Cooling the Earth, safely, naturally and in time.

Its strategic rationale and summary

Fifty years ago Charles Keeling's research confirmed that CO_2 levels had and were rising abnormally. That as CO_2 is a greenhouse gas this would raise the likelihood of abnormal greenhouse warming.

Even though mean global temperatures have only risen by 1oC to date, not the 4-6oC projected by late this century, hydrological extremes, be they more intense hurricanes, floods, sea level surges, aridification , droughts or wildfires already threaten many communities and their essential; water, food, bio-resources, economies, social stability and health.

While scientists and policy interests have been examining the risks, consequences and response options to these realities for much of this time, the science makes it clear that are 30 years too late to hope to avoid these extremes by just reducing CO_2 emissions.

Instead we need to find ways to urgently and safely cool the climate to offset these extremes.

To do this we need to understand how nature created and sustains the Earth's climate, what we have done to the processes that govern this and how we can restore its stability in time. Delusions that our geo-engineering ideas can fix it are dangerous given their unknown feedbacks and risks.

The scientific reality is that the Earth continually receives an average of 342 watts per square meter of incident solar energy from the sun to warm it and must reflect or re-radiate 342 w/m2 back out to space to sustain its stable temperature, climate, bio-systems and our safe future.

Over the past 250 and especially the past 70 years of the 'anthropocene' we have impaired the escape of some 3w/m2, or 1% of this incident energy, back out to space by increasing the Earth's natural greenhouse effect, resulting in the abnormal and now dangerous changes to its climate.

Three key processes govern this energy balance via the natural and enhanced greenhouse effect.

1. The amount of incident solar heat absorbed by the Earth's surface and thus its temperature.
2. The heat that is re-radiated from the Earth's surface back into the air. This is governed by the physics of black body radiators that dictates that the heat re-radiated is set by the 4^{th} power of that body's temperature in degrees Kelvin ; ie Hot bodies re-radiate far more heat.
3. The degree to which this re-radiated heat is absorbed by certain gas molecules in the lower atmosphere, with principally water vapour absorbing 60% and CO_2 20% of this heat.

Humanity has radically influenced each of these three greenhouse processes by altering;

1. The protective cover and thus albedo reflectance of solar energy by the Earth's surface.
2. The moisture, cooling and thus temperature of that surface and the heat re-radiated by it.
3. The quantity of greenhouse gases in the air able to absorb the massive increase of heat being re-radiated from the Earth's now often bare aridified and exposed surface.

While these scientific realities are not in dispute, to date our assumptions about the cause of climate change, our policies and response proposals have focused largely on only part of the last, and least significant, variable contributing to the greenhouse effect. That is the human induced abnormal rise in CO_2 molecules in the air from 280 to now over 400 ppm during the past century.

While atmospheric CO_2 levels have risen due to the human induced in-balance between the carbon annually oxidised and bio-sequestered by our landscape as evidenced by Charles keeling, so too have the other variables that have a far greater influence in driving the abnormal greenhouse effect.

Indeed the direct contribution to this CO_2 rise to the abnormal greenhouse effect may be minor (Manabe and Weatherald 1975) relative to that of the up to 50,000 ppm of water vapour that may now be in the air for longer or our changes to the absorption of solar heat by the Earth's surface and thus its re-radiation effects as a result of our widespread degradation of terrestrial bio-systems. .

While it may have been easier to 'market' the risks from our abnormal greenhouse warming to politicians and the public by assuming the confirmed rise in CO_2 was its primary cause (Schneider) and easier to mathematically model and generate scenarios for the IPCC; this should not negate consideration of these other, more dominant variables and changes in driving global warming.

By believing these assumptions we may have not only seriously impaired our understanding of the key hydrological drivers of the Earth's natural heat dynamics and climate but now most importantly our only means to safely and naturally cool the climate to avoid and buffer our climate crises. We must consider the long confirmed science that it is water that governs 95% of the heat dynamics of the blue planet via multiple interacting processes that 'civilizations' have altered radically resulting in dangerous consequences but may now be our only means to safely cool and re-stabilize climates.

This is critical as it is physically impossible to mitigate the abnormal greenhouse effects, let alone the dangerous hydrological extremes by any level of reduction in our future CO_2 emissions. Even the draw down of massive quantities of CO_2 from the air will take centuries to have an effect given the scale of the carbon sink in the Earth's oceans, and their lag, buffering and re-equilibration effects.

The reality is that we need an urgent safe means to offset and reverse the abnormal greenhouse warming within decades. This can only be now done by safely and naturally cooling the climate.

To do so we must be prepared to critically review the science of how nature regulates and cools the climate, how we may have impaired this, how this may contribute to the abnormal global warming and hydrological extremes and how we may be able to restore those processes we have impaired so as to restore the Earth's natural cooling, heat balance and climate; on which we all depend.

The question is, are we prepared to critically examine these options and use them to do so?

The following provides an outline of the key processes governing the heat dynamics and climate of the blue plant, how we have impaired them, the consequences and what we may need to do to restore them to allow nature to re-secure our safe climate and future, hopefully in time.

The natural processes governing the heat dynamics, cooling and stable climate of the blue planet.

Human civilizations have been able to develop over the past 10,000 years on this the blue planet largely due to the highly buffered stability of its Holocene climate. This stability is governed by a range of hydrological processes that regulate some 95% of the heat dynamics of the blue planet.

These ensure that the 342 watts per square meter of incident solar energy the Earth receives continually at the top of its troposphere are offset by the reflection and re-radiation of 342 w/m2 of infra red heat back out to space so as to sustain the Earth's stable temperature and climate.

As evidenced by Keeling 50 years ago, atmospheric levels of CO2 have increased abnormally over the past 250 years. This has increased the CO2 component of the natural greenhouse effect that governs some 4% of the heat dynamics and balance of the blue planet and would contribute to the 3 w/m2 of abnormal global warming resulting from the increased retention of heat by the Earth's surface.

It follows that to restore the Earth's heat balance we need reverse this abnormal warming effect. We need to do this urgently as even this abnormal 3w/m2 warming, or retention of less than 1% of the incident solar energy, is already inducing dangerous hydrological climate extremes that threaten the viability of many bio-systems and the communities dependent on them.

The issue is how can we do this, safely, practically and in time?

Despite over 30 years of political encouragement for nations to reduce their CO2 emissions, CO2 emissions and levels are accelerating. Even if possible it may take centuries for any reduction in CO2 emissions to result in lower CO2 levels and a return to the former natural CO2 greenhouse effect.

Given that dangerous hydrological extremes are intensifying now we clearly need more effective timely means to directly cool the climate to offset and buffer these dangerous climate extremes.

Fortunately we can do this safely and naturally by restoring the natural hydrological processes that we have impaired and naturally regulate 95% of the heat dynamics and stability of our climate.

The following outlines the sequence of 10 hydrological processes that naturally govern the climate of the blue planet by their balance of cooling and warming effects. While each of these 10 component processes and how we have impaired them, the consequences of this and what we must and can do to restore them are outlined in isolation, they need to be understood as an integrated interacting continuum and hydrological cycle.

Different processes dominate in different regions and times, thereby generating different climates. It follows that by naturally altering some of these processes we can naturally, safely change climates.

While science has long recognized these hydrological processes as the drivers of the Earth's climate, their variability in space and time make them and their effects difficult to model mathematically. This has caused them to be excluded from common greenhouse models and assumptions to date. It had also been assumed that, as they were so dominant in governing the Earth's climate, we could not possibly have altered them, to induce the abnormal climate changes that now confront us.

None of these assumptions have veracity given that our understanding and restoration of these hydrological processes is now essential to safely and naturally cool and secure our safe climate.

The key hydrological processes governing the Earth's heat dynamics, balance and stable climate.

1.Latent Heat fluxes.

a. The physical processes and their heat effects.

Some 71% of the surface of the blue planet is covered by oceans at an mean depth of 4000 meters. A further 3% of the land surface is covered by ponds, lakes, rivers and wetlands. The remaining land surface had mostly been covered by green vegetation growing on deep spongy organic soils.

All these surfaces would have continually evaporated and or transpired water vapour into the air. For water to do this it needs to be able to absorb enough heat from the sun for molecules of liquid water to be energised and converted into gaseous water vapour. Up to 590 calories of heat, water's latent heat of vaporization is needed to convert each gram of liquid water into water vapour.

As this water vapour rises from the Earth's water or vegetation surface into the atmosphere it transfers this trapped latent heat from that surface into the air, thereby cooling that surface.

As most of the surface of the blue planet is covered by water or by deep spongy soils and vegetation it naturally sustained high continual rates of evaporation and transpiration that cooled the Earth's surface. Some 24% of the mean incident solar energy reaching the Earth's is still transferred into the atmosphere via these latent heat fluxes, significantly cooling the land able to sustain such fluxes. These natural cooling fluxes may have been twice as large prior to our degradation and desiccation of most of the Earth's land surfaces including our conversion of 40% of them into man-made desert.

b. How we have impaired these processes.

Over the past 10,000 years of agriculture and civilization, but particularly over the past 250 years of industrial agriculture, humans have been highly effective in radically degrading the Earth's surface. While most oceans have only been marginally impacted, UNEP data indicates that to date we;

- Annually burn the vegetation regenerating on over 2 billion hectares of the Earth's residual 6 bh of rangelands and 0.4 bha of the Earth's 3.5 bha of residual and regrowth forest.
- Have cleared some 6.3 bha of the Earth's 8 bha of primary forest for agriculture.
- Have oxidised most of the stable carbon from these burnt and cleared soils into CO_2.
- Have drained and oxidised over 90% of the Earth's primary wetlands.
- Have eroded and incised many of the Earth's streams isolating their perched floodplains.
- Have converted some 5 bha of former vegetation into man made deserts and wastelands.

By definition this widespread oxidation of the Earth's soils and degradation of vegetation has had a profound effect on the desiccation of these landscapes, their incidence of rain, their capacity to infiltrate and retain rain, their further erosion via wind and floods and the capacity of these residual lands to sustain their former evaporation and transpiration rates, latent heat fluxes and cooling.

The clearing of over 75% of the Earth's primary tall forests with transpiring leaf areas that may be 10 times greater than their land area and the continued suppression of their regrowth via fire, clearing, bio-cides, overgrazing and feral animals would have also profoundly reduced their transpiration and latent cooling effects, far greater than reflected by just these surface area degradation data.

c. The consequences from this impairment.

While difficult to estimate but given that the residual latent heat fluxes transfer 24% of the solar energy reaching the Earth's surface back up into the atmosphere and the confirmed loss of moist soil wetlands and the extent, leaf area and longevity of green growth in our residual vegetation; cooling latent heat fluxes may have been twice as great, or up to 50% of solar input, pre human impacts.

In addition to their direct effect on evaporation, transpiration and thus latent heat fluxes and surface cooling, the degradation of vegetation at this global scale has also had profound effects on other land properties that greatly affect other hydrological processes and the natural cooling of the planet.

For example the vast areas of bare exposed soils as a result of fires and clearing have fundamentally different albedo and heat reflectance and absorption properties compared with their former state.

These bare exposed soils are subject to water and wind erosion and contribute to the over 3 billion tonnes of additional dust that is now dispersed annually into the air. This dust together with the carbon particulates from the increased burning of vegetation have vastly increased the micro-nuclei that result in the vast increase in persistent humid hazes over many arid and polluted regions. These hazes further repress rainfalls, intensify regional warming and increase respiratory disease levels.

The clearing of large proportions of the primary forests in many regions is also directly associated with the decline in the production of the natural hygroscopic precipitation nuclei so critical for the bio-coalescence of these warming humid haze micro-droplets into dense high albedo cooling clouds and then raindrops heavy enough to precipitate and replenish this critical hydrological cooling cycle.

While these and further consequences will be discussed in detail subsequently they highlight the many consequences from such disturbances to these hydrological processes and cycles as well as the many multiplier effects resulting from our degradation of the Earth's former forests, soils and lands.

d. What we must and can do to restore them

As these evaporation or transpiration processes and their cooling latent heat fluxes require water we need to make adequate water available across these areas and times if we are to restore them. As our desiccation and aridification of vegetated areas represents not just a loss of bio-systems but fundamentally impairs these processes and that cooling of such region's, we need to avoid this.

Given that we have degraded some 75% of the Earth's land surface and converted over 40% of it into man-made desert and wasteland we have a clear responsibility to rehydrate and regenerate them. Effective practical arid zone water harvesting, rehydration and regeneration strategies can do this.

We can do this, as nature did, in creating the Earth's soils and thereby its bio-systems and stable climate by simply regenerating the Earth's soil carbon sponge. By maximizing our draw down of CO2 from the air via growing green plants and ensuring the plant detritus is microbial bio-sequestered back into stable soil carbon.

Whereas nature does this at prodigious rates of up to 200 tC/ha/an to rapidly build healthy soil sponges, innovative regenerative farmers globally can also do this at rates of up to 10 tC/ha/an. Extended globally across some of our degraded landscapes we could readily draw down some 20 billion tC/an from the air back into our soils to aid their rehydration, regeneration and cooling.

Our key objective from this draw down of carbon must be to restore the Earth's soil carbon sponge, its hydrology and natural cooling process, not simply reduce CO2 levels in the air, which needs to be seen as a symptom of our landscape degradation that Charles Keeling confirmed 50 years ago.

We need to recognize carbon and CO2 as natural building blocks of our soils and life, not a pollutant. What matters is where it is, in healthy soils, where it can naturally enhance the Earth's hydrology, bio-systems and climate cooling; rather than marginally add to the abnormal greenhouse warming.

Case studies of the effectiveness of such regeneration strategies.

Numerous case studies from around the world confirm the scale of these latent heat cooling effects and how rapidly and effectively they can cool regions once restored. For example the micro-climate of Canberra, Australia's national capital has been changed over the past 100 years from a hot, dry, dusty, degraded 'clapped out sheep paddock' via planting extensive urban and perimeter forests that have substantially restored the former natural latent heat fluxes and hydrological cooling.

These forests have created a far more mesic, buffered micro-climate in which temperatures can be 7oC cooler on hot days than surrounding bare areas. Water retention and humidity have increased due to these forests as has the harvesting of dew and rain at night and under stress conditions.

Similar case studies of urban heat island effects have been documented. Numerous cases confirm how rainfalls, water retention and cooling have increased post such re-forestation. Many case studies have shown how the aridification and heating of regions can intensify after forest clearing.

2. The formation of warming humid hazes

a. Physical processes and their heat effects.

The water vapour transferred into the air via these latent heat fluxes can either remain in this gaseous form while temperatures remain high enough or else re-condense on particulate nuclei in the air as haze micro-droplets as that air cools.

As it condense this water vapour re-releases the latent heat that had converted it into the gas phase with this heat often warming these humid hazes, causing them to rise and persist in the air. While some of the water vapour may condense on cool surfaces as dew or form fog micro-droplets most of these are far too small and light to fall out of the air under gravity.

These persistent humid hazes often induce a double warming effect and persist for months in the air in that they directly absorb incident solar radiation while in the liquid phase, which re-evaporates them, so they then absorb more re-radiated infra red heat from the Earth via the greenhouse effect while in the gaseous phase. These daily cycles can often be observed as the hazes evaporate in mid-morning and reform at night.

These humid hazes with their dual warming effects can become dangerous in hot arid regions where temperatures exceed 37oC and very high relative humidity occurs as they may prevent mammals, including people from naturally cooling themselves by evaporation and risk overheating and death. Such hazes need to be reduced in such regions to help cool them and enable people to live.

The number and persistence of these haze micro-droplets depends on the number of haze micro-nuclei that have been dispersed into the air from processes such as the erosion of fine desert dusts, pollutant particulates from fires or burning fossil fuels and some aerosols from algae and plants. The hazes may be several thousand meters deep and impair the formation of raindrops, thereby further aridifying affected regions leading to the production of more haze micro-nuclei and warming.

b. How we have impaired these processes.

Humans have greatly increased the level, persistence and the dual atmospheric warming effects from these humid hazes by increasing the quantities and types of micro-nuclei dispersed into the atmosphere via;

- The burning of vegetation and dispersal of fine carbon and organic particulates in the air.
- The erosion of over 3 bt/an of additional dust from the resultant bare arid soil surfaces.
- The release of a wide range of industrial particulate pollutants and volatiles that form nuclei.
- The burning of fossil transport fuels all of which release emissions that add to such nuclei.
- The burning of jet fuels in the air that disperse further particulate nuclei in the upper air.
- The degradation of protective vegetation to limit surface wind speeds and desiccation.

This additional micro-nuclei dispersal far exceeds the haze micro-nuclei released naturally as organic volatiles from marine algae such as di-methyl sulphide or terpenes from forests that helped form and sustained the Earth's natural atmospheric haze levels and greenhouse effect for 3 billion years.

c.**The consequences of our impairment of these processes.**

For the past 3 billion years the production of organic volatiles such as di-methyl sulphide by marine algae may have been critical in sustaining adequate haze nuclei and hazes in the atmosphere to sustain the Earth's natural greenhouse effect and maintain relatively stable temperatures at some 33oC higher than they would otherwise be without this biological global heat regulating mechanism.

This natural biologically regulation and greenhouse warming has enabled the Earth to sustain its liquid oceans for all of this time and enabling the evolution and proliferation of life on Earth. Given that atmospheric CO2 levels varied significantly from some 900,000 to just 100 ppm over this period they are unlikely to have been a major factor regulating the Earth's elevated stable temperature over this period relative to the far more dominant stabilizing hydrological processes being discussed.

Given the significance of the natural greenhouse effect in sustaining the Earth's stable climate, its hydrological control, the marked changes in the level and persistence of these humid warming hazes should be of major concern. While we have not fully quantified their warming effects and feedbacks yet their full climate, bio-system and health consequences may be of major concern.

For example the evidence is that these increased levels of haze micro-droplets are absorbing up to 20% of the incident solar radiation in the lower atmosphere contributing to global dimming. In so doing the haze micro-droplets may be absorbing and retaining up to 60 w/m2 of extra incident heat.

The increased number of humid haze micro-droplets with similar electrostatic charges may also be impeding these micro-droplets to coalesce to form clouds and then raindrops accentuating the systemic further aridification of extensive arid regions; by up to 30% in the Asian brown haze.

Less certain is the effect of these humid hazes and their high pressure zones they form in blocking the normal inflow of moist marine low pressure air such as with the natural Asian monsoon. Any disruption to these hydrological and climate patterns may have acute consequences to the over 4 billion people that rely fundamentally on the reliability of this monsoon for their water and food.

Evidence of the significance of such humid hazes to regional climates was obtained in September 2001 when aircraft were grounded over North America resulting in the marked reduction in micro-nuclei emissions from jet fuels, haze levels, clearer skies and significant local cooling effects. While affecting only a part of the climate it confirms how substantially we have and can change them.

Major health consequences also arise from our increased emission of these haze micro-nuclei and the consequent denser more persistent pollution hazes that now blanket large parts of the Earth. The rate of mortalities and dis-ease in countries affected by such hazes are closely associated with their concentration and persistence.

Hazes such as the Asian brown haze threaten the health and ability of humans to live in regions such as the Persian Gulf in summer where humid heat levels already often exceed safe thresholds.

While there are many details that we don't know about the dynamics and consequences of such humid hazes there is no question from the global dimming and air quality data that they have and are profoundly affecting the Earth's heat dynamics, climate as well as water, food, bio-system and human health. Returning them to their former safe natural levels and effects must be a priority.

c. What we must and can do to restore them.

As the humid hazes and their microbial nuclei were and are a key natural component in regulating the greenhouse effect and thereby the Earth's elevated stable temperature and the evolution of life, care needs to be taken in restoring such natural balances, not further disrupting them.

Given that this balance and stability was regulated by the level and persistence of these haze micro-nuclei it follows that our impacts which have increased these levels via our dust and particulate emissions have altered these hydrological dynamics, heat balance, warming and climate stability.

It follows that by controlling our emission of these micro-nuclei we may be able to limit these effects and restore their natural dimming, greenhouse and hydrological effect and balance.

We can do this simply by protecting soils from desiccation and wind erosion via vegetation. This may help reduce the over 3 bt of additional dust micro-nuclei we have dispersed in the air each year. We can also limit the extent of additional wildfires that now burn over 2 bha of rangelands and 350 mha of forest each year, massively increasing the level of volatiles and carbon particulates dispersed into the air to form haze micro-nuclei. We can similarly limit the emission of particulates and volatiles from our burning of fossil fuel and from industry that can also form such haze micro-nuclei.

We can also rapidly and naturally help remove these extra micro-nuclei and their hazes from the air as discussed subsequently in increasing our precipitation of rain. Doing so should not only cool regions but help restore their rainfalls and their hydrological cooling, health and habitats.

d. Case studies of the effectiveness of such regeneration strategies.

Numerous case studies confirm how rapidly and effectively we can cool regional climates via the removal of these humid hazes or by preventing the emission of the micro-nuclei causing them.

The cessation of air flights and their emissions over North America in September 2001 confirms how rapidly skies cleared of the normal contrails and humid hazes can cool affected regions. Smog reduction strategies over many urban areas similarly confirm how such strategies can rapidly help reduce urban heat island effects and cool such reasons, even enabling frosts to reappear.

Practical options also exist to significantly reduce the warming and aridification impacts from the brown pollutant hazes that now often stretch from the Middle East to China by land management and industrial innovations that massively reduce their production of such haze micro-nuclei.

Case studies also confirm our capacity to remove such humid hazes from the air via the restoration of natural precipitation nucleation and rainfall induction processes. These are discussed in part 7.

More urgently and seriously options also exist to significantly reduce the humid dust hazes that now blanket, warm and further aridify much of the Middle East and Persian Gulf before the humidity and temperatures they generate limit the ability of people to cool themselves and live in these regions.

3.Surface albedo reflectance effects

a. The physical processes and their heat effects

The Earth is warmed by incident solar radiation that varies widely with; cloud cover, hazes, latitude, seasons, aspect and the time of day but on average continually inputs 342 w/m2 of solar heat into the top of the troposphere. How much of this solar radiation reaches the surface depends on these variables and its surface albedo, the degree to which this solar energy is reflected back into the air.

Surface albedo also varies widely with the colour and property of each surface. White snow and ice may reflect 90% of the incident energy back and sustain a cooler surface while dark soil and plants may reflect less than 10% of this energy, absorbing most of it to drive latent heat fluxes or heat soil.

It follows that the colour, protection and insulation properties of the land surface greatly influences how much of this incident energy is, reflected or absorbed, its temperature and thus the amount of infra red heat that is re-radiated to drive the natural and abnormal greenhouse effect and warming.

b. How we have impaired these processes.

Humans have profoundly altered the Earth's surface albedo over the past 10,000 years and thus its heat absorption, reflection, surface temperatures , hydrological dynamics and climate.

Our warming of the planet is already reducing the area and longevity of its snow and ice cover, thereby decreasing its albedo reflectance and increasing heat absorption, warming and further snow loss. Our emissions and fallout of dark particulate pollutants on such snow and ice also reduces their albedo reflectivity, further accelerating heat absorption, melting and the reduction of these areas.

Our annual burning of 2 bha of rangelands and 350 mha of forests creates vast dark areas with very low albedo that absorb most of their incident heat and where they don't have soil water to transfer the heat back into the air via latent heat fluxes, surface temperatures may increase significantly.

While the Earth's 6 bha of residual grasslands naturally 'yellow off' as they mature and increase their albedo reflectance, protection and insulation of soils; our burning of much of this grassland greatly lowers this reflectance and accentuates their warming, heat re-radiation and greenhouse effects.

These processes have contributed significantly to our creation of 5 bha of man-made desert and wasteland or 40% of the global land area that now absorbs much of its incident solar heat.

Our clearing of some 6 bha of primary forest and cultivation of 1,5b ha of soils over the past 10,000 years has similarly reduced their albedo reflectance, protective vegetation cover and increased their heat absorption, temperature and re-radiation of infra red heat that drives the greenhouse effect.

Whereas the temperature of vegetated moist soils rarely exceeds 20oC, nearby bare exposed soils often exceed 50oC with these differences profoundly increasing the greenhouse heat re-radiation.

c. The consequences of our impairment.

These systemic human induced changes in the albedo reflectance and heat absorption of the land surfaces have had and will continue to have profound impacts on our climate and safe future.

By desiccating and degrading our soils and landscapes at this scale we have greatly impaired their capacity to sustain the Earth's former hydrological cooling and our ability to secure the water, food, bio-materials and habitat we need for our social viability, health or stability.

As will be discussed in the next process the increased heating of the Earth's soils with their loss of high albedo covers may be a key factor driving our abnormal greenhouse warming and the induction of the dangerous hydrological climate extremes. The restoring of perennial soil covers and albedo may be critical to remediate these effects.

While it may be too late to revere the loss of snow and ice cover and their former albedo and cooling effects, it is still practical to moderate the decline of such albedo cooling effects in warmer regions receiving and re-radiating the most heat, by restoring shelterwoods and protective soil covers .

Similarly while it may not be possible to greatly influence the albedo of the Earth's oceans that cover 71% of the planet, the oceans currently absorb over 90% of the additional heat retained by the Earth due to our impairment of its heat balance. Over time this warming and associated acidification of the oceans will re-equilibrate with the atmosphere and surface climate and unless buffered will intensify major and dangerous hydrological changes to the Earth's climate and bio-systems.

As it may be impossible to predict or influence the nature, scale and timing of these changes, all we can and must do is to actively restore the natural hydrological buffers and cooling processes that still govern the terrestrial climate and hope that these can offset some of these dangerous impacts.

d. What we must and can do to restore them.

Given our limited agency across the land surface, let alone the 71% of the planet covered by oceans there are few simple effective ways to reverse the changes we have made to the Earth's albedo other than massively and urgently;

- Cease the degradation of the residual natural vegetation and its albedo by less burning.
- Restore the natural perennial vegetation covers over as much of the land as possible.
- Revegetate as much of the 5 bha of man-made desert and rangelands as possible.
- Minimize the area and duration of bare soils and exposure via our agriculture.
- Restore the key hydrological processes that naturally cooled the planet and may now be our only means to offset and buffer the intensified warming and further ice and snow loss.

What matters is that we protect as much of the Earth's soil surface as possible with vegetation to limit its direct solar exposure and its absorption and thus re-radiation of that incident heat so that this re-radiation does not add to the abnormal greenhouse effect. It does not matter greatly if the vegetation is dark or light given that light vegetation may reflect more heat and dark vegetation may need and use that heat to drive enhanced cooling latent heat fluxes.

While discussed latter inregards to clouds, we may be able to influence the Earth's most significant natural albedo cooling effect by enhancing the natural level, longevity and reflectivity of clouds which naturally reflect over 120 w/m2, or a third of the incident solar radiation back out to space.

However to effect this safe natural cloud cooling we first need to understand and regenerate the hydrological processes that may govern this, which is the objective of this brief analysis and review.

e. Case studies of the effectiveness of such regeneration strategies.

Most are aware of the significant direct cooling effect protective cover with high albedo reflectance can provide in shading areas. Similarly most are aware of the higher temperatures commonly above the surface of snow on a sunny day than in it due to the snow's albedo reflectance of solar heat.

At a landscape scale shelterwoods often create cooler micro-environment under them in summer even when not transpiring relative to nearby cleared areas due to these albedo shading effects.

Extensive regions such as the NE US were significantly cooler in summer before their dense natural broadleaf tree covers and albedo effects were cleared than after this clearing.

While not a surface albedo effect, major cooling readily occurs under dense cloud covers with high albedo reflectance values, relative to adjacent areas in full sunlight.

These and related case studies confirm how effective and consistent such albedo effects can be in safely cooling sites and how simple and beneficial the can be to implement via grass roots action.

4.The re-radiation of infra red heat from the Earth's surface.

a. The physical processes and their heat effects

As outlined above the incident solar energy that reached the Earth is either reflected back into the air, via surface albedo effects, or absorbed by the soil and oceans to raise the Earth's temperature.

The physics of black body radiators dictates that the heat absorbed by the Earth will be re-radiated back into the air as long wave infra red radiation. The amount of this re-radiation is governed by the Earth's temperature as defined by the Stefan Boltzman Law which dictates that the amount iis a direct function of the 4^{th} power of this temperature in degrees Kelvin.

This means that soils that have absorbed more incident solar energy and are at higher temperatures, re-radiate massively more infra red heat back into the air than soils that have been kept cooler.

This is significant as the Earth's natural and now abnormal greenhouse effect is governed primarily by how much infra red heat is being re-radiated from the Earth's surface, and only secondarily by how much of this heat can be absorbed by greenhouse gas molecules in the atmosphere. Water vapour is the dominant of these greenhouse gases absorbing 60% of this re-radiated heat when it is in the air, while CO2 absorbs 20% of this re-radiate heat as does a range of minor greenhouse gases.

Given that bare exposed soils can readily heat up to over 50oC, they can re-radiate exponentially more heat and induce far higher greenhouse warming than equivalent soils that have been shaded or cooled via latent heat fluxes and rarely have temperatures exceeding 20oC.

Importantly landscapes with minimal re-radiation of infra red heat is minimal due to protective covers, high albedo reflectance or high latent heat fluxes also contribute minimally togreenhouse warming; irrespective of how much water vapour or CO2 may be in the air; as they cant absorb heat that is not being re-radiated.

This scientifically verified reality changes our common public understanding of the greenhouse effect and our options to safely address it. While public concern and policies have focused on the risks from the extra abnormal warming from the 30% rise in the CO2 concentration in the air over the past century this may be the less significant of the greenhouse gases and least significant variable governing the greenhouse effect, dangerous climate extremes and what we can do about them.

More seriously this common mis-understanding has led us to largely ignore the major greenhouse variables and those that we can change practically, profitably and in time to safely and naturally cool the Earth and help buffer and offset the pending dangerous warming and hydrological extremes.

The physics of ocean lag and re-equilibration effects dictates that it may take centuries to reverse the abnormal rise in CO2 levels and its minor component greenhouse effect even if we stopped all CO2 emissions and or drew down massive quantities of CO2 from the air. While we need to do both of these massively and urgently in order to regenerate the Earth's soil carbon sponge, hydrology and natural cooling by returning carbon from the air back into our soils, we need to do this to address the primary cause of our dangerous warming and hydrological climate extremes, not just reduce its symptom, the recent rise in CO2 levels in the air, as evidenced by Charles Keeling 50 years ago.

Effectively and as nature does **we can readily and safely 'turn down' the greenhouse effect** by simply protecting and rehydrating soils so they don't absorb the abnormal levels of solar energy they now do and re-radiate this back into the air. We can do this irrespective of the concentration of CO2 in the air, as it cant absorb and retain infra red heat if this has not been re-radiated.

As our land management directly controls the solar energy absorbed by the earth, its temperature and the infra red heat being re-radiated, changing this can largely control the greenhouse effect.

Most importantly we can change our land management and its soil protection regionally within days via mass grass roots community action, to rapidly reduce the abnormal greenhouse warming. Extended globally this is now our only option to naturally and safely limit global warming and the dangerous climate extremes.

b. How we have impaired these processes.

In contrast to Venus and Mars, the Earth evolved key processes and balances that enabled it to regulate its natural greenhouse effect over 4 billion years to warm the planet 33oC above what it would otherwise be, maintain liquid water in its oceans to enable the evolution of life and repeated buffer and restore the Earth's stable climate following major geologic or galactic disruptions.

As these natural greenhouse processes and balances did this despite atmospheric CO2 levels reportedly varying from some 900,000 to 100 ppm over this period; it indicates that factors other than the CO2 concentration must have contributed significantly to these greenhouse controls.

The above analysis suggests key hydrological and related physical processes may have largely been overlooked in our assumptions on what causes the natural and abnormal greenhouse warming and outline how they operate. It follows that our recent radical changes to these processes via our mass degradation and change to the Earth's surface and hydrology could have seriously impaired their former natural global temperature regulation effects. The analyses outline how this could result.

Clearly our clearing, burning, oxidation, degradation and erosion of 75% of the Earth's primary forest and their soils over the past 10,000 but particularly the past 250 years (UNEP) has radically altered the Earth's terrestrial hydrology, cooling and heat dynamics. So too would the drainage of up to 90% of the natural wetlands in 'developed' countries and the creation of some 5 bha of man-made desert and wastelands covering 40% of the Earth's finite land surface. If we add to that the desiccation, particulate and haze effects from our annual burning of some 2 bha of residual rangelands, 350 mha of forest and emission of 8btC/an from fossil fuels plus the dispersal of well over 3 bt/an of fine dust into the air we can readily see how this and we may have affected the Earth's hydrology and climate.

More positively, in recognizing these realities and impacts we can also rectify them by restoring the former natural systems, processes and balances and through that our hydrology and climate.

Critical in this is to urgently reduce the area of the Earth's land surface that is bare and desiccated and thus exposed to the incident solar radiation and temperature rises that massively increase the re-radiation of infra red heat driving the natural and enhance greenhouse warming. By doing this we should be able to effectively and safely turn down regional and the global greenhouse effect within days, irrespective of the CO2 concentration, to help cool climates and help regenerate the Earth's natural hydrology, bio-systems, heat dynamics and climate.

< NB document is incomplete >

- **c. The consequences of our impairment.**
- **d. What we must and can do to restore them.**
- **e. Case studies of the effectiveness of such regeneration strategies.**