B. The processes governing the vegetation-aridification linkages and climate changes.

The former review presented evidence of how changes to our vegetation and soil structures have altered hydrological and atmospheric processes and thus the aridification and climate of regions. They confirm that our changes to soils and vegetation influence rainfalls and thus local 'droughts'.

While they indicate which processes are involved, we need to better understand how they govern these vegetation-climate relationships and how they have evolved and function to alter the climate. Significantly these processes all involve or operate via water and the hydrology of our bio-systems.

As it is water that has governed 95% of the heat dynamics of the blue planet for over 4 billion years it is of no surprise that our changes to the Earth's hydrology can profoundly effects its climate; to either warm or cool it or induce the dangerous hydrological climate extremes now confronting us. So how does water do this? What are the processes involved? Have and can we influence these?

To start with water needs to be available. Whether it is, depends not on the water in the Earth's oceans and air but what happens to each raindrop that is condensed and falls from the sky. Does it re-evaporate to form a hyper greenhouse warming effect with other gases as on Venus or get volatilized and lost out to space as it did on Mars? Does it simply fill up oceans that freeze such as believed on Neptune; or as on Earth does it cycle continually between its solid, liquid and gaseous states and between the oceans, atmosphere and land, and in so doing effectively buffer and regulate that planet's climate based on its unique molecular structure and thus heat transfer capacity.

Given that what happens to each raindrop profoundly influences the Earth's bio-systems and climate we need to understand the sequence of processes stages that govern what can happen to a raindrop and through that our climate so that we can hopefully influence this to secure our safe future.

As the raindrops falling on 71% of the Earth covered by oceans or the 3% covered by lakes and rivers simply return the water to its source from where it was evaporated, what matters for us are the 26% of raindrops that fall on soils over which we have some agency. Do these raindrop runoff back into oceans or lakes or do they infiltrate into the soil? What are the consequences of these alternatives?

As the answers to these questions are fundamental to whether there are 'droughts' our climate and our future this review seeks to outline the processes governing these alternative at each sequential stage of that raindrop's journey and its climate consequences; including its influence via its;

1. **Infiltration by the Earth's soil carbon sponge.**
2. **Retention in the Earth's 'in soil reservoirs', inland deltas and sub soil aquifers.**
3. **Availability to deep rooted perennial vegetation.**
4. **Ability to sustain the longevity of green growth and transpiration of that vegetation.**
5. **Protection from evaporative loss via shelterwoods that reduce wind scour effects.**
6. **Ability to be absorbed from humid air flows by hygroscopic plant surfaces.**
7. **Insulation by vegetative soil covers to limit heating, evaporation and re-radiation effects.**
8. **Limiting the erosion of soils by wind to contribute to aerosol and humid haze effects.**
9. **Role in limiting wildfires the oxidation of plant carbon and its particulate aerosol effects.**
10. **Role in forming and transpiring ice and microbial precipitation nuclei to create more rain.**
11. **Role in generating low pressure corridors to aid humid air inflows and more rainfalls.**
12. **Role in reversing the aridification of regions via the regeneration of monsoonal air flows.**

While the degree and effect of each of these stages in these hydrological processes will vary in different sites, individually and collectively they can greatly reduce the risk and impact of droughts. They can help us to rehydrate and regenerate the bio-systems and climates of those local regions. Extended at realistic scales they can safely and naturally help cool and secure a safe global climate.

1. The infiltration of raindrops by the Earth's soil carbon sponge.

Whether raindrops falling on soil either run off or can infiltrate depends largely on the level of cover, aggregation and structure of that soil surface. In turn these soil properties depend on the activity of microbes and plant and the degree to which they have bio-sequestered carbon into that soil.

Our current industrial agricultural practices such as clearing, burning, cultivation, fertilization, excess irrigation, use of biocides, overgrazing and bare fallows often impair these microbial processes and oxidize carbon from soils carbon leading to their structural collapse. Hygrographs demonstrate how such soil degradation can impede rainfall infiltration and increase runoff, floods and soil erosion.

Effectively this structural soil degradation and collapse can aridify soils and make them less resilient and bio-productive and more drought prone, even with normal or above normal rainfall. "Droughts' in such soils and agricultural systems are therefore often man-made. Calls for irrigation to overcome such 'droughts' are often counterproductive as the soil cant infiltrate and use this water efficiently.

Conversely we can readily improve the rainfall infiltration in most soils, and thus their ability to avoid and be resilient to 'drought' by regenerating the natural microbial processes that aggregate and build structure in soils via their bio-sequestration of carbon. Extended regionally ecological grazing, cropping or horticulture that aids the regeneration of the carbon content and structure of soils is our only practical means to help limit hydrological extremes and 'droughts', whatever the rainfall.

2.The retention of rain in the Earth's 'in soil reservoirs', inland deltas and sub soil aquifers.

Rainfall that infiltrates into the soil via the 'sponge' can then be retained in the voids and on the surfaces of well structured healthy soils. Up to two thirds of the volume of well structured soils may be voids. Such soil structures may extend to over several metres in depth. By contrast less than 20% of the surface soil and a minimal proportion below 20 centimetres may be voids in degraded soils whose structure has been collapsed or compacted by our current industrial agricultural practices.

It follows that the 'in soil reservoir' or capacity of soils to hold water that is available to plants may be much higher in healthy, well structured relative to adjacent collapsed soils of the same soil type.

As in nature, healthy well structured soils can be created, but only via the activity of microbes, like the hyphae of soil and mycorrhizal fungi that proliferate throughout the soil to create soil structure by aggregating and gluing together soil particles into fine crumbs. These crumbs then form a loose open matrix of mineral particles and soil carbon in spongy 'cathedrals' of largely voids that are held together by the soil fungi. It is these microscopic spongy cathederals of voids that enabled soils to serve as nature's in soil reservoirs and make available the sustained supply of fresh water from rain so essential for the evolution and maintenance of terrestrial bio-systems and life, including our own.

Consequently our degradation of such soil structures via our oxidative industrial agricultural can rapidly aridify such bio-systems, induce ‘droughts’ and increase their vulnerability to low rainfalls. As in nature the only way we can minimize these stresses and risks is to regenerate the microbial health, carbon content and thereby the physical structure of our soils and their in soil reservoirs.

This could be done naturally and practically over vast areas to rehydrate arid degraded regions. For example a proposal to ‘Regenerate Australia’, demonstrated that if we prevented some 330 mm/an of monsoonal rain from running from some 300 million hectares of rangeland across northern and inland Australia we could retain an extra 1 million gigalitres, or 200 Lake Humes across this landscape to provide water protected from evaporation where and when needed. This would help reverse the systemic arididification of these bio-systems and minimize our drought crises.

Regenerating these former natural in soil reservoirs would also help restore Australia’s former natural vast areas of inland deltas and marshes that ensured 90%+ of the rain in inland Australia was retained for plant use and the recharge of groundwater aquifers and did not just run off to the sea.

Our current management of the declining water resources of Australia’s inland basins and rivers and our increasing dependence on irrigation to compensate for the soil and hydrological degradation from our current farming practices have ignored the potential of these former natural hydrological realities. As aridification stresses intensify, they may be our only solutions to our future droughts.

3.Optimizing the availability of water to and by deep rooted perennial vegetation.

While our challenge and opportunity is to maximize the retention of water within our former natural in soil reservoirs, this is most beneficial where our desired plants can access this water. Perennial plants with deep extensive roots and well developed microbial symbioses will mostly be far better adapted to grow and survive as aridity intensify than many of our annual plants with limited roots. Plants with limited roots will be more prone to ‘drought’ sooner and more acutely and risk dyeing.

Our breeding of ‘superior’ plants in glasshouses with abundant water and nutrients has selected plants to maximize their ‘harvest index’ by favouring shoot or seed growth at the expense fewer roots and root exudates. While these plants may perform under optimum high input conditions, they may be more drought prone in the field where an optimal soil-microbial-root interface is critical to plant growth and survival. In doing so we have ‘designed in’ drought vulnerability and stresses.

Natural perennial plants adapted to arid conditions have often evolved root shoot ratios of over 10/1 with some roots growing down tens of metres to access critical subsoil moisture. By contrast many of our industrial plants now have root shoot ratios of 1/10 or less, making them highly input dependent and vulnerable to drought stress. In doing so we have ‘designed in’ future crop failures.

Our ‘superior’ crop plants also often have poorly developed mycorrhizal symbioses due to the lower root exudates they depend on. They are thus often more prone to root diseases that further limit the competiveness of the roots without artificial inputs. Without their symbionts plants may also only be able to take up water from soils below wilting point tensions. By contrast natural plants with mycorrhizal symbioses can often take up water from soil micro-films well beyond such wilting points.

The effectiveness of the soil-microbial-root interface is thus critical to the growth and survival of plants particularly in arid habitats and as climates aridify. Our current industrial agricultural systems and the plants selected for it are highly vulnerable to drought stresses and dependent on inputs under these conditions. We can limit such stress and drought risks by regenerating such resilient soil-microbial-root interfaces, but our agriculture needs to change radically and quickly to do this.

4.Why we must extend the longevity of green growth and its cooling transpiration effects.

Industrial agriculture for more than 100 years has sought to maximize yields and the efficiency of yield increases per unit of limiting factor or input; mostly of added water and nutrients.

To do this it has selected 'pioneer' plants that can grow big quickly via ecological 'weed' strategies. These fast growing pioneer plants can often escape modest droughts via their rapid growth and maturation while conditions remain good and rapid seed set and senescence once stresses and limits intensify.

By contrast most natural perennial plants invest biomass to establish resilient soil interfaces to help them access limiting factors and buffer stresses so as to sustain their longevity of green growth despite these stress conditions.

While both strategies can be effective, humanities growth and demand for food, the degradation of soil resources and the locked in increase in climate stresses, dictate that our current rapid opportunistic growth model may no longer be viable even with inputs.

For example if 100 mm of rain falls on degraded soil from which 80% runs off, the 20 mm of retained water may only be able to sustain growth for 2-3 weeks, far too short for even opportunistic plants to grow and set seed. Conversely that same 100 of rain falling on a healthy soil with 95% infiltration may sustain slower growing plants for up to 20 weeks via the efficient use of that stored soil water.

As rainfalls decline and become less reliable we need to focus on conserving and efficiently using our limiting soil water resource so as to extend the longevity of green growth so we can still secure good yields with minimal inputs. To do that we need to regenerate the structure, health, water holding capacity and the longevity of green growth of our agro-ecosystem, not the growth rate of a crop.

Breeding 'superior' plants, often via just higher harvest indicies and input dependencies has at best increase yields by some 50%, but with significant externalized natural capital and strategic costs.
By regenerating the structure, rainfall retention and the longevity of green growth of our soils we can readily grow plants for 10 times longer, yielding a potential 1000% growth response.

More importantly, as our industrially grown plants may not be able to finish and set seed as climates aridify, this relative difference in growth is infinite, and existentially of life or death significance.

5.The regeneration of shelterwoods to protect water in soils from evaporative losses.

Australia used to receive on average 452 mm/an of rain.Its potential evaporation rate is often four times this. Exposed surface water can thus be lost rapidly by evaporation and wind scour effects.

While most of the rain that fell on and infiltrated into the Earth's soil carbon sponge was protected naturally from evaporation by surface litter and plant covers, our industrial agriculture with its clearing, fires, overgrazing and cultivation and its associated oxidation of soil carbon and collapse of soil structures has resulted in vast areas now becoming bare and exposed to increased evaporation. As the climate aridifies and is more variable and the risk of major water losses have intensified.

Whereas over 90% of the rain that fell may have been naturally infiltrated and used efficiently by the native plant covers to extend the periods of green growth and cooling transpiration, up to 90% of the rain may now run off from the residual subsoils due to our 200 years of landscape degradation. While levels vary with site, seasons and the degree of past soil degradation, over half of that runoff may be lost to evaporation, a third may be transpired by the remaining vegetation with the remainder contributing to the 12% of rain that reaching streams and recharges deeper aquifers.

Naturally most of Australia's inland was also covered by an open grassy woodland or shelterwood of scattered trees that resembled an open park and greatly reduced surface and wind speeds and evaporation losses from the protected shaded soils and grasslands. Our extensive clearing of these trees by fire, overstocking and for cultivation and their limited regeneration as they age has exposed vast areas of these residual landscapes to increased evaporation losses, aridification and droughts.

If even half of the 50% of rainfall that now evaporates could be again be infiltrated into soil for use by plants this could significantly reduce the frequency and severity of our current 'droughts'. This could be achieved practically at minimal cost by regenerating the Earth's soil carbon sponge over much of this landscape via the simple ecological grazing ecologies discussed subsequently and by regenerating the protective shelterwoods that naturally limited wind speeds and evaporation .

This contrasts with desperate calls and political talk to build more dams to 'drought proof' Australia. Currently 2% of Australia's rainfall is able to be stored in dams. This water needs to meet Australia's irrigated agriculture (70%), industrial (20%) and domestic (10%) needs. Even if suitable sites existed that would not evaporate during drought, this water would need to be available across Australia's vast land area when and where needed at an affordable cost if it was to offset future 'droughts'.

In fact Australia already has major dam storages such as the 10,000 GL in Lake Argyll whose water is grossly under-utilized because of its distance from demand and the impossible cost of its transport.

Instead aiding land managers to regenerate the their soil carbon sponges as proposed in Regenerate Australia could readily provide the equivalent to an extra 100 lake Argylls to supply water where and when needed and protected from evaporation at minimal capital or public cost. All that is required is leadership and recognizing our imperative to reverse the systemic aridification of Australia in time.

6.Options to harvest water from humid air flows via hygroscopic plant surfaces.

For centuries science, the public and policies assumed that rainfalls are measured by rain gauges. While less apparent and more difficult to quantify plants also harvest water from the air as water vapour and hazes droplets and that these can comprise up to 5% of the weight of air. In fact rivers of water flow continually over most of the Earth's surface continually.

Even deserts where it may rarely rain may have humid air as, hazes, mists and fogs containing up to 500 mm of liquid water per square centimetre flowing over them but rarely condensing as rain. While we may not see this water, plants and bio-systems have evolved sophisticated processes to harvest this water to aid their survival in arid areas and droughts. Plants in the Nambib and Atacama deserts often survive exclusively by harvesting such aerial water. Up to 70% of the water to sustain the Earths tallest trees in California is harvested from local fogs.

Australia's and other arid zone plants have evolved highly effective surfaces to harvest water from such humid air flows. This includes the use of hygroscopic coatings on foliar surface that actively absorb water each night to help plants in arid areas grow and survive in extreme arid regions.

For example Australia's saltbushes flourish in hyper-arid environments via such water strategies. 'Weed' trees such as the Tamerisk, Athol pine have colonised arid habitats via similar strategies but different hygroscopic foliar exudates. While not fully understood, the common salt pans in arid areas may be harvesting moisture from such air flows at night to create saline biological 'oasis' habitats?

Can we, as arid zone plants do, use similar and other strategies and designs to harvest water from these humid air flows to help us avoid, buffer and survive 'droughts' or even rehydrate arid regions? Given their severe aridification risks, can such strategies help rehydrate California? Given our imperative to avoid, limit and survive 'droughts' we must see beyond what isnt in our rain gauge.

7.The insulation of soils by vegetative covers to limit their heating, re-radiation and droughts.

The Earth has warmed abnormally over the past century, accelerating over the past 50 years. This global warming and the dangerous hydrological climate extremes it has induced now threaten the health and survival of many bio-systems and their depended species including us. It follows that we need to reverse what is causing this warming so as to actively and safely cool the climate.

The Earth is continually warmed by the sun, intercepting on average 342 watts/square metre of solar radiation at the top of its troposphere. To sustain its balanced temperature and climate the Earth naturally re-transmitted342 w/m2 back out to space. It did this by reflecting up to half of this solar radiation directly back out to space from its reflective white clouds that used to cover 50% of the planet plus its extensive areas of white reflective snow and ice and pale grass covers.

These plant and snow covers also insulated soil surfaces to help keep them cool. This limited the amount of heat that these soils re-radiated into the atmosphere via the Stefan Boltzman law for black body radiators that dictates this re-radiation based on the 4^{th} power of a body's temperature.

If these high albedo and insulating covers are removed, soils will absorb this incident solar radiation and heat up and automatically re-radiate massively more infra red heat back into the air. The level of this re-radiated heat in turn drives both the natural and enhanced greenhouse effect as it governs how much heat can be absorbed by greenhouse gas principally water vapour (60%) and CO2 (20%). Indeed it is the level of soil heating and thus re-radiation that is the primary determinant governing greenhouse warming, not the now 410 parts per million of CO2 gas molecules in the atmosphere.

The level of this re-radiated heat energy also governs whether high pressure heat domes form over bare hot regions and impede the inflow of cool moist low pressure air needed to create rain. As such our clearing and heating of such bare soils can be a major factor governing the systemic aridification of regions and the occurrence and severity of 'droughts'.

As we substantially govern how much soil is left bare and exposed to heating and its re-radiation via our land management, we are responsible and fully in control of both the intensity of our abnormal enhanced greenhouse effect as well as the aridification of our landscape and its 'droughts'. As such our externalization of our responsibility for climate change and droughts onto climate variability, bad luck or God are simply excuses that trap us into further systemic aridification effects.

As we are responsible, we can also make ourselves response able by simply keeping soils covered and insulated by their natural plants and litter to reflect and limit their absorption of incident solar radiation and its re-radiation to drive greenhouse warming and the high pressure heat domes.

Whereas the temperature of natural covered soil rarely exceeds 20oC, bare exposed soils can heat up to exceed 70oC resulting in extreme differences in greenhouse warming and aridification effects. Keeping soils naturally covered and insulated is thus a major means to limit most regional 'droughts'.

2. Limiting the wind erosion of soils to limit aerosol and humid haze levels and impacts.

By keeping soils covered and insulated we can not only limit their heating and desiccation but also their erosion by wind to produce fine clay and organic dust particles. These dust aerosols often act as micro-nuclei that condense water vapour from the air to form haze micro-droplets that can alter local climates by accentuating both the warming and aridification of regions relative to green areas.

The warming results from the humid haze micro-droplets absorbing both incident solar radiation while in their liquid haze state and re-radiated infra red heat from the Earth's surface while a gas. Indeed these persistent humid hazes by far constitute the primary abnormal greenhouse gas effect.

The humid hazes also contribute to the aridification of regions and intensification of droughts in that the small haze micro-droplets are far too small and light to fall out of the air under gravity and stay suspended as high pressure charged hazes droplets over regions that block and prevent rainfalls.

Both the level and persistence of these humid hazes and thus their warming and aridification effects is governed by the production and the level of aerosol micro-nuclei in the air. While microbial aerosols such as di-methyl sulphide have been produced naturally for 3.5 billion years and are fundamental to maintain adequate water in the air to sustain the Earth's natural greenhouse warming effect and buffered stable climate, we have greatly altered the production of such aerosols and with that their warming and aridification effects.

For example as we cleared, burnt, oxidised, degraded and desiccated the Earth's soil surface we have emitted vast quantities of additional aerosol micro-nuclei, including dust, particulate carbon, smoke and pollutants into the air. These have all contributed to the intensification and spread of the pollutant brown humid hazes that now blanket cities and regions to warm and aridify them. These hazes now absorb up to 20% of additional incident solar energy 'dimming' the regions below.

Our generation of dust from the 5 billion hectares of man-made desert and wasteland across 40% of the Earth's land, our ongoing industrial agriculture and our burning of 10 billion tonnes of fossil fuel and similar quantities of biomass annually all intensify these humid haze levels and their effects.

We need to reduce these humid hazes and their warming and aridification impacts by reducing our production and emission of these pollutant haze micro-nuclei. We can also precipitate these hazes out of the air as drought breaking rains, as nature does by coalescing millions of these persistent haze micro-drops to form each raindrop which can then rehydrate our aridified landscapes.

9.Enhancing transpiration and the formation of precipitation nuclei to create rain.

The Earth, in contrast to its nearby planets, has been able to raise and buffer its temperature above its background level and in so doing evolve and sustain life. It did this via the capacity of water and its hydrological processes to regulate the heat dynamics and climate of the blue planet.

The Earth's regulation of its heat dynamics and avoidance of a runaway greenhouse effect as on Venus or the frozen future as on Mars, has been based on the Earth's unique evolution of two opposing and balancing types of microbial produced nuclei;

1. The aerosol haze micro-nuclei like di-methyl sulphide that warm the planet and
2. The larger hygroscopic microbial ice and precipitation nuclei that coalesce the humid haze micro-droplets into dense cooling clouds and then remove them by precipitation as rain.

The evolution of this opposing regulatory microbial control of the Earth's temperature has enabled the Earth to remain warm enough to sustain liquid water for the past 4 billion years and life for over 3.8 b years but also progressively cool the global climate to avoid a runaway greenhouse and buffer the periodic geological heat releases and the Earth's ever more intense incident solar radiation.

Given the Earth's natural microbial temperature controls, why has it not regulated global warming? As discussed our massive addition of haze micro-nuclei into the air has generated a significant abnormal increase in the greenhouse warming effect. As in nature this can now only be reduced and re-balanced by removing these excess haze micro-droplets and nuclei from the air.

This requires their precipitation which can be done naturally by stimulating the production of hygroscopic precipitation nuclei able to overcome the repulsive charges on the haze micro-droplets to coalesce them first into cloud droplets and then into rain. This simple act of coalescing these haze droplets into clouds converts their former dual warming effect into strong albedo cooling effect.

While both ice crystal and salt aerosols are hygroscopic and function as physical precipitation nuclei in high latitudes, altitudes and over the ocean respectively, microbial precipitation nuclei with highly hygroscopic organic constituents have evolved and may dominate the nucleation of rain over warmer and inland regions. These include highly hygroscopic bacteria that form in the stomatal cavity of specific trees and are emitted into the air as part of the tree's transpiration. The bacteria then nucleate and coalesce and rapidly return that water as rain to help sustain that forest's growth.

While there is more to know on how widely and under what conditions such processes are optimal, it reinforces much evidence that forests not only depend on rain but may also help to create it. Given that we largely influence the health of the Earth's residual forests via our management, we may also be able to influence the rainfalls induced by them. If so we may be able to reduce and regulate the abnormal levels of pollutant humid hazes that are warming and aridifying regions and in doing so limit their drought impacts.

Pre-agriculture some 8 bha of the 14 bha of ice free land on Earth was covered by primary forests. To date we have cleared 6.3 bha of this forest and with some regeneration now have 3.5 bha left. Given the critical role that these forests may play not just in providing and protecting our habitats but the nucleation of rain and regulation of the Earth's abnormal humid hazes and their warming and aridification effects, we need to look at our wise management of these forests, urgently.

10.Limiting wildfires, their oxidation of plant carbon and their particulates and aerosol effects.

Every year some 350 million hectares or 10% of the Earth's residual forests burn in wildfires. This oxidizes from 20-200 tC/ha as extra CO2 emissions and particulate aerosols. Every year 2 billion of our residual 6 bha of grassland, crop stubbles and rangelands also burn emitting 3-12 tC/ha as CO2 plus particulate carbon and haze micro-nuclei. These emissions exceed the 10 btC from our burning of fossil fuels and contribute to the Earth's total yearly emissions of some 130 btC.

We dont account for these wildfire emissions, but deem them to be 'natural', not our responsibility. Neither do we account for their particulate, aerosol, human health and humid haze consequences. Until we do most policies will continue to ignore them and the options they give to Regenerate Earth by practically avoiding some 20 btC/an from being emitted into the air and instead be retained to help regenerate the Earth's soil carbon sponge, hydrology, cooling, bio-systems and our safe climate.

As Charles Keeling confirmed 50 years ago, the Earth's residual bio-systems draw down some 120 btC/an via photosynthesis. Their ability to do this is limited largely by their access to water and nutrients from soils for photosynthesis. By simply limiting these wildfires and bio-sequestering that carbon into the Earth's soils more water and nutrients would be available to increase the Earth's current 120 btC/an draw down of carbon by its plants. Every gram of extra soil carbon may enable soil to retain 8-20g of extra water. This extra soil water would in turn limit fire risks and help reverse our aridification of landscapes and limit the occurrence and severity of 'droughts'.

As in nature we can also limit the occurrence and intensity of most wildfires by reducing fuel levels. Every gram of plant carbon that has been fixed by photosynthesis over the past 3.5 billion years has either been burnt or oxidised to reform the CO2 it was made from, or been microbially bio-digested largely by specialist fungi, and converted into stable soil carbon. We largely govern which of these processes dominate; whether plant detritus burns or is bio-digested by fire or fungi.

This microbial bio-digestion can occur in various forms; be it the in situ microbial breakdown of litter, the composting of concentrated organic detritus or its harvesting and use by mobile bio-digesters, herbivores that may range from leaf eating insects, soil biota to elephants. We can greatly aid the activity of this bio-conversion of fire fuels into stable soil carbon to help rehydrate soils and limit drought and fire risks.

As in nature the ecological re-stimulation of these microbial litter breakdown and cycling processes costs next to nothing; certainly relative to the major it creates in terms of the hydrology, health, resilience, extension and productivity of the resultant bio-systems. By contrast our current practices of burning or accumulating such plant wastes and fire risks can be prohibitively expensive.

11.The cooling of regions to induce low pressure air corridors, humid air inflows and rain.

By simply regenerating the Earth's soil carbon sponge we can create regions of rehydrated soils that enable green plants to sustain transpiration for longer. To transpire plants need 590 calories of heat from their surroundings to convert each gram of liquid water into water vapour. As such transpiring green plants significantly cool the soils, air and landscape from which the heat has been drawn from.

In fact these latent heat transfers by transpiring plants transfer some 24% of the 342 w/m2 of heat continually received by the Earth from its surface back into the air and then largely out into space. This natural cooling of the Earth's surface helps offset the natural greenhouse warming effect and enabled such natural hydrological processes to nature to regulate the Earth's stable climate and life.

Our abnormal warming of the Earth has to date caused 3 w/m2, or less than 1% of the incident solar radiation received by the Earth being retained by its atmosphere. To restore the Earth's former heat balance we need to return this 3 w/m2 of heat back out to space. We can do this safely by increasing the transpiration and thus latent heat transfers of green plants by some 4% globally. To do this plants need water from; hence our focus on restoring their 'in soil reservoirs', rehydration and rain.

This transfer of heat via transpiration from the landscape into the atmosphere will also cool it and often create low pressure zones into which humid marine air of slightly higher pressure can flow. This can result in 'biotic pump' effects in which moist air flows inland along such low pressure zones to enhance rainfalls in that corridor. By contrast dry bare land that re-radiates heat can create high pressure heat domes that block such inflows of moist low pressure air thereby creating droughts.

Many observations confirm how green forested regions and corridors can get regular, higher humid air inflows and fogs, mist and rain than adjacent cleared bare dry landscapes. Similarly rain often follows the green corridors of transpiring plants induced by the path of the first rains that season.

While it may be difficult to induce such biotic pump effects to rehydrate droughted regions with high pressure heat domes that impede such humid air inflows at will, we can prevent such droughts from forming if we avoid landscapes from becoming so degraded that they induce such aridification.

12.Can these processes reverse aridification and regenerate humid air flows and rainfalls?

The earlier examples of the systemic aridification of Australia and this outline of how hydrological and biological processes govern the aridification of regions and droughts raise critical question of whether we can reverse such aridification and its 'drought' symptoms by restoring these processes?

While changes may be difficult to induce at a macro climatic level where the climate is governed by global hydrological factors and its heat dynamics, the above analyses confirm that we have and are radically altering regional climates via our land management and its hydrological consequences. Given that we have altered such regional climates often in the negative, the opportunity should exist to reverse this by understanding how we have impacted these climate variables so as to reverse the conditions that have driven this degradation, including the warming and aridification of our climate.

In this context we can certainly regenerate the Earth's former natural processes that governed its more stable hydrology, heat dynamics, rainfall and climate so as to minimize drought impacts. Fundamental to any such regeneration of the Earth's natural climate is restoring the hydrological processes that have and still govern 95% of its heat dynamics and thus warming, cooling and rainfall.

While we may only be able to influence about 1% of the water on Earth, that 1% that cycles through the bio-sphere and atmosphere may be extremely significant given its role in balancing the multiple warming and cooling processes that directly govern 95% of the heat dynamics of the blue planet and what happens to the 342 w/m2 it continually receives from the sun and has to emit back int space.

More profoundly the biological soil and plant processes that have evolved on Earth and that we now influence, hopefully wisely, largely regulate this 1% of water and its powerful multiplier and cyclic effects to govern the Earth's climate. It and we may have agency out of all proportion of our size.

For example, each gram of carbon if deployed optimally can create soil structure, soil water holding capacity, transpiration cooling and the rainfall consequences discussed above and induce a series of positive multiplier effects on the climate vastly greater than that simple 1 gram of physical matter.

Similarly the climate consequences of emitting extra haze micro-nuclei even if only 10 billionth of a gram by weight, matter, given their potential profound warming and aridification multiplier effects.

While slightly larger, the multiplier climate impact from each microbial precipitation nucleus is also profound given their critical natural role in balancing the effects of and removing these humid hazes by transforming them into dense cooling clouds and the rain on which the climate and life depends.

To date we have largely ignored the substantial scientific evidence of the critical role and power of these microbial processes in creating and governing much of the Earth's hydrology, heat dynamics and thus climate for the past 3.5 billion years. While we have focused on the consequences and symptoms of our impairment of them, be it the abnormal rise in CO_2 levels, humid hazes, global dimming and dangerous hydrological climate extremes, we have ignored why they are occurring.

Our systemic aridification of many regions and the pending collapse of the bio-systems we depend on are a further symptom of our impairment of these fundamental processes and balances that by regulating some 1% of the Earth's water, govern much of its heat dynamics, climate and life. These symptoms warn us that we must regenerate these natural processes and balances urgently.

As nature demonstrated via pedogenesis, we need to regenerate the Earth's soil carbon sponge.

To draw down carbon from the air into our soils to restore their natural structure and hydrology.

As in nature to simply allow plants to grow to fix carbon via photosynthesis and then ensure that most of that bio-mass carbon is not just rapidly oxidized back to CO_2 but microbially bio-sequestered into stable soil carbon to form the healthy well structured soils that underpin terrestrial life.

As in nature this can readily initiate the sequence of hydrological processes, multiplier and feedback effects to rapidly rehydrate, cool and regenerate rain, resilient productive bio-systems and our safe climate. The key uncertain variable and question after 50 years of inaction is; do we still have time?

A following analysis will outline leading case studies and evidence of where and how this has been done and the potential climate and drought avoidance and limitation benefits from doing so.

This may provide an action template to help regenerate the Earths soil carbon sponge, its hydrology and through that our former rainfalls and safe climate, hopefully in time.