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INTERVIEW: SUPPORTING THE SOIL CARBON SPONGE

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Microbiologist, climate scientist and founder of Healthy Soils Australia Walter Jehne discusses climate and soil health.

Interviewed by Tracy Frisch

WALTER JEHNE is an internationally known Australian soil microbiologist and climate scientist and the founder of Healthy Soils Australia. He is passionate about educating farmers, policymakers and others about “the soil carbon sponge” and its crucial role in reversing and mitigating climate change. His work shows how we can safely cool the climate by repairing our disrupted hydrological cycles. That project requires us to return some of the excess carbon in the atmosphere to the soil, where it belongs. In 2017, he participated in an invitation-only United Nations Food and Agriculture Organization conference in Paris aimed at bringing soil into the next Intergovernmental Panel on Climate Change (IPCC) report.

Jehne was an early researcher on glomalin, mycorrhizal fungi and root ecology. He grew up in the bush, surrounded by nature. At university he chose the field of microbiology because it encompasses all life processes in microcosm. As a young man he started his career working on forest dieback diseases in relation to soil microbial interactions. Later he “switched to the dark side” when he realized that the disease fungi were actually our friends because they’re involved with symbiosis, and disease serves to remove and recycle moribund organisms.

As a research scientist at CSIRO (Australia’s scientific research organization), Jehne investigated the potential of mycorrhizal fungi to recolonize toxic, degraded soils and to rebuild productive biosystems. His curiosity took him to China to study why the country’s traditional agriculture was so productive. Later he worked with his federal government on changing the paradigm of land management to foster strategic innovation. He retired 15 years ago so he could get back to practically applying science and grassroots empowerment. He travels widely to share his understanding of the causes and solutions to climate change.

Walter Jehne.

ACRES U.S.A. You assert that for the past 50 years climate science has been misguided by the assumption that carbon dioxide is the dominant greenhouse gas, not water vapor. How did this misunderstanding arise, and why does it persist?

WALTER JEHNE. In 1958 the scientist Charles Keeling published data showing that carbon dioxide levels in the atmosphere were going up. For half a century we’ve had the warning about an abnormal change in the atmospheric dynamics of the whole planet that we need to seriously address. Since then, we’ve focused the debate on the increase in CO2 and assumed that this CO2 symptom is what’s driving the increased greenhouse effect and global warming. But going back to the 1940s, our understanding of the role of water in governing 95 percent of the heat dynamics of the blue planet was what anchored climatology.

ACRES U.S.A. Are you saying we already knew about the role of water vapor, but forgot?

JEHNE. Absolutely.

ACRES U.S.A. What’s the relationship between fossil fuels and the rise of CO2 in the atmosphere?

JEHNE. CO2 started going up abnormally from about 1750 AD, 270 years ago. But the major spike in fossil fuel use, particularly of oil, only occurred since the Second World War. And James Watt didn't even invent the steam engine until the 1770s, and it really only took off in the mid-1800s.

ACRES U.S.A. So was the CO2 rise initially caused by deforestation?

JEHNE. Precisely. Until around 1850, most of our energy came from burning wood. In Europe, smelting and heating relied on burning wood until the continent was effectively deforested. Of course, soil degradation and the oxidation of soil carbon are associated with deforestation and burning. In about 1800, they started burning coal instead. But until the Second World War, we were only using 1 or 2 billion tons of carbon a year, largely from coal. Now we burn about 8 billion tons of carbon from fossil fuels per year. But all through that period we had been burning about 5 or 6 billion tons of carbon from wood.

ACRES U.S.A. What forces make Earth's climate?

JEHNE. The incident solar radiation coming from the sun onto the Earth. We get about 342 watts per square meter of incident solar radiation at the top of the troposphere. For a stable climate, 342 watts have to go out. Otherwise, the Earth would heat up. But if climate was just a question of the energy coming in and going out, the Earth would be much, much cooler. For the last 4.3 billion years, the water vapor on Earth has created a natural greenhouse blanket and maintained stable, buffered temperatures 33 C higher than they would otherwise be. Rather than being -18 C, the average temperature on Earth is about 15 C. That natural greenhouse effect enabled the planet to function and for life on Earth to evolve.

ACRES U.S.A. Hasn't the temperature fluctuated at times? We've had ice ages as well as hot climatic periods.

JEHNE. Yes, though even the fluctuations have been minor compared to what's happening now. The average global temperature rarely drops to 10 C from 15 C. When it does, we get an ice age. If it gets 3 degrees warmer, we have a hot period. But the average temperature has never gotten down to -30 C. If it did, it would be like Mars or Neptune!

ACRES U.S.A. Let's talk about water vapor and carbon dioxide in the natural greenhouse effect.

JEHNE. Eighty percent of the natural greenhouse effect results from water vapor in the atmosphere. And the amount of atmospheric water vapor has been relatively constant at up to 40,000 ppm, or about 4 percent. By contrast, the level of CO2 in the atmosphere governs about 20 percent of the greenhouse effect, and those CO2 concentrations have varied enormously. When the Earth was first forming, CO2 levels were initially very high. Then it was drawn down by biology, first through the formation of corals, limestone and chalk by marine organisms in the oceans. Later, for the last 420 million years, plants on land and the formation of soils drew down atmospheric CO2.

ACRES U.S.A. How effective is water vapor at absorbing heat?

JEHNE. Water vapor is uniquely powerful at absorbing heat. Due to the way its two hydrogen atoms bond to its oxygen atom, 1 gram of water can absorb 590 calories of heat energy. That’s massively more heat per molecule than most other things can absorb. For example, a CO2 molecule — one carbon and two oxygens with two double bonds — can only absorb about an eighth of the heat per molecule that a water molecule can. And a water molecule weighs only one-third as much as a CO2 molecule. So the power of water vapor to absorb and transfer heat is 20 times higher than that of CO2, molecule per molecule. And by weight, there are 40,000 ppm of water vapor in the air compared to 400 ppm of CO2. There is no question about the power of water vapor. CO2 is not even in the contest as far as moving heat in the atmosphere.

ACRES U.S.A. How does nature cool the planet?

JEHNE. Nature uses a sequence of about a dozen hydrological processes to cool the planet. As a water molecule journeys through the atmosphere, it will sequentially go through each of the different processes that regulate 95 percent of the heat dynamics of the blue planet. For example, it takes 590 calories of energy to turn 1 gram of water from liquid to gas. That’s the latent heat of vaporization. It’s simple physics. When water evaporates from the land’s surface or is transpired by vegetation or forests, that heat gets transferred from the Earth’s surface up into the atmosphere, cooling the surface. When that water vapor condenses in the atmosphere, the energy is released. That’s what makes energy in storms. But most of that heat gets dissipated back out to space from the upper atmosphere. That process accounts for about 24 percent of the Earth's natural hydrological cooling. Clouds are another very important cooling process. That water vapor going into the air will form clouds. Some clouds are very dense, with high albedo — very high reflectance. At any given time, clouds cover over 50 percent of the planet. Clouds act as a regulator. They cool the planet by reflecting incident sunlight out to space, preventing it from reaching the Earth's surface. While this varies, roughly a third of the incident solar radiation — of that heat coming in — never makes it to Earth because it's reflected out to space. By increasing the level, density and duration of cloud cover, we can cool the planet. But to do that, we need green plants and organic matter in the soil to keep that whole hydrology working.

ACRES U.S.A. In terms of their cooling effect, how does transpiration from trees compare with evaporation from freshwater bodies and the oceans?

JEHNE. Oceans cover 71 percent of the Earth's surface; 29 percent is land. Trees are wonderfully efficient at cooling because they can have a leaf area 10 times greater than the land's surface area. But trees are much more significant for other reasons. The oceans are just liquid water, and water can only evaporate from a two-dimensional monomolecular layer on the surface. That is a very limited physical dimension. Also, that water is always being cooled by cool water from below, so for evaporation to occur the sun has to heat each molecule in this monomolecular layer. On land, with transpiration from leaves, a completely different dynamic occurs. The leaf area makes the process three-dimensional. And the longevity of green growth means time is involved, making it four-dimensional. The amount of surface area and the length of time that leaves transpire make this process phenomenally greater than evaporation from a monomolecular surface.

ACRES U.S.A. We love your description of the soil carbon sponge as a bit like a cathedral. How do biological processes create this awe-inspiring architecture?

JEHNE. What's awe-inspiring about a cathedral are the voids and the ethereal spaces — the nothingness they create — not the bricks and the cement. Well-aggregated soil is like a cathedral. The mineral particles in the soil are like the stones of a cathedral. Soil organic matter is analogous to the cement that holds the stones together. Adding just a small amount of organic matter — 1, 2 or 3 percent by weight — fundamentally changes soil's physical structure. That organic matter cement between the mineral component enables us to develop these massive, beautiful spaces. A healthy soil has a bulk density of about 1.2 g per cc or less. About 66 percent of a healthy soil is just space, air — nothing — and that creates massive capacity for the sponge to hold water. It allows water to infiltrate and be retained and made available over time. It's really the "nothing" that we add to soil which creates its health and viability, like a cathedral. What nature has done is exquisitely beautiful. There's one other dimension that is profound. The availability of nutrients is related to how much surface area of the mineral particles is exposed. In a healthy soil with a beautiful, open, spacy structure, we massively increase the mineral surface exposure for nutrient uptake and cycling. A lot of essential minerals and trace elements are cations that are absorbed onto these surfaces and held as if by Velcro. More than 80 percent of a soil's biofertility depends on this surface exposure, rather than on the quantity of nutrients we add as fertilizer. Creating these cathedrals — these spaces and surfaces — is fundamental for both soil hydrology and biofertility. And we can do this just by adding a few percent organic matter to the soil.

ACRES U.S.A. How did you come to this work?

JEHNE. I'm a microbiologist who was studying mycorrhizae. I was looking at the health, disease and productivity of pioneering vegetation systems. I always asked the question, how do such productive biosystems exist in extreme habitats? Microbiology has always been the pioneers enabling that to happen. Think about pedogenesis — soil formation. Some 420 million years ago the planet only had bare, consolidated rock that couldn't hold water. In colonizing the Earth's surface to get nutrients, fungi began breaking up that rock and leaving behind organic detritus of dead fungal matter to create cathedrals. Fungi make all those nutrients available by governing their solubilization, access, cycling and uptake.

ACRES U.S.A. You've written about how some of the most productive natural ecosystems occur on very-low-nutrient soils.

JEHNE. In the early '80s we were working on rain forests growing on sand dunes in Queensland. Nature created one of the world's most bioproductive terrestrial ecosystems on sand, which is effectively crushed glass — silicon dioxide. How is this possible? Wonderfully, it does that through fungi. The efficiency of their bionutrient recycling enables these rain forests to function. We can use those same efficient bionutrient cycles in agriculture to sustainably produce food, even on poor soils, as long as we also recycle those nutrients. In the 1970s I was working in Green Revolution space, where everything was based on the idea of adding more. I call this the more-on (or moron) mentality of agriculture. But you don't have to add more. What you have to do is enhance the natural efficiencies of cycling, solubilization, availability and fixation, and you can sustainably achieve very high productivities in every environment. That's the basis of biofertility in the organic world. Liebig, back in 1851, came up with a theory about the chemical limitations of fertility. He had a very simplistic more-on philosophy: basically, fertility is a function of the quantity of ions in the soil. But by the 1870s, even Liebig was realizing that this was wrong and that the organic agricultural people were right. It's those processes of biological cycling that govern the speed and the availability of nutrients, not the quantity of nutrients in the soil. In the 1920s, Rudolf Steiner was trying to encapsulate that in terms of the biodynamics of soils. What are the life processes? It's all one story.

ACRES U.S.A. Should we be testing soils for nutrient levels?

JEHNE. I don't want to be rude, but no, I believe we've wasted a lot of money on soil testing. What's found in nature is less than 10 percent of the story. The other 90 percent is "how well do you use whatever you've got?" We ignore that in agriculture. If we can more efficiently cycle and make available whatever is there, then we can get along very happily with a fraction of what we think we need in more-on agriculture. But there's a caveat. In Australia where I come from, parts of the country have very ancient soils where trace elements like selenium, copper and zinc have been leached out. When they're no longer present, we need bird droppings, rock dust, or some other source to get these essential elements. But most soils, especially younger ones, have enough nutrients.

ACRES U.S.A. Would you say that microbial systems are as effective as fertilizers in stimulating crop growth?

JEHNE. It's a 20/80 situation — not "all or nothing." Twenty percent is whether we have enough nutrients in the soil, which we do in most cases. Biofertility is about whether we’re managing our soils and their ecology so well that we are speeding up nutrient cycling. Are we moving closer to that rainforest scenario where every molecule of phosphorus is cycling 3,000 times more rapidly than it does in our current dead, industrial agriculture?

ACRES U.S.A. Have you and others measured the speed of that cycling?

JEHNE. Absolutely. That’s what the paper about the rainforest does.

ACRES U.S.A. Is it fair to say that plants without mycorrhizal fungi take up nutrients and toxins in the soil solution without any quality control?

JEHNE. In nature, most plants won’t survive alone; they need these microbial associations. Mycorrhizal fungi are very important, but there are also nitrogen-fixing organisms in the rhizosphere, including blue-green algae, Azotobacter and Azospirillum. There’s a whole beautiful zoo of them. Plants produce plenty of sugars, and in effect they’re exchanging those sugars as root exudates with these fungi and microbes and maintaining that healthy organic biodiversity. These fungi are really membrane interfaces between the mineral soil environment, which is often toxic, and the plants. Such a membrane interface allows for selective, intelligent nutrient uptake. These membranes will take up the nutrients that the fungus and the plants need while leaving behind, or positively excluding, toxic ions like aluminum, cadmium, or lead in that soil. The surface area of these microbial interfaces is enormous, with 25,000 kilometers of fungal hyphae in a cubic meter of healthy soil. But once we kill that microbial interface with biocides, excessive cultivation and excessive fertilizer, then plants have to rely exclusively on their root systems for nutrient uptake. A plant’s root system, including its root hairs, will have less than a thousandth of the surface area. And without mycorrhizae, plants don’t have the quality control system to discriminate between toxins and nutrients for healthy plant growth and human health. Their roots just indiscriminately suck up water from the soil solution as if they were straws and use it in their transpiration stream. In effect, such plants are growing hydroponically. The soil solution is full of soluble anions, like nitrates and sulfates and potassium. Without mycorrhizae, plants will take up a lot of these (negatively charged) anions, but often they will have very low levels of the essential (positively charged) cations that are absorbed onto soil surfaces — in the cation exchange capacity — rather than in the soil solution. Thus we’re living on food whose nutrition mainly comes from what’s in the soil solution via the application of soluble fertilizers. The nutritional integrity of these hydroponically grown plants is totally compromised compared to plants grown naturally in soil with these selective, intelligent interfaces.

ACRES U.S.A. Are you suggesting that industrial organic actually functions hydroponically?

JEHNE. By definition, if we’re relying on high levels of fertilizers, we’re going to kill all these microbial interfaces, and then have to depend on that soil solution slush. Our industrially grown food often contains as little as a third of the nutrients as it did before World War II, according to reports published by the UK Ministry of Health, USDA and CSIRO Human Nutrition. You’d have to eat three carrots to get the same nutrients as a pre-World War II carrot. These industrially grown foods often have no trace minerals. And we’re seeing chronic, diet-induced chronic diseases — like Alzheimer’s, cancers and cardiac and immunological disease — go through the roof. Enzymes drive all of our biochemical functions. Enzymes are protein’s molecules, which have a mineral cofactor at their heart. If we don’t get those mineral cofactors through our nutrition, we can’t make those enzymes. Without selenium, for example, we can’t make peroxidase enzymes, which kill cancer cells in animals. We lack the capacity to regulate biochemistry because we’ve compromised our nutrition, though obviously it’s more complicated than that.

ACRES U.S.A. How does the ability of the most innovative farmers to grow soil carbon compare to nature’s ability to do so?

JEHNE. As humans, we’re competitive. We’re always looking at how big and fast we are. But nature doesn’t work like that. Doing something well, slowly, is often much smarter than doing something faster, but poorly or inefficiently, even if it’s bigger! Nature has evolved some exquisite biosystems, and its capacity to fix carbon is prodigious. During the ice age 10,000 years ago, glacial clays washed out from glacial till areas in North America. Over the intervening years, tall bluegrass prairie grasses fixed remarkable quantities of carbon and created 10 or 15 meters of deep organic soils with 8 percent carbon levels. We’re in exactly the same game in farming. We can maximize the production of plants, but how we do that will govern whether the carbon will be oxidized or burned as CO2, or put into soil as stable soil carbon to build those cathedrals we talked about earlier. Take sugarcane, a tropical grass. In good environments it can produce roughly 200 tons of biomass per hectare per annum. Under suitable soil conditions — that we control — 60 to 70 percent of that carbon can be bio-sequestered as stable soil carbon, thus building highly productive organic soils very rapidly. Most organic farmers have the potential to do 5 to 10 tons of carbon per hectare per annum through wise, regenerative land management. Farmers like Gabe Brown are maybe fixing 15 tons of carbon per hectare per annum. But it's not a race. It's about doing the best you can in your situation and being grateful for every gram of carbon that you can put in the soils. We won't beat nature. For every bit of plant material that you produce, think about whether you are letting it oxidize or are putting it through composting and biosequestration processes to build healthy soils. That's the challenge.

ACRES U.S.A. Globally, to what extent has human activity degraded productive land?

JEHNE. For the last 8,000 years of "human civilization," we've been very effective at clearing and burning that land, cultivating those soils and building the industrial systems. We've oxidized the carbon and destroyed the biological cycles that underpin the health of those landscapes. We've done that with 5 billion hectares of land, turning 40 percent of the Earth's land surface into desert and wasteland. Of the 13.9 billion hectares of ice-free land on this planet, about 40 percent — 5 billion hectares — has become manmade desert and wasteland, and we're halfway through eating up that natural capital on the remainder. This is documented by United Nations Environment Programme data. Whereas we once had 8 billion hectares of old growth forest on this planet, we've cleared 6.3 billion hectares. Some of the forestlands that we've cleared have regenerated, like in New England, giving us 3 billion hectares of forest in total. We initially had about 5 billion hectares of grasslands rangelands, but we overgrazed, cultivated, degraded and burned that. The Sahara, Central Australia and the Middle East were all savannahs. Rome got lions and rhinoceros and other wildlife for the Coliseum from the savannahs of Libya. Today Libya is an arid wasteland. As we oxidize the carbon, by definition, those soils can't infiltrate, retain, or make available water from rain. Invariably, they go to desert. That's been the history of man on this planet.

ACRES U.S.A. What has been your experience with the use of biostimulants and inoculants to encourage soil life?

JEHNE. That rainforest that we talked about was extremely active microbially, so it had natural stimulatory factors at work. Next to that rainforest, on the same soil in the same climate, there was a heathland. It was a degraded, nonproductive biosystem because its microorganisms weren’t functioning well. Can we add things to soils to switch these organisms on? Sometimes yes, but it’s more important to create the right soil conditions through our land management so nature will do it naturally. Biostimulants off the shelf can be very important on degraded soils or pioneer sites where we’re trying to kick-start a system. But ultimately we want the natural system to be producing them itself. Inoculants are another category. All surfaces of the Earth are covered in organisms. But on virgin soils or highly disturbed sites like on mining waste, it can be beneficial to add new organisms because they aren’t there. Most of the time though, when you add an inoculant into an existing system, it won’t survive so it’s not going to have a long-term effect.

ACRES U.S.A. Do we have any idea of how much carbon dioxide has been released into the atmosphere by desertification?

JEHNE. There are about 750 billion tons of carbon in the atmosphere in CO_2 and about three times — 2,300 billion tons of carbon — in the soil. Most of the carbon that we’ve oxidized from the land over the last 8,000 years initially went into the atmosphere, but then the world’s oceans absorb it. We can do the accounting, but it’s not just in the atmosphere — it’s in the whole system.

ACRES U.S.A. Looking at the planet as a whole, how is rainfall changing?

JEHNE. As the planet warms, there is more evaporation from the oceans; so we’re getting more rain, but it’s coming down in extreme damaging storms. They’re not equally distributed, so along with more extreme flooding there are also more severe droughts. We’re already locked into getting more weather extremes. Our point of agency depends on our capacity to buffer these extremes. The only thing we can do is rebuild the Earth’s soil carbon sponge and those in-soil reservoirs. That’s a win-win-win. If we don’t do that, it’s lose-lose-dead.

ACRES U.S.A. Going back to basics, what’s required for precipitation to occur?

JEHNE. The water that goes up into the air has to come down. Water vapor goes up into the air, where it forms clouds as well as humid hazes, which play a key part in warming the planet. Those haze micro-droplets absorb solar radiation. For water vapor in the air to fall on the land as rain, a million cloud micro-droplets need to coalesce to form a raindrop that's large and heavy enough to fall out as rain. For that to happen, we need precipitation nuclei. Only three things in nature form these precipitation nuclei: ice crystals, salts and certain bacteria. Ice is hygroscopic; it will absorb and condense water around it. Ice is very important in high latitudes and for high altitude rain, where we've got cold fronts. Salts in the form of sea spray are responsible for a lot of marine rain. We've also used salts, like silver iodide, to artificially seed clouds to induce rainfall. But by far, the highly hydroscopic bacteria Aerobacter are the most effective nuclei in cloud chamber studies. (Aerobacter was formerly a genus, but has been reclassified and grouped into the gram negative enterobacter common in animal guts.) They govern more than half of the planet's rainfall dynamics. These bacteria are produced in the stomata of trees in inland and tropical areas. They move up in the transpiration stream and effectively bring that water back down to Earth. Rainfall in the Amazon is largely a symbiotic, bacterially driven process. The trees are regenerating their own rainfall by the precipitation nuclei they're putting up there!

ACRES U.S.A. So before the planet had trees, this source of rainfall wouldn't have existed, correct?

JEHNE. Rainfall existed from ice nuclei and salt nuclei, but there wasn't as much rain. We know that because when we've cleared forests from an island, its rainfall crashes. Only by reforesting that island can we now restore that rainfall. The evidence is very clear.

ACRES U.S.A. Could you give us some examples?

JEHNE. In around 1430, Portuguese marine explorers found the beautiful little island of Madeira in the Atlantic. It was covered in rainforest with many mahogany trees. The Portuguese decided to build ships out of these trees. They set up an industry on Madeira, cutting mahogany trees 2 meters in diameter. They floated the logs down the rivers and cut them up with water-driven sawmills to make their mahogany ships that allowed them to get into the spice trade in the East Indies. In no time, the Portuguese cleared Madeira of all of its mahogany forest. If you go to Madeira now, there's no streams so there's no way you could float a 2-meter diameter log down water or run a water-powered sawmill. It has semi-arid vegetation, like the Canary Islands. In 1495, Peter Columbus, Christopher's son, documented that the rainfall in Madeira had collapsed enormously. Madeira is now only getting 40 percent of the rainfall that it did previously. In Australia we cleared land for agriculture up to a certain area beyond which was considered too dry. Then we installed a rabbit-proof fence. Now, 40 or 50 years later, the area that we didn't clear gets 20 percent more rainfall than the cleared area, whereas before, it had been the reverse.

ACRES U.S.A. Living in the temperate northeast of the United States, I've always thought of humidity as a precursor to rain. I'm wondering how humid hazes aridify a region.

JEHNE. It's counterintuitive. In the U.S. northeast you get humid hazes, and precipitation nuclei coalesce these haze micro-droplets into the much larger raindrops. That's what happens in the Amazonian rainforest every day, where they get massive transpiration, humidity builds up and at 4:30 in the afternoon, bang, a thunderstorm brings all that moisture back down.

ACRES U.S.A. Increasingly, we have humid weather and no rain for many days.

JEHNE. Exactly. The Persian Gulf has persistent pollutant humid hazes with 80 percent relative humidity all summer, but it never rains. In the Middle East those humid hazes have become an existential health threat. Once you get temperatures above 35°C, even 40°C, with 90 percent humidity, we humans can't perspire enough to cool ourselves. Mammals can't survive. We're at that threshold now. Humid haze doesn't precipitate because water stays suspended in haze as micro-droplets. They're electrostatically charged so they repel each other and stay up there in the air. In the liquid phase, they're absorbing heat from the sun, and in the gaseous state they're absorbing re-radiated infrared radiation from the Earth in the greenhouse effect, so they have a double warming effect. But they never rain out because there is not any precipitation nuclei to bring them back down as rain. Instead humid hazes are nucleated on aerosols and dust particulates, and they are far too small and light to fall, just a millionth of the size of a raindrop. To turn a humid haze into rain, a million haze micro-droplets would somehow have to coalesce into a raindrop-sized drop. The process that nature evolved to do that involves these highly hydroscopic bacteria.

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ACRES U.S.A. Is there more water vapor in the atmosphere than there used to be?

JEHNE. Regionally, there is. We now have a pollutant brown haze sitting over half of the world, from Cairo to Beijing. The Asian brown haze contains up to 4 percent moisture plus pollutants. This is an emphysema problem, and it's killing lots of people.

ACRES U.S.A. That sounds like one of the positive feedback warming processes.

JEHNE. Exactly. By having taken out the precipitation nuclei so water in the atmosphere doesn't fall as rain, we end up with a positive feedback, which accelerates warming. There's the solar energy absorption, as well as the infrared greenhouse absorption effect.

ACRES U.S.A. If we regained our rain-forming nuclei, how much water vapor would we be removing from the atmosphere?

JEHNE. In a sense, as much as we wanted to. That's what happens in the Amazon, right? At 3 in the afternoon, the atmosphere in the Amazon might have 5 percent water by weight in it. But then, in the late afternoon, it comes back down again as rain. That rain keeps that luxuriant biosystem functioning. The vast quantities of heat taken up by this transpiration also cool the Amazon. It's always a nice steady 30 C there, rather than getting up to the 45 C or 50 C that we're seeing in the Middle East.

ACRES U.S.A. How does the biotic pump fit into this?

JEHNE. When we degrade an area and leave it bare, it will absorb incident solar radiation and heat up and enormously re-radiate back infrared radiation. That's just black body radiator physics. This creates high-pressure heat domes over those bare, dry areas. Cool, moist, low-pressure air cannot push away a high-pressure heat dome. This is one of the positive reinforcing feedbacks whereby degrading landscapes are desertified. In California's San Joaquin Valley, our agriculture has created a high-pressure heat dome. Previously, a lot of cool, moist marine air would come into the valley from the Pacific, but it no longer comes in. We're desertifying the land, and within the next decade that's going to collapse agriculture in that region. This will partly be due to the effects of this dynamic on the biotic pump. This powerfully illustrates how our land management is negatively changing regional hydrological dynamics.

ACRES U.S.A. What role do the oceans play as a carbon sink and in the heating of the planet?

JEHNE. There are 750 billion tons of carbon dioxide in the atmosphere. Fifty times more carbon dioxide — 38,000 billion tons of carbon dioxide — is dissolved in the world's oceans. Most of the CO2 that we've emitted went into the atmosphere, but from there it's been absorbed in the world's oceans. Of course, that's acidifying the oceans. The oceans are also a massive buffer. As we remove CO2 from the air, the oceans say thank you and release some of the CO2 that they've absorbed back into the air. The ocean re-equilibrates. We can't just take 750 billion tons of carbon out of the atmosphere, because the ocean will always replenish it. It's a longer-term game. In terms of the heat dynamics, the oceans' role is even more profound. The oceans are currently absorbing 93 percent of the additional heat that we're generating and retaining on this planet. We're seeing temperatures going up and think we've got global warming now. Well, sorry Charlie — we're only seeing 7 or 10 percent of the effect. At the moment, the world's oceans are buffering 90 percent or more of the additional heat from global warming. But that's not going to continue. As the oceans heat up, we're going to get more intense storms. In terms of carbon, energy and heat dynamics, water is the elephant in the room.

ACRES U.S.A. That's not talked about much publicly.

JEHNE. No, it's just assumed to be there passively. That's what we're doing, whether to our soils, land, oceans, all these biosystems. And we're so naïvely ignoring the actual impacts we're having.

ACRES U.S.A. Are the only long-term carbon sinks are on land?

JEHNE. The oceans, with their algae and phytoplankton, have a lot of photosynthesis as well. But much of the carbon that they fix then gets eaten by animals and is quickly recycled back as CO_2 through animal respiration. And some of that carbon falls to the ocean floor as sediments where biological processes turn it into methane. Over millions of years, it was land-based systems that formed the fossil fuel carbon sink, as deposits of coal, oil and gas. All of those resources come from carbon that has been fixed by plants and turned into organic matter. Oceans also have a massive carbon sink in the chalk, calcium carbonate and corals that they started sequestering 3.5 billion years ago. Calcium carbonate locks up an enormous amount of carbon, but that's really a geological sink and so not part of the discussion of climate carbon dynamics.

ACRES U.S.A. If we want to put some of the carbon in the atmosphere back into the Earth, do we have to do that with biology?

JEHNE. The only carbon drawdown process that nature's got involves green plants taking up CO2 and water and sunlight and making sugars through photosynthesis. It's wonderfully efficient. Where humans are critical is that we have agency over what happens to that molecule of carbon fixed by plants. For every CO2 molecule that a plant takes out of the air and turns into sugar, and then into cellulose or lignin, there are only two things that can happen. It can either be oxidized back to CO2, or turned into stable soil carbon. We call this the ABC of carbon fixation. A is about agriculture and maximizing the growth of green plants. B is about burning, and ensuring that not all of that carbon is rapidly burned or oxidized back to CO2. How we do that is through C, carbon biosequestration, by making sure that a big slice of the carbon fixed by plants is turned into humates and glomalin, stored in soil to enhance soil structure and build the cathedral we talked about and beneficial biosystems. It's really about that B to C ratio — burning less and biosequestering more as stable soil carbon. Burning and oxidizing refer to the process of turning organic carbon into the oxidized CO2 form. Burning involves active flames;

oxidation is like rust. Everything we've done in agriculture has burned off the soil carbon to try to mineralize more nutrients, whether it's burning, clearing, tillage, over-fertilization, biocides, or bare fallowing land. In the process, we have cannibalized that soil capital. Organic agriculture is all about saying no to all that. Instead, we must use that carbon as the structural building block for our cathedrals, for increasing soil biofertility, microbial activity, surface areas and moisture-holding capacity, thus rebuilding healthy, productive agricultural systems.

ACRES U.S.A. I've begun to think that many farmers and gardeners lack visual representation of what good, healthy soil looks like.

JEHNE. That's why I talk about the concept of a soil microbial root interface. It's not just the soil. It's that whole bridge — how that plant links to that soil and its microbes to optimize the relationship. Let's think about it as relationship optimization, rather than "here's my soil" and "here's my plant." How do I get that communication and transfer in that bridge?

ACRES U.S.A. Through Healthy Soils Australia, how have you been able to get this paradigm shift across to the farmers you work with?

JEHNE. We're doing that through continual communications and problem solving. For example, in Western Australia, we've got sandy soils that are becoming very acidic. Once soil drops below pH 4, you have an enormous problem with heavy metals that become soluble and toxic. The prescription is to add a lot of lime, so we're back in this more-on thing of having to add tons and tons of lime. But nature didn't have lime and didn't transport fertilizers. All that nature would do was say, we've got acid soils. That means very high numbers of hydrogen ions in soil solution. Nature would remove those hydrogen ions by absorbing them onto organic surfaces. That raised the organic matter status of the soil and massively increased the negative charges on that organic matter. Those negative charges absorb positive charges, that is, the hydrogen ions. Then there's no longer that high amount of hydrogen ions in solution. Therefore the pH goes up, and you solve the problem. By understanding those dynamics, people realize they don't need to add lime, but just get back to healthy organic soil.

ACRES U.S.A. Many people think that the way to increase organic matter is by bringing in compost or mulch. Or they believe that the aboveground biomass or the roots themselves of cover crops (or other plants) are the carbon-containing material that will become humus. But what I've learned from people like you and Dr. Christine Jones is that while these materials appear to be a potential source of soil organic matter, they really are not the primary source.

JEHNE. It's absolutely true. We live above the ground, so we see things above the ground, and we want to have agency. We ask, 'what should I do?' There's no harm in adding compost, but most of the soil carbon comes from plants' root exudates. Nature created soil by growing plants and making sure that potentially up to 60 or 70 percent of the biomass produced can be fixed into stable soil carbon. Currently though, little of it is. But we could do that. It's not rocket science. Instead of burning off 100 or 120 percent of the carbon that's fixed, as we do now in oxidative agriculture, we could keep half of it in the soil. That just requires a change in management practices.

ACRES U.S.A. Isn't that process always mediated by microorganisms and fungi?

JEHNE. Yes. The actual process of conversion of cellulose or lignin or root exudates in stable soil carbon, either as humates or glomalin, is totally mediated by different groups of fungi. These fungi are the drivers of stable soil carbon.

ACRES U.S.A. We've spoken a lot about how to remove excess carbon from the atmosphere and put it back in the soil, but that won't solve the incredibly pressing problem of cooling the Earth. To what extent do we need to cool the planet?

JEHNE. That's very simple. The Earth is continually receiving on average 342 watts per square meter of incident solar radiation. That's the energy coming in, like a radiator on the outside. For a stable climate, the Earth has to re-radiate or transmit 342 watts back out to space. But as a result of the enhanced greenhouse effect, that heat can't escape as well as it used to, and we're retaining an extra 3 watts per square meter. That's less than 1 percent of the incident solar radiation, so it's a 1 percent problem. How do we achieve that 1 percent? If we could just increase the natural hydrological processes a little in a sensible way, we can readily get to that one percent. The latent heat fluxes of transpiration transfer 85 watts per square meter of heat from the surface back out to space. If we increase transpiration globally by 5 percent, that would effectively be putting another 3 watts per square meter back out to space. Similarly, by increasing clouds by 2 percent, we would get an extra 3 watts per square meter reflected back out to space. The amount of regeneration and restoration we have to do is very realistic in scale, but we still have to do it.

ACRES U.S.A. Are people buying this?

JEHNE. For the last 10 years, we have been trying to inject hydrology into the climate management debate. CO2 drawdown is essential because we need to rebuild organic matter in soils in order to have the soil carbon sponge that supports the water cycle. But the only way we can safely and naturally cool the planet and prevent the climate catastrophe is by restoring these hydrological processes. We've been advocating, talking and educating about that for 10 years. In all of those years, not one person has ever said no, that's wrong. They all say yes, that's climatology 101. But in a sense it is new, because we've been focused on reducing CO2 emissions for so long. Of course, we have to do that, but really the solution lies in restoring these hydrological cooling balances by one percent.

ACRES U.S.A. Is the earth warming much faster than the models predict?

JEHNE. With these positive feedbacks kicking in and accelerating the warming processes, we're experiencing what the IPCC models were saying, five or 10 years ago, was going to happen in 2100. The Arctic Ocean is now bubbling up methane from methane hydrates that were frozen in the ocean. If that accelerates significantly, it's an enormous, dangerous problem.

ACRES U.S.A. You've also stated that the CO2 levels in the atmosphere are increasing faster than either our emission rate or the models predict.

JEHNE. Again, go back to Charles Keeling and 1958. Every year in that saw-tooth graph we've seen a peak in CO2 emissions and a valley of CO2 dropping back down. That's because in winter we get net emissions. Then in springtime and summer, everything goes green in the Northern hemisphere and we get a massive natural drawdown. Fossil fuel emissions are 8 billon tons of carbon per annum, but every year we are emitting 130 billion tons of carbon from our biosystem. The fossil fuel component is only about 5 percent of that! There are many other sources, like wildfires, land degradation, soils and cement production. With the tipping points accelerating things, we're reaching the point that, in a bad fire year, we will be emitting more CO2 from fires than we are from fossil fuel use. But we don't record that because we assume that it's Mother Nature, rather than Homo Hubris, that is driving to these tipping points. The same goes on the other side of the curve. Every year, photosynthesis in the green biosystem draws down 120 billion tons of carbon. But when forests burn, we compromise that carbon drawdown capacity. Land management is affecting emissions, and also nature's capacity to drive down those emissions, far more than all our fossil fuel emissions. Yet we only seem to want to focus on setting, say, a 5 percent reduction target for fossil fuel emissions. And then, the politicians go around patting themselves on the back.

ACRES U.S.A. That seasonal variation in atmospheric CO2 provides a good clue. If we think CO2 is what's causing the temperature rise, look again. The fact that lower CO2 levels occur in the spring and the summer because plants are drawing it down should tell us something.

JEHNE. You're saying it beautifully now. Like I said, the problem is the solution. If we look at Charles Keeling's 1958 graph, here it is going up; here it is going down. We want more down than up. How do we enhance the down? Keeling gave us the solution, but we've ignored it. Very powerfully, the solution is the actual amount, the area, and longevity of the green carbon drawdown by nature. That's the only thing that can save us.

ACRES U.S.A. Won't that also heal the water cycle?

JEHNE. Yeah, but not until we get more green transpiring. The water cycle becomes the medium, but the action on our part is to get that biosystem healthy again. We've got to get our boot off her throat.

ACRES U.S.A. I'd like to hear about your background and motivation.

JEHNE. I grew up in the bush — in nature — so natural forest functioning was in my blood. At the university I studied science. I was really turned on by microbiology because here all the life processes are in microcosm. When I graduated, I was very interested in forest disease dynamics. My initial work was at the Forest Research Institute in Australia with dieback diseases — which we've now got all over the world — and soil plant microbial interactions. I wanted to understand what governs health. When I realized that these fungi are actually our friends, I switched to the dark side. Fungi are involved with symbioses and positive functionality, and I realized that disease is a process for removing and recycling moribund organisms to make space and nutrients available for new productive growth. At CSIRO (Commonwealth Scientific and Industrial Research Organization), I studied mycorrhizal fungi for recolonizing toxic, degraded soils and forming new soil. How can we use our understanding of soil microbiology in rebuilding productive biosystems? I went to China and researched why their traditional agriculture was so productive. This was all great science, but the short-term thinking of industry prevented it from being applied. Finally, I worked in our federal government on changing the paradigm of land management to foster strategic innovation. I retired to get back to practically applying science and work on grassroots empowerment. We formed the NGO Healthy Soils Australia. For the last 15 years, I've been working with very innovative farmers on new paradigms for biological farming and rebuilding healthy biosystems in degraded landscapes. We're talking about hydrological cycles because water is fundamental for life. I've come to understand that the increase in atmospheric CO_2 is a symptom, a measure of land degradation or forest fires. It's really the blood on the floor. And it's not about mopping up the blood on the floor or predicting how much blood there will be on the floor. What's important is to stop the bleeding. CO_2 is a building block for healthy biosystems; we just don't need it in the air. Let's stop simplistically demonizing carbon emissions and recognize that it's us, Homo Hubris, that has disturbed these cycles. Don't blame the symptom; focus on the regeneration.

Editor's Note: An abridged version of this interview ran in the April 2019 issue of Acres U.S.A. magazine.

3 COMMENTS

Pedro Lobos on July 6, 2019 at 11:47 am

REPLY

Excellent and crystal clear as water the article. Congratulations

Jerry Schuelke on July 6, 2019 at 1:33 pm

REPLY

I enjoyed the discussion.

Caroline Metzler on July 10, 2019 at 8:40 am

REPLY

Excellent information; a new perspective on climate collapse very clearly presented. This should make our path to the needed solutions obvious and compelling.

Thank you!

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