because every year 130 billion tons of carbon is actually emitted, which is where we get this 10 billion tons of carbon deficit.

But we can increase this because at the moment, the residual biosystem that we have—the land surface still covered by green "Photosynthing" vegetation—is perhaps *half* of what it was 8,000 to 10,000 years ago. Again, there's all the data and numbers we could go through them. But basically, UNDP very clearly defined: we have done so much degradation of forests and grasslands, we've created **5 billion hectares**¹⁰ (12.5 billion acres) of man-made desert and wasteland over those 8,000 years.

And the issue is: can we increase the drawdown of carbon by *regenerating* that biosystem? So what we're talking about is: how do we do that? How do we enhance that? 18:00

Legacy Emissions and the Ocean Buffer Problems

There's a bigger problem, however. Because while this might be able to slow down the emissions of CO₂ and flatline them, it won't bring that CO₂ down. To bring the CO₂ back down we'd not just have to do 10 billion tons to offset our *current* net emissions—we might have to do *another* 10 billion tons per annum to actually draw back heritage legacy emissions that we've emitted previously. So the target might even be bigger—it might be 20 billion tons of carbon per annum.

8 Figueres, Christiana - The Costa Rican diplomat who led the United Nations climate negotiations that resulted in the 2015 Paris Agreement on climate change.

9 Keeling curve - The famous graph showing the steady increase in atmospheric carbon dioxide levels since 1958, named after scientist Charles Keeling who began the measurements.

10 hectare - about 2.5 acres

The good news is: yes, we can do that. We can do that through land regeneration by extending the area, the productivity, but particularly the *longevity* of green growth. 19:00

But *none* of this is possible—and this is a key point—*none* of this is possible unless these biosystems have water. Because for these biosystems to fix carbon, to draw down carbon, they need water, and that water can only come from the soils.

The whole take-home message from “can we draw down, can we try to balance this” is: we must regenerate the Earth’s “soil-carbon sponge.” Because only that water can enable this drawdown to operate. So that’s really important—that “sponge” is fundamental to that whole **photosynthetic potential** being realized.

30,000 Billion Tons of Carbon in the Oceans

But we have another problem. Even if we’re able to draw down 20 billion tons of carbon -- and we can; innovative land regeneration can do that --(we’re going to swing to negative net emissions, yes, we can do that) -- but even that’s not good enough. Because even if we draw down 20 billion tons, even if we draw down 50 billion tons, the oceans contain *30,000 billion tons of carbon*.

As we draw down more carbon from the air, the oceans say, “thank you; can I re-equilibrate some of the carbon that we’ve been absorbing from all your emissions over the last 8,000 years back into the air?” Because it’s a buffered equilibrium system. So it may take 100 years, 1,000 years for drawing down carbon before the CO2 content gets anywhere back to pre-industrial human intervention. 20:58

Schellnhuber has told us: dangerous climate extremes are already happening. We’re already seeing those: flooding, droughts, aridification. California’s [water] on the cusp of collapse – that’s why we went there. No more snowpack, no more groundwater, no more coastal ranges rehydrating landscapes through fog and mist. Wildfires in winter; the Napa Valley burnt in *winter*. Winter was when these Mediterranean areas should be getting their moist, cool air. Fires were unheard of in Mediterranean areas in winter. The Napa Valley *burnt* last winter.

The point is: we’re getting these climate extremes, and we haven’t got 100 years, we haven’t got 1,000 years. We’ve got perhaps 10 years unless we balance the system.

So this comes to the *second* key point we want to talk about. It’s not just regenerating the Earth’s soil-carbon sponge, but how do we naturally, safely cool regions **and** the planet? Very audacious— nobody’s actually talked about— well some people have, clouds, etc., but the point is: how do we bring that back into debate, and not just debate, but as practical grassroots *reality*? How do we *practically* cool, *safely* cool regions and the planet?

So that’s exactly the challenge we’ve given ourselves. 22:30

-----End of Part I-----

22:30 to 40:30

PART 2. Nature and Cooling; Life and Soil Formation; “Fossil Fuels”

Okay, so this is really to set the context of what we’re about: how do we actually regenerate the Earth’s soil-carbon “sponge,” and of course, how do we naturally cool the planet? We’ve always said *why* we have to do it, and I suppose the next question is: well, if this is *why* we have to do it, then let’s get busy and ask *what* is it that we have to do, and *how* do we do it? Logical, right? So, what is it we have to do?

And of course, the easiest place and the only place we can go to is to say: well, what did nature do? How did nature create this biosystem? How did nature create the Earth’s hydrology? How did nature create the Earth’s natural cooling?

Because it was 342 watts in, 342 watts out—stable for hundreds of millions of years. How did she do it? To do that, we just go back into nature and look at all the evidence. Very clear.

We go back to 420 million years ago when I was a bit younger. Basically, 420 million years ago, we had oceans, we had rock—dry, arid, hard rock. No life on land. There was complex multicellular life in the ocean after the **Cambrian explosion¹¹**, but that life depended on nutrients leaching from the rock into the oceans. That was a limiting factor on ocean life.

Life’s pretty competitive and pretty aggressive, and so straightaway life said, “Hey, if I can get onto that rock to **solubilize¹²** nutrients, I’ve got a competitive advantage. Let me do that.” So it grew tubes of **cyto-plasm¹³** basically onto the rock with enzymes to solubilize essential nutrients. Of course, these are our fungi. So fungi grew from the Asturian ages onto the rock to slowly solubilize nutrients to drive life processes further.

But fungi are just like us—they’re **heterotrophs¹⁴**. Biochemically, there’s nothing closer to us animals than these fungi. Like us, they can’t fix their own sugars, they can’t make their own energy. (Only plants and algae can do that, and some bacteria. But basically they needed to form a relationship, a symbiosis, with something that could give them sugars.

Of course, in the ocean there were plenty of blue-green **algae¹⁵**, so these **fungi¹⁶** and these algae got together, made a deal, and said, “Let’s form a **lichen¹⁷**.” We see those lichens all over this planet still, dissolving rocks, dissolving our buildings, concrete, wood, our cars—you name it, lichens are eating it up, biodegrading – having lunch. 25:38

Those lichens, in growing and moving on, leave behind organic detritus—the cell walls of those fungal- algal lichen cells. That organic detritus can hold water. It creates a mixture of mineral particles, organic material that can hold extra water. And that enabled—very rapidly—plant life to evolve from lichens to mosses to ferns to cycads to gymnosperms to angiosperms. And about 50 million years ago – grasses.

Parallel with that plant evolution, of course, we had the **herbivores¹⁸**, the insects, and everything that was feeding on those biosystems. Very rapidly, that process of **pedogenesis¹⁹**—of soil formation— because soil is simply a mixture of *mineral particles and organic detritus*, enabled life to extend right across the 13 billion hectares of ice-free land on this planet. 26:48s

So within 100 million years, we had a planet which was the Carboniferous-Permian: just lush, deep forests, deep organic soils, teeming with life. In fact, so teeming with life that the drawdown of carbon got down to carbon levels in the atmosphere down to 100 parts per million. When life had started on land, it had been 7,000- 8,000 parts per million and had drawn all that carbon into those faults. Of course, that's where we get all our coal and fossil fuels from—from that Permian-Carboniferous **fixation of carbon²⁰** through these plant materials. 27:28

11 Cambrian explosion - a period about 540 million years ago when many complex life forms first appeared in the oceans, marking a major milestone in the evolution of life on Earth.

12 solubilize - to dissolve or break down substances (like rock minerals) so they become available for plants and other organisms to use as nutrients.

13 cytoplasm - the jelly-like substance inside living cells that contains all the cell's working parts. It's where most of the cell's life processes happen.

14 heterotrophs - organisms (like animals and fungi) that cannot make their own food and must eat other organisms to survive, unlike plants which can make their own food.

15 algae - simple plant-like organisms that can make their own food through photosynthesis. They were among the first life forms and can live in water or moist environments.

16 fungi - organisms like mushrooms and molds that break down dead organic matter and form partnerships with plant roots to help them absorb nutrients from soil.

17 lichen - a partnership between fungi and algae that can grow on rocks and other harsh surfaces, slowly breaking them down and beginning the soil formation process.

18 herbivore - an animal that eats only plants. In grassland ecosystems, herbivores help maintain grass growth

17 pedogenesis - the natural process of soil formation, where rock is gradually broken down and mixed with organic matter to create soil over thousands of years. Organic matter is essentially the "stuff of life," encompassing living and dead organisms, as well as their decomposed remains.

Healthy Soil Sponge: 66% of Volume Available “Airspace” For Water Absorption

Okay, so what we had 420 million years ago, we’re going to have that same story now every day. This is exactly what happened on your Great Plains after the last glaciation. Basically, if you just have hard rock or solid rock or compacted soil or stardust, (4.6 billion years, supernova, etc.) these rocks are made of nutrients: phosphorus, calcium, zinc, magnesium—there are mineral particles amongst all of that. So basically, that was what the Earth, what the rock, was like 420 million years ago. [28:10](#)

You put a drop of water on that, and as Didi showed us with her flour, it just runs off—no effect. And what life did, just as Didi showed us with her bread and the sponge and the whole pedogenesis process, is—life basically as lichens grew on this rock, solubilized them, and created exactly the same mineral process.

We’ve got particles that are broken up into little clay *micelles*²¹. Basically, what life has done is basically solubilized these, broken these up and left organic detritus between those particles. This detritus— just figuratively, think of it as little carbon bedsprings. You want to bounce on it—sponge.

In a sense, that then goes from **rock** which has a bulk density of 2.6 to 3.5 grams per cubic centimeter— that’s a weight per unit volume—to a **healthy soil** which has a bulk density of about 1.2 grams per cubic centimeter. So straightaway, you can see healthy soil is made up 66% of nothing. Air—voids.

Nature has simply taken sunlight, CO₂, water, created carbon through these plant processes, microbial processes, and just added those to this mineral matrix—and has created a healthy soil which is made of mineral particles and these bedsprings of carbon detritus.

But what’s powerful about a healthy soil—and it really is the guts of our “sponge” discussion— now we have 66% of the volume which is available for infiltrating and retaining water. Just as Didi showed us in the bread example, now this soil can infiltrate water, retain water, and sustain living plant growth for far, far longer—the longevity of plant growth. [30:51](#)

Because of these voids and because of the surfaces they’ve created, this healthy soil can vastly increase the availability of nutrients. Here we had essential nutrients for plant growth, but they were all locked up, unavailable, inaccessible. Now we have the phosphorus, the calcium, the zinc—all exposed for microbial activity. So the *bioproductivity* of that soil increases *exponentially* simply by creating these surface exposures, just by having the voids, by having nothing. 31:31

Because we’ve got nothing in *these soils – voids*—the root-ability of this soil vastly increases. So roots can grow and proliferate and penetrate. Instead of six inches, they can go down to six feet, 20 feet. So the volume of soil resource that is now available for plant growth and the drawdown of carbon that we talked about earlier is exponentially increased. [32:01](#)

²⁰ fixation of carbon - the process by which plants capture carbon dioxide from the air and convert it into solid carbon compounds that can be stored in plant tissues and soil.

²¹ micelles - tiny clusters of particles in soil that help hold nutrients and water.

So the whole bio-productivity of these healthy soils, the **resilience** of those soils, the **capacity** to infiltrate, to buffer, to extend life, vastly increases. In a sense, this is what nature did to create the biosystem, to create the hydrology. And again, in a very simple form, that's all we have to do.

We do what nature did, we use plants, we use micro-organisms. Here we have a plant; we've got sun, CO₂, water. We've got photosynthesis, and we're putting stable soil carbon into the soil because the fungi and the organisms convert the sugars from photosynthesis into stable soil carbon, which is just this organic detritus or bedsprings. That's exactly what nature did. She just took sunshine, CO₂, water through plants, made sugars, made stable soil carbon. So that's what nature did.

That's how we created the biosystem. That's how we created the world's hydrology, the Earth's hydrology. And of course that's how the Earth ran 95% of its heat dynamics and its natural hydrological cooling. And so for us, it's very simple. If we've got to draw down 20 billion tons of carbon, if we've got to rebuild this sponge, it's easy, we say, "let's just copy nature." 33:48

Okay, so how do we copy nature? We've got the model there. We go back to the textbook, go back to primary school, and it's all as simple as "ABC." Here's our plant, because we know it's all about plant growth. (Comments.)

A is about **Agriculture**, both in terms of field cultivation but also now urban agriculture. We'll come back to that later because it's really powerful—it's a really important empowering breakout that we want to talk about. Agriculture is again where we've been dominant because we live above the ground and we've been all about maximizing yield, weight, because—we're alpha males maximizing weight, yield...we're still in that game. So A is "okay."

B Below Ground Biomes and Biosystems

But because we live above the ground and only see *things above the ground*, we only see 30% of the biomass, which is in the tops of the plants. What we tend to *not* see is the **30% plus** that is in the root systems. If you go to your bluegrass prairies, you've got root--shoot ratios of 5 to 1, so really 80% of the biomass is down under, not up here, for a very good reason. But the point is, we just see *things* above the ground, and we miss some of these very important things.

We also miss that there's 30% to 40% of the nutrients that actually **exudate**²² out from the roots—sugars and amino acids and various sugar substances. These are *critical* for feeding this microbial ecology that drives the formation of the healthy soils. So these support a vast population of the fungi, the bacteria, the **protozoa**²³, the **nematodes**²⁴, the **actinomycetes**²⁵, the **collembola**²⁶, the **earthworms**²⁷—*that whole life* in the soil. There's 10 times the weight of living animals in a healthy soil down under, than there are animals or humans

22 exudate - substances that leak or are actively released from plant roots into the surrounding soil. These include sugars and other nutrients that feed beneficial soil microorganisms

23 protozoa - single-celled organisms that live in soil and help control bacterial populations

24 nematodes - microscopic roundworms that live in soil and help control harmful bacteria and fungi

25 actinomycetes - soil bacteria that help break down organic matter and make nutrients available to plants.

26 collembola - tiny springtail insects that live in soil and help break down dead plant material, contributing to soil health and nutrient cycling.

27 earthworms - soil-dwelling worms that eat organic matter and create tunnels, helping to mix soil layers and improve soil structure for plant growth

grazing above it. All of those organisms are driving the solubilization, fixation, access, uptake, cycling of nutrients—constantly just driving the energetics and nutrient availability and productivity of those systems. Ten times the biomass!

These **Fungal hyphae**²⁸—25,000 kilometers of fungal hyphae per cubic meter of healthy soils. Twice the diameter of the Earth per cubic meter. We count them (but not with a ruler!) But the point is, a massive proliferation of fungal hyphae growing all through these healthy soil systems, again, solubilizing nutrients from surfaces, fixing nutrients, accessing, taking up, cycling nutrients. So massive activity and diversity in the life of their soils. (...) That soil is a living organism. It's a living microbiome, and really it's managing and enhancing that microbiome, as we'll show in a second is critically important. 37:47

What Happens to Carbon: Burn, or Stabilize in Soil?

Okay, so Agriculture is important, but we've got to look at these other parts. We tend to forget them.

What happens to every gram of carbon that has 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, and only two things that have happened to that carbon for the last 420 million years. Two things: it can either burn or **oxidize**²⁹ back to CO₂; or alternatively, it can turn into **stable soil-carbon**. Here we are—we're back to this situation. It can either oxidize off, or turn into bedsprings, Pretty simple.

So our whole future management of biosystems is all about **B:C** ratios—how much do we let **burn**, and how much do we let get fixed into stable soil-carbon?

We just talked a second ago about the tallgrass prairie grasses—root-to-shoot ratios of 5 to 1. They're putting 80% of the carbon they fix into the soil, building healthy carbon, building sponges, building bedsprings.

We go back to this story with the bluegrass. 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, it's this process—these tall bluegrass prairie grasses pumping carbon into bedsprings— that has created some of the world's most productive soils: 10 meters of beautiful prairie soils, 8% carbon content, able to retain and infiltrate rain, extend longevity of growth and green growth, maintain massive populations of herbivores—resilient, productive biosystems. Until we came along. That's another story.

Okay, so the capacity of these systems to grow, this capacity to grow healthy soils and fix carbon, is prodigious.

-----End of Part 2.-----

40:30 – 1:00

PART 3. Humans, Agriculture, Oxidizing Carbon, Adding "More On"

But then we come along, and what "we come along" is -- trying to grow things better. But in trying to grow things better—and I don't want to be rude—we had this "more on" agriculture. We add more. We can clear, we can burn, we can cultivate, we can over-fertilize, we can irrigate, we can fallow, and perhaps worst of all, we can add **biocides**³⁰. (Audience comment.) But they all do the same thing: they all oxidize carbon from the soils back into the air.

28 fungal hyphae - thread-like structures that make up the body of fungi. They form vast underground networks that help break down organic matter and transport nutrients

29 oxidize - a chemical process where organic matter breaks down and releases carbon dioxide, either through burning, decay, or other reactions with oxygen

30 biocides - chemical substances designed to kill living organisms, including pesticides, herbicides, and fungicides used in agriculture.

All of these processes, in excess—let's not be pure about it, but in *excess*— all of them are driving carbon, burning off “bedsprings,” putting it *back* into CO₂, collapsing soils *back* to compacted, impervious rock with lower productivities.

So the tragedy is: what we've been doing in our agriculture is we've invested now 40%+ 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 in any quantity—we've been oxidizing carbon from the landscape.

Forest Clearing, Exposing and Damaging the Soil

We started with 8 billion hectares (20 billion acres) of **primary forests** on this planet. We've cleared 6.3 billion hectares (15 billion acres). Basically, some of it has regenerated, as in the U.S. in the Northeast areas, but we now have only 3.5 billion hectares (8.6 billion acres). We've gone from 8 billion, cleared 6.3 billion, and regenerated 1.8 billion, so now we have 3.5 billion hectares of residual forest on this planet.

We burn every year 350 million hectares (0.9 billion acres) of forests—10% of that residual forest. Every year we burn some 2 billion hectares (5 billion acres) of grassland, crops stubbles, and rangelands, all driving CO₂.

As mentioned, we chose to “cultivate” the land. When we cultivate land, we expose it to ultraviolet radiation that kills the microorganisms, and of course oxidizes carbon. We add excessive fertilizer. Every gram of excess nitrate we add to the soil—as in a compost process—oxidizes 30 grams of carbon. That's just the biological composting reactions.

We irrigate, and basically again, we're accelerating, restricting the fungal growth, stopping different organisms from growing, restricting the bio-productivity. We fallow—obviously that's just starvation. If the fungi haven't got exudates, they can't grow, and everything just slows down and dies or just sits in a resting, dormant stage until plants come back again. And if we add biocides, it's just killing all these things outright. So we've done an enormous lot of damage.

Regenerative Agriculture – Benefits of Stable Soil Carbon

Conversely, and this is what **regenerative agriculture** is all about, we can focus on C. The question is: how much of these roots and root exudates can we turn into **humates**³¹? That's the **humics**³²—all the different **fulvic**³³ and **humic acids**³⁴. So this whole category of humus—in fact, there's a composting-type process. So how do we maximize that?

31 humates - stable organic compounds in soil formed from decomposed plant and animal matter. They improve soil structure and help retain water and nutrients

32 humics - the general term for all the stable organic compounds in soil, including humic acid and fulvic acid, that give soil its dark color and good structure

The other important thing is **mycorrhizal fungi**³⁵, these 25,000 kilometers of fungal network. They're all made out of **chitin**³⁶, so **glucosamine**³⁷. When the fungus moves on, it leaves behind this cell wall. That chitin cell wall turns into a compound called glomalin. Glomalin and humates then form the glue that aggregates soil and actually creates bedsprings. To bring it back to bedsprings, this is in the stable soil carbon.

Grazing Ecology and Benefits of “Mobile Biodigesters” (Cows)

Even the litter up here, or even the stubble—the plant material that we have after harvest— nature evolved these other very clever things we call mobile **biodigesters**³⁸. Because they're trying to get this stubble, this plant material, back into the soil. These mobile biodigesters are big bags they call rumens, full of bacteria.

But they had to move around, and didn't have wheels. So (...) they put legs on these things. They've got a “business end” with ears and eyes and a mouth, and they've got a “business end” out here which is putting bio-fertilizer down and stable soil carbon. These things actually produce protein.

So nature basically evolved these “mobile biodigesters” to do what we just said: optimum bacterial conditions to turn this “cardboard” litter into protein. Because if we didn't do that, all this litter goes up as fire. So we've got this beautiful choice: do we either **biodigest**, or do we **burn**? If we burn, we go back to deserts, we go back to hard rock. If you don't eat it, it's going to burn. The first lesson of ecology: if you can't beat it, you eat it. That was **Odum's rule**³⁹. 47:42

There's a lot more ecological advantages because these herbivores—they're moving around, they're breaking up surface crusts, they're spreading seed, they're spreading bio-fertilizer. So the wise integration of herbivores, particularly in grasslands, is critically important. Grasslands evolved 50 million years ago, and they exist only in a symbiotic association with the herbivores. If not, those grasslands will burn, and that whole biosystem crashes back to desert.

33 fulvic acid - a component of soil organic matter that helps plants absorb nutrients and improves soil structure. It's part of the natural “glue” that holds soil particles together

34 humic acid - a major component of soil organic matter that helps bind soil particles together and improves the soil's ability to hold water and nutrients

35 mycorrhizal fungi - beneficial fungi that form partnerships with plant roots, helping plants absorb nutrients and water in exchange for sugars from the plant

36 chitin - a tough, flexible material that makes up the cell walls of fungi and the shells of insects and crabs. When it breaks down in soil, it helps create stable soil structure

37 glucosamine - a building block of chitin, the material that makes up fungal cell walls. When fungi die, this compound helps create long-lasting soil organic matter

38 biodigester - a system where bacteria break down organic matter (like plant material or manure) in oxygen-free conditions, producing useful byproducts while recycling nutrients

39 Odum's rule - an ecological principle stating that if organisms don't consume available organic matter, it will burn in fires. “If you can't beat it, eat it”; the rule is named after brothers Eugene and Howard Odum, who were American ecologists and professors

So really, it's an absolutely knife-edge ecological balance—grazing ecology. But of course, we manage this. So the important thing is we manage all these things, and we can manage B and C beautifully through just **smart ecological regenerative agricultural practices**, which is of course what practitioners are doing regionally and locally. So how do we make these **practices** sing and dance? How do we make C dominate? **48:50**

Audience question: "Where does Methane from the ruminants fit in?"

Let's look at **methane**⁴⁰, because these are very, very important. You, me, anyone with a gut produces methane, because we've all got **anaerobic bacteria**⁴¹. So these things produce anaerobic bacteria, no question. And of course, under anaerobic conditions, we produce methane.

But also, because these herbivores create green grass—because they create the critical thing to keep that ecological health of those grasslands and stop them from burning—that green grass produces **transpiration**⁴². It produces water vapor. When sunlight hits water vapor, it **photo-oxidizes**⁴³ and produces **hydroxyl ions**⁴⁴ and hydrogen ions that form **bicarbonate ions**⁴⁵. So you've got sunlight on water vapor, photo-oxidizing the water vapor molecule into hydroxyl ions and bicarbonate ions.

Basically, these hydroxyl ions—as you know, free radicals—are aggressively **oxidative**⁴⁶, and they will basically turn that methane rapidly into CO₂ and water. So we've got this process. Now, a healthy green pasture will produce about 100 times the hydroxyl radical photo-oxidation than the herbivores grazing it have the potential to produce. There's also methanotrophs in the soil, but that's just the icing on the cake. But the real guts is this **hydroxyl process**⁴⁷. 50:52

Now, methane has been 700 parts per billion through the last 10 million years plus in the atmosphere. We've had massively increased and higher numbers of herbivores on this planet. If you look at the buffalo, if you look at the wildebeest, if you look at the springbok—all these natural grazing animals—far, far higher numbers. So basically, we've had far higher methane production previously, but methane levels in the atmosphere have stayed constant at 700 parts per billion thereabouts.

Recently, they went up to 1,700 parts per billion, and of course that was due to Russian oil-gas fields after Yeltsin and the USSR breakdown, not having any maintenance for 10 years. And the fugitive emissions were prolific. They've now gone up to 2,300, and it varies from place to place. Again, some nations have been fracking, and of course in fracking, the fugitive methane emissions from that fracking are prodigious.

40 methane - a potent greenhouse gas produced by bacteria in oxygen-free environments, such as in animal digestive systems, wetlands, and landfills

41 anaerobic bacteria - bacteria that live and function without oxygen. These are found in animal guts (including humans) and waterlogged soils, and they produce methane as a byproduct

42 transpiration - the process where plants release water vapor through their leaves, which cools the surrounding air and contributes to cloud formation and rainfall

43 photo-oxidize - a process where sunlight breaks apart molecules (especially water vapor) creating reactive particles that can break down other substances like methane

44 hydroxyl ions - highly reactive chemical particles formed when sunlight breaks apart water molecules. They help clean the atmosphere by breaking down pollutants like methane

45 bicarbonate ions - chemical particles formed when carbon dioxide dissolves in water. They are part of nature's system for moving carbon around and help neutralize acids

46 oxidative - Relating to chemical reactions that break down organic matter, often releasing carbon dioxide back into the atmosphere. Excessive oxidation depletes soil carbon

47 hydroxyl process - the natural atmospheric cleaning system where hydroxyl radicals (formed from water vapor and sunlight) break down harmful gases like methane

But there's a patsy in this game—they're called cows. So really, it's a really neat thing because cows can take the blame. "These cows produce methane." Yes, we all produce methane, but cows are the patsies. They can be vilified because they produce methane. But the point is, these cows are actually maintaining these healthy green pastures, maintaining that photo-oxidation potential, particularly at high latitudes.

The real issue of methane—and it's not in the literature, but the real issue about methane—is the **methane hydrates**⁴⁸ that are sitting in high-latitude sedimentary ocean sediments on continental shelves. They're bubbling up. The Russian Arctic is now like lemonade with methane coming up, and the tundra's releasing methane. The only thing, and methane previously, to our knowledge, caused mass extinctions. A bigger methane burp is one of the most dangerous things we face in this climate extremes scenario. And the only thing that's going to save humanity, or much of life on Earth, from a methane burp is cows. Because if those cows are there, or the caribou or whatever, producing enough sustainable green pastures to produce enough photo-oxidation, enough **hydroxyl radicals**⁴⁹—we've got that balance. We've got 100 times the hydroxyl from green pastures compared to the methane from the cows.

So what we've been talking about is this whole different picture of what are the new climate solutions. How do we step outside of the tunnel, the "black hole" we've created for ourselves on the CO₂, and open new windows and open new opportunities laterally by embracing this hydrological dimension?

The key point is we've gone through **why**, we've gone through **what**, we've gone through **how**—the ABC— and it's all about rebuilding the Earth's soil carbon sponge. (Question.)

D for Dividends of Stable Soil Carbon and Longevity of Green Growth

I've got ABC here, so we say that the whole critical thing is the balance between B and C. But of course, we've left a field here vacant, and in nature there's never a vacuum, there's never a vacancy. So we've got to have another thing: **D**, which are the **dividends**.

This is very important because this is really the guts of agriculture and where we're going. If we put carbon into the soil—C—for every gram of carbon that we put into that soil, as we've seen here already, for every gram of carbon we can hold **8 grams of extra water**. You can see that from the sponge, the bedsprings—the voids. We can massively increase the water retention, infiltration, and then longevity of green growth.

That's the important thing to understand. All of our Green Revolution stuff—where I started research, I didn't tell you what I've been doing, but I started as a researcher—it was all about "how do we increase the yield of plants." Green Revolution, right? We do genetics and fertilizer, and if we can get a 30% yield response, we get a new white lab coat, a clipboard, and a line up for a Nobel Prize. It's big stuff. But basically, the best we can do is 30%, 40%.

But if we increase the *longevity* of green growth—there's a rain, we've got a sponge, instead of the soil drying and we've got just 10 days worth of growth, now we've got **100 days of growth** because of the sponge— we've increased the longevity of green growth 1,000%, just through building the sponge. So the multiplier effect of longevity of green growth, extending drawdown, extending productivity, extending resilience, is powerful.

48 methane hydrates - frozen deposits of methane trapped in ice-like crystals, found in ocean sediments and permafrost. These could release large amounts of methane if they thaw

49 Hydroxyl radicals - Extremely reactive molecules that form in the atmosphere and act like atmospheric detergent, breaking down pollutants and greenhouse gases.

So one gram of carbon holds eight grams of water. Every gram of carbon we put in the soil massively increases the bio-fertility of that soil, as we've explained, as the nutrients become available. Eighty percent of the fertility of soils isn't about how many nutrients are in that soil in total—how many nutrients in total—it's about the availability of those nutrients. It's about the microbial solubilization, fixing, access, uptake, cycling of those nutrients. So the whole business about fertility is about the microbial ecology of the soils, not the content or how many “more ons” we put on.

The other thing: every gram of carbon we put into the soil, as we've said, massively increases the root ability, the volume of soil we've got access to—powerful exponential increases. And the same goes with the microbial activities, disease resistance, resilience, productivity.

The point we're making with D is: simply by increasing bedsprings, we can drive productivities as nature has, massively. We've got rainforests on sand dunes in Queensland where I was working when I was working at **CSIRO**⁵⁰. These are the world's most bio-productive terrestrial ecosystems, effectively on crushed glass with next to no nutrients in it, but every molecule is moving 1,000 times faster and therefore giving that productivity because there's microbial activity.

The point being that this is how nature drives productivity—not by Mac trucks putting fertilizers on, not by inventing biocides and all that stuff, not by “cultivating.” Simply by increasing soil carbon. More powerfully, because of these dividends, because there are dividends, we negate the need for all this “more on” stuff significantly. Because why do we need it when we've got carbon bedsprings?

So our innovative farmers are doing 100% of the yield, but they're getting 300% of the quality—the nutritional integrity in their food grains. They're doing it with less than 20% of the inputs, less than 10% of the risk, 300% the reliability, and 500% the natural capital asset land soil regeneration value. These are dividends.

So the whole basis of **regenerative farming**⁵¹, the whole revolution in agriculture, taking agriculture from the 19th into the 21st century, is all about **rebuilding healthy soils**, rebuilding that sponge. Because without that sponge, we've got cactus—nothing, desert. **1:00**

-----End of Part 3-----

1:00 – 1:20

PART 4: Cooling Through Transpiration – Heat Loss Through Liquid-to-Gas

Now we can forget all about that and we go into the important stuff. Because once we have a sponge with water in it, obviously, what we have is the capacity to grow biosystems. We've already talked about that longevity of green, and we've got transpiration—water going up as transpiration.

You and I and everybody knows: for every gram of water that transpires, it has to go from liquid to a gas. To go from liquid to a gas, every gram needs to have **590 calories** of energy in its latent heat of vaporization. Simple physics. So 590 calories of energy have to be taken from this soil surface, from where the water is, and from the vegetation.

So we can't avoid but *cool* this surface. That heat, of course, goes up. When this water **condenses**⁵², it again gets released, and most of it goes back out to space.

50 CSIRO - In Australia it refers to the Commonwealth Scientific and Industrial Research Organisation, Australia's national science agency that conducts research on various topics including climate and agriculture

51 regenerative farming - agricultural practices that focus on rebuilding soil health and carbon content while maintaining or improving crop yields and farm profitability

52 condense - the process when water vapor in the air turns back into liquid water, forming droplets. This happens when warm, moist air cools down

Nature has really driven the hydrological cooling of the planet by these latent heat fluxes. Even now, with half of the green vegetation on this planet—the residual green vegetation we talked about—24% of the incident solar radiation (that 342 watts coming in, some 85 watts per square meter) is constantly taken back up through these latent heat fluxes.

So that green vegetation is constantly taking 24% of the incoming energy that's striking the surface and taking it back out to space. So a 5% increase in green transpiration—we can effectively negate 3 watts per square meter. Roughly, it's obviously many factors, but the fact is: the 3 watts per square meter, how do we cool the planet 3 watts per square meter? Simple: increase transpiration 5%. And we're running at half of what there was 8,000 years ago. We're running at 50% of what there was.

Here we have-- (audience comment.) I live in a city called Canberra, which is Australia's national capital. It was designed and built from 1913 onwards. **Marion Mahony⁵³** and **Walter Burley Griffin⁵⁴** won the prize. They made a landscape city. It was a leading city for the 20th century—what urban future habitats need to look like.

Of course, what they did—Canberra initially was what we called a clapped-out, arid, dusty, dried-out sheep paddock. Basically, they built an urban forest and really created a whole new forested urban environment. It's now 7°C (13°F)—7 degrees Celsius cooler on a hot summer's day (i.e. 35-40 degrees Celsius or 95°- 104° F) than the adjacent urban heat island concrete in new suburbs just 2 kilometers away. Seven degrees Celsius cooler, absolutely. And it's all just because of **latent heat fluxes⁵⁵**.

So again, we in Canberra, we've got a thing from the grassroots called Cool Canberra, and it's all about urban trees, about porous pavements, about sponge, sponge, sponge—infiltration to keep these latent heat fluxes going. [1:04:49](#)

Water and Weather; Cloud Formation, Albedo Effect, and Cooling Rain

But it gets better. Obviously, we've got these hazes and these latent heat fluxes condensing into clouds and of course releasing the heat. So we end up with massive numbers of cloud micro-droplets. But these are far too small to fall out as rain, and of course they sit up there as hazes and as clouds. But then they'll basically form these nice white fluffy things. They'll form dense, **high-albedo⁵⁷** clouds.

There's a coalescence process involved—we can go through the physics, but I don't want to waste time on it. But the point is, these dense, high-albedo clouds basically reflect—because it's an albedo effect—they reflect that incident solar radiation directly back out to space. It doesn't even get to the soil surface. When a cloud comes over, you're reaching for another jumper—*significantly* cooler.

These clouds globally—50% of the Earth's surface is covered in dense clouds at any one time. What it used to be—it's getting less—but 50% of the surface of the planet is still covered in clouds at any time. These clouds, on average, reflect 120 watts per square meter back to space. About a third, roughly, of the incident solar radiation is just reflected back out to space.

53 Mahony, Marion - an American architect who, along with Walter Burley Griffin, designed Canberra, Australia's capital city as a "garden city" with extensive urban forests (1871-1961) - she and Griffin were married and worked together

54 Griffin, Walter Burley - An American architect who, with Marion Mahony, designed Canberra as a garden city that demonstrated how urban forests can naturally cool cities (1876-1937)

55 latent heat flux is the transfer of energy through evaporation or condensation of water.

56 albedo effect - the reflection of sunlight back into space by bright surfaces like clouds, snow, or light-colored ground. Higher albedo means more cooling as less solar energy is absorbed.

57 high-albedo - surfaces or objects that reflect a large amount of sunlight back into space, appearing bright or white. These surfaces help cool the environment.

So again, the same analogy: a 2% increase in cloud will offset 3 watts per square meter. And cloud can only happen if we get micro-droplets, and they can only happen if we have a sponge that's transpiring water up into the air. So you can see, all the time we bring it back to the sponge, because the sponge is a fundamental driver. But also, the sponge is what we influence—that's our point of agency. ABCD—it's what we can do. Every square meter, every acre, every region, every nation—grassroots empowerment of action.

So there are clouds, but we talked about the sponge being critical. But it's not good enough having clouds because we also need raindrops, don't we? Because if we have a dry sponge—no good. So we need rain.

Precipitation Nuclei and Bacteria

It takes about 1 million of these cloud condensation droplets to form a raindrop, because it's got to coalesce—about a million of these cloud micro-droplets to make a raindrop that's big enough and heavy enough to fall out under gravity.

There are three things that actually allow you to do that. They call them **precipitation nuclei**⁵⁸. Rain can't occur just by itself—it has to be precipitated through these precipitation nuclei. Three things:

- **Ice crystals** - Of course, they're very important at high altitudes, high latitudes, and **frontal rain**⁵⁹. It gets colder, it forms ice. You know, like a glass of whiskey—ice will collect and coalesce on the outside, condense on the outside. Same process.
- **Salt spray** - Over the ocean, of course, we have a lot of salt spray that comes up from the oceans. Again, salt, sea salt—we know when you're fishing in the ocean and you shake the saltshaker, it's all gluey because it's **hygroscopic**⁶⁰. It sucks up water, won't come out. And again, it's basically coalescing these droplets. Of course, it's these salts that we use for cloud seeding, where we use, for example, silver iodide to create artificial rain. Basically, we go up with airplanes, atomize silver iodide, drop it into particular types of clouds, and consistently get 20-30% more rainfall through that process.
- **Bacteria** - But by far the most important thing, particularly in inland areas and tropical and warmer areas, is bacteria. There are certain bacteria, and Louis Pasteur wrote about. He isolated them in the 1870s. He called them "aerobacter **aerogenes**⁶¹" because he certainly found them in all the air, but he didn't know what they were doing. In Greek, that translated to "I don't know what they're doing—they're aerogenes."

Well, he was a scientist—he's got to be objective about it. But the point is, there are bacteria. And so these—in cloud work, CSIRO atmospheric physics, detailed work we did—by far the most effective at nucleating clouds into raindrops, by far, orders of magnitude. But of course, atomizing bacteria to disperse in the atmosphere is a bit sophisticated, and until recently we weren't able to do that. But these actually are produced in nature. Of course, what nature does—and certain forests, and again, we've got this from the Amazon and a whole lot of studies—basically, it's not just transpiring water vapor, it's also putting up bacteria.

58 precipitation nuclei - in particles in the atmosphere (like dust, salt, or bacteria) around which water droplets can form and grow large enough to fall as rain

59 frontal rain - rainfall that occurs when different air masses (warm and cold) meet and push against each other, forcing moist air upward where it cools and forms clouds

60 hygroscopic - having the ability to absorb water from the air. Salt is hygroscopic, which is why it clumps up in humid conditions and helps form raindrops

61 aerogenes - bacteria found in the air that help form raindrops. The name literally means "air-born" and was coined by Louis Pasteur in the 1870s when he didn't yet understand their function

So half the rain—this is from radio isotope studies—*half* the rain in the Amazon is actually driven by these bacteria. It goes up, transpires every day. At 4:30 in the afternoon, you can set your watch on it—it comes back down in a thunderstorm. Every day you've got this hydrological cycle taking heat from the surface, dissipating it upstairs, returning rain back to the sponge.

And vast areas of forests have been cleared. We've talked about the 8 billion hectares of primary forests that we've cleared—6.3 billion hectares (15 billion acres). So what have we done to our rain? (You can write a song about it.)

So this is a question: again, by regenerating landscapes, can we actually start **restoring these hydrological dynamics?** Because these are critical if we're going to refill this sponge. So it all comes back to cooling, cooling—rain, more cooling, cooling, cooling. Powerfully natural, simple, safe processes to cool regions and the planet. We need rain; we can cool the planet, but it all depends on the sponge. [1:12:30](#)

Vast Differences in Land Surface Temperature

Because somebody made the point previously, there's a vast difference where we have – here we have a land system with plants, grass, green—and here we have a bare land surface. Vast differences, because this one is getting latent heat fluxes, so it's cooling, and very rarely does this soil here get above 20 degrees Centigrade (68° F), because it's got latent heat fluxes cooling. But it's also got the albedo and shading and cover effect.

But we know that a **bare surface**—soil, asphalt, roads, or whatever—**readily** gets up to 60 degrees Centigrade (140° F). Certainly in Australia, you know, you'd blister your feet. What it is, of course, is this incident energy coming in, heating these systems, and of course how much is actually taken back up—vast differences.

Fundamental Physics: Stefan-Boltzmann Law and Heat Radiation [1:13:30](#)

But there's again a simple, fundamental law of physics: the **Stefan-Boltzmann equation**⁶². Because the Earth is a blackbody radiator—it's like a stove. And the blackbody radiator, the Stefan-Boltzmann says the re-radiation from a blackbody is proportional to a constant *times the fourth power* of the temperature in degrees Kelvin. That means temperature times temperature times temperature times temperature.

So when we have two different surfaces—one at 20 degrees Celsius and one at 60 degrees Celsius— we get a massive, massive increase in the re-radiation of heat, infrared energy, from this bare, hot surface. Massive increase. Now the punchline is: we all know that, but what we don't recognize is **three** things that control both the **natural and the artificial** greenhouse effect:

- **First:** How much re-radiating there is (Re-radiation)
- **Second:** How much of that is absorbed by water (Water absorption)
- **Third:** How much is absorbed by CO2 molecules (CO2 absorption)

Three variables in both the natural and the artificial greenhouse effect. And the point is, we have *completely ignored* in all our climate models the effect of land management and these bare soils and this re-radiating in driving the greenhouse effect. Completely ignored it, because we said, "*Oh well, look, that's just the planet, and we're concerned*

about CO2."

⁶² Stefan-Boltzmann equation - a physics law that describes how much heat energy an object radiates based on its temperature. Hotter surfaces radiate more heat energy -- to the fourth power.

There's up to 40,000 parts per million water vapor in the air in these humid hazes. We know there's 400 parts per million of CO₂—406, let's say—parts per million of CO₂ in the air. We know that each water vapor molecule, because of its molecular structure, holds or can absorb *8 times more heat* than a CO₂ molecule—590 calories compared to about 72 calories.

Yet we're only concerned about *this* variable (CO₂), and we can't do anything about that variable for *1,000 years*. And we're saying, "Hey, doomsday, game over, can't go forward."

And we're saying there's a new solution to climate change because basically we control *this guy* [water], and this runs 90% plus of the greenhouse effect. We control this guy [water]—we've just gone through that in terms of rainfall induction, etc. And yet we're all focused on *that* (carbon.)

But we need this because this is the building blocks for building "bedsprings". So we're into building bedsprings through drawing down carbon to build the [soil] sponge. 1:16:58

What we're saying is: let's just get real. We've got climate extremes, climate crisis, we've got 10 years. So let's start talking to the elephants. Because we can do this. Whether we do *this* instead of *that* is existential. 1:17:18

Reversing Aridification; Land Management; Minimizing Bare Surfaces

So really, we've got—again, we're just talking about empowerment—through our land management, we have an **enormous, enormous capacity** to both cool the planet and avoid these dangerous extremes that we're facing.

Heat Domes: Stopping the Flow of Cool, Moist Ocean Air

There's another thing: when we actually reradiate from these **bare, dry, hard** surfaces, obviously this heat is just energy, and so this creates a very high **high-pressure heat dome**⁶³. We create this massive high-pressure heat dome because of this re-radiated energy.

So if we look at a country—let's look at [the California Coast] because we've got the ocean, we've got the coast, we've got the Coast Range, we've got the Central Valley, we've got the Sierra Nevada, we've got Death Valley, and then we go on to the Western Plains. The point is, if we, for example, take the Central Valley, and we clear that Central Valley in California—the San Joaquin Valley—of vegetation, what we do is we create a high-pressure heat dome over that landscape.

Of course, we've got cool and moist, low-pressure air from the oceans coming flowing in, but it's got "Buckley's"—which is an Australian word for no chance whatsoever—to be able to push this high-pressure heat dome out of the way.

So what it is: if we have cleared this landscape, we're in this position here. We've created a high-pressure heat dome because of all the radiation coming off. We have, in a sense, this mountain of hot air sitting on that landscape. We now have low-pressure air which has got moisture in it from the oceans. There is no way in physics that this moist air can flow into that area.

So really, we are actually *desertifying* regions and climates through our land management.

CONCLUSION - Cooling Regions by Restoring Water Cycles and the Soil-Carbon Sponge

The bottom line is, as we've gone through this whole extended discussion: yes, there are new paradigms, there are new doorways, new opportunities that we can use to naturally cool the planet, to address climatic changes, but also to secure the water, the food, the biosystems, the social stability that we just agreed depend on that.

As the gentleman said⁶⁴, there are seven missed meals between social stability and chaos, and that all depends on water and food—social stability, a la Syria. and the answer—this is critically important. Yes, Mark Twain said, “Whiskey is for drinking, water’s for fighting over,” and it’s true. That’s where it’s going to happen.

But the point is that these natural processes give us the option, an 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.

But the point of agency and the point of this whole discussion is: it’s about regenerating the Earth’s soil-carbon sponge. Because by drawing down that carbon to put the bedsprings into those spaces between those soil particles, we can do it profitably, practically. We can actually rebuild the sponge, and as we’ve seen—ABC—we can actually then restore healthy biosystems and a healthy future for California, and for all of us.

Thank you very much. [Applause.]

63 heat dome - a high-pressure weather system that traps hot air over a region like a lid, preventing cooling and causing extended periods of extreme heat

64 seven missed meals reference - a saying suggesting that social stability can collapse quickly - within just seven missed meals - highlighting how crucial food and water security are for civilization. The concept originates from Alfred Henry Lewis who wrote in 1896: “The only barrier between us and anarchy is the last nine meals we’ve had.” The “seven meals” version appeared in 1916 in a Brooklyn newspaper. The saying has been expressed with different numbers (three, seven)

END